THE EFFECTS OF OIL AND GAS EXPLORATION ON MAMMALIAN POPULATION DISTRIBUTION AND HABITAT CHANGE IN MURCHISON FALLS NATIONAL PARK, UGANDA

BY

AKISIIMIRE HINDRAH

17/U/14304/GMSM/PE

A DISSERTATION SUBMITTED TO KYAMBOGO UNIVERSITY GRADUATE SCHOOL IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN CONSERVATION AND NATURAL RESOURCES MANAGEMENT OF KYAMBOGO UNIVERSITY

FEBRUARY, 2021

DECLARATION

This dissertation is my original work and has never been presented for a degree in any other University.

Candidate's signature: ____

APPROVAL

This dissertation has been submitted to Kyambogo University Graduate School with our approval as University Supervisors.

Academic Supervisors	**Signature**
1. Professor Charles Twesigye	______________________________
2. Dr. William Tinzaara	______________________________

ACKNOWLEDGEMENTS

I would like to extend my sincere appreciation to my supervisors, Prof. Charles Twesigye and Dr. William Tinzaara who guided me, encouraged me, invested time and provided helpful information throughout the development of the concept note, research proposal up to the final dissertation. I am grateful to Uganda Wildlife Authority (UWA) for granting me access to Murchison Falls National Park. I wish to acknowledge the great support of Dr. Sylivia Nalubwama and Mr. Kitimbo Herbert for the valuable guidance throughout the study. I am deeply grateful to Mr. Keneth Tumwebaze for the technical support, generosity and direct collaboration during this study. Lastly, my sincere gratitude goes to my entire family for the support and encouragement to pursue this degree.

LIST OF ACRONYMS

EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
ESIA	Environmental and Social Impact Assessment
E& P	Exploration and Production
GPS	Geographical Position System
MFCA	Murchison Falls Conservation Area
MFNP	Murchison Falls National Park
MFPA	Murchison Falls Protected Area
NEMA	National Environment Management Authority
NP	National Park
PA	Protected Area
UWA	Uganda Wildlife Authority

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Uganda discovered petroleum deposits in commercially viable quantities in 2006. Most areas such as Murchison Falls National Park where petroleum has been discovered overlap with wildlife and nature conservation with high biodiversity and sensitive ecosystems. Oil development could destroy mammal habitats, disrupt animal abundance and people's lives if not well planned. This research aimed to find out the current status of mammals and their habitats as well as the social perception of oil and gas operations in the park five years after completion of exploration and restoration of oil pads. The specific objectives of the study were to; determine the change in mammal habitats in relation to oil and gas exploration, determine the effects of post exploration oil and gas infrastructure on the abundance and distribution of mammalian population and determine the social perception of the people living in and around MFNP regarding oil and gas operations in the protected area. The study used observation and survey methods for data collection. It involved measuring vegetation frequency index, vegetation relative abundance and vegetation diversity in oil pads and control areas. The study recorded grasses, shrubs and tree plant forms using different size quadrats along a 60m line transect. The quadrat sizes were (1x1m) for grasses, (5x5m) for shrubs, (10x10m) for trees. The number of quadrats and transects per site under study were (8 x4) in total. Indirect and direct mammal counts were conducted by walking along a 2km transect while recording physical mammals, footprints, fecal pallets, wallowing grounds, fur, palm seeds and kobleks. A social survey was conducted by administering 50 questionnaires to key informants to determine the perception of the community about oil and gas exploration. The key informants included 10 UWA administrators, 10 oil and gas workers and 30 local people from Nwoya (15) and Pakwach (15) Districts. The study recorded uniform and non-uniform plant species and the mean vegetation diversity of (1.9±0.058) in oil pads and (1.71±0.120) in control areas. The study identified 31 different plant species and among these 7 plant species were recorded in oil pads, 8 in control areas. 16 types of these plant species were recorded in both oil pads and control areas. The results indicate a non-significant difference in the vegetation relative abundance and diversity between oil pads and control areas**.** The study counted seven mammal species and the results show a non-significant difference of the mammal's population abundance and distribution in oil pads and control areas. The survey participants suggested improvement in areas of oil waste management, noise, animal disturbance and displacement. The local people fear that the park is at risk of losing its biodiversity. Further studies can be carried out using different methodologies such as chemical soil analysis, animal tagging, and genetics to further determine if there are any effects on mammals as a result of oil exploration activities. It's further recommended that similar studies could be conducted on other former oil pads in the national park to get the true representation of the whole ecosystem.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Much of Africa is currently undergoing unprecedented international investment and economic growth (African Development Bank, 2014). Six of the 13 fastest growing economies worldwide are found in Sub-Saharan Africa (Holodny, 2015). Despite the global perception of increased investment risk due to political, social, technical, and environmental issues (Frynas and Paulo, 2007), the continent's importance in the global oil and mineral market has been increasing faster than any other region of the world. This increased importance has sparked attention and competition between foreign investors and global petroleum companies, often leading to mineral extraction in and around protected areas (PAs) (Annan, 2012; Janneh and Ping, 2012; Osei and Mubiru, 2010).

Oil was first discovered in western Uganda in the 1870s, but commercially viable oil was only confirmed in 2006 (Rwakakamba and Lukwago, 2013). Approximately 2.5 billion barrels of commercially-viable oil of $2 billion worth in annual revenue for twenty years (Shepherd, 2013) was discovered under the Ugandan portion of the Albertine Rift in 2006.This would make Uganda the fifth largest oil producer in Africa (Vokes, 2012). The government of Uganda went ahead in the early 2000s and licensed the exploration of oil prospects in the country. The wildlife law in Uganda allows exploration and extraction of oil under protected areas, provided that the impacts to the environment are minimized and where possible the natural habitat is restored after extraction. Initial drilling was promising and it expanded from the Kabwoya Wildlife Reserve to other sites around Lake Albert including Murchison Falls National Park. MFNP is managed by the Ugandan Wildlife Authority (UWA) among other ten National Parks in Uganda, and it is among the seven which occur within the Albertine Graben.

Since 2010, MFNP has been a hot spot following the oil discovery thus attracting a numerous number of global oil and gas companies such as Total Exploration & Production. In 2012, Total E&P Uganda accepted the challenge of working in Uganda's largest protected area of MFNP. Prior to the discovery of oil, conservation and tourism were the only form of land use for MFNP. But with the oil discovery, the foot print by oil prospectors in the protected areas is becoming bigger. MFNP is one of the four savanna parks in Uganda which is recognized for its uniqueness and importance for biodiversity conservation (Lamprey, 2000). It has the most spectacular falls along the Nile and is important for its wildlife concentrations, and is the main representation of the Sudanian vegetation form in East Africa. It is thus accorded a high level of conservation priority by IUCN (UWA, 2001). It is also the only park in Uganda with a viable population of Rothschild's giraffe and crocodile, contains Uganda's largest population of Jackson's hartebeest, which has been nearly or completely eliminated from other protected areas in Uganda, and it is also one of the few places in Uganda with populations of soft-shelled turtle (Olupot *et al*., 2010).

Plumptre *et al*. (2003) noted that there are 190 mammal species in MFNP and 54 of these are large mammals. In the report of Biodiversity Surveys of Murchison Falls Protected Area, over 144 mammal species were recorded by Plumptre *et al*. (2015). MFNP is reported to have high ecological importance for a number of globally and regionally threatened species of mammals according to Plumptre (2007) and it is home to 76 species of mammals such as Cape buffalo, African elephants, lions, leopards and Rhinos, Hippopotamus, Giraffes, Antelopes according to https://www.nationalparks-worldwide.com website. In the 1960s wildlife population and diversity in Murchison Falls National Park, Karuma, and Bugungu Wildlife Reserves (now managed as Murchison Falls Conservation Area) was high. Wild animals used to range freely inside and outside the MFPA. The 1970 s and early '80s were devastating times for wildlife in MFPA, and the country as a whole due to heavy commercial poaching, mostly for meat and ivory as a result of the breakdown of rule and law at the time. Population estimates of large mammal species in Murchison Falls Protected Area are available from various counts conducted prior to 1973 and from aerial surveys conducted in 1980, 1995, 1999, 2005 and 2010 to determine animal population distribution and trends.

The Graben is divided into 10 exploration areas, three of which overlap MFPA. i.e. Paraa, Lye and Bulisa, with seven confirmed oil fields contained partially or completely within MFPA boundaries (PEPD, 2014). These areas are shared by Tullow Oil plc, Total E & P, and the China National Offshore Oil Corporation. National Academy of Sciences (2003) noted that oil and gas development negatively impact wildlife through direct mortality and displacement, reduced reproductive rates, and better conditions for predators. Mariano and La Rovere (1999) also noted that the oil industry holds a major potential of hazards for the environment, and may impact it at different levels: air, water, soil, and consequently all living organisms on our planet. Within this context, the most widespread and dangerous consequence of oil and gas industry activities is pollution which is associated with virtually all activities throughout all stages of oil and gas exploration and production up to refining. Pollutants include wastewaters, gas emissions, solid waste and aerosols generated during drilling, production, refining and transportation.

Wildlife populations will continue to be impacted through the direct conversion of habitat to industrial infrastructure and indirect losses associated with the avoidance of industrialized areas or abundance of predators Harju *et al.* (2010); Dzialak *et al.* (2011) and it is imperative to evaluate the potential intersection of high value habitat and oil and gas accumulations to achieve an effective balance between conservation and industrial development (Copeland *et al.,* 2009). Even in countries with strong environmental regulatory governance, production spills, burst pipelines, and tanker spills, have devastated the environment, wildlife, and livelihoods (Peterson *et al*., 2003;

Levy and Gopalakrishnan, 2010; Kark *et al*., 2015). It is important to assess the potential impacts of oil and gas exploration on the wildlife in the park based on the various phases and to attempt to suggest ways of minimizing any disturbances caused by these activities.

1.2 Problem statement

Exploration sites of Jobi 4 and Jobi East 7 are located inside the protected area of MFNP. These sites went through seismic surveys to obtain details of subsurface geological structures, vegetation clearing (Epstein and Selber, 2002) to set up equipment and opening up of new access routes/roads for transportation (Finer *et al.*, 2008) of oil and gas operations. Exploration involved drilling to determine commercial viability of the reserve. This was followed up by restoration of these sites once exploration was completed. Restoration included putting back soil layers in their initial state and replanting of vegetation. Drilling is associated with high human presence, running machines, hooting, lighting, vibrations which can all be stressful factors to wildlife behavior thus leading to intentional feeding and habituation (Gill, 2001). Oil extraction has shown to put biodiversity conservation at risk, as exemplified in the Niger Delta which records 221 annual oil spills (Osuji,2001). Oil spills and gas flaring have damaged biodiversity, destroyed mangrove forests, contaminated beaches, coated birds, endangered fish hatcheries, and disrupted food webs in the Niger Delta region (Ugochukwu and Ertel, 2008). Numerous studies have made it clear that migratory wildlife is detrimentally affected by the habitat loss and disturbance concomitant with oil and gas development (Sawyer *et al*., 2009; Beckmann *et al*., 2012; Lendrum *et al*., 2012). This study therefore sought to find out the current status of mammalian habitats five years after exploration had been completed and the sites had been restored.

1.3 General objective

To determine the exploration effects of oil and gas on mammals and their habitats in Murchison Falls National Park for sustainable management and wildlife conservation.

1.3.1. Specific objectives

1. To determine the changes in mammal habitats in relation to oil and gas exploration in MFNP.
2. To determine the effects of post exploration oil and gas infrastructure on the abundance and distribution of mammalian population in MFNP.
3. To determine the social perception of the people living in and around MFNP regarding oil and gas operations in the protected area.

1.4 Research questions

1. What is the change in mammal habitats in relation to oil and gas exploration in MFNP?
2. What are the effects of post exploration oil and gas infrastructure on the abundance and distribution of mammalian population in MFNP?
3. What is the social perception of the people living in and around MFNP regarding oil and gas operations in the protected area?

1.5 Null Hypotheses

1. There is no significant change in mammal habitats in relation to oil and gas exploration in MFNP.
2. Post exploration oil and gas infrastructure has no significant effect on the abundance and distribution of mammalian population in MFNP.

3. There is a negative social perception of the people living in and around MFNP regarding oil and gas operations in the protected area.

1.6 Significance of the study

The study sought to explore the effects of oil and gas exploration on mammals and their habitats in MFNP. This study contributes to the current knowledge base for striking a balance between wildlife conservation and oil developments for the promotion of biodiversity conservation and effective management. The studied mammal species are key flagship species for tourism and therefore associated with keen economic and social interest across MFNP landscape. The Cape Buffalo was studied for its cultural attributes in the area and therefore associated with significant vulnerability threat from poaching, the Rothschild's Giraffe population in MFNP is the only remaining species and therefore selected for its significant global value, the Uganda Kobs in MFNP form a larger population of prey for many predators particularly the large carnivores. These mammal species exhibit territorial tendencies and have home ranging requirements which are likely to be affected by activities of oil and gas explorations around. They are easily vulnerable to anthropogenic factors, diseases, long maturity and low birth rates.

1.7 Scope of study

The study was conducted in Murchison Falls National Park GPS coordinates of 2^{o} 08 ˈ44.9 ̎ N, 31^{o} 48 ˈ24.8 ̎ E. which sits on the shore of Lake Albert, in northwest Uganda. MFNP covers an area of 3867 km^2(Prinsloo *et al.*, 2011) but the study focused on Exploration Area 1 encompassing of various Jobi Exploration sites. The elevation in MFCA ranges from 619 to 1291 m and temperatures in the region range from a minimum of 22°C to a maximum of 29°C.The average annual rainfall ranges from 1100 mm in the west to 1500 mm in the east and far south, and occurs in a bimodal seasonal pattern (Prinsloo *et al*., 2011). The park occupies a relatively flat land 2^{o} north of the equator of Uganda (Harcourt, 2001) and it straddles the Ugandan districts of Bulisa, Nwoya, Pakwach, Kiryandongo, and Masindi.

The research studied sites of Jobi 4, Jobi East 7, Control Area 1 and 2 for both dry and wet seasons. The study focused on the effects of oil and gas exploration on mammals and their habitats by measuring vegetation frequency index, relative abundance and diversity as well as counting of mammals in and outside the former exploration oil pads. The study also administered questionnaires to determine the social perception of the people living in and around MFNP regarding oil and gas operations in the protected area. However, the study was limited to only two oil pads and did not cover all the post exploration sites located inside the park.

1.9 Operational definition of key terms

1. **Impact:** Is any change, potential or actual, to the physical, natural, or cultural/social environment, and affects the surroundings as a result of the activity being proposed.
2. **Present Impacts:** Refers to as the current observed effects of something (oil and gas exploration)
3. **Oil and Gas Exploration:** Refers to the search for hydrocarbons beneath the ground that entails geophysical prospecting of an area that hold deposits of oil and natural gas. It involves seismology, a process whereby substantial vibrations, via explosives or machinery, are produced at the Earth's surface. Seismic waves travel to the earth's mantle, and the respondent force is analyzed at the surface to identify layers of rock that trap reservoirs of oil and natural gas.
4. **Development:** In oil and gas exploration, this occurs after identifying potentially viable fields; engineers determine the number of wells needed to meet production requirements

and the method of extraction of the liquid hydrocarbons. Platform construction costs are estimated with regard to the site, offshore or onshore, and designs are rendered for systems used to facilitate environmental protections.

5. **Production:** This is a stage in oil and gas chain where liquid hydrocarbons extracted from wells are separated from the non-saleable components such as water and solid residuals.
6. **Habitats:** It is an ecological or environmental area that is inhabited by a particular species of animal, plant or other type of organism. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilized by) a species population. It can also be defined as an area an organism can live, reproduce and able to mate.
7. **National Park:** Uganda Wildlife Act (1996) under Section 18 defines a National Park as any area of international or national importance because of its biological diversity, landscape or natural heritage. While IUCN (1994) defines it as Large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.
8. **Environmental and Social Impact Assessment (ESIA) Process:** Is an analytical process that systematically examines the likely environmental and social impacts of a proposed project, evaluates alternatives and designs appropriate mitigation, management and monitoring measures, considering inter-related social-economic, cultural and human health impacts, both beneficial and adverse.

9. **Placard:** Highighi *et al*. (2017) described a placard as a source of information in a company. It is a marker indicating where oil and gas has been discovered with site name and GPS points.
10. **Borehole:** a hole driven into the ground to obtain geological information to release water. The borehole supplies water to the settlement camp at the oil pad.

CHAPTER TWO

LITERATURE REVIEW

2.1 Oil and gas exploration

Drilling a well for exploration is a multistage process during which the upper parts of a borehole, once drilled, are sealed with steel casing and cemented into place. Oil wells can be categorized as producing, abandoned, idle and orphaned. In its report of Environmental management in oil and gas exploration and production UNEP (1997) noted that specific exploration for oil, in the modern sense, begun in 1912 when geologists were first involved in the discovery of the Cushing Field in Oklahoma, USA.

King and King (2013) noted that boreholes drilled to explore and extract hydrocarbons must penetrate shallower strata before reaching the target horizons. Some of the shallower strata may contain groundwater used for human consumption or which supports surface water flows and wetland ecosystems. Modern production of oil and gas involves various activities that take the form of steps. The seismic data acquisition process is a short time operation that has mostly short-term direct impacts for biodiversity but may also have long term impacts if not properly managed. There are so many operations that oil and gas production pertain, that may lead to disruption of traditional migratory routes by anthropogenic disturbances that may shift patterns of resource selection by many species and in some instances cause populations to decline (Lendrum *et al.*, 2012).

Oil and gas operations are bound to disrupt migrations which are a remarkable life-history strategy that represents an essential component of the ecological niche of a variety of taxa, including mammals (Dingle and Drake, 2007). Disruption of migratory routes has caused rapid population collapses especially to mule deer in the Intermountain West, USA (Unsworth *et al*., 1999, Johnson *et al*., 2007).

2.2 Pad construction, infrastructure development and maintenance

Pad construction at the chosen site is meant to accommodate drilling equipment and support services. UNEP (1997) commented that a pad for a single exploration well occupies between 4000-15000 m^2 and the type of pad construction depends on terrain, soil conditions and seasonal constraints. Infrastructure development may include construction of access roads, support camp which tends to be self-contained and generally provides workforce accommodations, canteen facilities, communications, waste treatment and disposal, vehicle maintenance, parking areas, a fence and sometimes a helipad if need be to access remote areas. Total appraise oil fields used cable less 3D seismic surveys, which do not require removal of vegetation along seismic lines (Ocowun and Okethwengu, 2013). Total and Tullow used horizontal rather than vertical drilling to minimize the surface footprint by reducing the number of drill pads (100 m x 100 m) and roads constructed inside MFPA (Kagolo, 2014).

Sometimes, oil well sites may include processing facilities, offices and workshops which may require occupation of several hectares depending on the capacity of the field. Part of the infrastructure development by oil and gas industries in protected areas and also MFNP is construction of access roads to reach areas with hydrocarbon deposits or even to set up machinery to assist in oil drilling among other operations. The main concern among conservationists and environmental planners is that roads and traffic may be reducing or even eliminating wildlife populations (Trombulak and Frissell,2000). Increased frequency with which animals enter the road may increase their mortality risk (Forman *et al*.,2003).

From an ecological perspective, development can cause large-scale and novel alterations to ecosystems, resulting in habitat loss and fragmentation (Leu *et al*., 2008; McDonald *et al.*, 2009) that strongly impact terrestrial wildlife populations and their ecosystems. The other impacts of unconventional oil and gas development on ungulates and other large mammals were well characterized due to the economic and conservation importance of these species. For large mammals, behavioral impacts were most commonly documented and included large-scale displacement from developed areas and around development infrastructure (Sawyer *et al.*, 2006).

2.3 Mammal habitats and population abundance

Human disturbance affects wildlife at multiple scales (Leblond *et al*., 2011). At a landscape level, disturbance may affect the distribution and persistence of wildlife populations and alter the structure and composition of wildlife communities (Vistnes and Nellmann, 2008). Over the time mammals have evolved from reptiles and diversified to fill the many vacated niches in a wide range of habitats. Mammals such as bats now patrol the skies, whales and dolphins inhabit the seas, and animals as diverse as otters and elephants fill habitats across the land living in varied habitats from the open savannah to the desert and high rainforest. Elephants are herbivores and need to eat about 350 pounds of vegetation daily. Because elephants require substantial amounts of food and a large area in which to forage, habitat destruction across their range is a major threat to survival as well as semi-aquatic mammals such as Hippopotamus and rhinoceros which in habit both land and aquatic habitats. Giraffes which are the tallest living terrestrial animals and the largest ruminants inhabiting savannahs and open wood lands; and majorly feed on leaves, fruits and flowers of woody plants.

The most important and large-scale cause of habitat fragmentation is the expansion and intensification of human land use (Burgess and Sharpe, 1981). Habitat fragmentation has three major components, namely loss of the original habitat, reduction in habitat patch size, and increasing isolation of habitat patches, all of which contribute to a decline in biological diversity within the original habitat (Wilcox and Murphy, 1985). Plumptre *et al*. (2016) noted that noise caused mainly by large machinery vibrations, trucks and hydraulic ramming (to insert the first pipe for drilling) caused elephants to move away from seismic operations up to 4-5 km away in MFNP. Whether this is due to the vibrations, noise or the presence of people undertaking the work is unclear and responses may be greater where elephants are more nervous of people. World Conservation Society (WCS) report of (Plumptre A.J., unpublished data) indicated that elephants sometimes avoid roads up to 2-3 km away and they will avoid drill sites up to 5-6 km in MFNP.

Reynolds *et al*. (1986) observed that seismic activities can as well produce physiological responses in large mammals such as increased heart rate. Humpback whales can suffer temporally damage to their auditory systems Ketten *et al*. (1993). Jaeger *et al*. (2005) observed three behavioral responses to roads and traffic; such as avoidance of the road surface, avoidance of traffic emissions and disturbance (noise, lights, and chemical emissions), and the ability of the animal to move out of the path of an oncoming vehicle labeled as car avoidance. Avoidance of the road surface reduces animal mortality on roads but also reduces accessibility of habitats and other resources. The road-surface avoidance also includes situations where the animal may not behaviorally avoid the road, but the road design represents a physical barrier to animal movement for example a fenced road. Jaeger and Fahrig (2004) referred to complete road avoidance as the “fence effect.” emphasizing its functional equivalency to a physical barrier. Avoidance of traffic disturbance and emissions reduces habitat quality within the vicinity of roads in a sense that the higher the amount of traffic on the road, the more the avoidance. Noise can have significant impacts on animals because increased disturbance levels reduce the distance and area which might be perceived by animals as suitable for foraging. It can place them at greater risk of predation, can cause stress that affects reproduction and reproductive success and can lead to increased stress caused diseases (Kolowski, and Alonso, 2010).

2.4 Human activities in the national park

Global economic development and demand for energy have led to an expansion in oil and gas exploration, and oil and gas reserves in many cases overlap with protected areas and biodiversity Hot spots (Harfoot *et al.*, 2018). Anthropogenic noise such as traffic or industrial noise is often both louder and more frequent than natural sounds and can have a variety of deleterious impacts on wildlife (Blickley and Patricelli, 2010). Human activity on trails and roads within the national park may lead to indirect habitat loss or further limiting the available habitat thus disrupting ecological processes. It can be observed by complex interaction between the distance animals are located from trails and human activity level resulting in species adopting both mutual avoidance and differential response behaviors (Rogala *et al.*, 2011).

Human activities in a national park can lead to habitat loss from an increasing and expanding human population which is the greatest threat to a wide diversity of species (Wilcove *et al.*, 1998, Brooks *et al.*, 2002). Further causes of habitat loss can be recreation and transportation which may have an array of immediate and long-term impacts on species within wilderness parks (Trombulak and Frissell, 2000).

Kityo (2011) also noted that other potential impacts due to increased human presence and traffic would include increased incidents of road kills, soil spills (an oil or fuel spill) on site which would result into an ecological disaster, destroying wildlife grazing rangelands and wildlife. He also reported that in the past waste treatment at other drilling sites has been found inadequate in Murchison Falls National Park. The solid waste itself continues to pile up from all the drilled well sites, these wastes have heavy metals and toxic chemicals that Uganda and the oil industry are as of now not well equipped to deal with.

Larkin and Trites (1996) made a comment about the consequences of increased pressure on protected areas. Many of the projects in these particular areas involve high noise production such as chain saw noise for logging and the extraction of certain minerals. The most common behavior change exhibited by wildlife to intense human produced noise is active avoidance. Clearing of vegetation along seismic lines and pipelines can fragment habitat and alter predator–prey interactions (Borasin *et al*., 2002).

Construction of drill pads, new roads and fences results in to habitat loss and exacerbates fragmentation (UWA, 2012). Additionally, improved access to remote areas can increase poaching and the oil spills can have devastating effects on entire ecosystems (Johnson, 2007; Rwakakamba *et al*., 2014). Northrup and Wittemyer (2013) pointed out energy development impacts on wildlife as pollution, removal of vegetation for roads and oil pads, increased poacher access, altered animal migration and foraging habits. Oil and natural gas development poses heavy threats and dangers towards environmental conservation and the health and safety of the earth's biodiversity (Ericson, 2014). Increased road and rail coverage due to mining can also threaten PAs due to increased access to biodiverse regions (Laurance *et al*., 2009), causing drastic change to land cover due to large human migration into areas with low human population density (Laurance *et al*., 2014; Wilkie and Carpenter, 1999; Wilkie *et al*., 2000).

2.5 Social perception of oil and gas operations in protected areas

While most of the attention is devoted to possible environmental impacts of oil and gas operations in protected areas such as national parks, focusing on the impacts on its biodiversity, less attention is given to opportunity-threat and socio-environmental impacts typically associated with rapid energy development (Gramling and Freudenburg 1992).

Haselip and Romera (2011) also commented about the impacts of rapid changes brought about by oil and gas industrial development at the micro-level, such as those that affect local communities and the environment. Ever since the World Wildlife Fund (WWF) revealed that Total E&P (Exploration and Production) was set for a nine-month seismic study of the Murchison Falls national park for oil starting September 2012.The National Environment Management Authority (NEMA) then successfully conducted two public hearings linked to the Environment and Social Impact Assessment (ESIA) Report for the Tilenga Oil Project. The hearings were held on November 12th and 15th of 2018, in Bulisa and Nwoya districts respectively in conjunction with the Petroleum Authority of Uganda.

2.5.1 Approaches of conserving animal habitats in protected areas

Loehle and Li (1996); Ceballos and Ehrlich (2002) noted that there is much efforts focused on identifying and protecting important habitat resources and reducing or mitigating limiting factors such as excessive sources of human-caused mortality as one of the strategies of animal habitat conservation. Some species are the targets of policies to conserve dwindling populations Price (1989) while others are increasing in number and need to be controlled, for example deer in UK woodlands (Putman and Moore 1998).

The approaches towards management and conservation of large mammals is one of the main objectives and It requires long-term planning based on a deep understanding of how population processes, such as birth rate, death rate and age structure which are affected by changes in land use. One of the approaches towards large mammal conservation is co-operative management groups that allow all interested parties to be involved in the development of management plans. Olson *et al*. (2001) commented that the tapestry of life on Earth is unraveling as humans increasingly dominate and transform natural ecosystems which have led to highly uneven distribution of species and threats. He suggested a global biodiversity map with sufficient biogeographic resolution to accurately reflect the complex distribution of the Earth's natural communities as an approach towards conservation.

2.5.2 Policies, Governance and compliance

Uganda Wildlife Authority Operational Guidelines for oil and gas exploration and production in Wildlife Protected Areas (2014) suggests that if oil/gas and conservation are to co-exist, a number of tools need to be put in place to minimize the impacts associated with oil and gas operations. It is against this background that Uganda Wildlife Authority has prepared the guidelines for oil and gas operations within the protected areas.

The National Forestry and Tree Planting Act, (2003) Section 38 of the National Forestry and Tree Planting Act requires any person intending to undertake a project or any activity which may, or is likely to have a significant impact on a forest shall undertake an environmental impact assessment. The Land Act, (1999) Section 43 provides for management and utilization of land in accordance with the Uganda Wildlife Act and other laws. Section 44 (I) mandates the government or local governments to hold in trust for the people and protect national parks, wetlands, forest reserves among others for ecological and touristic purposes for the common good of the citizens of Uganda.

The Petroleum (Exploration and Production) Act, (1995); Under this Act, it is the duty of the company to carry out exploration operations in a proper, safe and in accordance with good oil field practices and to take reasonable steps necessary to secure the safety, health and prevent pollution or any other waste products or effluence that may occur; and where pollution occurs, the company should treat or disperse it in an environmentally acceptable manner. The National Environment (Noise Standards and Control) Regulations, (2003) in Part III Section 8 (1) of these regulations, it is required of machinery operators, to use the best practicable means to ensure that the emission of noise does not exceed the permissible noise levels. Uganda's Constitution, the supreme law governing the country has provisions for the Environment in article 245, "Protection and preservation of the environment"; Parliament shall, by law, provide for measures intended"— which aims to protect and preserve the environment from abuse, pollution and degradation; to manage the environment for sustainable development; and to promote environmental awareness. It is on the basis of this supreme law that other enabling laws have been enacted and is in place to take care of various special interests. Objective 27 of the Constitution is specifically concerned with on "the Environment" and its protection and wise and sustainable use.

The principal agency in Uganda for monitoring environmental impacts and for coordination of management and protection of the environment is NEMA. For each proposed oil investment, the company in question must produce an EIA, which NEMA must then make public, giving the affected community and other stakeholders the right to respond. The National Environmental Act (Cap 153) and Environmental Impact Assessment Regulations (1998) are the foundational legislation governing EIA studies in Uganda. The National Environment Management Policy, (1994), has as its overall goal, the promotion of sustainable economic and social development mindful of the needs of future generations and EIA is one of the vital tools it considers necessary to ensure environmental quality and resource productivity on long-term basis.

It calls for integration of environmental concerns into development policies, plans and projects at national, district and local levels. Hence, the policy requires that projects or policies likely to have significant adverse ecological or social impacts undertake an EIA before their implementation. This is also reaffirmed in the National Environment Act, Cap 153 which makes EIA a requirement for eligible projects.

The Petroleum Exploration and Production Act (2000) mandates the line Ministry Minister the authority to grant a petroleum exploration license, on such conditions as he may determine. Objective 9 of the National Oil and Gas Policy for Uganda, (2008) seeks to ensure that oil and gas activities are undertaken in a manner that conserves environment and biodiversity through strategies such as; strengthening environmental monitoring of oil activities, ensuring that sites at which oil activities are undertaken are restored to original conditions. The policy considers environmental protection to include both physical and social aspects and seeks to mitigate typical forms of environmental damage and hazards associated with oil and gas activities. Specifically, the policy supports measures against improper discharge of waste into the natural environment (air, water, soil) to ensure safety of animal, fish and human life. The policy also recognizes a need to minimize the impact footprint in ecologically sensitive sites such as wildlife conservation areas. For instance, access roads in such areas should be kept at a minimum and their construction or maintenance should be done in an environmentally responsible manner (Section 6.2.4).

The National Oil and Gas Policy for Uganda, (2008) (NOGP) enshrines ‘Protection of the Environment and Conservation of Biodiversity’ as one of its guiding principles. To ensure this, the NOGP recognizes the need for; putting in place the right ‘institutional and regulatory framework to address environment and biodiversity issues relevant to oil and gas activities’ and ensuring there is ‘the necessary capacity and facilities to monitor the impact of oil and gas activities on the environment and biodiversity’.

2.8 Summary of gaps in literature

UNEP (1997) gave the general environmental management in the oil and gas industry focusing on legislation that applies to oil operations, industrial guidelines to the environment, international and regional frameworks. However, the report pointed out the potential impacts (atmospheric, terrestrial, aquatic, human, social-economic and cultural) of each oil activity. It neglected the onshore post exploration effects of oil and gas industry on mammals and their habitats.

Plumptre *et al.* (2016); in his report “Documentation of existing and potential oil/geothermal projects, mapping their likely adverse negative effects on the biodiversity conservation and community livelihoods in the Greater Virunga Landscape” focuses on Species likely to be affected by oil/gas and geothermal activities which is does not indicate the potential effect on mammals and their habitats. The same study just documents and maps the existing and potential oil projects but does not quantify the extent of the impacts.

Kityo (2011) highlights issues and documents the potential effects of exploration on species, sites and habitats as per observation and where possible use quantitative representation to highlight the magnitude of the problem which is a bit general and neglects animal habitats. In the same report he highlights potential and resultant effects of approving the development of the golf course in Chobe sector which is not enough to show the effects of oil and gas exploration on animals and their habitats. The study is broad covering the whole Albertine Rift thus giving less focus to Murchison Falls National Park.

Andren (1994) assessed the effects of habitat fragmentation focusing on birds and mammals in landscapes with different proportions of suitable habitat. The study looked at the scale of habitat fragmentation and population responses to habitat fragmentation while identifying the factors influencing the abundance and distribution of species in landscapes with different degrees of habitat fragmentation but the study does not specify the causes of mammal habitat fragmentation in relation to the oil industry.

Mulondo (2015) investigated the spatial distribution of Elephant, Buffalo, Giraffe and Uganda Kob in relation to oil exploration drilling. The study focused on oil drilling in response to mammal patterns thus this study focused on the post exploration status of mammal habitats five years after drilling and restoration.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

The study location is on the northern bank of MFNP in the main tourism circuit area. The study area habitat consists mainly of mosaic grassland, dense borassus woodland, open borassus woodland; open woodland, wooded grassland and bush/shrub. The park's topography is rolling, reaching a maximum elevation of 1,291 m at Rabongo Hill in the south east of the park, and a low elevation of 619 m at Lake Albert on the rift valley floor in the west. The park is hot with mean minima of 22^{0}C and maxima of 29^{0}C all year round. The eastern part of the park is wetter than the western part; Chobe to the East receives around 1,500 mm whilst Paraa receives about 1,100 mm. Murchison Falls National Park has two rainy seasons, from mid-March to mid-June, and from August to November (UWA 2001).

The study sites were located in Exploration Area 1 and they included Jobi 4 coordinates 2 ^{o}20ˈ09.5ˮ N, 31 ^{o}29ˈ52.4ˮ E and Jobi East 7 coordinates 2^{o}20ˈ45.4ˮ N,31^{o}32ˈ26.8ˮ E. These were paired with two control areas i.e. Control Area 1 coordinates 2^{o}17ˈ54.4ˮ N, 31^{o}28ˈ28.2ˮ E and Control Area 2 coordinates 2^{o}20ˈ46.8ˮ N,31^{o}34ˈ44.5ˮ E for comparison purposes (Figure 3.1) (Table 3.1). The two exploration sites were drilled and restored at different time periods. Control area 1 had similar environmental conditions as Jobi 4; the two sites were relatively flat with open savanna grasslands. Similarly, Jobi East 7 had the same environmental conditions as Control area 2; the two sites both had open savannah grasslands with Borassus palm trees and a narrow gully cutting across the sites.

Table 3.1: Time period for different exploration sites and their respective control areas

Exploration Site	Drilled	Restored	Paired Control Area
Jobi 4	March- April 2013	June 2013	Control Area 1
Jobi East 7	July- August 2013	May 2014.	Control Area 2

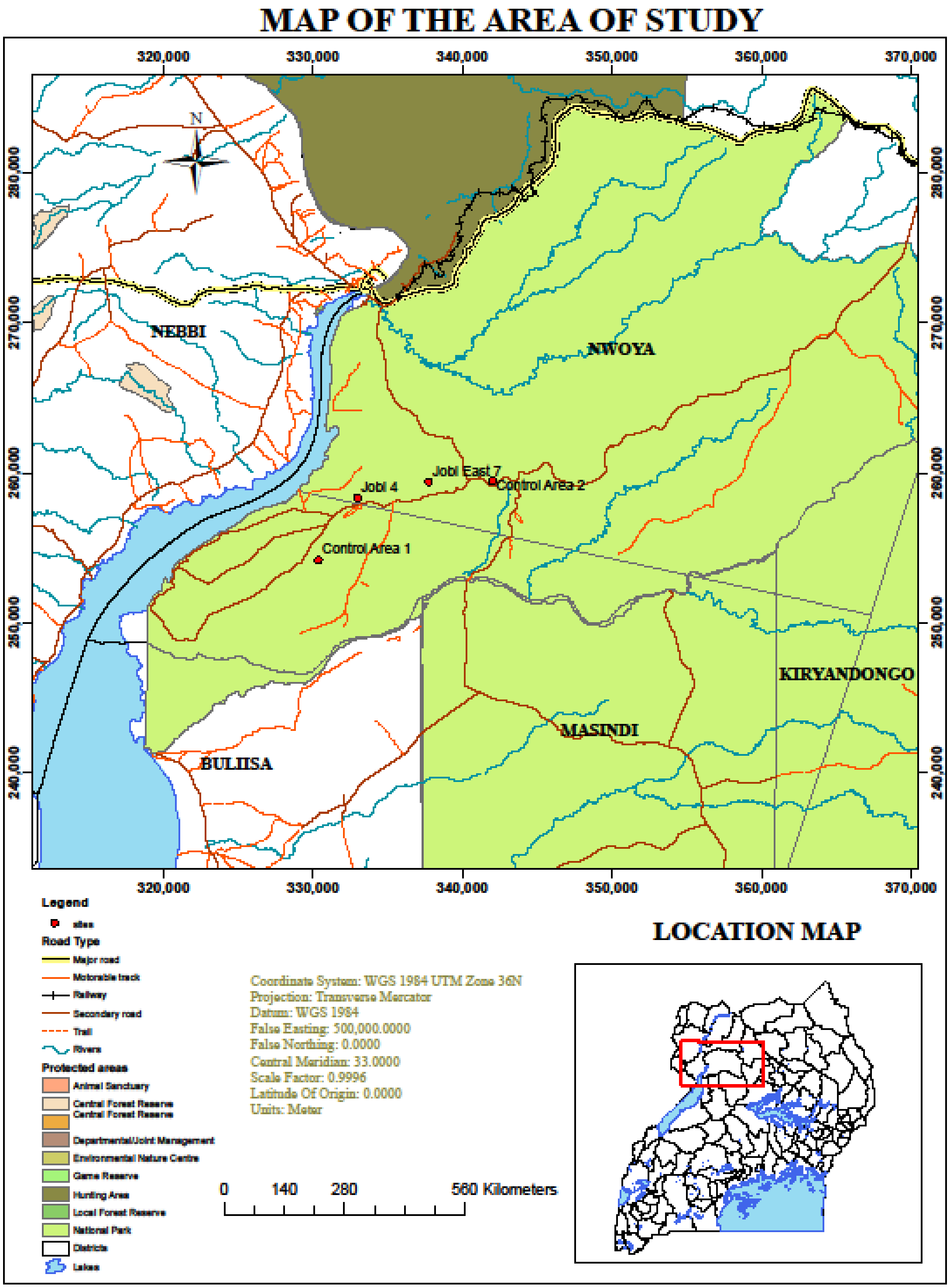

Figure 3.1: A map of Murchison Falls National Park showing study sites

3.2 Research design

The research used both qualitative and quantitative research designs. The quantitative designs involved purposive sampling to select the exploration sites and control areas. This was on basis of easy accessibility, the cost involved in travelling, time available, accessibility of the respondents for questionnaires and sites must be under the mandate of Uganda Wildlife Authority. The oil pad sites under the study were selected basing on the fact that they must be somewhat a habitat to the mammals in the park. The control area sites were selected based on the fact that, they had the same environmental conditions as the oil pads (Jobi 4 and Jobi East 7) and had never gone through any human disturbance.

Research methods were replicated for both wet (April 2019) and dry (June 2019) seasons. Animal counts were conducted both in the morning and evening for a period of twenty days for each season. Numeric plant data was also collected for both wet and dry seasons in and outside the oil pads. The study used the assistance of UWA game rangers to identify the foot prints, fecal pallets and physical mammals under study. The study also used a dichotomous key to identify the plants during the study. The distance between exploration areas and control areas was approximately 5km.

The study conducted replicated counts and transect lines as one of the sampling principles to ensure that variation in encounter rate (number of objects detected per unit survey effort) can be adequately estimated. All transect lines were replicated following similar randomization scheme to give all locations in the study area a known, non-zero probability of being covered by a transect.

Finally, the study used key informants to participate in the answering of questionnaires. The study participants were selected on basis of their level of expertise in the field of oil and gas, their position in the administration ladder of oil and gas, availability and willingness to take part in the study.

3.3 Data collection tools and methods

3.3.1 Change in mammal habitats in relation to oil and gas exploration

The study used observation and recording method. Systematically traversing the study area and identifying all plant species observed assessed the composition of the vegetation. The study recorded the number of times the identified species occurred in a quadrat in the area under study (Frequency Index). The number of these plant species was also recorded using (Cox, 1990) sampling technique of using quadrats to study plant communities. A systematic random pattern of selection (Greig-Smith, 1983) was followed by using a (1x1m) quadrat for grasses, (5x5m) quadrat for shrubs, and (10x10m) quadrat for trees (Figure 3.2). Data was collected following a 60m line transect to record the identified plant species. A quadrat was placed every after 7m along the line transect in and outside the oil pads. In total 8 quadrats x 4 line transects were followed for the sites under the study. Each transect begun from the center (placard) of the oil pad going in directions of center to north, center to south, center to east, and center to west. This was carried out for purposes of replication in order to get the true representation of each site and the same procedure was carried out for the control area. The same procedure was conducted at a frequency of wet (4^{th}-30^{th} April 2019) and dry (1^{st}-30^{th} June 2019) seasons (Figure 3.2). Noteworthy, that Jobi East 7 and Jobi 4 were controlled burnt in December 2018 -January 2019. Controlled burning of vegetation at Control Area 1 and 2 was done January-February 2019 and the grass had just rejuvenated at approximately 4 inches tall.

3.3.2 Effects of post exploration oil and gas infrastructure on mammal's population abundance and distribution

The study used observation and recording method. Direct and indirect counts of mammal species were conducted. This included walking a 2km transect while recording the estimated number of mammals and the distance at which the animals were observed from the center (placard) (Figure 3.3) of the oil pad or the presumed center of the selected control area. In total, four transects were used per site in the directions of north, south, east and west. The study followed Buckland *et al.* (2004) sampling design where he suggested shorter transect lines because they yield more precise estimates of the encounter rate variance than do a few long lines. Indirect counts included estimating animal numbers from the observed indicators such as fecal materials (Figure 3.3), foot prints, wallowing grounds, dung, palm seeds and kobleks. In indirect surveys, animal signs were surveyed by one of the above- mentioned methods (Marques and Buckland, 2003). Direct counts involved counting of physical observed mammal species found along transects in all the sites under study (Figure 3.3). The study identified animal trails of different animals found in the exploration areas and control areas too as one of the variables to indicate the presence of mammals. This procedure was conducted at a frequency of morning and evening for a period of twenty days for both wet (4^{th}-30^{th} April 2019) and dry (1^{st}-30^{th} June 2019) seasons. The same procedures were conducted in the control area.

Figure 3.2: **(A)** quadrat used to count plants along a transect, **(B)** is the placard bearing site name, time of drilling and restoration, **(C)** is the borehole that once supplied water to the oil pad camp

Figure 3.3: **(A)** direct mammal counts of African Elephants, **(B)** direct mammal counts of Cape Buffalos, **(C)** palm seeds indicating presence of African Elephants, **(D)** Fecal pallets indicating the presence of Uganda Kobs

3.3.3 Social perception of oil and gas operations in protected areas

Questionnaires were administered during the month of February 2019 to fifty (50) respondents. The method of purposive sampling method was used to develop the sample of the research under discussion. According to this method, which belongs to the category of non-probability sampling techniques, sample members were selected on the basis of their knowledge, relationships and expertise regarding a research subject (Freedman *et al*., 2007). The survey used key informants that included 10 MFNP administrators, 10 oil and gas workers in the park and 30 local people from Pakwach and Nwoya districts. The study used participants that had knowledge about the park before, during and after oil and gas exploration.

The questionnaire was in English language and it contained structured, closed ended and open-ended questions in three sections; i.e. A, B and C. Section A investigated respondents' demographics, Section B investigated the perception of oil and gas operations in the park and Section C investigated the possibility of restoration of mammal habitats after oil and gas operations, how it will be accomplished, the period of time it might take to restore a site to its original state, the techniques needed to restore the affected sites as well as major issues to be considered as part of conserving large mammals ant their habitats amidst oil and gas operations. In the process of developing the measurement for the constructs of this study, most of the scales were self-developed to suit the requirement of this study based on related conceptual studies. Some returned responses were grossly incomplete, therefore, the data from those responses were excluded from the analysis.

3.4 Ethical considerations

The following ethical guidelines were put into place for the research period:

1. The researcher obtained approval to carry out the study from the governing body of Uganda Wildlife Authority (Appendix 1).
2. The study exercised voluntary participation of respondents in the research survey. Participants had rights to withdraw from the study at any stage if they wished to do so.
3. Survey respondents participated on the basis of informed consent (Appendix 4). Participants were given sufficient information and assurances about taking part in the study. Individuals were allowed to understand the implications of participating in the study and reach a fully informed decision whether to take part in the study without the exercise of any pressure or coercion.
4. The research data remained confidential throughout the study and the researcher obtained the participants' permission to use their real names in the research. The dignity and wellbeing of the participants was protected at all times. The use of offensive, discriminatory, or other unacceptable language was avoided in the formulation of the questionnaire.

3.5 Data analysis

The percentage vegetation frequencies for each identified plant species were calculated by formula in order to assess the vegetation abundance in oil pads and control areas. Frequency index analysis used Raunkiaer's law of frequency (1934) which is often used to study the homogeneity or uniformity of plant species in an area. This law of frequency assumes bimodality occurrences to describe vegetation abundance per unit area. It assumes that species are either present or absent. In Raunkiaer's law, species are categorized in levels/classes based on frequency as: level A (0-

20%); B (21-40%); C (41-60%;) D (61-80%); and E (80-100%). The normal frequency ratio is useful in many kinds of studies in testing the uniformity of the vegetation in a given area. Frequency levels are interpreted as A>B<C>D<E; In general, the higher class E has greater homogeneity / uniformity of the vegetation. The most essential point being that class E should be larger than class D with greater number of species in class E than in D. Class A means the plant species under study are very scarce, B means occasional presence, C means infrequent presence, D means frequent presence and E means abundant or very numerous presence of the plant species under the study. Shannon Weiner diversity index (H) was determined by formula and corresponding H Max values were calculated as well as equitability values for each transect using Microsoft Word Excel 2010 before exporting it to SPSS version 20 for statistical analysis. Vegetation relative abundancy and diversity between oil pads and control areas was analyzed using t statistical tests in SPSS version 20. The animal count data was log transformed before it was analyzed with a student's t-test. The t-tests were used to show if there were any significant differences between oil pads and control areas. Data gathered from the survey questionnaires was categorized in themes and sub-themes and analyzed using chi square tests.

CHAPTER FOUR

RESULTS

4.1 Change in mammal habitats in relation to oil and gas exploration in Murchison Falls National Park.

This section presents results of the parameters of vegetation frequency index, vegetation relative abundance, observed plant species and Shannon Weiner vegetation diversity index for both oil pads and control areas recorded during the study.

4.1.1 Vegetation frequency index per transect as observed at oil pads and control areas.

The frequency index analysis from the study shows that some plant species are more uniform than others (Table 4.1). The plant species that were observed to be uniform in both oil pads and control areas include; Thatching grass (*Hyparrhenia hirta*), Cat's tail drop seed (*Sporobolus pyramidalis*), Nut grass (*Cyperus rotundus*) and Wandering jew (*Commelina benghalensis*). More uniform plant species in oil pads than control areas include; Garden signal grass (*Urochba panicoides*), Hippo grass (*Vossia cuspidate*), Creeping wood-sorrel (*Oxalis corniculata*), Star grass (*Cynodon dactylon*), Goats weed (*Ageratum conyzoides*), Devil horsewhip (*Achyranthes aspera*), Pickerel weed (*Pontederia cantata*), Tick berry (*Lantana camara*), Wait a bit thorn (*Acacia mellifera*), Whitethorn acacia tree (Vachellia constricta), and Candle bush (*Senna alata*).

However, some plant species were recorded to be less uniform in oil pads than control areas and they include; Feathered chloris (*Chloris virgate*), Bur bristled grass (*Seteria verticullata*), Desert date (Balanites aegyptiaca), Hoket horn (*Arisonia abyssinica*), Garden pink-sorrel (*Oxalis latifolia*), Borassus palm tree (*Palmyra palm*), Edible canna (*Canna eduls*), Guntamala (*Tribsacum laxom*), Sticking weed (*Acacia okidetalia*), Treedax daisy (*Tridax *procumbens*), and Whistling acacia (*Acacia hoki*). Other recorded plant species in the study had similar uniformity in oil pads and control areas. They include; Finger grass (*Digitaria eriantha*), Fibrous drop seed (*Sporobolus stafianus*), Nandi grass (*Cetera ancient*), Wild canny lilly flower (*Canna indical*), Baboon apple (*Annona glabra*)

Table 4.1: Vegetation frequency index of observed plant species and Raunkiaer's frequency classes

Observed plant species	Scientific Name	OP-FI	FC	CA-FI	FC
Thatching grass	*Hyparrhenia hirta*	100	E	87.5	E
Cat's tail drop seed	*Sporobolus pyramidalis*	100	E	87.5	E
Nut grass	*Cyperus rotundus*	100	E	100	E
Wandering jew	*Commelina benghalensis*	100	E	100	E
Feathered chloris	*Chloris virgata*	12.5	A	50	C
Bur bristled grass	*Seteria verticullata*	0	A	12.5	A
Desert date	*Balanites aegyptiaca*	0	A	37.5	B
Hoket horn	*Arisonia abyssinica*	0	A	12.5	A
Candle bush	*Senna alata*	12.5	A	0	A
Garden signal grass	*Urochba panicoides*	50	C	0	A
Hippo grass	*Vossia cuspidata*	50	C	0	A
Creeping wood-sorrel	*Oxalis corniculata*	50	C	37.5	B
Finger grass	*Digitaria eriantha*	50	C	50	C
Garden pink-sorrel	*Oxalis latifolia*	50	C	75	D
Star grass	*Cynodon dactylon*	87.5	E	75	D
Fibrous drop seed	*Sporobolus stafianus*	25	B	37.5	B
Whitethorn acacia tree	*Vachellia constricta*	37.5	B	12.5	A
Baboon apple	*Annona glabra*	25	B	12.5	A
Borassus palm tree	*Palmyra palm*	12.5	A	50	C
Goats weed	*Ageratum conyzoides*	62.5	D	25	B
Nandi grass	*Cetera ancient*	12.5	A	12.5	A
Wild canny lilly flower	*Canna indical*	50	C	50	C
Devil horsewhip	*Achyranthes aspera*	12.5	A	0	A
Edible canna	*Canna eduls*	0	A	12.5	A
Guntamala	*Tribsacum laxom*	0	A	12.5	A
Pickerel weed	*Pontederia cantata*	12.5	A	0	A
Sticking weed	*Acacia okidetalia*	0	A	12.5	A
Tick berry	*Lantana camara*	12.5	A	0	A
Treedax daisy	*Tridax procumbens*	0	A	12.5	A
Wait a bit thorn	*Acacia mellifera*	37.5	B	0	A
Whistling acacia	*Acacia hoki*	0	A	25	B

OP = oil pads, CA = control areas, FI = vegetation frequency index / percentage frequency, FC = Raunkiaer's frequency classes, A = (0-20%), B = (21-40%), C = (41-60%), D = (61-80%), E = (81-100%), Raunkiaer's formula A>B>C<D<E, Total No of Quadrats per transect= 8

4.1.2 Vegetation relative abundance per transect in oil pads and control areas

The results revealed vegetation relative abundance of the various plant species observed during the study (Table 4.2). The vegetation relative abundance in oil pads has a no significant difference from the vegetation relative abundance in control areas (t= -1.946, d.f=30, p=0.061). However, the results show that there were some plant species that were significantly more abundant in control areas than in the oil pads (Table 4.2). They include; Thatching grass (*Hyparrhenia hirta*), Cat's tail drop seed (*Sporobolus pyramidalis*), Nut grass (*Cyperus rotundus*), Wandering Jew (*Commelina benghalensis*), Feathered chloris (*Chloris virgate*), Bur bristled grass (*Seteria verticullata*), Desert date (*Balanites aegyptiaca*), and Hoket horn (*Arisonia abyssinica).*

On the other hand, some recorded plant species were more significantly abundant in oil pads than control areas and they include; Candle bush (*Senna alata*), Garden signal grass (*Urochba panicoides*), and Hippo grass (*Vossia cuspidata*). The study also recorded a non-significant difference in the vegetation relative abundance of some plant species between oil pads and control areas. They include; Creeping wood-sorrel (*Oxalis corniculata*), Finger grass(*Digitaria eriantha*), Garden Pink-sorrel (*Oxalis latifolia*), Star Grass (*Cynodon dactylon*), Fibrous drop seed-(*Sporobolus stafianus*), Whitethorn acacia tree (*Vachellia constricta*), Baboon apple (*Annona glabra*), Borassus palm tree (*Palmyra palm*), Goats weed (*Ageratum conyzoides),* Nandi grass (*Cetera ancient),* Wild canny lilly flower (*Canna indical*), Devil horsewhip (*Achyranthes aspera*), Edible canna (*Canna eduls*), Guntamala (*Tribsacum laxom*), Pickerel weed (*Pontederia cantata*), Sticking weed (*Acacia okidetalia*), Tick berry (*Lantana camara*), Treedax daisy (*Tridax procumbens*), Wait a bit thorn (*Acacia mellifera*), and Whistling acacia (*Acacia hoki*).

Table 4.2: Mean (± S.E) vegetation relative abundance of each observed plant species per transect in oil pads and control areas

Observed plant species	**Scientific Name**	**Oil pads**	**Control areas**	***Sig. Value***
Thatching grass	*Hyparrhenia hirta*	103.8±30.6	169.6±47.8	*
Cat's tail drop seed	*Sporobolus pyramidalis*	95.8±20.1	148.1±41.8	*
Nut grass	*Cyperus rotundus*	42.3±9.8	95.5±20.0	*
Wandering jew	*Commelina benghalensis*	48.6±10.2	58±8.5	*
Feathered chloris	*Chloris virgata*	9.8±4.9	57.5±28.1	*
Bur bristled grass	*Seteria verticullata*	0±0	0.75±0.74	***
Desert date	*Balanites aegyptiaca*	0±0	9.8±8.9	***
Hoket horn	*Arisonia abyssinica*	0±0	2.8±2.7	**
Candle bush	*Senna alata*	4.1±4.1	0±0	***
Garden signal grass	*Urochba panicoides*	1.4±1.4	0±0	**
Hippo grass	*Vossia cuspidata*	7.8±3.1	0±0	***
Creeping wood-sorrel	*Oxalis corniculata*	18.6±11.6	14.6±8.0	NS
Finger grass	*Digitaria eriantha*	17.4±8.9	9.8±4.0	NS
Garden pink-sorrel	*Oxalis latifolia*	15.3±8.4	9.8±4.5	NS
Star grass	*Cynodon dactylon*	14.5±5.5	13.4±4.2	NS
Fibrous drop seed	*Sporobolusstafianus*	11.1±8.9	14.1±10.4	NS
Whitethorn acacia tree	*Vachellia constricta*	0.9±0.4	0.9±0.9	NS
Baboon apple	*Annona glabra*	0.9±0.6	10.6±10.6	NS
Borassus palm tree	*Palmyra palm*	0.3±0.2	2.6±1.5	NS
Goatsweed	*Ageratum conyzoides*	8±3.7	0.9±0.7	NS
Nandi grass	*Cetera ancient*	0.6±0.6	1.5±1.5	NS
Wild canny lilly flower	*Canna indical*	4.6±2.1	5.5±2.2	NS
Devil horsewhip	*Achyranthes aspera*	0.3±0.2	0±0	NS
Edible canna	*Canna eduls*	0±0	0.4±0.4	NS
Guntamala	*Tribsacum laxom*	0±0	0.3±0.2	NS
Pickerel weed	*Pontederia cantata*	2.8±2.7	0±0	NS
Sticking weed	*Acacia okidetalia*	0±0	0.1±0.1	NS
Tick berry	*Lantana camara*	2.9±2.9	0±0	NS
Treedax daisy	*Tridax procumbens*	0±0	2±1.9	NS
Wait a bit thorn	*Acacia mellifera*	0.8±0.4	0±0	NS
Whistling acacia	*Acacia hoki*	0±0	3±2.0	NS

*Significant value are indicated with * (p<0.05); ** (p<0.01); ***(p<0.001) NS=Non significant difference, d.f=1, χ^2 test, Total No of Quadrats per Transect = 8, Total No of Transects in Oil Pads= 16, Total No of Transects in Control Areas=16*

4.1.3 Observed plant species per transect in oil pads and control areas

A total of 16 various grass plant species, 4 shrub plant species and 3 tree species were recorded in oil pads whilst a total number of 17 grasses, 4 shrubs, and 3 trees were recorded in control areas. Some of the observed plant species were recorded in both oil pads and control areas, while others were in either of the two sites (Table 4.3). However, the total number of plant species recorded in oil pads were not significantly different from the ones recorded in control areas (χ^2= 8.29, d.f=1, $p > 0.05$).

Table 4.3: Plant species recorded per transect in oil pads and control areas.

Species Common Name	Scientific Name	Type of Plant	Oil Pads	Control Areas
Baboon apple	*Hyparrhenia hirta*	Shrub	+	+
Borassus palm tree	*Sporobolus pyramidalis*	Tree	+	+
Bur bristled grass	*Cyperus rotundus*	Grass	-	+
Candle bush	*Commelina benghalensis*	Tree	+	-
Cat's tail drop seed	*Chloris virgate*	Grass	+	+
Creeping wood-sorrel	*Seteria verticullata*	Grass	+	+
Desert date	*Balanites aegyptiaca*	Shrub	-	+
Devil horsewhip	*Arisonia abyssinica*	Shrub	+	-
Edible canna	*Senna alata*	Shrub	-	+
Feathered chloris	*Urochba panicoides*	Grass	+	+
Fibrous drop seed	*Vossia cuspidate*	Grass	+	+
Finger grass	*Oxalis corniculata*	Grass	+	+
Garden Pink-sorrel	*Digitaria eriantha*	Grass	+	+
Garden signal grass	*Oxalis latifolia*	Grass	+	-
Goats weed	*Cynodon dactylon*	Grass	+	+
Guntamala	*Sporobolus stafianus*	Grass	-	+
Hippo grass	*Vachellia constricta*	Grass	+	-
Hokes horn	*Annona glabra*	Grass	-	+
Nandi grass	*Palmyra palm*	Grass	+	+
Nut grass	*Ageratum conyzoides*	Grass	+	+
Pickerel weed	*Cetera ancient*	Grass	+	-
Star grass	*Canna indical*	Grass	+	+
Sticking weed	*Achyranthes aspera*	Grass	-	+
Thatching grass	*Canna eduls*	Grass	+	+
Tick berry	*Tribsacum laxom*	Grass	+	-
Treedax daisy	*Pontederia cantata*	Grass	-	+
Wait a bit thorn	*Acacia okidetalia*	Shrub	+	-
Wandering jew	*Lantana camara*	Grass	+	+
Whitethorn acacia tree	*Tridax procumbens*	Tree	+	+
Whistling acacia	*Acacia mellifera*	Tree	-	+
Wild canna lilly flower	*Acacia hoki*	Shrub	+	+
Total number of plant species present			**23**	**24**

+ = Plant species present, - = Plant species absent

4.1.4 Vegetation diversity per transect in oil pads and control areas

The results of Shannon Weiner vegetation index per transect at both oil pads and control areas are presented in Table 4.4. The results show (1.9±0.058) as the mean vegetation diversity per transect at oil pads and (1.71±0.120) at control areas. The study results show a non-significant difference in the vegetation diversity between the former oil pads and control areas ($t = 2.114$, d.f =7, $p=0.072$). This indicates that there are no habitat variations post oil and gas exploration. The results indicate a non-significant difference between the vegetation species equitability between oil pads and control areas ($t = 2.118$, d.f=7, $p = 0.072$). The mean equitability of vegetation per transect in oil pads and control areas is (0.80±0.014) and (0.75±0.029) respectively.

Table 4.4: Vegetation Diversity at oil pads and control areas

Oil pads transects	***H value***	***H max***	***E value***	**Control areas transects**	***H value***	***H max***	***E value***
Jobi4 ET	2.05	2.48	0.83	CA1 ET	1.83	2.20	0.83
Jobi4 ST	2.16	2.56	0.84	CA1 ST	2.47	2.71	0.91
Jobi4 WT	1.89	2.40	0.79	CA1 WT	1.42	1.95	0.73
Jobi4 NT	1.78	2.20	0.81	CA1 NT	1.38	2.08	0.66
JE7 ST	1.61	2.20	0.73	CA2 ST	1.63	2.30	0.71
JE7 WT	1.93	2.40	0.81	CA2 WT	1.63	2.20	0.74
JE7 NT	1.91	2.48	0.77	CA2 NT	1.60	2.40	0.67
JE7 ET	1.86	2.20	0.85	CA2 ET	1.72	2.20	0.78

JE7-Jobi East 7, H value- Shannon Weiner vegetation index, H max- Maximum species', E value- Species' equitability. ET-East transect, ST- South transect, WT- West transect, NT- North transect, CA1- Control area 1, CA2- Control area 2.

4.2 Effects of post exploration oil and gas infrastructure on the abundance and distribution of mammalian population in MFNP.

The study recorded the population abundance and distribution of different mammal species which included; Oribi (*Ourebia ourebia*), Uganda Kob (*Kobus kob*), Cape Buffalo (*Syncerus caffernanus*), Jackson's Hartebeest (*Alcelaphus buselaphus*), African Elephant (*Loxodonta africana*), Warthog (*Phacochoerus africanus*), and Rothschild Giraffe (*Giraffa Camelopardalis rothschildi*). The results of the population abundance and distribution of mammals in both oil pads and the control areas are presented in Table 4.5. The study observed that giraffes were grossly few in both oil pads and control areas throughout the study, however the commonest mammal species observed in big numbers during the study were Oribi, Uganda Kob and Cape buffalo.

The study observed two Uganda Kob mammal trails of 3m width North of Jobi East 7 and a 2m oribi mammal trail west of Jobi 4. This indicates the presence of mammals in the former oil pads. The study also observed two Uganda Kobs' animal trails of 2m width north of control area 2. All mammal species observed in control areas such as Oribi, Cape buffalo, African Elephants, Jackson's Hartebeest, and Uganda Kobs were also observed in oil pads. However, there was an observed absence of Rothschild Giraffes in the control areas from a distance of 1000m from the center up to 2000m. The mean number of mammal species recorded per distance interval in oil pads are not significantly different from the ones recorded in control areas ($t = 0.920$, d. f = 27, $p = 0.365$).

Table 4.5: Overall mean (±S.E) recorded mammal species per distance interval in oil pads and control areas

	Scientific Name	Distance Intervals (m)	Oil Pads	Control Areas
Oribi	*Ourebia ourebia*	0-500	139.5±9.66	126.8±14.09
		501-1000	88.5±7.91	69.7±9.72
		1001-1500	57.6±6.77	46.2±6.47
		1501-2000	75.5±8.81	41.4±7.34
Uganda Kob	*Kobus kob*	0-500	247.4±21.24	171.5±22.23
		501-1000	148.5±18.98	139.2±21.83
		1001-1500	75.3±12.59	93.5±13.21
		1501-2000	75.7±7.33	73.5±6.26
Cape Buffalo	*Syncerus caffernanus*	0-500	146.2±24.06	152.8±20.36
		501-1000	73.4±10.32	118.6±22.08
		1001-1500	39.3±5.94	89.1±14.05
		1501-2000	42.5±5.37	55.0±8.01
Jackson's Hartebeest	*Alcelaphus buselaphus*	0-500	72.8±13.09	86.6±13.57
		501-1000	60.0±10.32	57.5±7.38
		1001-1500	25.5±4.69	63.3±13.20
		1501-2000	47.6±6.16	48.0±7.36
African Elephant	*Loxodonta africana*	0-500	48.4±4.06	26.5±4.88
		501-1000	30.5±3.45	30.3±6.46
		1001-1500	16.2±2.57	17.4±3.85
		1501-2000	28.1±1.76	6.2±1.7
Warthog	*Phacochoerus africanus*	0-500	32.1±3.91	52.2±6.26
		501-1000	26.5±4.0	40.1±5.36
		1001-1500	20.6±3.05	27.1±7.73
		1501-2000	17.6±4.7	23.5±3.26
Rothschild Giraffe	*Giraffa camelopardalis*	0-500	6.0±1.17	2.7±0.57
		501-1000	4.0±1.15	3.1±0.76
		1001-1500	1.8±0.6	0.4±0.16
		1501-2000	2.3±0.85	0.0±0

*S. E=Standard Error, Total number of transects per site = 4, Total transects = 4*4*

4.2.1 Seasonal mammal specie's population abundance and distribution per distance interval in oil pads and control areas.

The study recorded different mean number of mammal species under the study for wet and dry seasons. The mean number of mammal species recorded in the oil pads during wet season significantly differed from the mammal species recorded in the oil pads during dry season of the study ($t = 3.363$, $d.f = 27$, $p < 0.05$). The mean number of mammal of species recorded in the control areas during the wet season of the study significantly differed from the ones recorded during the dry season of the study ($t = 3.622$, d.f = 27, $p < 0.05$).

There was no significant difference in the mean number of mammal species recorded in the oil pads and control areas during wet season of the study ($t = 0.998$, d.f =27, $p = 0.327$). The mean number of mammals recorded in oil pads and control areas during dry season were not significantly different from one another ($t = 0.795$, d.f = 27, $p = 0.434$).

4.2.1.1 Oribi (*Ourebia ourebia*)

The results show that, there were more Oribi mammals recorded in the wet season than the dry season in both oil pads and control areas (Figure 4.1) along increasing distance.

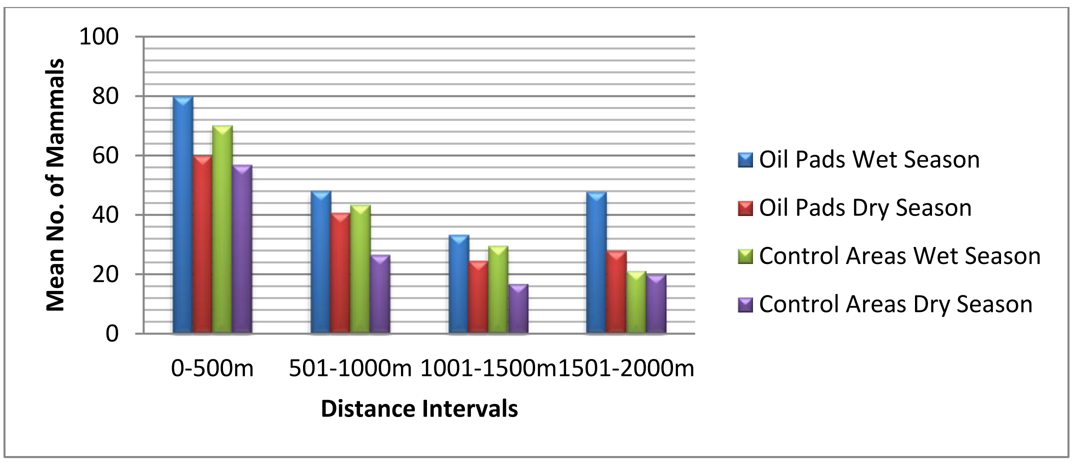

Figure 4.1: Mean number of Oribi mammals recorded per distance interval for wet and dry season in oil pads and control areas

4.2.1.2 Uganda Kob (*Kobus kob*)

The study recorded more Uganda kobs during wet season for the distance of 0-500m in both oil pads and control areas. There was a slight variation in the mean number of Uganda Kobs from 501m – 2000m in oil pads and control areas for both wet and dry seasons (Figure 4.2).

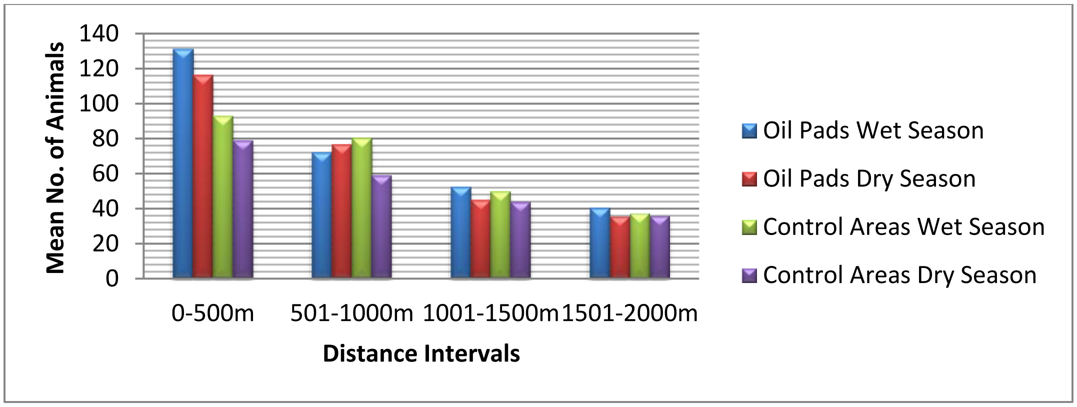

Figure 4.2: Mean number of Uganda Kob mammals recorded per distance interval for wet and dry season in oil pads and control areas

4.2.1.3 Cape Buffalo (*Syncerus caffernanus*)

The study revealed that more cape buffalos were recorded in wet season than dry season within the distance of 0-500m in oil pads and control areas (Figure 4.3).

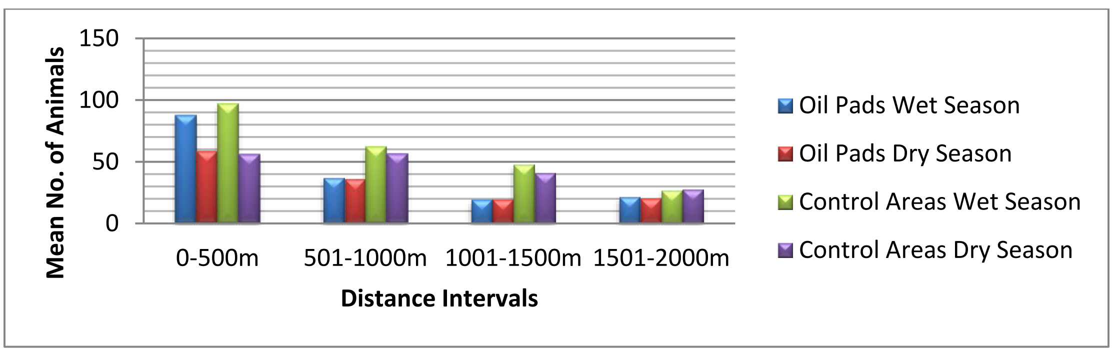

Figure 4.3: Mean number of Cape Buffalo mammals recorded per distance interval for wet and dry season in oil pads and control areas

4.2.1.4 Jackson's Hartebeest (*Alcelaphus buselaphus*)

The study recorded significantly higher numbers of Jackson's Hartebeest mammals in control areas than oil pads within a distance of 500m and 1001-1500m during the wet season (Fiure4.4).

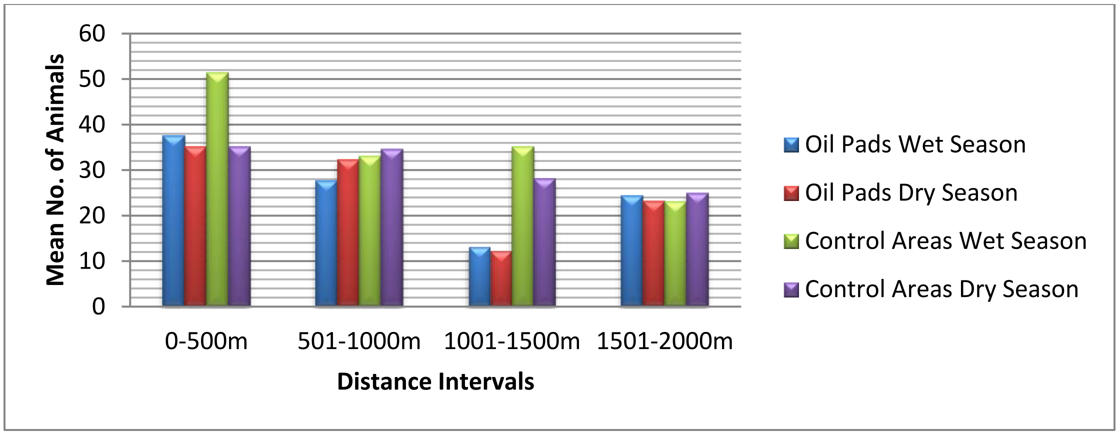

Figure 4.4: Mean number of Jackson's Hartebeest mammals recorded per distance interval for wet and dry season in oil pads and control areas

4.2.1.5 African Elephant (*Loxodonta africana*)

The study recorded a relatively similar number of African elephants within oil pads and control areas for both wet and dry seasons (Figure 4.5).

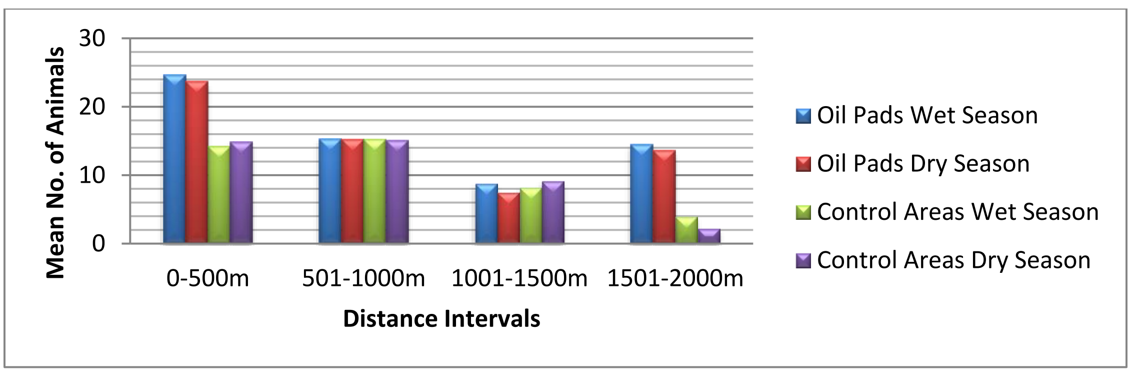

Figure 4.5: Mean number of African Elephant mammals recorded per distance interval for wet and dry season in oil pads and control areas

4.2.1.6 Warthog (*Phacochoerus africanus*)

The study recorded significantly higher mean numbers of warthogs in the wet season than dry season within oil pads and control areas (Figure 4.6).

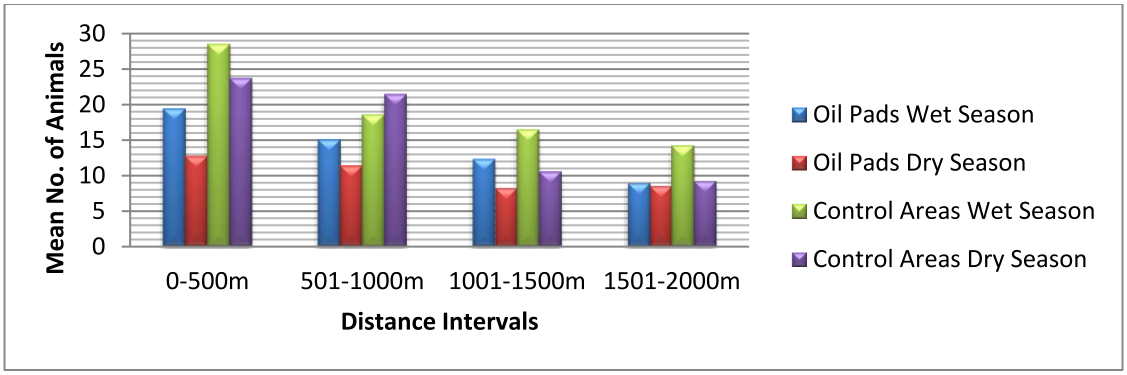

Figure 4.6: Mean number of Warthog mammals recorded per distance interval for wet and dry season in oil pads and control areas

4.2.1.7 Rothschild Giraffe (*Giraffa Camelopardalis rothschildi*)

The study recorded very few mammal species of the Rothschild giraffes but there was also an observed gross absence of these mammals in control areas from the distance of 1501m – 2000m (Figure 4.7).

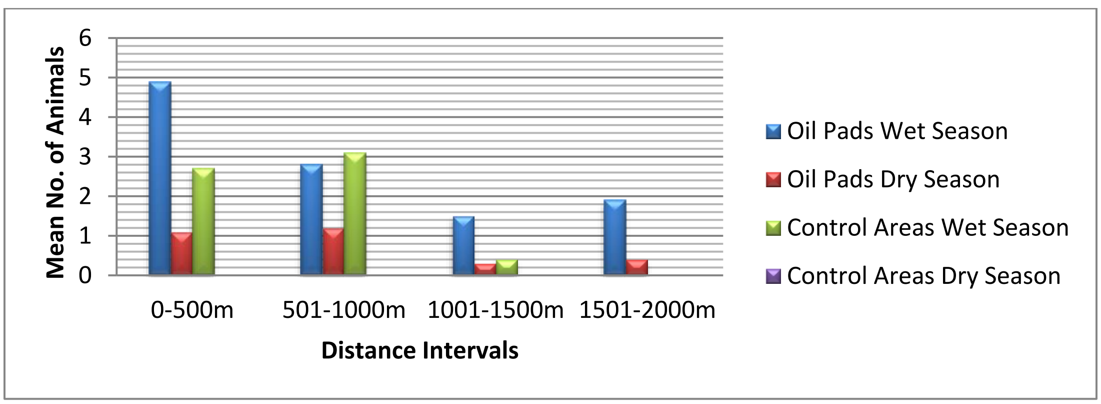

Figure 4.7: Mean number of Rothschild Giraffe mammals recorded per distance interval for wet and dry season in oil pads and control areas

4.3 Social perception of oil and gas operations in the protected area

All comments collected from the administered questionnaires were coded and presented in themes and subheadings. This section shows the results of the research survey.

4.3.1 Compliance standards of oil operations

The survey shows that 64% of the respondents (n=50) think oil operations in the park meet the regulatory compliance standards (Figure 4.8). The number of respondents who agree that oil operations in the park meet compliance standards are significantly different from the number of respondents that disagree (χ^2=3.92, d.f =1, $p<0.05$).

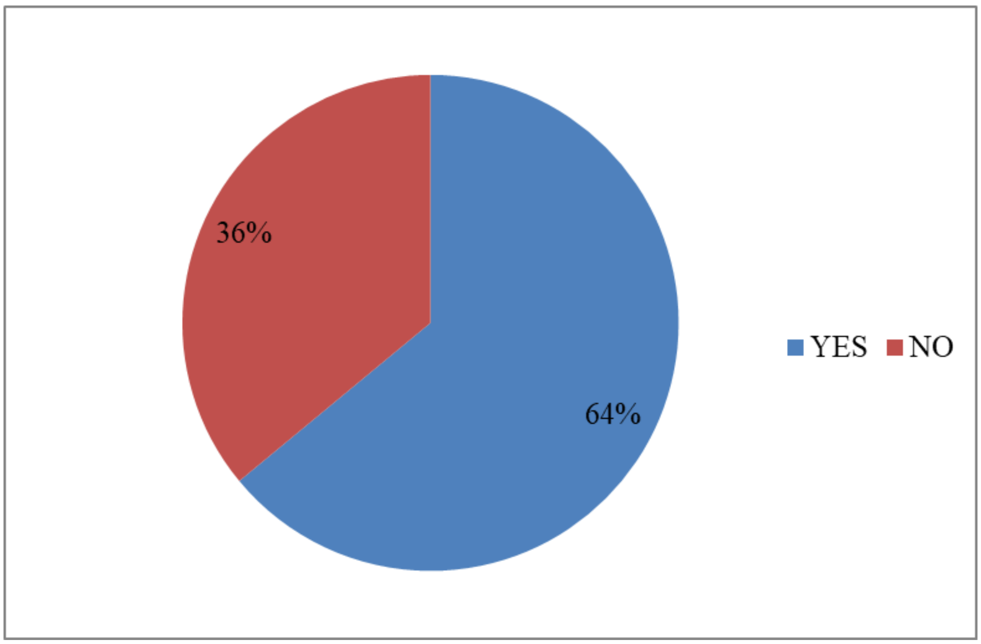

Figure 4.8: Percentage of respondents who think oil operations meet regulatory compliance standards.

The study shows that most respondents (90%) indicated that oil waste management is being done in a satisfactory manner. Similarly, most respondents (70%) indicated that there is no animal displacement and disturbance due to oil operations in the park (Figure 4.9). The number of respondents who are dissatisfied with oil waste management have a significant difference from the number of respondents that disagree (χ^2=32, d.f =1, p<0.05). The number of respondents who feel that animal displacement and disturbance are a result of oil operations in the park are significantly different from the number of respondents that disagree (χ^2=8, d.f=1, p<0.05).

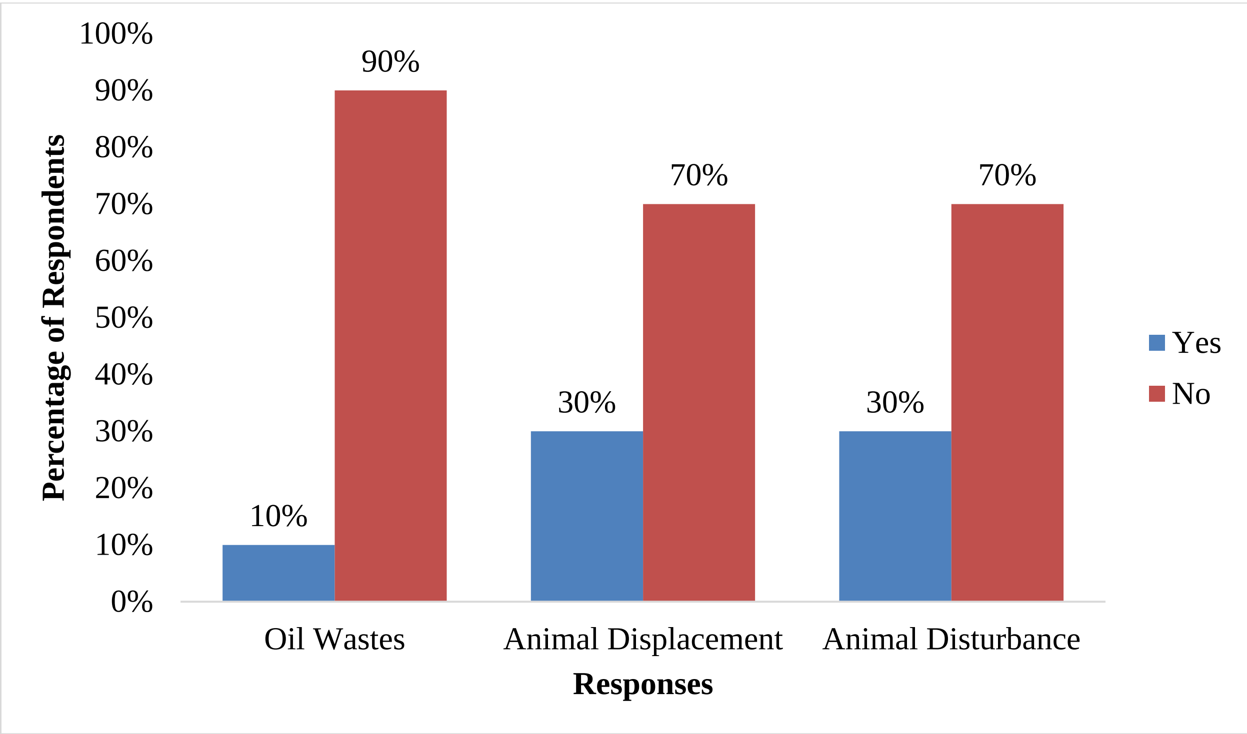

Figure 4.9: Percentage of dissatisfied compliance standards as suggested by respondents

4.3.2 Effects of oil operations on mammals

The results of the study show that 50% of respondents (n=50) feel that oil and gas operations in the park adversely affect mammals and their habitats. The researcher further asked, in what ways the oil and gas operations were affecting mammals and their habitats in the protected area. The survey shows that; 32% of the number of respondents feel oil and gas operations cause noise, 44% of the number of respondents said it causes animal disturbance while 20% of the number of respondents(n=50) think it causes animal displacement (Figure 4.10). The number of respondents who think oil and gas operations causes noise are significantly different from the number of respondents that disagree (χ^2=3.84, d.f=1,p<0.05). The number of respondents who suggested that animal disturbance is as a result of oil operations do not differ significantly from the number of respondents that disagree (χ^2=0.75, d.f =1,p>0.05) and the number of respondents who think animal displacement is caused by oil operations in the park differ significantly from the number of respondents that disagree (χ^2=18, d.f =2, p<0.05).

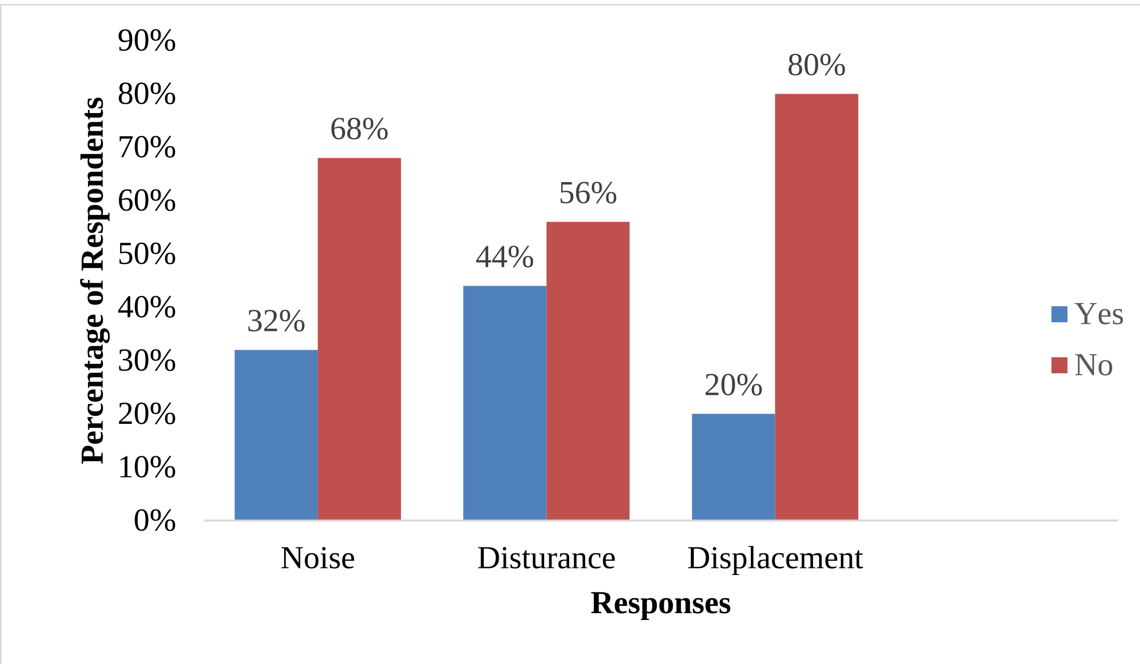

Figure 4.10: Percentage of oil and gas effects on mammals as suggested by respondents

4.3.3 Decommissioning effects of oil operations on Mammals

Decommissioning an onshore oil pad involves removing all surface equipment, production tubing and uncementing the casing. To plug the well, sections of the wellbore are filled with concrete to isolate the flow of reservoir fluids from each other and to the surface. Finally, the surface casing is cut off and a cap is welded in place several feet below the ground; as required by the regulators. The survey shows that 78% of the respondents (n=50) feel decommissioning of an oil well has effects on mammals. The number of respondents who think decommissioning of an oil pad causes effects on mammals differ significantly from the number of respondents that disagree (χ^2=15.68, d.f=1, $p<0.05$).The study shows 62% of the respondents feel decommissioning of an oil pad causes animal displacement and 68% of the of respondents feel it causes relocation of animals (Figure 4.11). The number of respondents who think animal displacement is as a result of oil pad decommissioning are significantly different from the number of respondents that disagree (χ^2=2.88, d.f=1, $p<0.05$). The number of respondents who suggested animal relocation is a result of decommissioning of an oil pad differ significantly from the number of respondents that disagree (χ^2=6.48, d.f=1, $p<0.05$).

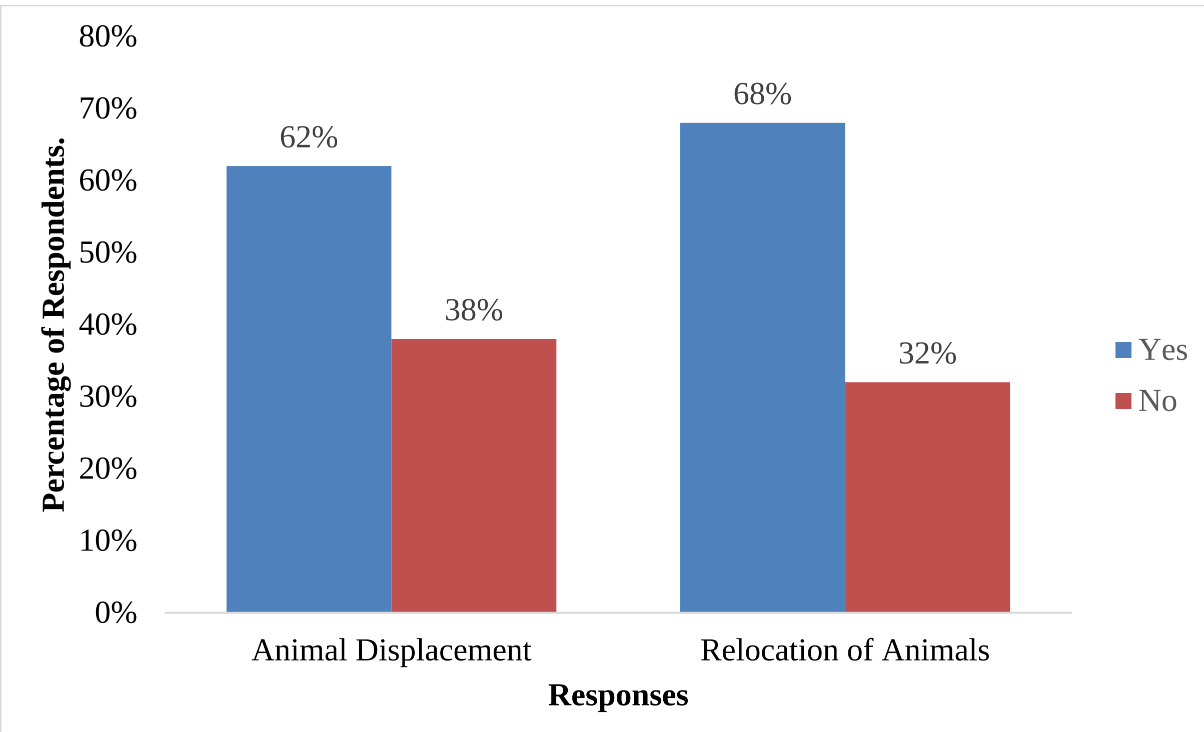

Figure 4.11: Percentage of decommissioning effects on mammals as suggested by respondents

4.3.4 Oil exploration in the protected area of Murchison Falls National Park

The survey shows 14% of the respondents (n=50) feel that oil operations in the park is a bad idea, 74% of the respondents feel the park is at risk of losing its biodiversity and 10% of the number of respondents think that under proper care it can co-exist with wildlife (Figure 4.12).The number of respondents who feel oil activities in the park are a bad idea are statistically significant from the number of respondents that disagree (χ^2=25.92, d.f =1, $p<0.05$). The number of respondents who think that the park is at a risk of losing its biodiversity differ significantly from the number of respondents that disagree (χ^2=11.52, d.f=2, $p<0.05$). The number of respondents who feel oil operations are a good idea under proper care differ significantly from the number of respondents that disagree (χ^2=32, d.f=1, $p<0.05$).

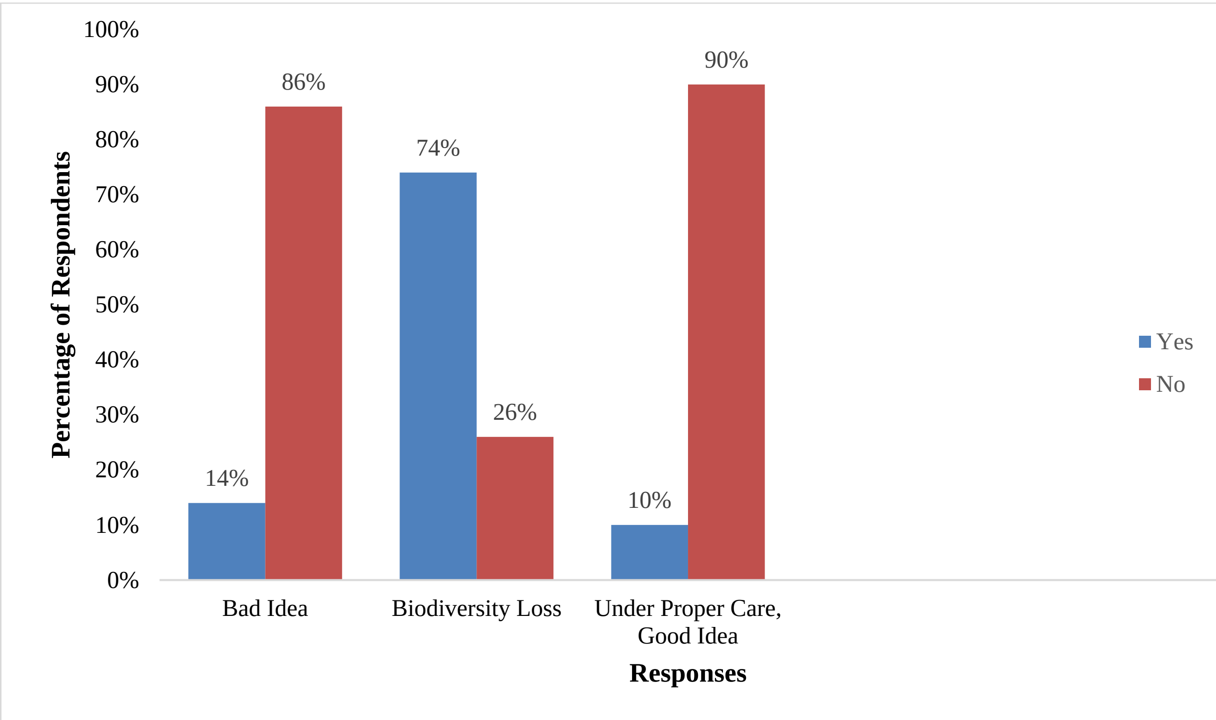

Figure 4.12: Percentage number of respondents' perception of oil and gas operations in the protected area

4.3.5 Restoration

Restoration is considered to be the final stage of an oil and gas project. When a field production cycle comes to an end and all the usable oil and gas has been processed; the facilities must be dismantled and the surrounding area returned to its natural condition. Respondents were asked whether it was possible to restore mammalian habitats to their natural state after oil and gas exploration and 52% of the respondents think it's possible (Figure 4.13). There is no significant difference in the number of respondents who agree and disagree that restoration of an oil pad is possible ($\chi^2=0.08$, d.f=1, $p>0.05$).

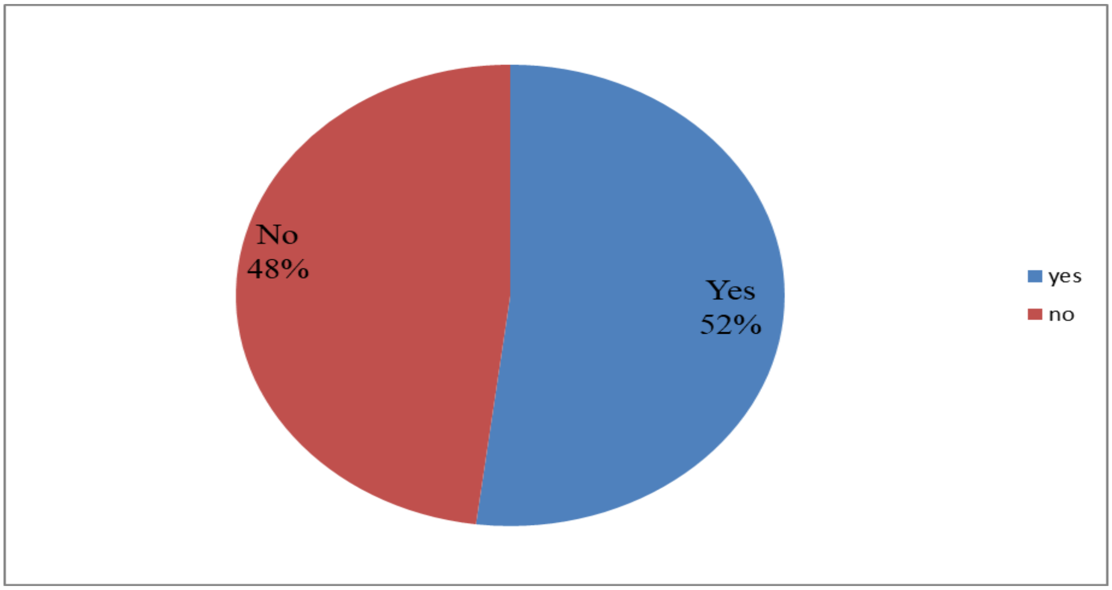

Figure 4.13: Percentage number of respondents who think it is possible to restore mammalian habitats

When asked the period of time it would take for an oil pad to be restored to its natural state; 58% of the number of respondents feel it can take two years to restore an oil pad and 34% think it may take four years (Figure 4.14).The number of respondents who think two years is enough to restore an oil pad have no significant difference from the number of respondents that disagree($\chi^2=1.28$, d.f=1, $p> 0.05$). The number of respondents that think four years is enough to restore an oil pad have a significant difference from the number of respondents that disagree ($\chi^2=5.12$, d.f =1, $p< 0.05$).

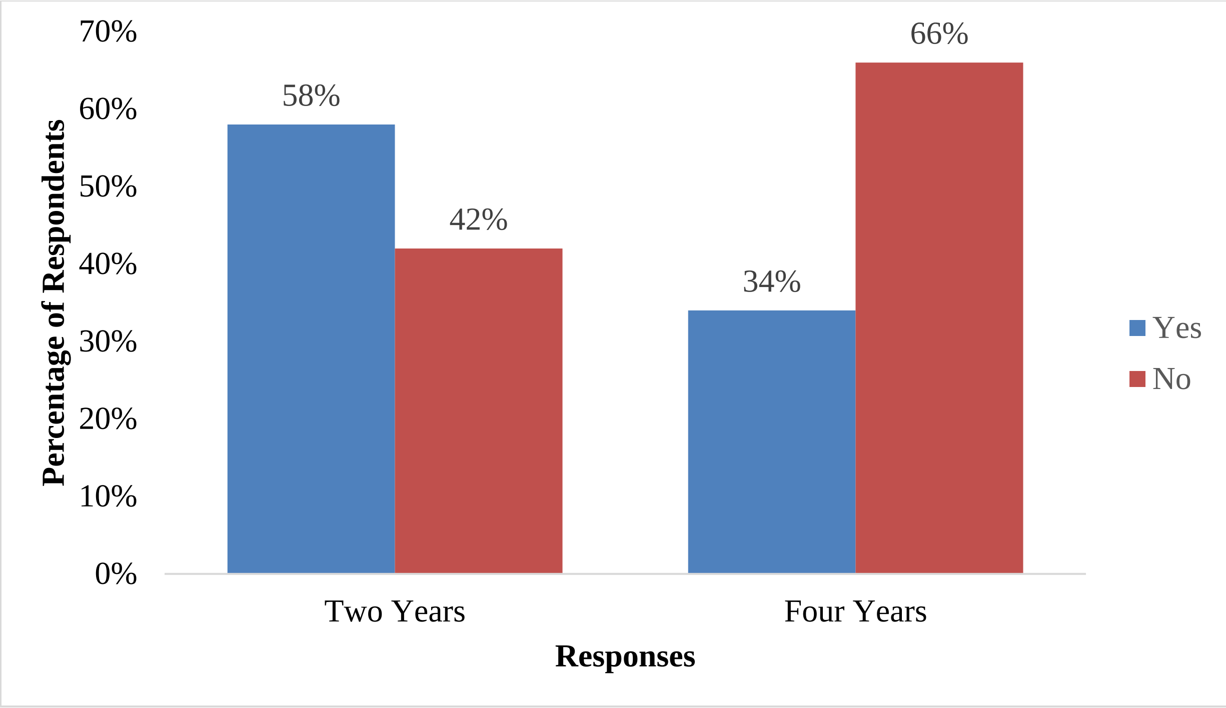

Figure 4.14: Percentage number of respondents' suggestion of the time period of oil pad restoration

4.3.6 Restoration techniques

The survey shows 96% of the respondents feel drainage ditch and excavation filling, and restoration of buffers are some of the techniques for restoring an oil pad/site and 100% of the respondents feel replanting of vegetation as the best technique to restore an oil pad back to its original state (Figure 4.15). The number of respondents who think filling drainage ditches, excavation fill, restoration of buffers can restore an oil pad differ significantly from the number of respondents that disagree (χ^2=42.32, d.f=1, p<0.05). The number of respondents who suggested replanting of vegetation to restore an oil pad differ significantly from the number of respondents that disagree (χ^2=50, d.f= 1, p<0.05).

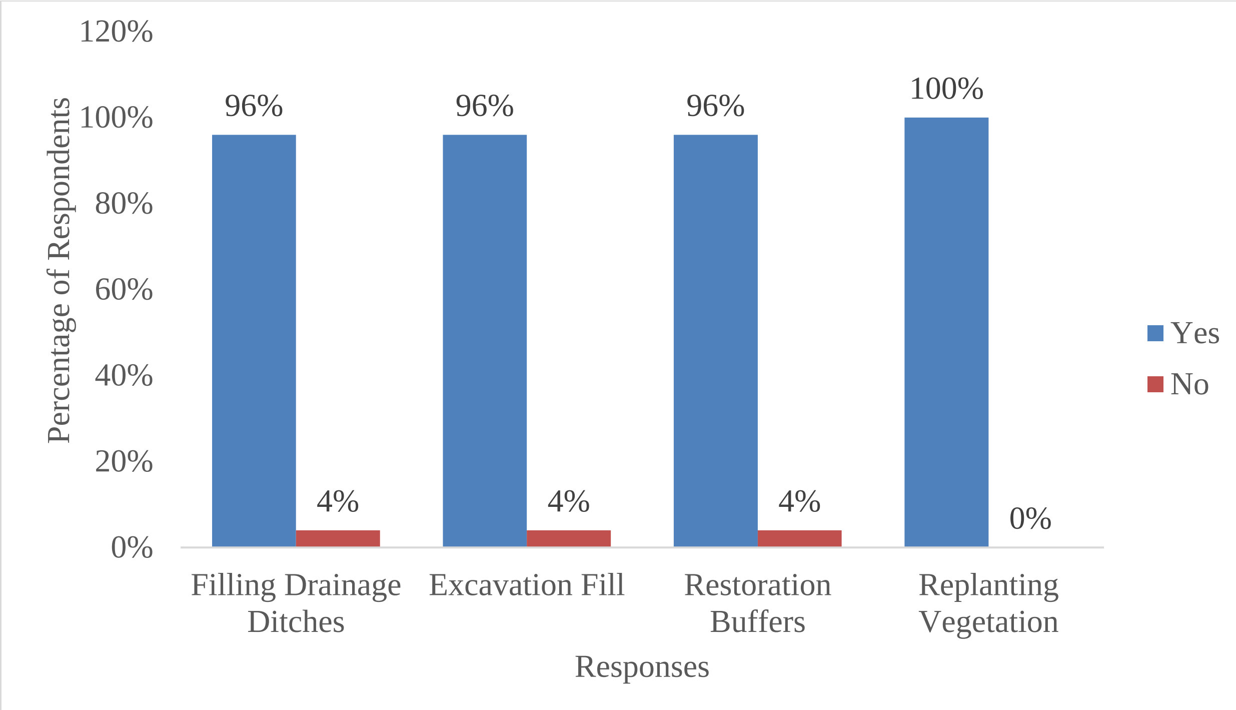

Figure 4.15: Restoration techniques for mammalian habitats suggested by respondents

4.3.7 Conservation of mammals and their habitats

The respondents were asked about the major issues that should be considered as part of the conservation of mammals and their habitats during oil and gas operations in the protected area. The survey shows 82% of the respondents feel core ecosystem parts such as cobleks should be conserved and oil operations should comply with EIA. 80% of the number of respondents feel that UWA guidelines of operating in the park should be upheld, 90% of the respondents feel oil and gas operations in the park should be monitored by the government, and 86% feel that in cases of oil operations, animals should be relocated to less disturbed areas. The number of respondents who think core ecosystem parts should be conserved and EIA compliance have a significant difference from the number of respondents that disagree (χ^2= 20.48, d.f =1, $p<0.05$). The number of respondents that feel UWA guidelines should be upheld differ significantly from the number of respondents that disagree (χ^2=18, d.f =1, $p<0.05$). There is a significant difference between the number of respondents who agree and disagree with government monitoring of oil and gas operations in the park (χ^2= 35, d.f=1, $p<0.05$). The number of respondents who suggested relocation of mammals differ significantly from the number of respondents that disagree (χ^2=25.92, d.f=1, $p<0.05$).

CHAPTER FIVE

DISCUSSIONS

5.1 Mammalian habitat variations

Results from the vegetation frequency index analyzed by Raunkiaer's law of frequency (1934) recorded the uniformity or non-uniformity of plant species in the study area. Uniform vegetation signified stable community whilst non-uniformity may suggest a disturbed vegetation community. Thatching grass (*Hyparrhenia hirta*), Cat's tail drop seed (*Sporobolus pyramidalis*), Nut grass (*Cyperus rotundus*), Star grass (*Cynodon dactylon*) and Wandering jew (*Commelina benghalensis*) were some of the plant species that were recorded to be highly uniform in both oil pads and control areas. The study recorded a number of plant species which were more uniform in control areas than oil pads. This may suggest that these plant species are more abundant in control areas than oil pads; they include; Feathered chloris (*Chloris virgate*), Bur bristled grass (*Seteria verticullata*), Desert date (*Balanites aegyptiaca*), Hoket horn (*Arisonia abyssinica*), Garden pink-sorrel (*Oxalis latifolia*), Borassus palm tree (*Palmyra palm*), Edible canna (*Canna eduls*), Guntamala (*Tribsacum laxom*), Sticking weed (*Acacia okidetalia*), Treedax daisy (*Tridax procumbens*), and Whistling acacia (*Acacia hoki*). However, it should be noted that distribution of frequencies "depends on the number of quadrats, the size of the quadrats, and on the Index of Diversity of the population." Unless all of these factors are considered the distribution of frequencies in classes is not meaningful. (Williams, 1950). Another challenge with this methodology of vegetation assessment is that the distribution of species in the frequency classes varies with the size of sample. The results are highly influenced by the composition of the total population in terms of numbers of individuals per species.

Altogether, the study recorded a non-significant difference in the vegetation relative abundance between oil pads and control areas. The results reveal that the plant communities have been able to recover from the human disturbances caused by oil exploration which is not in line with Forbes *et al*. (2001) who commented that there is a general slow recovery of plant communities from human disturbances, and other physical impacts of development for decades or centuries. The study revealed that the vegetation at the former oil pads has been fully restored with different types of vegetation; and the most dominant plants observed in oil pads included; Thatching grass (*Hyparrhenia hirta*), Cat's tail drop seed (*Sporobolus pyramidalis*), Nut grass (*Cyperus rotundus*), Wandering Jew (*Commelina benghalensis*) and Feathered chloris (*Chloris virgate*). The mentioned plant species were observed in both oil pads and control areas but were significantly more abundant in control areas. This is in line with Simmers and Galatowitsch (2010) who commented that in semi-arid environments, habitats heavily disturbed by anthropogenic activities often have lower species richness compared with undisturbed areas.

The study also recorded three plant species that were more significantly abundant in oil pads than control areas which include; Candle bush (*Senna alata*), Garden signal grass (*Urochba panicoides*), and Hippo grass (*Vossia cuspidata*). The observation of more presence of certain plant species in oil pads is proof that the effect on plant vegetation was only for a short period of time but the vegetation has gone back to its original state which is contrary to Prinsloo *et al.* (2011) who stated that oil and gas development leads to decrease in vegetation cover. The plant species that were significantly more in oil pads than control areas are an indicator that the mammalian habitats in oil pads have not been affected by oil and gas exploration which is contrary to Edwards *et al*. (2014) who noted that mining infrastructure fragments and degrades natural habitat through the creation of roads. The study also measured vegetation diversity and the results showed no significant difference of plant diversity in oil pads and control areas. This is different from Cui *et al*. (2009) who noted that disturbances can have immediate and persistent effects with slow recovery times on vegetation.

The study recorded similar vegetation relative abundance in oil pads and control areas of some plant species such as; Creeping wood-sorrel (*Oxalis corniculata*), Finger grass(*Digitaria eriantha*), Garden Pink-sorrel (*Oxalis latifolia*), Star Grass (*Cynodon dactylon*), Fibrous drop seed (*Sporobolus stafianus*), Whitethorn acacia tree (*Vachellia constricta*), Baboon apple (*Annona glabra*), Borassus palm tree (*Palmyra palm*), Goats weed (*Ageratum denyzoides*), Nandi grass (*Cetera ancient*), Wild canny lilly flower (*Canna indical*), Devil horsewhip (*Achyranthes aspera*), Edible canna (*Canna eduls*), Guntamala (*Tribsacum laxom*), Pickerel weed (*Pontederia cantata*), Sticking weed (*Acacia okidetalia*), Tick berry (*Lantana camara*), Treedax daisy (*Tridax procumbens*), Wait a bit thorn (*Acacia mellifera*), and Whistling acacia (*Acacia hoki*). This discovery indicates that the habitats have not been altered which is not in line with Lee *et al*. (2013) who suggested that that species richness and total vegetation cover (Fiori and Zalba, 2003) may decrease in response to road construction and natural resource extraction. The results are also contrary to (UNEP 1997; Epstein and Selber, 2002; Kumpula *et al*. 2011; OGP/IPIECA 2011) who commented that natural resource extraction of oil and gas exploration had well documented impacts on wildlife as well as vegetation. The fact that the vegetation diversity in oil pads is similar to that in control areas is a good indicator that the habitats for mammals are not affected by oil and gas exploration which is different from Kamara *et al*. (2019) who stated that oil exploration led to loss of habitats in well pad sites.

It should be noted that the study intentionally measured vegetation frequency index, vegetation relative abundance and vegetation diversity but did not put in to account the relative cover of the observed plant species due to the limited time and resources that were available for the study. The study was primarily concerned with the uniformity and composition of the plant communities as a whole not the nature of plants and coverage across the sites under the study.

5.2 Effect of post exploration oil and gas infrastructure on mammal's population abundance and distribution

The results of the study showed that the mammal species recorded per distance intervals in oil pads and control areas are not significantly different. This can be perceived that the presence of mammals in oil pads is an indicator that the post exploration infrastructure such as roads, placards and boreholes do not affect the population abundance and distribution of animals in the park. This is in line with Fuda *et al.* (2018) who commented that mammals can go back to their former habitats after completion of drilling. The findings of the study were restricted to the counting of animals found in the sites under the study but did not cover the spatial distribution of animals from one oil pad to another or the distribution of animals from the existing roads. Instead the study considered the distribution of animals from the center of the oil pads up to a distance of 2km.

The study recorded no significant difference in the total number of mammals observed in oil pads and control areas five years after the completion of oil and gas exploration. This suggests that the mammals have been able to return to their habitats located in the former oil pads and the post exploration infrastructure in these sites do not affect their abundance. This is not in line with Hartley *et al*. (2007) who stated that habitats are considered highly irreplaceable after oil developments. The current state of the former oil pads is suitable for the survival of mammals which is in line with Williams (1997) and Williams *et al*. (2002) who stated that ideal environmental gradient shows interactions between habitat structure and the mammal assemblage.

The animal trails recorded within oil pads that are used by Uganda Kobs and Oribi suggested that the mammals have been able to return to their habitats post exploration which is contrary to Plumptre *et al.* (2015); Prinsloo *et al.* (2011) who commented that several mammal species tend to avoid areas affected by human activities up to 2km away. The study observed few numbers of the Rothschild Giraffes in oil pads and control areas which can be attributed to the fact that the sites under the study were located in areas that do not have big numbers of the mammal species in question. Similar mammal species that were observed in oil pads were also recorded in control areas which is contrary to Sawyer *et al*. (2006) who commented that large mammals are displaced on a large-scale from developed areas and around development infrastructure.

The study observed the abundance and distribution of mammals across oil pads and control areas for wet and dry season. The number of mammal species counted in oil pads and control areas for the two seasons were significantly different; more numbers of mammals were counted during wet season. This can be attributed to the favorable environmental conditions that come with wet season such as fresh pastures for the animals to feed. This is in line with Happlod and Happold, (2013) who stated that population size of mammals increases during rainy season.

Oribi mammals recorded during the study, were recorded in bigger numbers in the time period of wet season than the dry season in both oil pads and control areas along increasing distance. This was the same observation for Uganda Kobs, Cape Buffalos, Jackson's Hartebeests, African Elephants, Warthogs but not the Rothschild Giraffes. The Rothschild Giraffes were completely absent in control areas for the dry season. However, the study could not justify why giraffes were absent for the dry season but can relate it to Wiens (1989) who noted that local ecological interactions such as species-specific responses to habitat, habitat diversity, competition, predation, and disturbance may limit species richness.

The results show that the number of elephants were relatively the same in oil pads compared to control areas up to a distance of 2000m. This proves that mammals return to their habitats after completion of oil and gas exploration. However, Plumptre (2016) noted that noise due to the effect of vibration, caused mainly by large machinery vibrations, trucks and hydraulic ramming affects elephants. The vibrations study shows that they do move away from seismic operations up to 4-5km. The study observed big numbers of Oribi, Uganda Kobs, Cape Buffalos, Jackson's hartebeest, Elephants and warthogs in oil pads which can be attributed to the fact that post exploration infrastructure has no effect on mammal's abundance. This is in line with Southwood (1996) who stated that local diversity is determined by the "habitat capacity," of the habitat area and the length of time over which the environment has been relatively stable.

5.3 Social perception of oil and gas operations in the protected area

Local perception of any development project is key to its success and it is very important to understand the social perception the local communities have towards any project. Such engagement when it occurs, 'can assist in developing open, meaningful dialogue, and can influence decision making, build trust, legitimacy, capacities, address community concerns, manage expectations, tap local knowledge and negotiate mutually beneficial futures that are more sustainable and locally relevant' Franks *et al*. (2012)**.**

In this context, Shepherd and Bowler (1997) have argued that "even when the scientific characterization of risk is thorough, complexities persist because what is 'acceptable' depends on more than scientific criteria; acceptability depends on public perception". The study survey discovered that majority of the local people feel oil operations in the park meet the set regulatory standards, however there is need to improve oil waste management and minimize animal displacement and disturbance. This is in line with the UWA strategic plan which acknowledges that oil exploration has resulted in degradation of habitats, disturbance to wildlife, and environmental damage (UWA ,2013). However, the findings of my study do not imply that the oil companies in the park are not complying with the set regulatory standards of operation in protected areas but the results are only the perception of the key informants that answered the questionnaires of the study.

The results show that decommissioning of an oil pad after the completion of exploration affects mammals in form of displacement and relocation. This perception is in line with O'Rourke and Connolly (2003) who states that On- and off-shore exploration, drilling, and extraction activities are inherently invasive and affect ecosystems, human health, and local cultures. However, conclusions should not be drawn from this finding since this is only a perception of the participants of the study and lacks scientific facts to back up such claims.

The study discovered that local people fear that the park will lose its biodiversity due to oil operations. Wiegle (2011) who in his research discovered that residents cited impacts on key habitats, animal reproduction and migration, hunting, bird watching, and threatened/endangered species. Recent sociological research on local attitudes toward unconventional shale gas development has consistently identified both positive and negative impacts on the community (Anderson and Theodori, 2009; Brasier *et al.*, 2011; Weigle, 2011; Wynveen, 2011).

The results show that most respondents reported there is a possibility of restoring oil pads to their natural state in a period of two to four years which is similar to (Fuda, 2015) who conducted a camera-trap study in MFPA post-appraisal period and found no evidence that wildlife avoided restored drill pads. This is also similar to preliminary research which indicates that oil exploration is influencing animal behavior, but after exploratory drill pads are restored, animals return to these locations Plumptre *et al*. (2015).

Overall, the findings of this research survey illustrated the growing concerns and debates about dissatisfied compliance standards such as oil waste management, animal displacement and disturbance. This corresponds with Pierson (2009) who in his study discovered that residents voiced noise complaints from drilling rigs and truck traffic, as well as anxiety about the high decibel levels from the enormous compressor stations used to pump gas from well sites and public perceptions of environmental harm (Brasier *et al*., 2011; Forsyth *et al*., 2007).

In a survey of residents 'perceptions toward gas development in the Barnett Shale region, Theodori (2009) found that respondents generally considered social and/or environmental issues (e.g., truck traffic and freshwater use) as "getting worse" due to development. In a related study, Anderson and Theodori (2009) also found similar paradoxical perceptions among local leaders in the Barnett Shale region with respondents expressing negative apprehensions about the potential threats to public health and safety, environmental concerns, and quality of life.

Chief among other concerns that were studied was restoration of oil sites after the completion of exploration; the results widely expressed that restoration is possible through various restoration techniques such as filling drainage ditches, excavation fill, restoration buffers, and replanting of vegetation. It is bound to happen for land to go through degradation during preparations for exploration; in that regard it is essential for vegetative restoration processes to be well understood (Winslow *et al*., 2009).

Natural resource development may be curtailed in the future if wildlife habitat and ecological degradation is not mitigated with positive and effective reclamation practices Stahl and Williams (2010). Some of the restoration techniques suggested by participants from the study survey were replanting of vegetation which is compatible with McKendrick (1997) who states that reclamation projects have to establish plants as quickly as possible and allow for natural succession to occur. Eventually natural succession will lead to similar vegetation of the surrounding tundra.

Another restoration technique from the study survey was filling excavation and drainage ditches, this is similar to McKendrick *et al*. (1992) who stated that the first steps taken for reclamation are identifying native plants, experimenting with seeding practices, and manipulating ground fill for better plant establishment.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Oil and gas exploration is associated with high human presence, running machines, hooting, lighting, and vibrations. The results of this study revealed that the vegetation at the former exploration oil pads has been fully restored. The most dominant/uniform plants observed in oil pads included; Thatching grass (*Hyparrhenia hirta*), Cat's tail drop seed (*Sporobolus pyramidalis*), Nut grass (*Cyperus rotundus*), Wandering Jew (*Commelina benghalensis*) and Feathered chloris (*Chloris virgate*). This discovery indicates that oil and gas exploration in the park has not changed mammal habitats n the study area.

The presence of big numbers of Oribi, Uganda Kob, Cape Buffalo, J. Hartebeest, and Elephant mammals in oil pads, is an indicator that the post exploration infrastructure such as access roads, placards and boreholes do not affect the population abundance and distribution of animals in the park.

The study survey discovered that majority of the local people feel oil operations in the park meet the set regulatory standards, however they suggested a need to improve oil waste management and minimize animal displacement and disturbance. The survey shows that people feel oil and gas activities affect mammals through noise, disturbance and displacement. The study respondents suggested that decommissioning of an oil pad affects mammals through displacement thus leading to the relocation of animals from their habitats. The study respondents think that oil and gas exploration in the protected area is a bad idea and the park is at risk of losing its biodiversity. However, some respondents believe that it can co-exist alongside wildlife if proper care/precautions are taken. The respondents from the research survey think there is a possibility of restoring mammal habitats once oil and gas exploration has been completed in a minimum of two years up to a maximum of four years. The possible restoration techniques suggested by participants included; filling drainage ditches, excavating fill, restoration buffers and replanting of vegetation. Respondents feel that amidst oil and gas operations in the protected area, core ecosystem parts should not be tampered with, ensure ESIA compliance; uphold UWA guidelines of operating in protected areas and re-allocation of animals to less disturbed areas of the park if possible.

6.2 Recommendations

Based on the results and conclusions of this study, here are recommendations to be considered;

1. The oil and gas companies should commit themselves to replanting of the exact plant species that were initially found in the oil pad sites before development.
2. The oil and gas companies should use other options of marking boreholes and drilling holes rather than the big placards which are likely to interfere with animal movement and migration. This may eventually affect animal population abundance and distribution.
3. The stakeholders need to adopt an effective comprehensive approach of engaging the local people in oil and gas development matters through public consultations.
4. Since this research used vegetation diversity and animal counts as indicators, it would be more effective if another similar study is conducted using soil analysis to determine the chemical composition of soil in the former oil pads and control areas.
5. Similar studies should be conducted on other former oil pads in the national park to get the true representation of the whole ecosystem.
6. Besides the methodologies used in this study, other methods such as animal tagging can be used to map the feeding habits/animal range of mammals in order to establish if animals feed in the former oil pads.

7. Future studies can test the genetic makeup of the mammals to check if it has changed as a result of oil and gas activities in the protected area.

REFERENCES

African Development Bank. (2014). African Development Bank group strategy for addressing fragility and building resilience in Africa. Abidjan, Cˆote d'Ivoire:African Development Bank Group. Available athttp://www.afdb.org/fileadmin/uploads/afdb/Documents/Policy-Documents/Addressing_Fragility_and_Building_Resilience_in_Africa_The_AfDB_Group_Strategy_2014%E2%80%932019.pdf. Accessed November 12,2015.

Anderson, B. J., and Theodori, G. L. (2009). Local Leaders 'Perceptions of Energy Development in the Barnett Shale. *Southern rural sociology*, 24(1).

Andren, H. (1994). Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos*, 355-366.

Annan, K. (2012). Momentum rises to lift Africa's resource curse. *New York Times*, 14.

Beckmann, J. P., Murray, K., Seidler, R. G., and Berger, J. (2012). Human-mediated shifts in animal habitat use: sequential changes in pronghorn use of a natural gas field in Greater Yellowstone. *Biological Conservation*, 147(1), 222-233.

Blickley 1, J. L., and Patricelli 2, G. L. (2010). Impacts of anthropogenic noise on wildlife: research priorities for the development of standards and mitigation. *Journal of International Wildlife Law and Policy*, 13(4), 274-292.

Borasin, S., Foster, S., Jobarteh, K., Link, N., Miranda, J., and Pomeranse, E., Somaia, P.,(2002). Oil: A life cycle analysis of its health and environmental impacts. Retrieved from https://www.fraw.org.uk/library/toxics/epstein_2006.pdf.

Brasier, K. J., Filteau, M. R., McLaughlin, D. K., Jacquet, J., Stedman, R. C., Kelsey, T. W., and Goetz, S. J. (2011). Residents' Perceptions of Community and Environmental Impacts from Development of Natural Gas in The Marcellus Shale: A Comparison of Pennsylvania and New York Cases. *Journal of Rural Social Sciences*, 26(1), 32.

Brooks, T. M., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., Rylands, A. B., Konstant, W. R., and Hilton-Taylor, C. (2002). Habitat loss and extinction in the hotspots of biodiversity. *Conservation biology*, 16(4), 909-923.

Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L., and Thomas, L. (2004). *Advanced distance sampling* (Vol. 2). Oxford: Oxford University Press.

Burgess, R.L. and Sharpe, D.M. (eds.) 1981. Forest island dynamics in man dominated landscapes. Springer-Verlag, New York.

Ceballos, G., and Ehrlich, P. R. (2002). Mammal population losses and the extinction crisis. *Science*, 296(5569), 904-907.

Copeland, H. E., Doherty, K. E., Naugle, D. E., Pocewicz, A., and Kiesecker, J. M. (2009). Mapping oil and gas development potential in the US Intermountain West and estimating impacts to species. *PloS one*, 4(10).

Cox, G. (1990). Laboratory manual of general ecology 6th Ed. *Dubuque, Iowa*: William C. Brown.

Cui, B., Zhao, S., Zhang, K., Li, S., Dong, S., and Bai, J. (2009). Disturbance of Dabao highway construction on plant species and soil nutrients in Longitudinal Range Gorge Region (LRGR) of Southwestern China. *Environmental monitoring and assessment*, 158(1-4), 545.

Dingle, H., and Drake, V. A. (2007). What is migration? *Bioscience*, 57(2), 113-121.

Dzialak, M. R., Webb, S. L., Harju, S. M., Winstead, J. B., Wondzell, J. J., Mudd, J. P., and Hayden-Wing, L. D. (2011). The spatial pattern of demographic performance as a component of sustainable landscape management and planning. *Landscape Ecology*, 26(6), 775-790.

Edwards, D. P., Sloan, S., Weng, L., Dirks, P., Sayer, J., and Laurance, W. F. (2014). Mining and the African Environment. *Conservation Letters*, 7, 302-311.

Environmental Impact Assessment Regulations. (1998): The Republic of Uganda. *National Environment Management Authority*: Kampala, Uganda.

Epstein, P. R., and Selber, J. (2002). Oil: A life cycle analysis of its health and environmental impacts. The Center for Health and the Global Environment. Harvard Medical School, Boston.

Ericson, K, (2014) "A Crude Awakening: The Relationship between Petroleum Exploration and Environmental Conservation in Western Uganda". *Independent Study Project (ISP) Collection.*1924.

Finer, M., Jenkins, C. N., Pimm, S. L., Keane, B., and Ross, C. (2008). Oil and gas projects in the western Amazon: threats to wilderness, biodiversity, and indigenous peoples. PloS one, 3(8).

Fiori, S. M., and Zalba, S. M. (2003). Potential impacts of petroleum exploration and exploitation on biodiversity in a Patagonian Nature Reserve, Argentina. *Biodiversity and Conservation*, 12(6), 1261-1270.

Forbes, B. C., Ebersole, J. J., and Strandberg, B. (2001). Anthropogenic disturbance and patch dynamics in circumpolar arctic ecosystems. *Conservation Biology*, 15(4), 954-969.

Forman, R. T. T., D. Sperling, J. A. Bissonette, A.P. Clevenger, C. D. Cutshall, V. H. Dale, L. Fahrig, R. France, C. R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine and T.C. Winter. (2003). Road ecology: *Science and Solutions*. Island Press, Washington, D.C., USA.

Forsyth, C. J., Luthra, A. D., and Bankston, W. B. (2007). Framing perceptions of oil development and social disruption. *The Social Science Journal*, 44(2), 287-299.

Franks, D. (2012). Social impact assessment of resource projects. *International Mining for Development Centre*, *3*.

Freedman SD, Callery MP. (2007). Central control of pancreatic cancer pain: protecting theenemy? Gastroenterology 2007;132:1191–2. PMID: 17383443.

Frynas, J. G., and Paulo, M. (2007). A new scramble for African oil? Historical, political, and business perspectives. *African affairs*, 106(423), 229-251.

Fuda, R. K. (2015). A park under pressure: the impacts of human disturbance in Murchison Falls Conservation Area, Uganda. State University of New York College of Environmental Science and Forestry.

Fuda, R. K., Ryan, S. J., Cohen, J. B., Hartter, J., and Frair, J. L. (2018). Assessing the impacts of oil exploration and restoration on mammals in Murchison Falls Conservation Area, Uganda. *African journal of ecology*, 56(4), 804-817.

Gill, J. A., Norris, K., and Sutherland, W. J. (2001). Why behavioral responses may not reflect the population consequences of human disturbance. *Biological Conservation*, 97(2), 265-268.

Gramling, R., and Freudenburg, W. R. (1992). Opportunity-threat, development, and adaptation: Toward a comprehensive framework for social impact assessment 1. *Rural Sociology*, 57(2), 216-234.

Greig-Smith, P. (1983). *Quantitative plant ecology* (Vol. 9). Univ of California Press.

Haghighi, M., Taghdisi, M. H., Nadrian, H., Moghaddam, H. R., Mahmoodi, H., and Alimohammadi, I. (2017). Safety Culture Promotion Intervention Program (SCPIP) in an oil refinery factory: an integrated application of Geller and Health Belief Models. *Safety science*, *93*, 76-85.

Happold, D. C. D., and Happold, D. C. D. (2013). Mammals of Africa. *Volume III: Rodents, hares and rabbits*.

Harcourt, A. H., Parks, S. A., and Woodroffe, R. (2001). Human density as an influence on species/area relationships: double jeopardy for small African reserves? *Biodiversity and Conservation*, 10(6), 1011-1026.

Harfoot, M. B., Tittensor, D. P., Knight, S., Arnell, A. P., Blyth, S., Brooks, S., and Scharlemann, J. P. (2018). Present and future biodiversity risks from fossil fuel exploitation. *Conservation Letters*, 11(4), e12448.

Harju, S. M., Dzialak, M. R., Taylor, R. C., HAYDEN-WING, L. D., and Winstead, J. B. (2010). Thresholds and time lags in effects of energy development on greater sage-grouse populations. *The Journal of Wildlife Management*, 74(3), 437-448.

Hartley, D., J. Koivula, M., R. Spence, J., Pelletier, R., and E. Ball, G. (2007). Effects of urbanization on ground beetle assemblages (Coleoptera, Carabidae) of grassland habitats in western Canada. *Ecography*, *30*(5), 673-684.

Haselip, J., and Romera, B. M. (2011). Peru's Amazonian oil and gas industry: risks, interests and the politics of grievance surrounding the development of block 76, Madre de Dios. *International Development Planning Review*, 33(1), 1-26.

Holodny, E. (2015). The 13 fastest-growing economies in the world. *Business Insider* UK.

IUCN (1994). IUCN Red List Categories. Gland, Switzerland: International Union for the Conservation of Nature, Species Survival Commission.

Jaeger, J. A., and Fahrig, L. (2004). Effects of road fencing on population persistence. *Conservation Biology*, 18(6), 1651-1657.

Jaeger, J. A., Bowman, J., Brennan, J., Fahrig, L., Bert, D., Bouchard, J., and von Toschanowitz, K. T. (2005). Predicting when animal populations are at risk from roads: an interactive model of road avoidance behavior. *Ecological modelling*, 185(2-4), 329-348.

Janneh, A., and Ping, J. (2012). Africa as a pole of global growth. *Economic Commission for Africa and African Union Commission*: Addis Ababa.

Johnson, L. (2007). Assessing the impacts of energy developments and developing appropriate mitigation in the Uganda portion of the Albertine Rift. *Wildlife Conservation Society and Uganda Wildlife Authority*, Kampala, Uganda.

Kagolo, F. (2014). Government adopts friendlier oil drilling method. Kampala, Uganda: New Vision.

Kamara, E. D., Nina, P. M., and Ochieng, L. A. (2019). Effects of Oil and Gas Exploration in Murchison Falls National Park on Wildlife Resources. *African Journal of Environment and Natural Science Research*, 2(2), 48-57.

Kark, S., Tulloch, A., Gordon, A., Mazor, T., Bunnefeld, N., and Levin, N. (2015). Cross-boundary collaboration: key to the conservation puzzle. *Current Opinion in Environmental Sustainability*, 12, 12-24.

Ketten, D. R., Lien, J., and Todd, S. (1993). Blast injury in humpback whale ears: evidence and implications. *The Journal of the Acoustical Society of America*, 94(3), 1849-1850.

King, G. E., and King, D. E. (2013). Environmental risk arising from well-construction failure--differences between barrier and well failure, and estimates of failure frequency across common well types, locations, and well Age. *SPE Production and Operations*, 28(04), 323-344.

Kityo, R. M. (2011). The effects of oil and gas exploration in the Albertine Rift region on biodiversity: *A case of protected areas (Murchison Falls National Park) (Nature Uganda, Kampala, Uganda).*

Kolowski, J. M., and Alonso, A. (2010). Density and activity patterns of ocelots (Leopardus pardalis) in northern Peru and the impact of oil exploration activities. *Biological Conservation*, 143(4), 917-925.

Kumpula, T., Pajunen, A., Kaarlejärvi, E., Forbes, B. C., and Stammler, F. (2011). Land use and land cover change in Arctic Russia: Ecological and social implications of industrial development. *Global Environmental Change*, 21(2), 550-562.

Lamprey, R. (2000). Aerial Wildlife Surveys in Murchison Falls National Park and Queen Elizabeth National Park, 1999-2000. *Report to Uganda Wildlife Authority*. Protected Area Assessment Programme.

Larkin, P.A. and Trites, A.W. (1996) Changes in the abundance of Steller sea lions (Eumetopiasjubatus) in Alaska from 1956 to 1992: how many were there? *Aquatic Mammals*, 22, 153–166.

Laurance, W. F., Clements, G. R., Sloan, S., O'connell, C. S., Mueller, N. D., Goosem, M., and Van Der Ree, R. (2014). A global strategy for road building. *Nature*, 513(7517), 229-232.

Laurance, W. F., Goosem, M., and Laurance, S. G. (2009). Impacts of roads and linear clearings on tropical forests. *Trends in ecology & evolution*, 24(12), 659-669.

Leblond, M., Frair, J., Fortin, D., Dussault, C., Ouellet, J. P., and Courtois, R. (2011). Assessing the influence of resource covariates at multiple spatial scales: an application to forest-dwelling caribou faced with intensive human activity. *Landscape Ecology*, 26(10), 1433-1446.

Lee, C. B., Chun, J. H., Song, H. K., and Cho, H. J. (2013). Altitudinal patterns of plant species richness on the Baekdudaegan Mountains, South Korea: mid-domain effect, area, climate, and Rapoport's rule. *Ecological research*, *28*(1), 67-79.

Lendrum, P. E., Anderson Jr, C. R., Long, R. A., Kie, J. G., and Bowyer, R. T. (2012). Habitat selection by mule deer during migration: effects of landscape structure and natural-gas development. *Ecosphere*, 3(9), 1-19.

Leu, M., Hanser, S. E., and Knick, S. T. (2008). The human footprint in the west: a large-scale analysis of anthropogenic impacts. *Ecological Applications*, 18(5), 1119-1139.

Levy, J. K., and Gopalakrishnan, C. (2010). Promoting ecological sustainability and community resilience in the US Gulf Coast after the 2010 Deepwater Horizon oil spill. *Journal of Natural Resources Policy Research*, 2(3), 297-315.

Loehle, C., and Li, B. L. (1996). Habitat destruction and the extinction debt revisited. *Ecological applications*, 6(3), 784-789.

Mariano J.B and La Rovere E L. (1999) Environmental impacts of the oil industry. *Petroleum Engineering Downstream.*

Marques, F. F., and Buckland, S. T. (2003). Incorporating covariates into standard line transect analyses. *Biometrics*, 59(4), 924-935.

McDonald-Madden, E., Gordon, A., Wintle, B. A., Walker, S., Grantham, H., Carvalho, S., and Possingham, H. P. (2009). " True" conservation progress. *Science*, 323(5910), 43-44.

McKendrick, J. D. (1997). Long-term tundra recovery in northern Alaska. *Disturbance and recovery in Arctic lands*, *2*, 503-518.

McKendrick, J. D., Scroup, P. C., Fiscus, W. E., and Turner, G. L. (1992). Gravel vegetation experiments: Alaska North Slope. *Agroborealis Alaska Agricultural and Forestry Experiment Station, University of Alaska Fairbanks*.

Mulondo, P. (2015). Spatial distribution of savannah large mammals in relation to oil exploration drilling in Murchison Falls National Park, Uganda.

National Academy of Sciences (2003): Impacts to Wildlife.

National Environment Act. (1995). The National Environment Act Cap 153 of the Republic of Uganda. *National Environment Management Authority*.

Northrup, J. M., and Wittemyer, G. (2013). Characterising the impacts of emerging energy development on wildlife, with an eye towards mitigation. *Ecology letters*, *16*(1), 112-125.

Ocowun, C., and Okethwengu, B. (2013). New method to aid oil search in Murchison. *Kampala, Uganda: New Vision*.

OGP/IPIECA/API. (2011). Petroleum Industry Guidelines for Reporting Greenhouse gas Emissions.

Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V., Underwood, E. C., and Loucks, C. J. (2001). Terrestrial Ecoregions of the World: A New Map of Life on Earth A new global map of terrestrial ecoregions provides an innovative tool for conserving biodiversity. *BioScience*, *51*(11), 933-938.

Olupot, W., Parry, L., Gunnes, M., and Plumptre, A. (2010). Conservation Research in Uganda's Savannas: *A Review of Park History, Applied Research, And Application of Research to Park Management*. Nova Science Publishers, Inc.

O'Rourke, D., and Connolly, S. (2003). Just oil? The distribution of environmental and social impacts of oil production and consumption. *Annual Review of Environment and Resources*, *28*(1), 587-617.

Osei, B., and Mubiru, A. M. (2010). Chinese trade and investment activities in Africa. *African Development Bank's Policy Brief*, 1(4), 1-12.

Osuji, L C (2001). Post impact assessment of oil pollution in Agbada west plain of Niger Delta, Nigeria: field reconnaissance and total extractable hydrocarbon content. *Journal of Applied Sciences & Environmental Management*, **5**(35), 1569–1578.

PEPD (2014), Petroleum discoveries in the Albertine Graben. Ugandan Petroleum Exploration and Production Department

Peterson, C. H., Rice, S. D., Short, J. W., Esler, D., Bodkin, J. L., Ballachey, B. E., and Irons, D. B. (2003). Long-term ecosystem response to the Exxon Valdez oil spill. *Science*, *302*(5653), 2082-2086.

Pierson, D. (2009). "Noise an Issue with Natural Gas Drilling." *The ShreveportTimes.*

Plumptre, A. J., Ayebare, S., Mugabe, H., Kirunda, B., Kityo, R., Waswa, S., and Mulondo, P. (2015). Biodiversity surveys of Murchison Falls Protected Area. *Wildlife Conservation Society, Kampala, Uganda*, 26.

Plumptre, A. J., Davenport, T. R., Behangana, M., Kityo, R., Eilu, G., Ssegawa, P., and Peterhans, J. K. (2007). The biodiversity of the Albertine Rift. *Biological conservation*, *134*(2), 178-194.

Plumptre, A.J., Behangana, M., Davenport, T.R.B., Kahindo, C., Kityo, R., Ndomba, E., Nkuutu, D., Owiunji, I., Ssegawa, P., and Eilu, G. (2003). The Biodiversity of the Albertine Rift. Albertine Rift. *Biological Conservation,* Technical Reports No.3.

Plumptre, A.J., Prinsloo, S., Ayebare, S. and Nangendo, G. (2016). Documentation of existing and potential oil/geothermal projects, mapping their likely adverse negative effects on the biodiversity conservation and community livelihoods in the Greater Virunga Landscape. Unpublished report to Greater Virunga Transboundary Collaboration.

Price, M. R. S. (1989). Animal reintroductions: the Arabian oryx in Oman. Cambridge University Press.

Prinsloo, S., Mulondo, P., Mugiru, G., and Plumptre, A. J. (2011). Measuring responses of wildlife to oil operations in Murchison Falls National Park. *Wildlife Conservation Society and Uganda Wildlife Authority*.

Putman, R. J., and Moore, N. P. (1998). Impact of deer in lowland Britain on agriculture, forestry and conservation habitats. *Mammal Review*, *28*(4), 141-164.

Reynolds, P. E., Reynolds III, H. V., and Follmann, E. H. (1986). Responses of grizzly bears to seismic surveys in northern Alaska. *Bears: Their Biology and Management*, 169-175.

Rogala, J. K., Hebblewhite, M., Whittington, J., White, C. A., Coleshill, J., and Musiani, M. (2011). Human activity differentially redistributes large mammals in the Canadian Rockies National Parks. *Ecology and Society*, *16*(3).

Rwakakamba, M., and Lukwago, D. (2013). Farmers in Uganda's oil economy: deal or no deal. *Kampala: Agency for Transformation*.

Rwakakamba, M., Mpiira, A. S., and Turyatemba, J. (2014). Tourism in Uganda's oil economy: Deal or no Deal! *Agency for Transformation*.

Sawyer, H., Kauffman, M. J., and Nielson, R. M. (2009). Influence of well pad activity on winter habitat selection patterns of mule deer. *The Journal of Wildlife Management*, *73*(7), 1052-1061.

Sawyer, H., Nielson, R. M., Lindzey, F., and McDonald, L. L. (2006). Winter habitat selection of mule deer before and during development of a natural gas field. *The Journal of Wildlife Management*, *70*(2), 396-403.

Shepherd, A. and Bowler, C. (1997). Beyond the requirements: Improving public participation in EIA. *Journal of Environmental Planning and Management*, 40(6), 725-738.

Shepherd, B. (2013). *Oil in Uganda: international lessons for success*. London, UK: Royal Institute of International Affairs.

Simmers, S. M., and Galatowitsch, S. M. (2010). Factors affecting revegetation of oil field access roads in semiarid grassland. *Restoration Ecology*, *18*, 27-39.

Southwood, S. R. (1996). The Croonian lecture, 1995 natural communities: Structure and dynamics. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 351(1344), 1113-1129.

Stahl, P. D., and Williams, S. E. (2010). Original Project Proposal: Identifying successful reclamation techniques for natural gas well pads in Wyoming. *Wyoming Reclamation and Restoration Center. School of Energy Resources, University of Wyoming.*

The Land Act. (1999). Government of Uganda.: *Ministry of Lands, Water, and Environment.*

The National Environment Management Policy. (1994). Kampala: The Republic of Uganda.

The National Forestry and Tree Planting Act. (2003). Government of Uganda. *National Forestry and Tree Planting Act. Government Printer,* Entebbe.

The National Oil and Gas Policy. (2008). The Republic of Uganda. *Ugandan Ministry of Energy and Mineral Development*: Kampala, Uganda.

The Petroleum (Exploration and Production) Act. (1985). The Republic of Uganda. *National Environment Management Authority.*

The Petroleum Exploration and Production Act. (2000). The Republic of Uganda. *National Environment Management Authority.*

Theodori, G. L. (2009). Paradoxical perceptions of problems associated with unconventional natural gas development. *Southern Rural Sociology*, *24*(3).

Trombulak, S. C., and Frissell, C. A. (2000). Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation biology*, *14*(1), 18-30.

Uganda Wildlife Act (1996). The Republic of Uganda, Kampala, Uganda

Uganda Wildlife Authority. (2001). Murchison Falls National Park, Bugungu Wildlife Reserve, Karuma Wildlife Reserve. *General Management Plan (July 2001-June 2011)*.

Uganda Wildlife Policy. (2014). Uganda Wildlife Authority Operational Guidelines for Oil and Gas Exploration and Production in Wildlife Protected Areas

Ugochukwu, C. N., and Ertel, J. (2008). Negative impacts of oil exploration on biodiversity management in the Niger De area of Nigeria. *Impact assessment and project appraisal*, *26*(2), 139-147.

UNEP (1997) World Atlas of Desertification. United Nations Environment Programme, London.

Unsworth, J. W., Pac, D. F., White, G. C., and Bartmann, R. M. (1999). Mule deer survival in Colorado, Idaho, and Montana. *The Journal of Wildlife Management*, 315-326.

UWA (2012). General management plan for Murchison Falls National Park, Karuma Wildlife Reserve, and Bugungu Wildlife Reserve 2012–2022. *Ministry of Tourism, Wildlife and Heritage, Kampala, Uganda*.

UWA. (2013). Uganda Wildlife Authority Strategic Plan 2013-2018.: *Uganda Wildlife Authority*, Kampala, Uganda

Vistnes, I., and Nellemann, C. (2008). The matter of spatial and temporal scales: a review of reindeer and caribou response to human activity. *Polar Biology*, *31*(4), 399-407.

Vokes, R. (2012). The politics of oil in Uganda. *African Affairs*, *111*(443), 303-314.

Weigle, J. L. (2011). Resilience, community, and perceptions of Marcellus Shale development in the Pennsylvania wilds: reframing the discussion. *Sociological Viewpoints*, *27*(1), 3.

Wiens, J. A. (1989).: Spatial scaling in ecology. Functional Ecology 3, 385-397.

Wilcove, D. S., Rothstein, D., Dubow, J., Phillips, A., and Losos, E. (1998). Quantifying threats to imperiled species in the United States. *BioScience*, *48*(8), 607-615.

Wilcox, B. A., and Murphy, D. D. (1985). Conservation strategy: the effects of fragmentation on extinction. *The American Naturalist*, *125*(6), 879-887.

Wilkie, D. S., and Carpenter, J. F. (1999). Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation. *Biodiversity and Conservation*, 8(7), 927-955.

Wilkie, D., Shaw, E., Rotberg, F., Morelli, G., and Auzel, P. (2000). Roads, development, and conservation in the Congo Basin. *Conservation Biology*, 14(6), 1614-1622.

Williams, S. E. (1997). Patterns of mammalian species richness in the Australian tropical rainforests: are extinctions during historical contractions of the rainforest the primary determinants of current regional patterns in biodiversity? *Wildlife Research*, *24*(5), 513-530.

Williams, S. E., Marsh, H., and Winter, J. (2002). Spatial scale, species diversity, and habitat structure: small mammals in Australian tropical rain forest. *Ecology, 83*(5), 1317-1329.

Williams, C. B. (1950). The application of the logarithmic series to the frequency of occurrence of plant species in quadrats. - *J. Ecol*. 38: 107-138.

Winslow, S. R., Clause, K. J., Jacobs, J. S., and Hybner, R. M. (2009). Revegetation Trials in the Pinedale Anticline Project Area1. *Proceedings America Society of Mining and Reclamation*, 1627-1661.

Wynveen, B. J. (2011). A Thematic Analysis of Local Respondents' perceptions of Barnett Shale Energy Development. *Journal of Rural Social Sciences*, *26*(1).

Appendices

Appendix 1: UWA Research Approval

UGANDA WILDLIFE AUTHORITY

UWA
Conserving for Generations

OFFICE OF THE EXECUTIVE DIRECTOR
PLOT 7 KIRA ROAD KAMWOKYA
P. O. Box 3530, Kampala, Uganda

Our Ref: COD/96/05

25th October 2018

Akisiimire Hindra
Kampala International University
P. O. Box 1
KAMPALA

RESEARCH APPLICATION APPROVAL

I am in receipt of your application dated 22nd October 2018 seeking permission to carry out a study titled ***"The Impacts of Oil and Gas production on Selected Large Mammals and their Habitats in Murchison Falls National Park"***.

I wish to inform you that your research application has been approved with effect from 1st January 2019 to 1st October 2019. Permission is further given to your co-investigator **Mr Kenneth Tumwebaze**. You are expected to submit to Uganda Wildlife Authority a progress report by June 2019 and a final report of your findings by end of December 2019. In case you are unable to work within these dates, please notify us in writing.

Kindly, note that any researcher failing to submit reports will not be allowed to come back to Protected Areas for further research.

You will be required to pay to Uganda Wildlife Authority an application fee of **UGX 20,000.**

Please report to the Chief Warden of Murchison Falls Conservation Area on arrival for registration and further guidance.

Conserving for Generations
Yours sincerely,

EXECUTIVE DIRECTOR
UGANDA WILDLIFE AUTHORITY

Stephen Masaba
FOR: EXECUTIVE DIRECTOR

cc Chief Warden, MFCA
cc Warden Ecological Monitoring& Research, MFCA

Uganda Tel: +256-41-4355000, +256-31-2355000 Fax: +256-41-4346291, E-Mail: info@ugandawildlife.org, Website: www.ugandawildlife.org

Appendix 2: Some of the mammal species in the study area.

African Elephant (*Loxodonta africana*)

Cape Buffalo (*Syncerus caffernanus*)

Jackson's Hartebeest (*Alcelaphus buselaphus*)

Appendix 3: Questionnaire

My name is **Hindrah Akisiimire**; as one of the partial requirements for the Degree of Masters of Science in Conservation and Natural Resources Management of Kyambogo University; I will be conducting a study titled "**The Effects of oil and gas exploration on mammals and their habitats in Murchison Falls National Park"**. You are kindly requested to fill the questionnaire, a tool to help the researcher collect data. The information that will be obtained is strictly for research purposes and will be treated with confidentiality.

SECTION A: RESPONDENTS DETAILS

Name: ___________________________________ Age: _____________ Gender (√): M/ F

Mobile Number: ____________________________ Education: ________________________

Name of Organization: ____

SECTION B: OIL AND GAS OPERATIONS

1. In your view, do you think the ongoing oil operations in the park are meeting the respective regulatory compliance standards? (a) Yes (b) No
2. If no, in what ways are they not meeting the respective compliance standards?

   ____

   ____

   ____

3. Oil operations are adversely affecting animals? (a)Yes (b) No
4. If yes, explain in which ways are animals affected?

   ____

   ____

   ____

5. Is there an observed effect of facility construction, site preparation/ excavation/ ground breaking and or demolition on animals? (a) Yes (b) No

6. If yes, what have you observed?

____

____

____

7. Animals are sensitive to construction, installation, and/or demolition activities. i.e. roads, utilities system right-of-ways, parking lots, buildings, laboratories, storage tanks, fueling facilities, pipelines, or other structures. (a) Yes (b) No

8. What is your perception about oil mining in protected areas? (a)It is a bad idea (b)The national park is at risk of losing its biodiversity (c) Under proper care, it is a good idea

9. Do you think animal abundance, population density, species presence or absence, or species richness can be affected by anthropogenic factors in the protected areas? (*a)yes (b) No*

SECTION C: RESTORATION

10. Is it possible to restore large mammal habitats after oil and gas production? (a) Yes (b)No

11. How will the restoration be accomplished?

____

____

12. How do you know the restoration project will work**?**

____

____

13. Will restoration, creation, or enhancement at these affected sites compensate for loss of functions and values of another site? (a) Yes (b) No

14. How long will it take for a restored or recreated system to approximate the original system?

____

15. What techniques are needed/available to restore, create, or enhance large mammal habitats?

(a) Filling drainage ditches (b) Excavating fill (c) Restoring buffers (d) Replanting of Vegetation (e) Others Specify ___________________________________

16. What do you think are the major issues that should be considered as part of the conservation of the large mammals and their habitats during oil and gas operations?

____

____

____

____

____

____

Thank you for participating in this survey.

Appendix 4: Informed Consent Form

Title of Study: **The effects of oil and gas exploration on mammals and their habitats in Murchison Falls National Park, Uganda**

Investigators:

1. **Name:** Dr. Charles Twesigye (Associate Professor)

   Address: Department of Biological Sciences.

   Kyambogo University, P. O Box 1, Kampala.

   Tel; +256-782-353.

   email; twesigyeck@yahoo.com

2. **Name:** Dr. William Tinzaara

   Address: Department of Biological Sciences.

   Kyambogo University, P. O Box 1, Kampala.

   Tel; +256-782-353.

   email; w.tinzaara@cgiar.org

Introduction

- You are being asked to be in a research study of "The effects of oil and gas exploration on mammals and their habitats in Murchison Falls National Park".
- You were selected as a possible participant because of your expertise in the field of oil and gas industry as well as conservation of the environment.
- We ask that you read this form and ask any questions that you may have before agreeing to be in the study.

Purpose of Study

Ultimately, this research may be will be submitted to the Department of Biological Sciences Kyambogo University as one of the partial requirements for the degree of Masters of science in Conservation and Natural Resources Management.

Description of the Study Procedures

If you agree to be in this study, you will be asked to answer some questions relevant to the oil and gas operations in the protected area of the Murchison Falls National Park.

Risks/Discomforts of Being in this Study

The study has risks of exposing confidential information about the oil companies operating in the National park of Murchison falls and also discovery of non-compliance with standard rules of conservation of the parks' biodiversity.

Confidentiality

The records of this study will be kept strictly confidential. Research records will be kept in a locked file and all electronic information will be coded and secured using a password protected file. We will not include any information in any report we may publish that would make it possible to identify you.

Payments

There will be no payments for your participation in the study.

Right to Refuse or Withdraw

The decision to participate in this study is entirely up to you. You may refuse to take part in the study at any time without affecting your relationship with the investigators of this study or the researcher and Kyambogo University. You have the right not to answer any single question, as well as to withdraw completely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material.

Right to Ask Questions and Report Concerns

You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. If you have any further questions about the study, at any time feel free to contact me, Hindrah Akisiimire at 1992hindrah@gmail.com or by telephone at +256-704-667-550/+256-774-677-924. If you like, a summary of the results of the study will be sent to you. If you have any other concerns about your rights as a research participant that has not been answered by the investigators, you may contact Dr. Nora Mutekanga the Head of Department Biological Science Kyambogo by email noramutekanga@gmail.com.

Consent

Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigators.

Name: ……………….....................Signature of participant: ……………………Age.………….

Date (DD/MM/YY): ……………………………

Name: ………………………………… Signature of Interviewer: ………………………….

Date (DD/MM/YY): ………………………...