

**ABUNDANCE AND DISTRIBUTION OF WILD ANIMALS AROUND OIL AND
GAS FACILITIES AND INFRASTRUCTURE IN MURCHISON FALLS
NATIONAL PARK, UGANDA**

BY

NAHABWE ENOS

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DECLARATION

I **Enos Nahebwa**, declare that this dissertation is my original work and has never been presented for a degree in any other University or Institution of Higher learning before.

Signature:  _____ Date: **December 29, 2025**

APPROVAL

This dissertation has been submitted to Makerere University, Directorate of Research and Graduate training under the guidance and supervision of;

Professor Michael Ocaido

Department of Wildlife and Aquatic Resources,
School of Veterinary Medicine and Animal Resources,
College of Veterinary Medicine Animal Resources and Biosecurity,
Makerere University, P. O Box 7062, Kampala.

Signature: _____

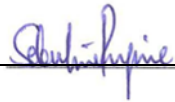


Date: **December 29, 2025**

Dr. Sebulime Peregrine

Department of Wildlife and Aquatic Resources,
School of Veterinary Medicine and Animal Resources,
College of Veterinary Medicine Animal Resources and Biosecurity,
Makerere University, P. O Box 7062, Kampala.

Signature: _____



Date: **December 29, 2025**

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TABLE OF CONTENTS

DECLARATION.....	i
APPROVAL	ii
ACKNOWLEDGEMENTS.....	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	ix
LIST OF FIGURES	xii
LIST OF ACRONYMS AND DEFINITIONS	xiv
ABSTRACT.....	xv
CHAPTER ONE	1
INTRODUCTION.....	1
1.1 Background of study	1
1.2 Problem statement of the study	2
1.3 Objectives of the study	2
1.3.1 General Objective.....	2
1.3.2 Specific Objectives.....	2
1.4 Research questions	3
1.5 Significance of the study	3
1.6 Justification of study	3
1.7 Conceptual frame work	3
CHAPTER TWO	6

LITERATURE REVIEW	6
2.1 Overview of the study: Potential impact of oil and gas exploration and exploitation in MFNP.....	6
2.2 Oil and gas development in conservation/protected areas	8
2.3 Access roads development in exploration and exploitation of oil and gas	9
2.4 Pipeline development in exploration and exploitation of oil and gas industry	9
2.5 Well pads and drilling sites during exploration and exploitation of oil and gas industry.....	11
2.6 Social perception of oil and gas facilities.....	12
2.7 Wildlife Monitoring and Assessment: Use of camera traps for estimating and management of wildlife populations	13
CHAPTER THREE	15
MATERIALS AND METHODS	15
3.1 Description of the study area.....	15
3.2 Study design	16
3.3 Determination of wild animals' abundance, distribution and behaviour	17
3.3.1 Wild animal transect counts at access road and pipeline sites	17
3.4 Wild animal transect counts at oil well pads and the Horizontal Directional Drilling (HDD) sites	18
3.4 Status of the facilities and infrastructure during the study period.....	19
3.4.1 JBR 05.....	19
3.4.2 JBR 04.....	19
3.4.3 JBR 03.....	20

3.4.4 JBR 02.....	20
3.4.5 JBR 09.....	20
3.4.6 JBR 08.....	21
3.4.7 JBR 06.....	21
3.4.8 JBR 10.....	22
3.4.9 Horizontal Directional Drilling (HDD) and Stringing Area.....	22
3.5 Vegetation cover variations at the oil and gas infrastructure and facilities.....	23
3.5.1 Vegetation cover variations at JBR8, JBR6, JBR5 and Victoria track vegetation cover	23
3.5.2 Vegetation cover variations at JBR9, project access road and Albert Track	24
3.5.3 Vegetation cover variations at HDD, JBR2, JBR10 and Stringing Area	24
3.5.4 Vegetation Cover Variations at JBR4, JBR3 and New Buligi Track.....	24
3.4 Camera trap surveys	25
3.5 Data analysis	26
3.5.1 Determination of wild animal population density at road counts and around the well pads	26
CHAPTER FOUR.....	28
RESULTS	28
4.1 Dynamics of activities across oil and gas facilities and infrastructure in MFNP.....	28
4.1.1 Weather patterns from November 2024 to April 2025.	29
4.2 Dynamics of wild animal species population densities and behaviour across oil and gas facilities and infrastructure	29

4.2.1 Dynamics of elephant population densities and behaviour at various oil and gas infrastructures and facilities in MFNP	29
4.2.2 Dynamics of giraffe population densities and behaviour across oil and gas infrastructures and facilities and tourist tracks in MFNP.....	31
4.2.3 Dynamics of buffalo population densities and behaviour at various oil and gas infrastructures and facilities and tourist tracks in MFNP	33
4.2.4 Dynamics of Uganda kob population densities and behaviour across oil and gas facilities and infrastructure and tourist tracks in MFNP.....	34
4.2.5 Dynamics of Jackson’s hartebeest population densities and behaviour across oil and gas facilities and infrastructure in MFNP	36
4.2.6 Dynamics of oribi population densities at various oil and gas infrastructures and facilities and tourist tracks in MFNP	38
4.2.6 Dynamics of baboon populations and behaviour at various oil and gas infrastructures and facilities and tourist sites in MFNP.....	40
4.2.7 Dynamics of warthog population density and behaviour at various oil and gas infrastructures and facilities in MFNP	41
4.2.8 Dynamics of waterbuck population densities and behaviour at various oil and gas infrastructures and facilities and tourist tracks in MFNP.....	42
4.2.9 Dynamics of patas monkey population densities and behaviour at various oil and gas infrastructures and facilities in MFNP.....	44
4.2.10 Dynamics of carnivore population densities and behaviour at various oil and gas infrastructures and facilities in MFNP	45
4.3 Effect of Light to mammal species.....	46
4.4 Dynamics of bird Species at the Ramsar Site Wetland.....	47
4.5 Camera Trap Survey.....	49

4.5.1 The mammal species captured by camera trap at night at JBR8.....	49
4.5.2 The mammal species captured by camera trap at night at HDD.....	50
4.5.3 The mammal species captured by camera trap at night at JBR10.....	50
4.5.4 The mammal species captured by camera trap at night at JBR2.....	51
4.5.5 The mammal species captured by camera trap at night at JBR3.....	52
4.5.6 The mammal species captured by camera trap at night at JBR4.....	53
4.5.10 The mammal species captured by camera trap at night at the stringing area.....	56
CHAPTER FIVE	58
DISCUSSION	58
CHAPTER SIX	67
CONCLUSION AND RECOMMENDATIONS	67
6.1 Conclusion.....	67
6.2 Recommendations	68
REFERENCES.....	69
APPENDICES	76
Appendix I: UWA Approval	76
Appendix II: Data collection Form	77
Appendix III: Camera trap photos of animal Species at the Sites in the study Area	78
Appendix IV: Species occurrences and behaviour across sites.....	82
Appendix V: Species Occurrences across Sites	83

LIST OF TABLES

Table 1: Variation of elephant population densities across oil and gas facilities and infrastructure and control tracks in MFNP.....	31
Table 2: The mean monthly counts / Km ² of elephants at different sites in MFNP at the Tilenga project area.....	31
Table 3: Variation of giraffe population density across oil and gas facilities and infrastructure and control tracks in MFNP.....	32
Table 4: The mean monthly counts / Km ² of giraffes at different sites in MFNP at the Tilenga project area and tourist tracks.	32
Table 5: Variation of buffalo population density across oil and gas facilities and infrastructure and tourist control tracks in MFNP	34
Table 6: The mean monthly counts / Km ² of buffalo at different sites in MFNP at the Tilenga project area and tourist tracks.	34
Table 7: Variation of Uganda kob population density across oil and gas facilities and infrastructure and control tracks in MFNP.....	35
Table 8: The mean monthly counts / Km ² of Uganda kobs at different sites in MFNP at the Tilenga project area and control sites.....	36
Table 9: Variation of Jackson’s hartebeest population density across oil and gas facilities and infrastructure and control tracks in MFNP.....	37
Table 10: The mean monthly counts / Km ² of Jackson’s hartebeest at different sites in MFNP at the Tilenga project area and tourist tracks.....	38
Table 11: Variation of oribi population densities across oil and gas facilities and infrastructure and tourist tracks in MFNP.....	39
Table 12: The mean monthly counts / Km ² of oribi at different sites in MFNP at the Tilenga project area and the tourist tracks.....	39

Table 13: Variation of baboon population density across oil and gas facilities and infrastructure and tourist tracks in MFNP.....	40
Table 14: The mean monthly counts / Km ² of baboons at different sites in MFNP at the Tilenga project area and the tourist tracks.	41
Table 15: Variation of warthog population density across oil and gas facilities and infrastructure and tourist tracks in MFNP.....	42
Table 16: The mean monthly counts / Km ² of warthog at different sites in MFNP at the TILENGA project area and tourist tracks.	42
Table 17: Variation of waterbuck population densities across oil and gas facilities and infrastructure and tourist sites in MFNP	43
Table 18: The mean monthly counts / Km ² of waterbuck at different sites in MFNP at the Tilenga project area and tourist tracks	44
Table 19: Variation of patas monkey population density across oil and gas facilities and infrastructure and control tracks in MFNP.....	44
Table 20: The mean monthly counts / Km ² of patas monkey at different sites in MFNP at the Tilenga project area and tourist tracks	45
Table 21: Variation of bird species population density at the HDD (Ramsar site wetland)	47
Table 22: The mean monthly counts / Km ² of Birds at the Ramsar site wetland in the Tilenga project area MFNP	48
Table 23: Estimated number of mammal species population across the Tilenga project area	48
Table 24: The mammal species captured by camera trap at night at JBR8.....	49
Table 25: The mammal species captured by camera trap at night at HDD.....	50
Table 26: The mammal species captured by camera trap at night at JBR10	51

Table 27: The mammal species captured by camera trap at night at JBR2.....	52
Table 28: The mammal species captured by camera trap at night at JBR3.....	52
Table 29: The mammal species captured by camera trap at night at JBR4.....	53
Table 30: The mammal species captured by camera trap at night at JBR5.....	54
Table 31: The mammal species captured by camera trap at night at JBR5.....	55
Table 32: The mammal species captured by camera trap at night at JBR9.....	56
Table 33: The mammal species captured by camera trap at night at the stringing area.....	56

LIST OF FIGURES

Figure 1: Conceptual framework.....	5
Figure 2: A map of the planned Tilenga development and the East African Crude Oil Pipeline.....	15
Figure 3: Map of the study area (Tilenga Footprint Area) showing study sites.....	16
Figure 4: Status of JBR5	19
Figure 5: Activity variation at JBR4- Drilling, rig demobilization and post drilling activities e.g., site cleaning at JBR4	19
Figure 6: Well pad preparation at JR3.....	20
Figure 7: Drilling at JBR2	20
Figure 8: Variation of activities at JBR9 (well pad preparation and rig setup).....	21
Figure 9: Site preparation for drilling at JBR8.....	21
Figure 10: Site preparation for drilling and soil ban at JBR6.....	22
Figure 11: Site preparation for drilling at JBR10.....	22
Figure 12: Pipes at the HDD pulled below the Nile River Bed	23
Figure 13: Vegetation Cover variations at JBR8, JBR6, JBR5 and Victoria track vegetation cover.....	23
Figure 14: Vegetation cover variations at JBR9, project access road and Albert Track....	24
Figure 15: Vegetation cover variations at HDD, JBR2, JBR10, and Stringing Area.....	24
Figure 16: Vegetation Cover Variations at JBR4, JBR3 and New Buligi Track	25
Figure 17: Bushnell Camera Trap mounted at the periphery-fence of Well pad	26
Figure 18: Variation of activities across oil and gas facilities and infrastructure during the study period.....	28

Figure 19: Variation of the activities at the project road.....	29
Figure 20: Fence broken by elephants at JBR4.....	30
Figure 21: Buffaloes at the stagnant water point along project access road.	33
Figure 22: Uganda kobs feeding on the fresh grass in the pipeline area along Project access road.....	35
Figure 23: Jackson’s hartebeest nursing/breastfeeding in the pipeline area along the project road.....	37
Figure 24: Oribi leaking along project access road.....	38
Figure 25: Warthog feeding at the pipeline area along project access road and Leaking the aggregate road material at JBR3	41
Figure 26: Waterbuck mating behaviour along the Stringing area.....	43
Figure 27: Lion crossing the swamp at JBR10	45
Figure 28: A herd of Buffalos at JBR4 captured during the post drilling activities phase	46
Figure 29: Camera trap photos of Jackson’s Hartebeests, Waterbucks and Oribis	46
Figure 30: Hyena and Leopard at JBR2 captured by camera traps	47
Figure 31: Camera trap photo of lion at JBR5	49

LIST OF ACRONYMS AND DEFINITIONS

AFIEGO	Africa Institute for Energy Governance.
E& P	Exploration and Production
ESIA	Environmental Social Impact Assessment
GHG	Greenhouse Gases
GPS	Geographical Position System
HDD	Horizontal Directional Drilling
IPCC	Intergovernmental Panel on Climate Change CSCO Civil Society Coalition on oil and Gas.
MFCA	Murchison Falls Conservation Area.
MFNP	Murchison Falls National Park.
PAR	Project Access Road
SA	Stringing Area
Tr_A	Albert Track
Tr_B	New Buligi Track
Tr_V	Victoria Track
WCS	Wildlife Conservation Society UWA Uganda Wildlife Authority.

ABSTRACT

Oil and gas resources exploitation is being done by Total E & P in Murchison Falls National Park (MFNP). A study was carried out to determine the dynamics of wild animal interactions with oil and gas facilities and infrastructure with the aim of understanding how wild animals interact with and are affected by the facilities and infrastructure at different stages of development. The specific objectives of the study were: to determine the abundance, distribution, behaviour and ecology of wild animals around oil and gas facilities and infrastructures. The study was conducted at fourteen sites, eleven of which represented oil and gas facilities and infrastructures whereas the other three were tourist tracks. The vegetation characteristics differed remarkably across the study sites. The study involved field physical observations, use of camera traps and direct animal counts. Animal counts were done by use of transects with a width of 400 meters for large animals such as elephants, buffalos and giraffes; 200 meters for medium sized animals such as waterbuck, bushbuck, Uganda kob and 100 meters for small sized wild animals such as oribi, baboons, patas monkeys and birds. A pair of binoculars and field book guides and keys aided in animal identification. Animal behaviour was observed and recorded on designed data sheets. The well pads JBR 9 and 4 were natural favoured habitats for elephants; JBR2 was occasionally visited. Elephants were significantly more at JBR 4 than project access road ($p=0.03$, $t=2.47$) during the study period. Elephants, left JBR9 in March when drilling started. Elephants tolerated well pad preparation activities. Giraffes appeared in JBR 9; and occurred in JBR 8, 5 and 3 (their most favoured habitats only when pad site preparations were done in November during late rainy season and disappeared till April- during the early rainy season when forage was recovering. This finding suggested that there was seasonal giraffe migration dictated by seasonal nutritional feed abundance. There were significantly more giraffe populations seen in Victoria track than project access road ($p=0.04$, $t=2.25$). Buffalo were found in their favoured habitats JBR 8 site which was under preparatory phase, JBR5 which was already drilled and Victoria tourist track. Their population was more in Victoria tourist track than project access road ($P=0.02$, $t=2.86$). Currently buffaloes were not affected by Tilenga project activities. Population of Uganda kobs were more in their most favored habitats of JBR 8, 5 and Victoria track. The Uganda kobs were not currently being affected by project activities. Few Uganda kobs were seen at project access road than in Victoria track ($p=0.03$, $t=2.39$) and JBR5 ($p=0.04$, $t=2.22$). There was a significant difference of mean Jackson's hartebeest abundance

between project road and Victoria track ($p=0.03$, $t=2.54$), stringing area ($p=0.02$, $t=2.78$), and JBR9 ($p=0.03$, $t=2.46$). JBR8 was natural habitat for hartebeest which had undergone preparatory phase. Although JBR 5 was supposed to be a favored habitat, they were only seen during in November when feed nutrients were available but disappeared when they got exhausted. This implied that hartebeest fled to a refugee habitat when feed resources got exhausted. More hartebeest populations were found in the newly constructed access project road than Victoria track ($p=0.03$, $t=2.54$), stringing area ($p=0.02$, $t=2.78$) and JBR9 ($p=0.03$, $t=2.46$). The project road provided lush pasture and easy predator visibility detection. Overall, there was a significant difference of variation of oribi populations across sites at MFNP ($p=0.03$, df 10,55, $F=2.18$). Oribis were more abundant in the project access road than other tourists tracks (Albert track ($p=0.004$, $t=4.18$ and New Buligi Track ($p=0.01$, $t=3.22$); and JBR8 ($p=0.05$, $t=1.92$), and JBR2 ($p=0.001$, $t=5.38$). There significantly less oribi populations seen in JBR 9 and JBR 2 when drilling activities were being carried out. This implied that they moved out of these sites. There was no significant variations of baboons populations across sites at MFNP ($p=0.2$, df 9,50, $F=1.46$). However less significant populations of baboon populations were seen in JBR9, 10 and JBR 2.

There was significant difference of mean abundance of warthog between project access road and the other tourist tracks (New Buligi Track ($p=0.006$, $t= 3.71$); Albert track ($p=0.04$, $t=2.24$) and Victoria track ($p=0.003$, $t=4.52$)); and Stringing Area ($p=0.004$, $t=4.19$). The project access road provided habitat for wallowing and gravel stone salt leaking sites. There were more waterbucks at JBR 9 near the water sources in November and December during late rainy season and thereafter disappeared. There were less waterbucks seen at the project road than New Buligi Track ($p=0.004$, $t=4.19$) and Albert track ($p=0.004$, $t=4.36$). There were significantly more patas monkeys seen in Albert track than the project road ($p=0.04$, $t=2.12$). There was substantial number of aquatic fowl (Egyptian geese (7.7 ± 2.8); grey crowned crane (4.7 ± 3.1); herons (2.6 ± 2.4) and ibis (1.7 ± 1.2) to sustain water game fowl viewing at the designated Ramsar site wetland with the oil and gas facilities and infrastructure. Carnivores mainly lions, hyenas and leopards were not easily seen during day time at oil and gas facilities but were captured at night by camera traps.

Generally, there was significant difference of species across sites ($p= 0.002$. $F= 2.67$) however, more wild animal species were sighted along Victoria track than JBR3 ($p=0.04$), JBR4 ($P=0.02$), JBR6 (0.03), Project access road ($p=0.03$), JBR9 ($P=0.02$), JBR8 ($p= 0.01$)

Overall, with the exception of the drilling activity, there were no apparent negative effects of oil and gas facilities and infrastructures on wild mammal species during the study period.

CHAPTER ONE

INTRODUCTION

1.1 Background of study

Government of Uganda is exploiting oil and gas resources in the Albertine Graben in which lies Murchison Falls National Park (MFNP), the largest National Park in Uganda known for its diverse wildlife and natural beauty (Ssekatawa, 2024). The Albertine Graben contains seven of Uganda's protected areas and a growing ecotourism industry (MacKenzie *et al.*, 2017).

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. (Uganda Wildlife Act, 2019). The project includes the development of a central processing facility (CPF) with capacity to process 190,000 barrels of oil and 700,000 barrels of total liquids. It involves drilling of 200 water-injector wells, 196 oil-producer wells, 2 polymer pilot wells and 28 reference wells. Over 160 km of flowlines to transport crude oil and water from the wells to the CPF (Wright, 2022) will be built.

The estimated discovered oil resources in the country have increased from 300 million barrels in 2006 to 2 billion and 3.5 billion barrels in 2010 and 2012 respectively. As of May 2019, the discovered oil resources in the country were estimated at 6.0 billion barrels with about 1.4 billion barrels recoverable. The area explored presently represents less than 40% of the total area with the potential for petroleum production in the Albertine Graben. There is therefore high potential for more petroleum resources to be discovered (Kgosana *et al.*, 2014).

The Tilenga project footprint area is a fragile and sensitive ecosystem which needs to be protected from negative effects associated with oil and gas exploitation. Several studies have showed that the facilities and infrastructures cause disturbance to wild animals; alter or make loss of their natural habitats. This will lead to reduction of wild animal populations by causing migrations, increased mortalities and also change their behavior which can bring about reproductive failures. (Ugochukwu and Ertel 2008, Plumptre *et al.*, 2015 and Ayebare 2011).

It was against this background that this study was designed to determine the dynamics of wild animal interacting with oils and gas facilities and infrastructure associated mostly with the development phase of this project in MFNP.

1.2 Problem statement of the study

Oil and natural gas developments in the Albertine rift, one of Africa's biodiversity hotspots, have raised concerns about the potential impacts to wildlife populations and the associated land-cover change (Ayebare *et al.*, 2011),

Usually, activities carried out by resource extraction industries in and adjacent to protected areas have caused disruption of normal activities of wild animals, destroyed their habitats, disrupted migratory routes, breeding areas and refuge critical habitats in many parts of the world (Dyer *et al.*, 2001, Uganda National Academy of Sciences, 2003, Johnson *et al.*, 2005, Sawyer *et al.*, 2009). The formation of social structures of large mammals which can be categorized into families, herds, packs, prides and as solitary animals can be interfered with. The home ranges of large mammals may be affected due to interfered habitat avoidance behaviour leading to poor productivity and reproductivity performance (Johnson *et al.*, 2005). However, the impact of the development of oil and gas infrastructures and facilities on distribution, abundance, ecology and behaviour of wild animals in MFNP has not been adequately assessed.

1.3 Objectives of the study

1.3.1 General Objective

The general objective of this study was to determine the dynamics of wild animal interactions with oil and gas facilities and infrastructure in Murchison Falls National Park, Uganda

1.3.2 Specific Objectives.

- i) To determine the abundance and distribution of wild animals at oil and gas facilities and infrastructures.
- ii) To document the ecological behaviour of wild animals at oil and gas facilities and infrastructures.

1.4 Research questions

1. What is the abundance and distribution of wild animals around oil and gas facilities and infrastructures?
2. What is the ecological behaviour of wild animals around oil and gas facilities and infrastructures?
3. What effects do activities at oil and gas facilities and infrastructures have to wild animals interacting with them?

1.5 Significance of the study

The outputs of this study will be used for designing new mitigation measures or implementation of mitigation measures that had already been identified in Environmental Social Impact Assessment (ESIA) when the Tilenga project was approved for implementation.

1.6 Justification of study

The outputs of this study would be used for designing mitigation measures to overcome negative effects associated with wild animal interactions with oil and gas facilities and infra-structures. It would also help in implementation of mitigation measures that had already been identified in Environmental and Social Impact Statement when the Tilenga project was approved for implementation. (Tilenga ESIA 2018). Ongoing oil exploration and extraction activities necessitate the need for careful management to balance economic development with the conservation of this critical ecosystem.

1.7 Conceptual frame work

Oil and gas exploration activities include; infrastructure development for example roads, oil and gas pipelines, well pads and human settlement camps resulting into habitat loss/ habitat destruction as a result of for example increased human presence, light, machinery and noise pollution.

This leads to wildlife behavioral change for example avoidance, habituation, tolerance and aggressive behaviour, physiological changes such as stress, reduction of population abundance and distribution as a result of habitat fragmentation/destruction and food

availability, increase in human wildlife conflicts such as human-wildlife injury and death. Details of the conceptual framework would be as shown in Figure 1.

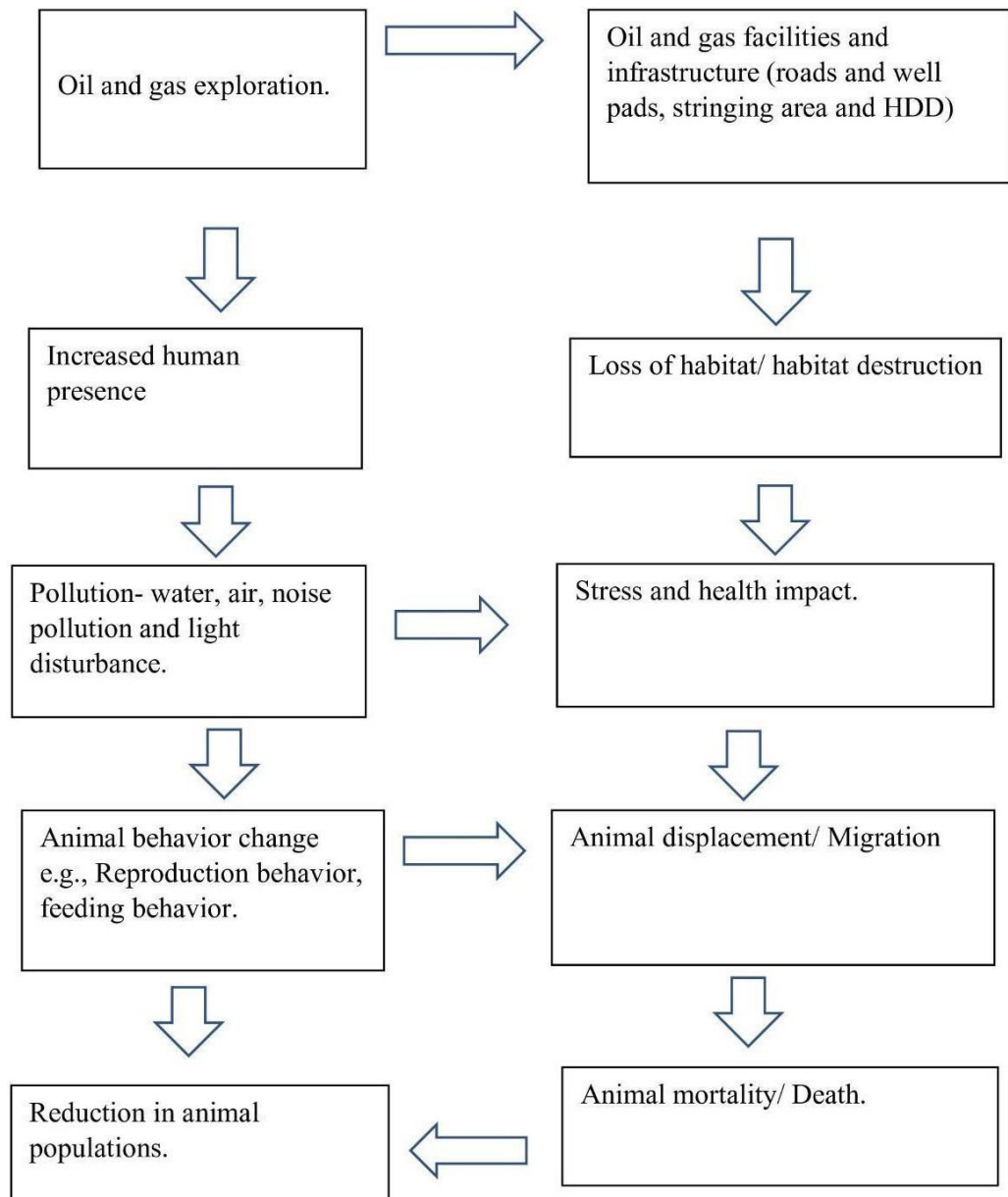


Figure 1: Conceptual framework

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of the study: Potential impact of oil and gas exploration and exploitation in MFNP

The Wildlife Policy (2014) recognizes that wildlife is a key socio-economic resource for Uganda, and outlines the status and threats to wildlife in Uganda. (Tilenga Project ESIA 2018). Murchison Falls National Park (MFNP) where petroleum has been discovered overlap with wildlife and nature conservation with high biodiversity and sensitive ecosystems (Kityo 2011). Oil development destroy mammal habitats, disrupt animal abundance and people's lives if not well planned. Potential impacts due to increased human presence and traffic would include; increased incidents of road kills, oil spills which result in an ecological disaster, destroying wildlife and their habitats (Kityo 2011).

The MFNP has a high biological diversity value and it is a tourist hotspot in Uganda. In 2023, the park received 141,335 visitors (MTWA, 2024), which was 36.4% of total tourists that visited Uganda's ten national parks. Further, in 2022, this increased to 39.8% of the total tourists that visited Uganda's national parks (MTWA, 2024).

MFNP is inhabited by 144 species of mammals, 451 birds, 51 reptile species, 28 known amphibians' species and 755 plant species (Plumptre *et al.*, 2015). The large mammals found in the park are buffaloes (*Syncerus caffer*), giraffes (*Giraffa cameopardalis*), bush duiker (*Sylvicapra grimmia*), African civet (*Civettictis civetta*), patas monkey (*Erythrocebus patas*), Savanna baboon (*Papio cynocephalus*) Uganda kob (*Kobus kob*), elephants (*Loxodonta africana*), waterbuck (*Kobus ellisiprymns*), warthog (*Phacochoerus aethiopicus*), bush buck (*Tragelephus scriptus*), hartebeest (*Alcelaphus buselaphus*), reed buck (*Redunca redunca*), lions (*Panthera leo*), leopards (*Panthera pardus*), oribi (*Ourebia ourebi*), spotted hyena (*Crocuta crocuta*) and jackals (*Canus adustus*). There are resident crocodiles and hippotamus. Also, there are migratory bird species which visit the park usually nesting in the riverine sites (Plumptre *et al.*, 2015).

Oil and gas activities can impact the environment from several angles. They may affect human beings, wildlife and biodiversity, together with the associated tourism activities Transboundary water resources and the economy of the Albertine Graben ecosystem may

also be affected. Furthermore, the corridor in which oil pipelines or other transport systems will pass will also be affected (National Oil and Gas Policy for Uganda, 2008).

Oil extraction has been shown to put biodiversity conservation at risk, as shown in the Niger Delta, Nigeria, here oil spills and gas flaring have destroyed biodiversity, mangrove forests, contaminated beaches, killing water birds, endangered fish hatcheries and disrupted food webs for various animals (Ugochukwu and Ertel, 2008).

The effects of oil and gas associated industries on wildlife have raised concerns about their potential impacts on wildlife populations and the associated land-cover changes (Ayebare *et al.*, 2011). These involve disruption of individual animal activities, wild animal habitat disturbance, wild animal habitat avoidance and mortality of wild animals. Wild animal habitat avoidance behavior has been recorded amongst elephants, hartebeests, buffalo and giraffe. (Ayebare *et al.*, 2011). The magnitude of observed impact varied from species to species (Jalkotzy *et al.*, 1997). In Alaska, the caribou have been found to get tolerant and habituated with oil and gas field infrastructure and facilities (Haskell *et al.*, 2006).

Oil exploitation in MFNP Albertine graben is expected to last for over 20 years (Shepherd 2013). This will cause great impacts on wildlife. Oil wells in MFCAs are located at biodiversity hot spots and forests (Tamale *et al.*, 2023). It is habitat of big five listed as endangered species which includes elephants and the lions (IUCN red list, 2018). Oil exploration involves construction of facilities such as access roads, oil well pads and pipelines. These facilities can cause negative impacts on the environment for example accidents can occur at pipelines leading to oil spills contaminating soil and water (Tamale *et al.*, 2023).

The exploitation of oil is expected to cause increase in human population which will affect MFNP ecosystem. The rich biodiversity of the Albertine Graben is maintained and supported by an interconnected system of savanna, forest and woodland habitats. Increase of human population caused by development of oil projects such as Tilenga will lead to overexploitation of natural resources hence causing changes in land use leading to natural vegetation land cover degradation (Tilenga EISA, 2018).

Machinery used in seismic activities may kill or disrupt movement of wild animals. Increased vehicle numbers and reckless driving may lead to increase in road-kills and stress of wildlife. Cleared open space for road and construction of support infrastructure

for oil and gas exploration and exploitation will form a barrier for some of the mammals and birds access resources on the opposite side of the open space “Edge effects”.

Construction and operation of the oil and gas pipelines cause loss of biodiversity along the route causing a threat to wildlife habitats and corridors, (Ndenecho and Banyuy (2009).

2.2 Oil and gas development in conservation/protected areas

Oil and gas exploration infrastructure development cause air and water pollution, greenhouse gas emissions, land contamination, over-extraction of resources, labor abuses and social disruption. These impacts, in turn, contribute to climate change, environmental degradation and deterioration (Fischedick *et al.*, 2014).

Emissions from the facilities contribute to the climate crisis and pose significant health risks to surrounding communities and wildlife. Emissions from oil and gas related industrial infrastructures and facilities contribute to global Green House Gas (GHG) emissions which cause global warming (IPCC 2019). In addition, these facilities and infrastructures emit fine dust, heavy metals, volatile organic compounds and polycyclic aromatic hydrocarbons (Fischedick *et al.*, 2014).

Infrastructure development includes construction of access roads and support camps providing workforce accommodations, canteen facilities, communications, waste treatment and disposal sites, vehicle maintenance, parking areas, a fence and sometimes a helipad for accessing remote areas. Sometimes, oil well sites may have oil processing facilities, offices and workshops which require occupation of several hectares of land (AFIEGO, 2024).

Satellite imagery done in 2024 inside MFNP showed rapid development of the ten well pads and clearing for roads as well as the pipeline network and access points for the Victoria Nile pipeline crossing (AFIEGO, 2024). The development oil infrastructure and facilities bring in increased human population in MFNP (AFIEGO) 2024). The presence of human beings has been shown to lead to habitat avoidance by wildlife, especially larger mammalian predators to these areas (Nickel et al, 2020).

2.3 Access roads development in exploration and exploitation of oil and gas

Part of the infrastructure development by oil and gas industries is construction of access roads to reach areas with oil and gas deposits and also assist in setting up machinery used in oil drilling and for other associated operations. The main concern among conservationists and environmental planners is that roads and traffic may reduce or even eliminate wildlife populations at these sites (Trombulak and Frissell, 2000). Increased frequency with which animals enter the road may increase their road kills (Forman *et al.*, 2003). for example, Sabrina (2020) reported 24 wild animal skills including two chimpanzees along Sebitoli road in Kibale National Park, Uganda.

The effects of road construction on ecosystems in sub-Saharan Africa influence land use patterns, increase human wildlife conflicts, cause land degradation and the spread of invasive plant species (Perumal *et al.*, 2021). Roads cause land fragmentation. Roads act as barriers to foraging and corridors for wild animal movement, cause habitat avoidance and others attract wild animals (Sabrina *et al.*, 2020 and Perumal *et al.*, 2021). Roads increases human access for illegal hunting and harvesting of wild animals in protected areas

Studies quantifying responses of wildlife behavior to industrial disturbances have shown that activities carried out at the different phases of oil and gas exploration, and production have resulted into direct loss of wildlife, their habitats, as well as reduction in habitat use following avoidance behavior (Theobald *et al.*, 1997, Wilkie *et al.*, 2000, Dyer *et al.*, 2001, Sawyer *et al.*, 2009, Rabanal *et al.*, 2010).

2.4 Pipeline development in exploration and exploitation of oil and gas industry

Total Energies is developing a pipeline called the Victoria Nile Crossing. The pipeline has a length of approximately 1,760 M that will be constructed through wetlands associated with the Victoria Nile. The Victoria Nile Crossing, which will include three horizontal directional drilling (HDD) pipelines for transporting oil extracted from MFNP to a central processing facility in Buliisa district where the impurities in oil will be cleaned. Oil production, water injection and electrical pipelines is expected to have a footprint of 28 hectares (Total Energies, 2019).

The Eastern Africa region is rife with oil and gas resources and new discoveries continue to be documented and reported across the region. Several oil and gas development infrastructure projects are being planned across the region with significant potential to transform the region's landscape and biological diversity. Of major concern to conservation organizations operating in the region are the potential negative ecological impacts these oil and gas development are likely to have on the region's landscapes, most of which are high value conservation areas with rich and unique biodiversity. One such proposed infrastructure development is the 1,445km long Hoima-Tanga pipeline that is being proposed to transport crude oil from the oil fields in Hoima, Western Uganda to the Coastal Town of Tanga in Tanzania (WWF 2017).

Wildlife corridors are important for the maintenance of ecological processes including allowing for the movement of animals and the maintenance of viable populations. The preliminary assessment showed that the EACOP will traverse a number of wildlife corridors hence interfering with animal movements and behavior, especially during the construction phase of the pipeline infrastructure development (WWF and CSCO, 2017).

According to Heeded (2022) the Climate Accountability Institute has reported that EACOP is expected to emit 379 million tons of CO₂ during 25 years of operation, hence making a significant global impact on global warming.

In addition, the construction and operation of the pipelines leads to opening of previously inaccessible areas, temporary or permanent establishment of infrastructure such as roads, monitoring posts and settlements that could lead to fragmentation of these important habitats.

Petroleum activities are known to have a high footprint due to the many activities and infrastructural developments associated with the industry. For instance, seismic lines, a feature expected to be of temporary nature, sometimes persist for years because communities or other people carrying out activities in the protected area keep using them (WWF and CSCO, 2017). WWF and CSCO (2017) and Agbagwa *et al.*, (2014) highlighted that oil and gas pipeline construction in the Niger Delta resulted into loss of biodiversity due to habitat displacement, forest fragmentation and deforestation, and escalated exploitation of plant species.

Ndenecho and Banyuy (2009) observed that a previous oil pipeline of similar magnitude to that of EACOP, is the 1070km Chad-Cameroon oil pipeline demonstrated that damaged 68% of wildlife habitats and more significantly led to loss of 71% of biological diversity.

2.5 Well pads and drilling sites during exploration and exploitation of oil and gas industry

The oil fields under the Tilenga project have a combined oil volume of oil 5.8 billion barrels of oil (Petroleum Authority of Uganda 2024). The Tilenga foot print area JBR Field, which occupies 20% lies within the MFNP, which hosts a wide range of emblematic wildlife and attracts national and international tourism (Tilenga Project ESIA, 2018). The Tilenga Project ESIA (2018) acknowledged that impacts on flora and habitats may occur as a result of direct losses and also due to indirect impacts. The oil fields in the development area located north of Victoria Nile are entirely located within the MFNP (Tilenga Project ESIA, 2018).

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 (Plumptre *et al.*, 2016). Whether this was due to the vibrations, noise or the presence of people undertaking the work was unclear. The responses may be greater where elephants are more nervous of people. World Conservation Society (WCS) (Plumptre *et al.*, 2016) indicated that elephants sometimes avoid roads up to 2-3 Km away and avoid drill sites up to 5-6 Km away.

The effects of industrial activities on wildlife include individual interruption, habitat disturbance and avoidance, direct and indirect mortality. However, the effect of a particular impact varies from species to species (Jalkotzy *et al.*, 1997).

A study by Holker *et al.* (2010) indicated that light shot over wild animals' routine grazing and play grounds often affect their behavior. Avoidance behavior was one of the survival mechanisms adopted. Such animal reaction to light should be expected because most mammals are nocturnal (Gerkema *et al.*, 2013).

The extraction, processing, and distribution of oil require a great deal of infrastructure development, which demand to occupy considerable size of land (Ogwanga, 2019) which would influence the distribution of wild animals. Mean populations of wild animals in the

oil exploration sites was significantly lower than undisturbed sites within the National Park. As regards well pads, (Ogwanga, 2019) showed that the ten well pads within MFNP were within various stages of development by May 2024. Concerns remain over the closeness of two well pads, JBR 10 and JBR1 occur near Murchison Falls Albert Delta Ramsar Wetland approximately 950 and 750 metres respectively thus putting the Ramsar site and its biodiversity at risk of contamination. (Agbagwa, 2008).

The use of excavators and other earth-moving equipment soil backfilling after pipe laying is mostly haphazard resulting in blockage of natural drainages and eventual flooding (Agbagwa, 2008).

2.6 Social perception of oil and gas facilities

MFNP is the largest and the second-most visited national park in Uganda. However, there are other protected areas in the Project area such as Bugungu Wildlife Reserve (WR) and Budongo Forest Reserve. The Murchison Falls Protected Area (MFPA) includes these three areas and therefore comprises a diverse array of protected sites that form important wild animal corridors, representing biodiversity hotspot areas for tourism and also for recreational purposes (Tilenga Project ESIA, 2018). These areas are experiencing declining wild animal species due to various pressures on natural resources including increasing human populations and development pressures. Previously these habitats were intact both in protected and on private lands. These lands have been converted, cleared or degraded (IUCN red list, 2018).

The discovery of Natural gas in Tanzania in 1970s and its subsequent production in 2000s had sparked high development and economic expectations in various sectors of the Tanzanian economy. Both the government and local people had positive expectations. However, the exploration and extractions of the petroleum products created both beneficial and detrimental changes in the predominant people's livelihood systems (Wema, 2019). The impacts were viewed to be more detrimental on environmental side. The use of environmental resources was unsustainable due to overpopulation resulting from an influx of new people coming from other areas expecting to grasp good paying jobs that would uplift their living standards (Wema, 2019).

2.7 Wildlife Monitoring and Assessment: Use of camera traps for estimating and management of wildlife populations

Burton et al (2025), the problem of reliably assessing animal populations has challenged wildlife ecologists and managers for decades (Caughley 1977). Past studies for example for carnivores relied on indirect evidence of animal presence such as tracks, however using camera traps offer researchers more reliable evidence of animal presence (Sollmann *et al.*, 2013).

Compared to tracks, pictures from camera traps allow animal identification and verification, additionally, camera traps can record information such as the date and time of the photograph, temperature, and location, either directly stamped on each picture, recorded as image file properties, or noted on a related datasheet. (Sollmann *et al.*, 2013). Camera traps are minimally invasive, cost-effective method of monitoring mammals in all kinds of habitats and conditions, and over long periods of time (Kucera and Barrett 2011). Compared with other techniques, camera traps can be used to study a wider variety of landscapes and species (Palencia *et al.* 2021), including rare and elusive animals which are typically very difficult to research (Blanc *et al.*, 2013). Assessment of wild animal populations is a long-standing challenge in wildlife ecology, technological advances have led to widespread adoption of camera traps to survey wildlife distribution, abundance and behaviour. (Burton *et al.*, 2015).

Accurate estimates of wildlife populations are critical for successful management (Rich *et al.*, 2014). Measures of a population size, composition, and distribution and how they change over time help guide conservation actions (Ronnegard *et al.*, 2008), such as protecting threatened species. Such information can also be used to forecast population trends into the future, as wildlife face the compounding pressures of climate and landscape changes (Stewart 2022).

Estimates of population density are of particular importance for conservation and management (Williams *et al.*, 2002). Over the past thirty years, camera traps (also called trail or remote wildlife cameras) have exploded in popularity (Burton *et al.*, 2015, Deslisle *et al.*, 2021).

Camera trapping is often superior to other survey methods: for example, in species inventories, camera trapping proved to perform better than interviews (Can & Togan, 2009), or direct observation/count (Griffiths & Schaick, 1993; Silveira *et al.*, 2003).

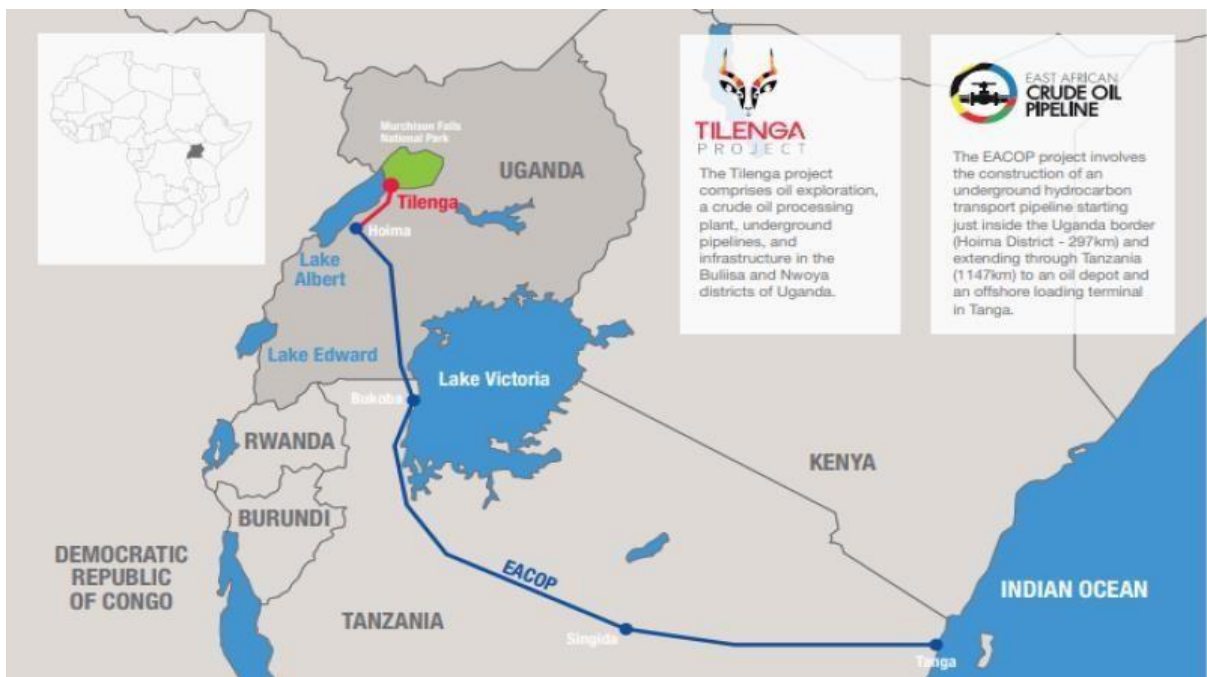
Unlike most of other research techniques that require some analysis to reveal ecological processes and patterns before the data become useful, camera trapping has the advantage that the raw material, i.e., the pictures themselves, can generate powerful information providing immediate access to scientific works, much more so than any sophisticated statistics or graphs. (Sollmann *et al.*, 2013).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the study area

Murchison fall National Park is the largest National Park in Uganda (nearly 3,480 Km²) and was initially gazetted in 1926 as a game reserve and subsequently in 1952 as a National Park, based on its animal conservation status. The Park is recognized by the IUCN as a Category II Protected Area. The MFNP is bisected by the Victoria Nile for 80 Km flowing in an East to West direction and overlaps with the Murchison Falls-Albert Delta Wetland System Ramsar Site. The MFNP supports rich and varied habitat types including grassland savannas, wooded grasslands, bush lands, woodlands, forests and wetlands that provide varied ecosystems that supports a high diversity of both flora and fauna (UWA, 2016). Together with the adjacent 748 Km² of Bugungu Wildlife Reserve and the 720 Km² of Karuma Wildlife Reserve, the park forms the Murchison Falls Conservation Area (MFCA) (UWA, 2016).



SOURCE: Total Energies.com

Figure 2: A map of the planned Tilenga development and the East African Crude Oil Pipeline



Figure 3: Map of the study area (Tilenga Footprint Area) showing study sites.

3.2 Study design

Six months field study was conducted at the facilities/sites having Tilenga project foot prints between the months of November 2024 to April 2025. These infrastructures and facilities included access road, oil pipe line, oil well pads, human settlements and Horizontal Directional Drilling (HDD) site. These facilities and infrastructures were at various stages of development. Some have been developed or are being developed. This study covered the development phase of these facilities and infrastructures.

The Tilenga project is one of the two flagship upstream petroleum production projects in the country. The project consists of nine onshore oilfields with one field in the Murchison Falls National Park (MFNP) – North of River Nile, and eight fields in the South of the

Nile (outside the park) (Petroleum Authority of Uganda, 2024). The project involves drilling of the four hundred, and twenty-six (426) wells on thirty-one well pads implying that each well pad will have about fourteen (14) wells. This study only focused on the facilities in the northern part of the MFNP.

The ongoing activities include land surface preparations, working on pipe welding and coating, and treatment of flowline pipe surfaces and mobilization of construction equipment such as pipe layers, wheel loaders and mobile power stations. There were also operational drilling rigs in the project area in Murchison Falls National Park.

3.3 Determination of wild animals' abundance, distribution and behaviour

3.3.1 Wild animal transect counts at access road and pipeline sites

The study used observation and recording methods. Project access murram road has been constructed measuring approximately 23 Km. Along it, oil pipe line has been or is going to be laid. Animal road and oil pad transect counts and monitoring of their behaviour was conducted on both sides of the road while driving and all-round the oil pads. Large mammals such as buffaloes, elephants, giraffe, hippopotamus were observed within transect width of 400 M, medium sized animals like waterbucks, Uganda kobs, and hartebeest with in transect width of 200 M and small sized animals like oribi, hyena, warthog, guinea fowl, other birds with in transect width of 100 M were monitored and counted, vegetation cover and environmental factors such as weather patterns were also recorded. The counts and monitoring were conducted with the aid of a binoculars and a range finder to estimate distance of the animal species from the facility. The sex and age category of the animal species was recorded in specifically designed form using Kobo collect.

Control studies of wild animal road transect counts and monitoring their behaviour was conducted at three tourist roads: New Buligi track, Albert track and Victoria track. In addition, light effect was monitored at the oil well pads that had night activities for example JBR2 where drilling at night was ongoing during the study period.

During the survey each site was monitored two (2) times within a period of twenty-one (21) days, totaling to twelve (12) times per site from November 2024 to April 2025, data was collected in the morning hours of the day. The distance where the animal or a group

of animals were observed was recorded using a range finder. The study considered different indicators including; feeding behaviour, social interaction, habitat use, movement patterns for example hunting, posture such as alertness, resting, reproduction behaviour e.g. mating while observing wild animals at the oil and gas facilities, infrastructure and control tracks.

3.4 Wild animal transect counts at oil well pads and the Horizontal Directional Drilling (HDD) sites

The study was designed to cover eight (8) oil well pads designated as JBR2, JBR3, JBR4, JBR5, JBR6, JBR8, JBR10, JBR9, stringing area and Horizontal Directional Drilling (HDD). The well pads were at different stages of development. The development activities involved: well pad preparation like bush clearing and soil excavations, laying of oil pipes, construction and drilling of oil wells.

Development of oil pads could be grouped into two:

Group 1: These were oil pads which were in advanced stages of development. This group included JBR3, JBR4, JBR2 and JBR5

Group 2: Development on these well pads involved well pad preparation like laying of oil pipes and construction well pads. This group includes JBR9, JBR8, JBR6 and JBR10.

Bushnell camera traps were deployed at the periphery of the well pads to provide 24 hour monitoring of wild animals interacting with the oil and gas facilities and infrastructure.

HDD site had the pipeline stringing assembly area and terminal end drilling area. The pipe line stringing area was 1.8 Km long. Stringing of oil and optic fiber pipes was being done. Terminal end of HDD for drilling was being built at the pipeline stringing assembly area. At the terminal end drilling area, wild animal transect counts and monitoring was done all around them. In addition, camera traps were also mounted at the terminal drilling area to determine occupancy and relative abundance of the animal species. The level of activities varied across the facilities during the time of data collection and included; drilling, well pad preparation, restoration and rig mobilization and demobilization.

3.4 Status of the facilities and infrastructure during the study period

3.4.1 JBR 05

This was the first well pad to be drilled wells under the Tilenga project which started on 28th June 2023 with the objective of collecting additional data to improve the understanding of the field field status of petroleum (Petroleum Authority of Uganda). At the time of data collection drilling was complete, the activities included; preparation for minicamp setup, oil pump installation and drill stem test.



Figure 4: Status of JBR5

3.4.2 JBR 04

Activities on this well pad include installation of cellar precast walls, steel, and formwork assembly, casting of concrete for the cellar bases and installation of the precast walls, excavation of the subgrade layer between the cellars, hauling of the dump soil to the stockpile, and backfilling of the excavated subgrade between the cellars. (Petroleum Authority of Uganda, 2024). At the time of data collection, the activities included; drilling, rig demobilization to JBR3 and post drilling activities.



Figure 5: Activity variation at JBR4- Drilling, rig demobilization and post drilling activities e.g., site cleaning at JBR4

3.4.3 JBR 03

Well pad site preparation, including cut and fill operations to level as well as compaction of the platform. At the time of data collection, well pad preparation and drilling were completed during the last month of data collection.



Figure 6: Well pad preparation at JR3

3.4.4 JBR 02

Activities on this well pad included construction of a temporary fencing around the pad, clearing, and topsoil removal (Petroleum Authority of Uganda, 2024). Drilling was ongoing throughout the study period.



Figure 7: Drilling at JBR2

3.4.5 JBR 09

The activities included; well pad preparation and in April 2025, mobilization of the rig started in preparation for drilling.



Figure 8: Variation of activities at JBR9 (well pad preparation and rig setup)

3.4.6 JBR 08

Well pad site preparation, including cut and fill operations to level as well as compaction of the platform.



Figure 9: Site preparation for drilling at JBR8

3.4.7 JBR 06

Preparation of the well pad completed during the time of data collection.



Figure 10: Site preparation for drilling and soil ban at JBR6

3.4.8 JBR 10

Well pad preparation for drilling including; installation of cellar precast walls, steel, and formwork assembly, casting of concrete for the cellar bases and installation of the precast walls, excavation of the subgrade layer between the cellars, hauling of the dump soil to the stockpile, and backfilling of the excavated subgrade between the cellars



Figure 11: Site preparation for drilling at JBR10

3.4.9 Horizontal Directional Drilling (HDD) and Stringing Area

The activities included; preparation, drilling, welding of pipes, mud extraction and pulling of the pipes below the Nile River bed.



Figure 12: Pipes at the HDD pulled below the Nile River Bed

3.5 Vegetation cover variations at the oil and gas infrastructure and facilities

Oil well pads, flow lines and roads in the north of the Nile, are characterized by open savanna dominated by *Hyparrhenia* with few trees. Grassland and woodland within the MFPA and to its north contains extensive areas of moist combretum savannah and *Hyparrhenia* grassland savannah including the Murchison Falls-Albert Delta Wetland System Ramsar Site important bird area and Victoria Nile Horizontal Directional Drilling (HDD) Crossing (Tilenga EISA, 2018).

3.5.1 Vegetation cover variations at JBR8, JBR6, JBR5 and Victoria track vegetation cover

The vegetation is dominated by short grass, with patches of *Acacia* and Borasus palm tree species as shown in Figure 13.



Figure 13: Vegetation Cover variations at JBR8, JBR6, JBR5 and Victoria track vegetation cover

3.5.2 Vegetation cover variations at JBR9, project access road and Albert Track

This site is located within well wooded vegetation with moderate to tall grass. The vegetation is woodland dominated by Acacia trees and dominant grass species as shown in Figure 14.



Figure 14: Vegetation cover variations at JBR9, project access road and Albert Track

3.5.3 Vegetation cover variations at HDD, JBR2, JBR10 and Stringing Area

The vegetation is dominated by riverine dense woodland with Acacia trees and thickets, Ramsar site wetland at the HDD, JBR2, stringing area and JBR10 as shown in Figure 15.



Figure 15: Vegetation cover variations at HDD, JBR2, JBR10, and Stringing Area

3.5.4 Vegetation Cover Variations at JBR4, JBR3 and New Buligi Track

The vegetation is mainly open savannah grassland with very sparse acacia trees cover as shown in Figure 16.



Figure 16: Vegetation Cover Variations at JBR4, JBR3 and New Buligi Track

3.4 Camera trap surveys

Twenty (20) camera trap stations were spread across the well pads in the study area, which were rotated after three months at the different dimensions of the same well pads, two alternating camera stations for each well pad, stringing area and HDD. Camera traps were set with the sensor approximately 30cm to 120 cm off the ground. At this height, camera traps were slightly tilted downwards to enable detection of a wide range of mammal species (Majelantle *et al.*, 2020).

Opportunistic approach was used to distribute cameras at the periphery of the well pads and the stringing area, natural attractants such as trails and specific habitat features like open areas, signs of animal trails, and footprints (MacKenzie *et al.*, 2006) along the well pads.

Bushnell Trophy Cam infrared camera traps were mounted at each well pad, stringing area and the HDD between the month of November 2024 to April 2025. To increase probability of photographing wildlife, the camera traps were mounted on periphery fence of the well pads.

The camera traps were programmed to take three photographs when triggered with a delay of 15 seconds between photograph events (Lepard *et al.*, 2018), at night-time, the infrared cameras took three photographs when triggered, with a delay of 15s due to the flash having to recharge. The cameras were checked every 7–21 days to download photographs, replace batteries and ensure that cameras were operational. The camera traps were housed in metallic cases to prevent destruction by wildlife such as hyenas as shown in Figure 17.

The camera traps were set to capture everything that passes in front of them. The photographs captured were identified to species levels as done by Blanc *et al.* (2013), MacKenzie *et al.*, (2002) and Harris *et al.*, (2010).

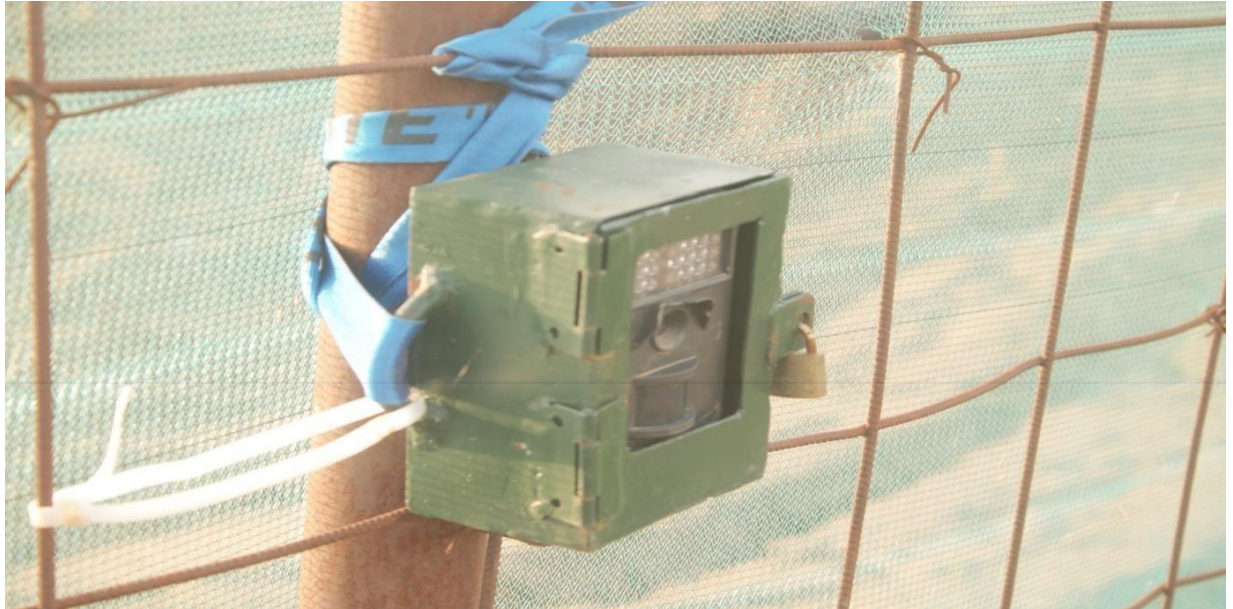


Figure 17: Bushnell Camera Trap mounted at the periphery-fence of Well pad

3.5 Data analysis

Data was collected using Kobo collect tool box, cleaned, sorted and entered into Excel sheet before exporting to R-Software for statistical analysis. The study used R- Packages library (ggplot2) and library (dplyr). Descriptive analysis focused on mean frequencies and standard deviation, whereas Pearson correlation tests measured association of wild animals with each of the oil and gas facility sites. The animal population density per Km² per study site and around facilities was computed.

3.5.1 Determination of wild animal population density at road counts and around the well pads

Vehicle was driven along the project road, Victoria track, Albert track and new Buligi track. The road count was for 23 Km for the project road and 10 Km for other roads/control tracks.

The population density of animals at road count per Km² was calculated as: the animals counted / sample area where the animals were counted denoted as A

The sample area (A) was calculated as transect width (W) and the total distance (L) travelled by the vehicle as $= (2 \times W \times L)$.

The well pad animals' population density count per Km^2 was calculated as: $= (N / A)$ where N = Number of animals counted in the sample area.

$A = P \times$ transects width of oil drilling pad where animals were counted.

P= The length of the oil well pad where the animals were counted.

CHAPTER FOUR

RESULTS

4.1 Dynamics of activities across oil and gas facilities and infrastructure in MFNP

The variation of activities across oil and gas facilities and infrastructure were as shown in Figure 18. At JBR4 the level of activity reduced to low/post drilling phase in the second month of data collection, signs of elephants breaking the fence into the well pad were observed suggesting that species responses varied across the sites due to different levels of activity from the well pads perceived as disturbance. The variation of activities along the project road during the study period were as shown in Figure 19.

Facility	Nov	Dec	Jan	Feb	March	April
JBR4	Red	Red	Red	Green	Green	Green
JBR2	Red	Red	Red	Red	Red	Red
JBR3	Yellow	Yellow	Yellow	Red	Red	Green
JBR9	Yellow	Yellow	Yellow	Yellow	Red	Red
JBR5	Blue	Blue	Blue	Blue	Blue	Blue
JBR6	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
JBR8	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
JBR10	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
HDD	Red	Red	Red	Green	Green	Green
Stringing Area	Red	Red	Red	Green	Green	Green

Key





	Drilling, stringing, rig setup and rig demobilization
	Drilling complete and Drill stem test
	Well pad preparation
	Post drilling activities, restoration, site cleaning, fencing.

Figure 18: Variation of activities across oil and gas facilities and infrastructure during the study period

Activity	Nov	Dec	Jan	Feb	March	April
Movement of people, materials and equipment at the project road	X	X	X	X	X	X
Project road maintenance between C1 connector and JBR9			X			
Project road maintenance between JBR9, JBR8 and JBR6					X	X
Project road restoration of pipeline area from JBR 5, JBR3, JBR 10		X	X	X	X	X
Laying of pipes on project road from JBR5						X
Laying of the pipes on project road between New Buligi crossing and JBR2						X
Laying of the pipes on project road between JBR10 and HDD						X
Restoration at the Stringing area in March to April 2025.					X	X

Figure 19: Variation of the activities at the project road

4.1.1 Weather patterns from November 2024 to April 2025.

The weather patterns in MFNP variations; January to march was peak dry season and usually the rainfall is about 50mm on average per month, April to September there was moderate rainfall between 100-150mm, October to December was light rainy season. During the period of data collection, the weather was dominantly sunny.

4.2 Dynamics of wild animal species population densities and behaviour across oil and gas facilities and infrastructure.

4.2.1 Dynamics of elephant population densities and behaviour at various oil and gas infrastructures and facilities in MFNP

Dynamics of elephant populations across oil and gas facilities and infrastructure and control tourist tracks in MFNP were as shown in Table 1. The mean monthly counts / Km² of elephants at different sites in MFNP at the Tilenga project area and tourist tracks were as shown in Table 2.

Elephants exhibited feeding behaviour across sites except observed walking along project road in January and February. Throughout the study period elephants were captured at night by camera traps at JBR8, HDD, JBR10, JBR9 and stringing area, occasionally were seen at JBR2, JBR3, JBR4, JBR6 and only once at JBR5 in December 2024. March to April 2025 there was breaking into the outer fence at JBR4 by Elephants to feed on the fresh grass growing on the soil ban see Figure 21.



Figure 20: Fence broken by elephants at JBR4

Table 1: Variation of elephant population densities across oil and gas facilities and infrastructure and control tracks in MFNP

Months	JBR9	JBR8	JBR4	JBR2	New Buligi Track	Albert Track	Project Road
November	2.3	0	22.7	0	0.1	0.1	0
December	9.1	2.5	4.5	2.3	1.1	2	0.3
January	38.6	20	22.7	0	0	6.8	1.4
February	0	0	0	0	0	4.4	0.2
March	1.4	2.5	22.7	2.3	0	0	0.4
April	0	0	0	0	0	0.1	0.3

There was no significant variation of elephants across all sites at MFNP ($p=0.08$, $df\ 6,35$, $F=2.03$). There was a significant difference between mean elephant abundance between project access road and JBR4 ($p=0.03$, $t=2.47$).

Table 2: The mean monthly counts / Km² of elephants at different sites in MFNP at the Tilenga project area.

JBR9	JBR8	JBR4	JBR2	New Buligi Track	Albert Track	Project Road
8.6±6.2	4.2±3.2	12.1±4.8	0.8±0.5	0.2±0.2	2.2±1.2	0.4±0.2

4.2.2 Dynamics of giraffe population densities and behaviour across oil and gas infrastructures and facilities and tourist tracks in MFNP

The population dynamics of giraffe across oil and gas facilities and infrastructure and control tracks in MFNP were as shown in Table 3. The mean monthly counts / Km² of giraffes at different sites in MFNP at the Tilenga project area and tourist tracks were as shown in Table 4.

The giraffes exhibited normal feeding behaviour across sites except walking along the project road in March, along JBR5 in November and JBR2 in April, giraffes few giraffes were captured by camera traps at JBR8, HDD, JBR2, JBR5, occasionally at JBR10, JBR4 and stringing area.

Table 3: Variation of giraffe population density across oil and gas facilities and infrastructure and control tracks in MFNP

	JBR9	JBR8	JBR5	JBR4	JBR3	JBR2	Stringing	Project Road	New Buligi Track	Victoria Track	Albert Track
November	11.4	7.5	21	0	50	0	2.5	0	3.3	4	0
December	0	0	0	0	0	0	0	0	4.5	7.5	1.3
January	0	0	0	0	0	0	0	1.5	2.3	5.6	0.5
February	0	0	0	0	0	0	0	1.1	0.9	1	0.9
March	0	25	0	0	0	0	0	0	4	3.6	0
April	0	0	0	13	0	4.2	0	2	0	0.6	0

There was no significant variation of giraffes at various sites in MFNP ($p=0.81$, $df 10,55$, $F=0.6$). There was significant difference between mean abundance of giraffes between Victoria track and project road ($p=0.04$, $t=2.25$).

Table 4: The mean monthly counts / Km² of giraffes at different sites in MFNP at the Tilenga project area and tourist tracks.

JBR9	JBR8	JBR5	JBR3	JBR2	Stringing Area	Project Road	New Buligi Track	Victoria Track	Albert Track
1.9±1.9	5.4±4.1	3.5±3.5	8.3±8.3	0.7±0.7	0.4±0.4	0.8±0.4	2.5±0.7	3.7±1.1	0.5±0.2

4.2.3 Dynamics of buffalo population densities and behaviour at various oil and gas infrastructures and facilities and tourist tracks in MFNP

Dynamics of buffalo population densities across oil and gas facilities and infrastructure and control tracks in MFNP were as shown in Table 5. The mean monthly counts / Km² of buffalo at different sites in MFNP at the Tilenga project area were as shown in Table 6.

Buffaloes exhibited normal feeding behaviour across sites except lying down at JBR6, walking at JBR5 JBR4 and wallowing along the Victoria track and project road as shown in Figure 22. Buffaloes were captured by camera traps at night in JBR8 and JBR6 throughout the study period, occasionally they were seen at JBR10, JBR3, JBR5, JBR9, Stringing area, very rarely seen at JBR2, JBR4 the number of buffaloes increased during the periods of post drilling phase.



Figure 21: Buffaloes at the stagnant water point along project access road.

Table 5: Variation of buffalo population density across oil and gas facilities and infrastructure and tourist control tracks in MFNP

	JBR9	JBR8	JBR5	JBR6	JBR4	JBR2	JBR3	New Buligi Track	Albert Track	Victoria Track	Project Road
November	2.3	0	10.4	11.4	0	0	0	0	0.3	22.5	2.7
December	0	20	45.8	0	0	0	0	5.6	0.5	9.4	0.2
January	0	0	2.1	0	0	0	0	4.5	0	10	8
February	0	0	0	0	0	0	0	2.5	0.3	6.8	0.6
March	0	10	0	0	0	6.8	0	4.4	9.4	41.5	6.1
April	0	45	0	4.5	40.9	0	22.7	18.5	3.5	13.4	0.9

There was no significant variation of buffalo at various sites at MFNP ($p=0.19$, $df 10,55$, $F=1.43$). There was a significant difference between mean buffalo abundance between project access road and Victoria track ($p= 0.02$, $t= 2.89$).

Table 6: The mean monthly counts / Km² of buffalo at different sites in MFNP at the Tilenga project area and tourist tracks.

JBR9	JBR8	JBR5	JBR6	JBR4	JBR2	JBR3	New Buligi Track	Albert Track	Victoria Track	Project Road
0.4±0.4	12.5±7.3	9.7±7.4	2.7±1.9	6.8±6.8	1.1±1.1	3.8±3.8	5.9±2.6	2.3±1.5	17.3±5.3	3.1±1.3

4.2.4 Dynamics of Uganda kob population densities and behaviour across oil and gas facilities and infrastructure and tourist tracks in MFNP

Dynamics of Uganda kob population density across oil and gas facilities and infrastructure and control tracks in MFNP were as shown in Table 7. The mean monthly counts / Km²

of Uganda kob at different sites in MFNP at the Tilenga project area were as shown in Table 8.

The Uganda kob were majorly observed feeding as shown in Figure 23 at the oil and gas facilities and infrastructure except in February when they were observed running at JBR5, lying down along the project road in January, drinking water along Victoria track in February, lying down at JBR8 in March, lying down in March at project road and walking across Albert track in April to the River Nile for water. The Uganda kobs were also captured by the camera traps around the oil and gas facilities.



Figure 22: Uganda kobs feeding on the fresh grass in the pipeline area along Project access road

Table 7: Variation of Uganda kob population density across oil and gas facilities and infrastructure and control tracks in MFNP

	JBR 5	JB6	JBR8	Victoria Track	Project road	New Buligi Track	Albert Track
November	720.8	0	175	88.3	8.2	81.5	9.8
December	54.2	13.6	80	258	2.53	106.8	19.3
January	916.7	0	50	740	36	31	10.5
February	141.7	0	1460	160.3	77	3	24
March	154.2	59.1	290	582.3	42	237.5	183.3
April	250	22.7	130	82.3	82.3	222.5	132.8

There was no significant difference in variation of Uganda kobs at various sites MFNP (P=0.14, df 4,25 F=1.91). There was a significant difference between mean Uganda kob abundance between the project road and Victoria track (p=0.03, t=2.39) and JBR5 (p=0.04, t=2.22). The other sites showed no significant difference of mean Uganda kob abundance.

Table 8: The mean monthly counts / Km² of Uganda kobs at different sites in MFNP at the Tilenga project area and control sites

JBR5	JBR6	JBR8	Victoria Track	Project Road	New Buligi Track	Albert Track
372.9±145.5	15.9±9.4	364±221.8	318±113.2	41.3±13.6	113.7±39.7	63.3±30.7

4.2.5 Dynamics of Jackson's hartebeest population densities and behaviour across oil and gas facilities and infrastructure in MFNP

Dynamics of Jackson's hartebeest population densities across oil and gas facilities and infrastructure and control tracks in MFNP were as shown in Table 9. The mean monthly counts / Km² of Jackson's hartebeest at different sites in MFNP at the Tilenga project area and tourist tracks were as shown in Table 10.

The Jackson's hartebeests were observed feeding at the oil and gas facilities, they were sighted walking at JBR8 in November, running at JBR4 in December, lying down at the Stringing area in November, walking along Victoria track in November, lying down in the pipeline area along project road in November, at JBR3 in January, JBR9 in April and nursing/ breastfeeding at the project road as shown in Figure 24.



Figure 23: Jackson's hartebeest nursing/breastfeeding in the pipeline area along the project road

Table 9: Variation of Jackson's hartebeest population density across oil and gas facilities and infrastructure and control tracks in MFNP

	JBR9	JBR8	JBR6	JBR5	JBR4	JBR2	JBR3	Stringing Area	Buligi Track	Albert Track	Victoria Track	Project Road
Nov	4.5	40	45.5	50	22.7	0	4.5	0	11	0.5	0.8	1.4
Dec	0	5	0	0	4.5	0	9.1	15.7	20.8	1.5	4.3	28.4
Jan	9.1	60	0	0	4.5	0	18	0	5.5	1.8	5	21.8
Feb	0	0	0	0	0	4.5	0	0	0.3	1.5	0	2.6
Mar	0	15	0	0	0	0	0	0	10.5	4.3	0.3	6.8
April	9.1	5	4.5	0	18.2	36.4	36	0	4.8	5.3	0.3	6.3

There was no significant variation of hartebeest populations at various sites in MFNP ($p=0.25$, df 13,70, $F=1.28$). There was a significant difference between mean hartebeest abundance between project road and Victoria track ($p=0.03$, $t=2.54$), stringing area ($p=0.02$, $t=2.78$), and JBR9 ($p=0.03$, $t=2.46$).

Table 10: The mean monthly counts / Km² of Jackson’s hartebeest at different sites in MFNP at the Tilenga project area and tourist tracks.

JBR 9	JBR8	JBR 6	JBR 5	JBR 4	JBR 2	JBR3	Stringing Area	New Buli Trac k	Alb ert Trac k	Vict oria Trac k	Proje ct Road
3.8±1.8	20.8±9.7	8.3±7.5	8.3±8.3	8.3±4.0	6.8±6.0	11.4±5.7	2.6±2.6	8.8±2.9	2.5±0.8	1.8±0.9	11.2±4.6

4.2.6 Dynamics of oribi population densities at various oil and gas infrastructures and facilities and tourist tracks in MFNP

Dynamics of oribi population densities across oil and gas facilities and infrastructure and tourist tracks in MFNP were as shown in Table 11. The mean monthly counts / Km² of Oribi at different sites in MFNP at the Tilenga project area were as shown in Table 12.

Oribi exhibited normal feeding behaviour across the oil and gas facilities and infrastructure, they were found lying down in November, February and April at JBR6, at JBR5 in January, JBR4 in March and project road in April. They were standing still at JBR4 in November, and walking at JBR8 in December, they were found lekking at JBR4 and soil leaking along the project road (see Figure 25).



Figure 24: Oribi leaking along project access road.

Table 11: Variation of oribi population densities across oil and gas facilities and infrastructure and tourist tracks in MFNP

	JBR9	JBR8	JBR6	JBR5	JBR4	JBR3	JBR2	Project Road	New Buligi Track	Victoria Track	Albert Track
November	18.2	20	27.3	25	90.9	90.9	0	4.5	0	4.5	1.5
December	45.5	20	0	16.7	36.4	0	0	23.9	4.5	21.5	6
January	0	30	0	50	0	0	0	25.4	0.5	15	0
February	0	30	72.7	0	0	0	0	13.4	0	10.5	0.5
March	0	160	90.9	75	9.9	90.9	18.2	36.2	34	36.5	24
April	0	130	36.4	58.3	18.2	81.8	0	26.1	19.5	30.5	18

Overall, it was shown that there was a significant variation of oribi at various sites at MFNP ($p=0.03$, $df\ 10,55$, $F=2.18$). There was a significant difference between mean oribi abundance between project access road and Albert track ($p=0.004$, $t=4.18$), New Buligi Track ($p=0.01$, $t=3.22$) JBR8 ($p=0.05$, $t=1.92$) and JBR2 ($p=0.001$, $t=5.38$).

Table 12: The mean monthly counts / Km² of oribi at different sites in MFNP at the Tilenga project area and the tourist tracks

JBR9	JBR8	JBR6	JBR5	JBR4	JBR3	JBR2	Project Road	New Buligi Track	Victoria Track	Albert Track
10.6±7.6	65±25.7	37.9±15.3	37.5±11.5	25.9±14.1	43.9±19.7	3.0±3.0	21.6±4.5	9.8±5.7	19.8±5.0	8.3±4.2

4.2.6 Dynamics of baboon populations and behaviour at various oil and gas infrastructures and facilities and tourist sites in MFNP.

Dynamics of baboon population densities across oil and gas facilities and infrastructure and control tracks in MFNP were as shown in Table 13. The mean monthly counts / Km² of baboons at different sites in MFNP at the Tilenga project area and the tourist tracks were as shown in Table 14. The baboons were observed feeding throughout the study period whenever they encountered.

Table 13: Variation of baboon population density across oil and gas facilities and infrastructure and tourist tracks in MFNP

	JBR9	JBR8	JBR10	JBR4	JBR2	JBR3	Stringing Area	New Buligi Track	Albert Track	Project Road
November	0	80	0	0	36	0	0	0	0	0
December	146	0	0	0	0	54.5	0	7	2.1	8.6
January	0	0	310	9.1	27	0	7.9	0	4.5	0
February	0	0	0	0	0	0	78.5	0	10	0
March	0	0	150	0	0	0	7.9	0	11	0.6
April	273	0	0	0	0	0	0	5	0.5	1.7

There was no significant variation of baboons at various sites at MFNP ($p=0.2$, $df 9,50$, $F=1.46$). There was no significant difference between mean abundance of baboons across oil and gas facilities and infrastructure.

Table 14: The mean monthly counts / Km² of baboons at different sites in MFNP at the Tilenga project area and the tourist tracks.

JBR9	JBR8	JBR10	JBR4	JBR2	JBR3	Stringing Area	New Buligi Track	Albert Track	Project Road
69.7±47.0	13.3±13.3	76.9±52.7	1.5±1.5	10.6±6.8	9.1±9.1	15.7±12.7	2±1.3	4.7±2.0	1.8±1.4

4.2.7 Dynamics of warthog population density and behaviour at various oil and gas infrastructures and facilities in MFNP

Dynamics of warthog population densities across oil and gas facilities and infrastructure and control tracks in MFNP were as shown in Table 15. The mean monthly counts / Km² of warthog at different sites in MFNP at the Tilenga project area and tourist tracks were as shown in Table 16.

Warthogs were observed feeding as shown in Figure 26 across the study sites, wallowing along project road in November, and February at JBR6.



Figure 25: Warthog feeding at the pipeline area along project access road and Leaking the aggregate road material at JBR3

Table 15: Variation of warthog population density across oil and gas facilities and infrastructure and tourist tracks in MFNP

Month	JBR9	JBR8	JBR6	JBR10	JBR5	JBR4	JBR3	Stringing Area	New Buligi Track	Albert Track	Victoria Track	Project Road
November	0	0	9.1	0	8.3	9.1	4.5	0	0.8	0	0	0.8
December	14	0	0	0	12.5	0	0	0	3.3	3.5	1.5	5.3
January	0	0	0	10	0	0	0	1.3	1	1	0	5
February	0	5	4.5	0	0	9.1	0	0	0	2.5	0	1.6
March	0	20	4.5	0	0	4.5	18.2	0	1.5	3.8	0.8	5.7
April	0	5	9.1	5	0	0	0	0	0.5	1.8	0	3

There was no significant difference in variation of warthog at various sites at MFNP ($p=0.7$, df 11,60, $F=0.74$). There was significant difference observed among populations of warthog between project access road and stringing area ($p=0.004$, $t=4.19$), New Buligi Track ($p=0.006$, $t=3.71$), Albert track ($p=0.04$, $t=2.24$), Victoria track ($p=0.003$, $t=4.52$).

Table 16: The mean monthly counts / Km² of warthog at different sites in MFNP at the TILENGA project area and tourist tracks.

JBR9	JBR8	JBR6	JBR10	JBR5	JBR4	JBR3	Stringing Area	New Buligi Track	Albert Track	Victoria Track	Project Road
2.3±2.3	5±3.2	4.5±1.7	2.5±1.7	3.5±2.6	3.8±1.8	3.8±3.0	0.2±0.2	1.2±0.5	2.1±0.6	0.4±0.3	3.6±0.8

4.2.8 Dynamics of waterbuck population densities and behaviour at various oil and gas infrastructures and facilities and tourist tracks in MFNP

Dynamics of waterbuck population densities across oil and gas facilities and infrastructure and control tracks in MFNP were as shown in Table 18. The mean monthly counts / Km² of waterbuck at different sites in MFNP at the Tilenga project area and tourist tracks were as shown in Table 19.

The waterbuck exhibited normal feeding, walking, and mating behaviour across oil and gas facilities as shown in Figure 27.



Figure 26: Waterbuck mating behaviour along the Stringing area.

Table 17: Variation of waterbuck population densities across oil and gas facilities and infrastructure and tourist sites in MFNP

	JBR9	Stringing Area	New Buligi Track	Albert Track	Victoria Track	Project Road
November	31.8	0	1	3.5	0	0
December	45.5	0	4.5	5.5	0	0.4
January	0	0	7.3	7.5	0.5	2.3
February	0	1.3	2.5	4.3	0.3	0
March	0	23.6	1	12.3	0	0.2
April	0	2.6	4.5	4.5	0	0.5

There was no significant difference of waterbuck at various sites at MFNP ($p=0.23$, df 5,30, $F=1.5$). There was significant difference between abundance of waterbuck between project access road and New Buligi Track ($p=0.004$, $t=4.19$) and Albert track ($p=0.004$, $t=4.36$).

Table 18: The mean monthly counts / Km² of waterbuck at different sites in MFNP at the Tilenga project area and tourist tracks

JBR9	Stringing Area	New Buligi Track	Albert Track	Victoria Track	Project Road
12.9±8.3	4.6±3.8	3.5±1.0	6.3±1.3	0.1±0.1	0.6±0.4

4.2.9 Dynamics of patas monkey population densities and behaviour at various oil and gas infrastructures and facilities in MFNP

Dynamics of patas monkey population densities across oil and gas facilities and infrastructure and control tracks in MFNP were as shown in Table 19. The mean monthly counts / Km² of patas monkey at different sites in MFNP at the Tilenga project area were as shown in Table 20. The patas monkeys were majorly observed feeding.

Table 19: Variation of patas monkey population density across oil and gas facilities and infrastructure and control tracks in MFNP

	JBR8	JBR5	JBR2	JBR3	Stringing Area	New Buligi Track	Albert Track	Victoria Track	Project Road
November	30	0	0	36.4	0	0	7.5	0	0
December	0	0	0	0	0	0.5	23.5	5.5	1.9
January	0	0	9.1	0	0	3	10.5	0.5	2.6
February	0	0	0	0	0	0	4.5	0	3
March	0	50	0	27.3	2.6	7.5	12	2	0
April	0	0	0	0	0	0	0	3.5	4.3

There was no significant difference of patas monkey at various sites at MFNP ($p=0.62$, df 5, 30, $F=0.7$). The mean monthly counts/ Km² of patas monkey at different sites in MFNP were as shown in Table 20. There was significant difference between abundance of patas monkey between project access road and Albert track ($p=0.04$, $t=2.12$).

Table 20: The mean monthly counts / Km² of patas monkey at different sites in MFNP at the Tilenga project area and tourist tracks

Site	JBR8	JBR5	JBR2	JBR3	Stringing area	New Buligi Track	Albert Track	Victoria track	Project road
Mean	5±5	8.3±8.3	1.5±1.5	10.6±6.8	0.4±0.4	1.8±1.2	9.6±3.2	1.9±0.9	2.0±0.7

4.2.10 Dynamics of carnivore population densities and behaviour at various oil and gas infrastructures and facilities in MFNP

Hyenas were sighted walking along the New Buligi track in February and lion captured by camera trap crossing the swamp in the diurnal period at JBR10 as shown in Figure 28. The carnivorous species were captured by camera traps across sites at night as shown in camera trap surveys 4.5.



Figure 27: Lion crossing the swamp at JBR10

There was an increase in the number of species such as elephants, at the stringing area and HDD, JBR4 during the post stringing activities suggested avoidance behaviour due to presence of humans and noise from machinery as shown in Figure 29.



Figure 28: A herd of Buffalos at JBR4 captured during the post drilling activities phase

The increased nocturnal activity was detected among several mammal species as shown in Figure 30.



Figure 29: Camera trap photos of Jackson's Hartebeests, Waterbucks and Oribis

4.3 Effect of Light to mammal species

The study also looked at the light effect on the distribution of predators such as lions, hyenas and leopards. The study recorded very low occurrence of predators at sites with high level of activity/drilling at night, suggesting that light affected the distribution of predators across oil and gas facilities and infrastructure as shown in Figure 31.



Figure 30: Hyena and Leopard at JBR2 captured by camera traps

4.4 Dynamics of bird Species at the Ramsar Site Wetland

The horizontal directional drilling HDD used as part of the Tilenga project for the construction of the Victoria Nile pipeline through the Ramsar site wetland an important hotspot for biodiversity such as birds as shown in Table 21. The mean monthly counts/Km² of Birds at the Ramsar site wetland were as shown in Table 22. The bird species were observed feeding at the Ramsar site wetland.

Table 21: Variation of bird species population density at the HDD (Ramsar site wetland)

	Grey Crowned crane	Egyptian geese	Ibis	Heron	Saddle-billed stork
December	7.9	5.2	0	0	0
January	15.7	17.5	2.5	1	0
February	0	0	6.3	12	0
March	0	8	0	0	6.9
April	0	7.9	0	0	0

There were no bird species sighted at the Ramsar site wetland during the month of November and very few bird species throughout the study period were sighted.

Table 22: The mean monthly counts / Km² of Birds at the Ramsar site wetland in the Tilenga project area MFNP

Grey crowned crane	Egyptian geese	Ibis	Heron	Saddle-billed stork
4.7±3.1	7.7±2.8	1.7±1.2	2.6±2.4	1.4±1.4

The study estimated the total number of animal species in the Tilenga project area as shown in table 23.

Table 23: Estimated number of mammal species population across the Tilenga project area

Species	Total Animal Species.
Elephant	157
Buffalo	1167
Giraffe	353
Hartebeest	626
Oribi	808
Uganda kob	9228
Warthog	201
Waterbuck	191
Baboons	190
Patas monkey	155

4.5 Camera Trap Survey

A total of 24,200 photos were captured within the period of six months (November 2024 to April 2025), mammal species identified for example Figure 32 shows the photo of lion captured at JBR5.



Figure 31: Camera trap photo of lion at JBR5

4.5.1 The mammal species captured by camera trap at night at JBR8

The mammal species captured by camera trap at night at JBR8 were as shown in Table 24

Table 24: The mammal species captured by camera trap at night at JBR8.

	November	December	January	February	March	April
Elephant	1	3	2	1	0	1
Buffalo	1	3	5	5	0	5
Hyena	1	6	3	1	1	0
Leopard	1	1	2	0	0	1
Waterbuck	1	2	0	0	0	0
Porcupine	2	1	3	1	2	0
Stripped_Jackal	1	0	0	0	0	0
Mongoose	0	2	2	0	0	1
Hartebeest	0	11	6	0	3	0

Oribi	0	4	1	11	0	4
Uganda kob	0	18	0	0	0	15
warthog	0	7	3	2	3	0
Hare/ Bunyoro rabbit	0	1	0	0	2	0
Baboon	0	1	0	6	5	0
Genet cat	0	0	0	1	0	0
Lion	0	0	0	0	0	1
Giraffe	0	0	0	0	0	3

4.5.2 The mammal species captured by camera trap at night at HDD.

The mammal species captured by camera trap at night at HDD were as shown in Table 25

Table 25: The mammal species captured by camera trap at night at HDD.

	November	December	January	February	March	April
Baboon	11	9	8	13	5	
Elephant	7	5	7	3	8	3
Hippopotamus	3	2	2	2	1	
Leopard	1	9	0	0	0	
Giraffe	0	1	0	0	0	
Hyena	0	1	0	1	0	
Waterbuck	0	1	1	0	2	
Warthog	0	0	3	0	0	
Uganda kob	0	0	0	0	0	2
Bushbuck	0	0	0	0	0	

4.5.3 The mammal species captured by camera trap at night at JBR10

The mammal species captured by camera trap at night at JBR10 were as shown in Table 26

Table 26: The mammal species captured by camera trap at night at JBR10

	November	December	January	February	March	
Waterbuck	4	4	6	2	0	
Baboon	8	1	7	14	8	
Elephant	4	2	1	2	2	
Bushbuck	1	0	0	0	2	0
Hippopotamus	1	1	2	0	1	
Lion	2	0	0	0	0	0
Mongoose	1	0	0	0	0	
Warthog	0	5	5	4	4	0
Buffalo	0	2	2	3	0	0
African Civet	0	1	1	0	0	1
Giraffe	0	2	2	0	0	1
Genet cat	0	1	1	1	1	0
Mongoose	0	1	3	0	0	0
Hyena	0	0	2	0	1	0
Porcupine	0	0	2	0	2	
Leopard	0	0	1	1	1	
Serval cat	0	0	0	1	0	
Uganda kob	0	0	0	0	0	

4.5.4 The mammal species captured by camera trap at night at JBR2

The mammal species captured by camera trap at night at JBR2 were as shown in Table 27

Table 27: The mammal species captured by camera trap at night at JBR2

	November	December	January	February	March	April
Baboon	2	0	5	0	1	3
Warthog	1	3	4	0	0	1
Mongoose	0	1	3	3	0	0
Elephant	0	1	4	2	1	0
Lion	0	2	0	0	0	0
Hare	0	1	2	0	0	0
Hartebeest	0	0	1	0	0	5
Leopard	0	0	1	0	0	0
Genet cat	0	0	1	0	1	0
Buffalo	0	0	0	0	1	0
Waterbuck	0	0	0	0	10	0
Hyena	0	0	0	0	0	4
Bushbuck	0	0	0	0	0	1
Giraffe	0	0	0	0	0	3
Oribi	0	0	0	0	0	2

4.5.5 The mammal species captured by camera trap at night at JBR3

The mammal species captured by camera trap at night at JBR3 were as shown in Table 28.

Table 28: The mammal species captured by camera trap at night at JBR3.

	November	December	January	February	March	April
Oribi	2	0	4	0	4	10
Buffalo	2	0	2	0	0	3
Elephant	1	3	0	0	0	0
Hartebeest	0	4	3	1	0	4
Warthog	0	1	3	0	1	0
Hyena	0	1	0	0	0	0

4.5.6 The mammal species captured by camera trap at night at JBR4

The mammal species captured by camera trap at night at JBR4 were as shown in Table 29.

Table 29: The mammal species captured by camera trap at night at JBR4

	November	December	January	February	March	April
Baboon	6	4	2	9	0	0
Elephant	3	4	2	4	0	3
Porcupine	0	1	1	1	0	0
Mongoose	0	1	1	1	1	1
Hartebeest	0	1	1	1	7	0
Oribi	0	1	4	1	0	0
Buffalo	0	1	35	6	21	0
Giraffe	0	4	6	0	0	4
Hyena	0	1	0	0	2	0
Hare	0	1	2	0	0	1
Warthog	0	1	2	2	4	0
Genet cat	0	1	0	0	0	0
Leopard	0	1	2	1	0	1
Lion	0	0	0	0	6	0
Bushbuck	0	0	0	0	0	2

4.5.7 The mammal species captured by camera trap at night at JBR5

The mammal species captured by camera trap at night at JBR5 were as shown in Table 30

Table 30: The mammal species captured by camera trap at night at JBR5

	November	December	January	February	March	April
Warthog	3	2	0	0	0	0
Hare	3	4	1	2	2	1
Uganda_kob	44	24	12	4	16	8
Genet cat	1	1	0	0	0	0
Oribi	3	9	8	0	16	2
Lion	2	0	0	0	0	0
Hartebeest	6	4	2	1	0	0
Buffalo	3	0	0	0	0	2
Mongoose	1	2	2	2	0	0
Porcupine	0	2	1	0	0	0
Elephant	0	1	0	0	0	0
Giraffe	0	3	0	0	0	0
Lion	0	0	1	0	0	0
Leopard	0	0	0	0	1	0
Hyena	0	0	0	0	0	1

4.5.8 The mammal species captured by camera trap at night at JBR6

The mammal species captured by camera trap at night at JBR6 were as shown in Table 31.

Table 31: The mammal species captured by camera trap at night at JBR5

	November	December	January	February	March	April
Buffalo	15	6	5	14	6	2
Mongoose	1	1	0	1	3	0
Warthog	1	1	0	2	0	0
Oribi	5	3	8	8	0	9
Uganda_Kob	4	10	12	7	0	9
Bushbuck	1	1	0	0	0	0
Elephant	1	0	0	0	0	0
Hyena	2	2	0	1	0	0
Porcupine	1	1	0	0	0	0
Lion	0	2	0	2	1	1
Hare	0	1	1	0	0	0
Leopard	0	1	0	0	0	0
Genet cat	0	2	0	1	1	0
Hartebeest	0	4	6	1	0	0

4.5.9 The mammal species captured by camera trap at night at JBR9

The mammal species captured by camera trap at night at JBR9 were as shown in Table 32.

Table 32: The mammal species captured by camera trap at night at JBR9.

	November	December	January	February	March	April
Elephant	4	2	6	3	0	0
Oribi	2	1	3	10	2	0
Genet cat	1	1	2	0	0	1
Hyena	1	0	0	2	1	1
Leopard	1	1	0	1	0	0
Buffalo	3	2	0	3	0	0
Waterbuck	0	3	4	2	0	5
Hartebeest	0	2	3	1	1	0
Warthog	0	1	2	4	4	0
Bushbuck	0	1	0	0	0	0
Uganda kob	0	2	0	2	0	0
Baboon	0	0	0	5	4	0
Lion	0	0	0	1	0	0
Mongoose	0	0	0	2	2	1

4.5.10 The mammal species captured by camera trap at night at the stringing area

The mammal species captured by camera trap at night at the stringing area were as shown in Table 33.

Table 33: The mammal species captured by camera trap at night at the stringing area

	December	January	February	March	April
Elephant	3	8	9	5	8
Warthog	3	3	0	4	0
Waterbuck	1	10	6	12	7
Giraffe	6	2	0	7	0
Hippopotamus	1	0	0	0	0
Porcupine	1	0	0	0	0
Leopard	1	2	0	0	0

Baboon	0	3	7	0	0
Hyena	0	1	2	0	0
Bushbuck	0	1	0	0	2
African civet	0	0	0	1	1
Mongoose	0	0	0	1	0
Bushpig	0	0	0	0	2
Hare	0	0	0	0	1
Buffalo	0	0	2	0	0
Genet cat	0	0	0	0	1

CHAPTER FIVE

DISCUSSION

Dynamics of activities at oil and gas facilities and infrastructures at MFNP

The level of activity at the oil and gas facilities and infrastructure varied across sites from November 2024 to April 2025 including; drilling, well pad preparation, drilling stem test, post drilling activities, laying of pipes, restoration, stringing and road maintenance across the project access road, for example JBR3 activity varied from well pad preparation to drilling and post drilling activities, JBR9 activity included; well pad preparation and drilling rig set up, JBR2 drilling, JBR5 drilling stem test, JBR4 drilling and post drilling activities, JBR6, JBR8, JBR10 well pad preparation for drilling, HDD and stringing area included; drilling, post drilling activities and restoration see Figure 18 and 19.

Dynamics of wild animal population density, ecology and behaviour at oil and gas facilities and infrastructures at MFNP

Wild animal favored habitats

Oil well pads, flow lines and roads in the north of the Nile, are characterized by open savanna dominated by *Hyparrhenia* with few acacia trees and Borassus palm including the Murchison Falls Albert Delta Wetland System Ramsar Site important bird area and Victoria Nile Horizontal Directional Drilling (HDD) Crossing as shown in Figure 13, 14, 15, 16.

JBR8, JBR6, JBR5 and Victoria track were characterized by short grass with scattered acacia and Borassus palm vegetation that are the favorable habitats for the Uganda kob, Jackson's hartebeest, oribi and buffalos

JBR9, C1 access road and Albert track were characterized by wooded acacia and modest tall grass vegetation that are favorable habitats for elephants. JBR4, JBR3 and New Buligi track were characterized by open grassland with sparse acacia trees that are the favorable habitats for giraffes and buffalos. HDD, JBR10, JBR2, and stringing area were characterized by riverine dense vegetation and Ramsar site wetland that are favorable habitats for elephants, bushbucks, waterbucks, giraffes and birds.

Impact of oil and gas facilities and infrastructure on dynamics of Elephant population density and ecology at oil and gas facilities

The distribution and abundance of elephant variation across oil and gas facilities and infrastructure was influenced by the level of activity at the sites. JBR9, JBR4, were natural favorable habitat for elephants. At the HDD and stringing area, the number of elephants increased post the stringing activities when the pipes were pulled below the Nile River bed. Elephants exhibited avoidance behaviour at oil and gas facilities and infrastructure with high level of activity but returned as the level of activity reduced after drilling in agreement with Prinsloo and Plumptre et al., (2011) who highlighted that most large mammals were negatively affected by the activities at a drill pad site, even pad maintenance where there is not much activity but presence of people and some vehicle traffic, with elephants exhibiting avoidance up to 750-1000 meters being exhibited. Plumptre et al., (2011). There was a significant difference between mean elephant abundance between project access road and JBR4 as shown on Table 2.

Throughout the study period elephants were captured at night by camera traps at JBR8, HDD, JBR10, JBR9 and stringing area, occasionally at JBR2, JBR3, JBR4, JBR6 and only once at JBR5 in December 2024. Both nocturnal and diurnal elephants exhibited normal feeding behaviour for example grazing and browsing.

Impact of oil and gas facilities and infrastructure on dynamics of Giraffe population density and ecology at oil and gas facilities

Giraffe population abundance and distribution showed a significant difference between Victoria track and the project access road. The distribution of giraffes was majorly influenced by vegetation cover and seasonality rather than the level of activity at the oil and gas facilities and infrastructure in agreement with (Deacon, 2015) who commented that giraffes are herbivores and in an unconstrained environment they expand their home ranges as far as is required to satisfy their resource requirements, supporting the observation that longer distances are travelled during periods of low resource availability.

There was significant difference of mean abundance of giraffes between Victoria track and project road as shown in Table 4. The giraffes exhibited feeding walking, resting behaviour, JBR5 and JBR2 acted as transit routes/ corridors for giraffes. Giraffes were

captured by camera traps rarely at JBR8, HDD, JBR2, JBR5, occasionally at JBR10, JBR4 and stringing area.

Presence of giraffes at the facilities and infrastructure at night could have been favored due to cooler temperatures, prompting the giraffes to move when is cooler in order to save energy, feeding during the night may also have been a reason for night-time roaming due to the higher moisture contents of the leaves, which could be an adaption to more arid areas in agreement with (Deacon et al., 2023).

Impact of oil and gas facilities and infrastructure on dynamics of Buffalo population density and ecology at oil and gas facilities

There was a significant difference of mean buffalo densities between project road and the Victoria track the mean buffalo abundance showed a significant difference as shown in Table 6.

Buffaloes exhibited feeding, resting/lying down, walking and wallowing. The nocturnal buffalo behaviour including feeding, walking and resting suggested no variation between the diurnal and nocturnal behaviour.

Buffaloes were captured by camera traps in the night at JBR8 and JBR6 throughout the study period, occasionally at JBR10, JBR3, JBR5, JBR9, very rarely at JBR2, at JBR4 the number of buffaloes increased during the post drilling phase, at the stringing area the Buffalo was captured by camera traps in February after the pipe was pulled suggesting habitat avoidance and use due to disturbance by human activities. (“UWA ranger stated that the Buffalos used to cross through the old Buligi track but no longer do because of the oil and gas activities at the HDD and stringing area”) suggesting that the high level of activity at the HDD and stringing area blocked the migratory route for buffalos.

There were higher numbers of buffaloes at the Victoria track compared to project road due to forage abundance. Presence of water and wallowing points at the facilities and infrastructure acted as an attractant for buffaloes suggesting habitat use and preference. Presence of buffaloes at night at the sites where they were not sighted during day suggested disturbance as a result of human presence, machinery and noise pollution in agreement with Prinsloo and Plumtre et al., (2011).

Impact of oil and gas facilities and infrastructure on dynamics of Uganda kob population density and ecology at oil and gas facilities

Uganda kob distribution was influenced by the type of vegetation both at the oil and gas facilities and infrastructure and the control sites characterized by short grass with a few acacia tree species and Borassus palm at JBR8, JBR5 and Victoria track suggesting that vegetation cover influenced distribution of Uganda kobs. There was a significant difference of mean Uganda kobs abundance between the project road and Victoria track and JBR5 as shown in Table 8.

The Uganda kob were majorly observed feeding, running, resting/lying, drinking water, walking. Oil and gas facilities and infrastructure such as access road created high quality habitat where food resources are more abundant compared to adjacent areas which acted as an attractant for Uganda kobs to the pipeline area along project access road in agreement with Clevenger et al (2011).

Impact of oil and gas facilities and infrastructure on dynamics of Jackson's hartebeest population density and ecology at oil and gas facilities

The occurrence and distribution of hartebeests was influenced by vegetation cover, open areas along the project road provided feeding and resting spots, avoiding predation and opportunities for salt leaks which influenced the distribution of oribi and hartebeest which seemed tolerant to the oil and gas facilities and infrastructure, the restored areas also provided fresh grass for the oribi and hartebeest. There was a seasonal effect observed amongst hartebeest. There was a significant difference of mean Jackson's hartebeest abundance between project road and Victoria track stringing area and JBR9 as shown in Table 10.

The Jackson's hartebeests were observed feeding, running, resting/lying down, walking, nursing/breastfeeding along project road. The Jackson's hartebeest population density along across the pipeline area along project road suggested opportunity for predator avoidance.

Impact of oil and gas facilities on dynamics of Oribi population density and ecology at oil and gas facilities

Oribi exhibited feeding, resting/lying, standing still, walking, lekking and leaking behaviour. Excavation exposed soil leaks which attracted oribi's along the project road and also creating opportunity to avoid predation and fresh grass for feeding. There was also a significant difference of mean oribi abundance between project access road and Albert track, New Buligi Track, JBR8 and JBR2 as shown in Table 12.

Oil and gas facilities and infrastructure affect the distribution and abundance oribi by causing habitat loss, fragmentation and degradation leading to habitat use shift to open areas where they can avoid predation thus shifting their spatial distribution. This agrees with Prinsloo and Plumtre et al., (2011) who suggested that relatively high densities near the pad could be away to avoid predation by staying around the pads at night where there are spotlights.

Impact of oil and gas facilities on dynamics of warthog population densities and ecology at oil and gas facilities

There was a significant difference observed amongst the mean warthog abundance project road and Stringing area, New Buligi track, Albert track and Victoria track as shown in Table 16. Warthog was observed feeding, wallowing, there was no variation between the diurnal and nocturnal warthog behaviour. The population density and distribution of warthog was influenced by vegetation cover/ short fresh grass along the open areas at the oil and gas facilities provided opportunity to avoid predation and presence of wallowing points for example at the pipeline area along the project access road, presence of warthogs feeding at night suggested nocturnal warthog behaviour at the oil and gas facilities.

Impact of oil and gas facilities and infrastructure on dynamics of baboon population densities and ecology at oil and gas facilities

There was no significant difference between mean abundance of baboons across the study sites. Baboons were mostly sighted at JBR10 and JBR9 as shown in Table 14.

Baboons were tolerant to oil and gas facilities and infrastructure and they exhibited feeding behaviour throughout the study period and their abundance and distribution was

influenced by vegetation cover for example savannah woodland vegetation rather than the level of activities at the oil and gas facilities and infrastructure.

Impact of oil and gas facilities and infrastructure on dynamics of hippopotamus population densities and ecology at oil and gas facilities

Hippopotamus were not sighted at the facilities during day however they were photographed by the camera traps at JBR10, HDD and Stringing area throughout the study period as shown in Table 25, 26 and 33. The distribution of hippopotamus was influenced by habitat use and preference rather than the level of activity at the oil and gas facilities and infrastructure however, presence of fresh short grass around the facilities such as stringing area acted as an attractant for the hippopotamus suggesting shift in habitat use.

Impact of oil and gas facilities and infrastructure on dynamics of Carnivore population density and ecology at oil and gas facilities

The major predators such as lions, hyena and leopard were not seen during the day at the facilities except a lion which was captured by camera trap during the day at JBR10 see Figure 28 and hyenas were sighted once along New Buligi Track.

Carnivores were photographed at night by camera traps at the sites such as JBR2, JBR10, JBR8, JBR9, JBR5, JBR6, JBR6, HDD and Stringing area see Figure 32.

Distribution of predators such as lions, hyenas and leopards could have been influenced by the nocturnal behaviour and distribution of prey such as Uganda kobs present at the oil and gas facilities in the night. The study recorded very low population density of predators at sites with high level of activity/drilling at night for example JBR2, suggesting that light affected the distribution of predators across oil and gas facilities and infrastructure. The oil and gas facilities also acted as transit routes/ corridors for predators for example leopard and hyena at JBR8 were captured walking throughout the study period.

Impact of oil and gas facilities and infrastructure on dynamics of bushbuck population density and ecology at oil and gas facilities

Bushbucks were not sighted at the facilities during day however they were photographed by the camera traps at HDD in April see Table 25, JBR10 in November and March see table 26, JBR2 in April see Table 27, JBR4 in April see Table 29, JBR6 in November and

December see Table 31, JBR9 in December see Table 32 and Stringing area in December see Table 33.

Impact of oil and gas facilities and infrastructure on dynamics Birds population densities and ecology at oil and gas facilities

Habitat destruction, fragmentation and loss of breeding sites influenced the spatial distribution of birds at the Ramsar site wetland, the sighted bird species such as grey crowned crane exhibited normal behaviour such as feeding. The very low population density of birds recorded during the month of November and December was attributed to the high level of activities at the HDD and stringing area. See Table 21, suggesting avoidance behaviour due to presence of humans, and machinery causing disturbance in agreement with in agreement with Prinsloo and Plumtre et al., (2011) who suggested that total bird density was lower near the pads but stabilized between 200-400 meters from the pad/drill site.

Effects of oil and gas developments of wild animals in MFNP

The mammal species abundance varied across oil and gas facilities and infrastructure indicating more sightings at the control sites Victoria track, Albert track and New Buligi track. Oribi, Jackson's hartebeest, warthogs, were more sighted along the project road compared to the control sites and the well pads classified with low level activities such as JBR8, JBR6, JBR5, very low animal species sightings were made in very high activity sites such as JBR4, JBR3, JBR9 during the drilling phase and JBR2 where drilling was ongoing throughout the study period which suggesting that distribution and abundance of wild animal species was influenced by the level activity at different oil and gas facilities and infrastructure.

The high levels of species abundance across access roads suggested that the level of disturbance at the well pads is higher than the access road. Presence of the pipes at the stringing area acted as a barrier preventing large mammals such as elephants, Jackson's hartebeests, waterbucks, giraffes from crossing suggesting indirect habitat loss influencing the habitat use evidenced by camera trap photos showing increased animal species abundance and distribution after the pipes were pulled below the Nile river bed in the consecutive months, in agreement with (Fuda et al. 2018) who highlighted that mammals can go back to their former habitats after completion of drilling.

The study observed that some animal species appeared at the oil and gas facilities at night suggesting that the high level of disturbance as a result of noise from machines and presence of humans influenced the distribution and abundance of mammal species across oil and gas facilities and infrastructure for example presence of hippopotamus, elephants, bushbucks, waterbuck, buffalo, lion, giraffes, at JBR10, Stringing area and the HDD. The waterbuck mating behaviour captured by camera trap at the stringing area post the stringing activities suggested the high level of activity at the stringing area influenced the distribution and abundance of animal species causing habitat avoidance due to presence of humans, and machinery.

Uganda kob, Jackson's hartebeest, warthog, oribi, baboons showed tolerant behavior and were not affected by the level of activity at the sites suggesting that large mammals are more likely affected by the oil and gas activities in terms of habitat loss, light, noise and presence of humans, this is in agreement with Plumptre *et al.* (2015); who suggested that several mammal species tend to avoid areas affected by human activities up to 2km away.

Indirect and direct habitat destruction/ loss, and fragmentation resulted into shift in the habitat use for example oribi, hartebeest, waterbuck, giraffes, elephants, buffaloes, which influenced the distribution and abundance of animal species across oil and gas facilities and infrastructure in MFNP for example stringing area in agreement with Ayebare (2011), who suggested that there was indirect habitat loss at different temporal and spatial scales due to avoidance behaviour.

Large mammals such as elephants and buffaloes were tolerant to the preparatory stages of the well pads however exhibited avoidance behaviour to drilling activities due to noise and machinery disturbance however returned to facilities after when the drilling was completed in agreement with Akisiimire (2022) who concluded that animals returned to the former oil pads in big numbers.

Other mammal species such as Jackson's hartebeest, Uganda kob, oribi and warthog exhibited tolerance behaviour to the oil and gas facilities and infrastructure in agreement with Ayebare (2011). Bird species exhibited avoidance behaviour to oil and gas facilities and infrastructure.

The increased nocturnal activity was detected among several animal species in agreement with (Carter et al., 2012, Gaynor et al., 2018; Patten et al., 2019) who commented that the nocturnal activity is a strategy to avoid anthropogenic disturbance thus, competition, predation, and anthropogenic disturbance forces that drive temporal variation in species activity (Kronfeld-Schor & Dayan, 2003).

Generally animal species exhibited normal behaviour at the oil and gas facilities included; feeding, drinking water, resting/laying down, running, standing still, walking and wallowing and lekking as shown in Appendix 4. The most common behaviours observed near the oil and gas facilities and infrastructure were feeding and resting (laying down), suggesting that animals find food resources or suitable resting spots near the oil and gas facilities and infrastructure.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

1. Large mammals such as elephants exhibited avoidance behaviour especially during drilling and tolerated the preparatory phases for example well pad preparation and excavation. However, elephants returned to the sites during the post drilling and stringing attributed to reduced disturbance by presence humans, machinery and vehicles.
2. Uganda kob, Hartebeests, Oribi, baboons, patas monkey and warthogs were among the most frequently observed species near the facilities, more hartebeests and oribis were observed along the project access road than well pads and the control sites suggesting that the project road provided lush pasture, salt leaks and predator visibility that resulted into shift in habitat use for oribis and hartebeests concentrating more along the project access road compared to other sites. Uganda kob, Jackson's hartebeest, warthog, oribi, baboons showed tolerant behavior and were not affected by the level of activities at the Tilenga footprint area.
3. Increased nocturnal behaviour amongst mammal species was detected as strategy to avoid predation, amongst Uganda kobs, oribi, hartebeest and warthog however for large mammals it was attributed to the level of disturbance by presence of humans and machinery at the oil and gas facilities and infrastructure during the day.
4. Carnivores were not sighted during the day however they were photographed by camera traps at night at the oil and gas facilities and infrastructure.
5. There were valuable bird species at the Ramsar site wetland where there is HDD (Horizontal Directional Drilling) that requires to be protected from the impacts oil and gas facilities and infrastructure.

6.2 Recommendations

Based on the results for the study, the following are the recommendations.

1. Conduct long term study focusing on the interaction of wild animal with oil and gas facilities and infrastructure in MFNP at least two (2) years because the six months study period was short.
2. A study about predator population (predator population census) should be conducted to obtain the exact approximate number of predators in the Tilenga project footprint area
3. Ensure proper drainage of water from the well pads since it attracts large mammals such as elephants.
4. Minimize movement of vehicles, machinery and personnel during, rig mobilization and demobilization phases of well pads.
5. Emphasis on protection of critical habitats; e.g. expansion of the outer fence at JBR10 that covered the swamp that acted as a habitat for different bird species and source of water for large mammals such as lions, buffalo, waterbucks and elephants.
6. Use of murrum instead of road aggregate in areas outside the well pads to avoid animal from leaking the introduced gravel or cement.
7. Undertake routine monitoring of wildlife/ large mammals such as elephants, buffalos, giraffe for stress in the Tilenga footprint area.

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APPENDICES

Appendix I: UWA Approval



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

Our Ref: COD/96/05 17th June 2024

Philippe Grouiex
General Manager
TotalEnergies EP Uganda
P. O Box 34867
KAMPALA

NOTIFICATION OF STUDENTSHIP ON DYNAMICS OF WILD ANIMAL INTERACTION WITH OIL AND GAS FACILITIES AND INFRASTRUCTURE IN MURCHISON FALLS NATIONAL PARK

Reference is made to your letter dated June 6, 2024 in regard to the above subject.



This is to inform you that permission is granted to **Mr. Enos Nahabwe** to undertake the aforementioned study in Murchison Falls National Park from 17th June 2024 to 17th June 2025.

Please, note that TotalEnergies will be required to submit to Uganda Wildlife Authority progress reports every year in June starting 2025 and a final report of findings at the end of July 2025 for use in making informed decisions, plans and management interventions.

By copy of this letter, the Chief Warden, Murchison Falls Conservation Area (MFCA) is notified to accord the student the necessary support.

I look forward to your continued support and collaboration.

Conserving for Generations
Yours sincerely,



John Makombo
FOR: EXECUTIVE DIRECTOR

Copy to: Chief Warden, MFCA
Director Conservation, UWA
Senior Manager Monitoring and Research, UWA

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

Appendix III: Camera trap photos of animal Species at the Sites in the study Area.

Oribi



Leopard



Hyena



Buffalo



Elephants



Porcupine



Bunyoro Rabbit/ Hare



White tailed Mongoose



Serval cat.



Genet cat



Waterbuck



African Civet.



Bush pig



Hippopotamus



Grey Heron



Baboon



Bushbuck.



Giraffe



Jackson's Hartebeests



Uganda Kob.



Lioness and Cubs at JBR4



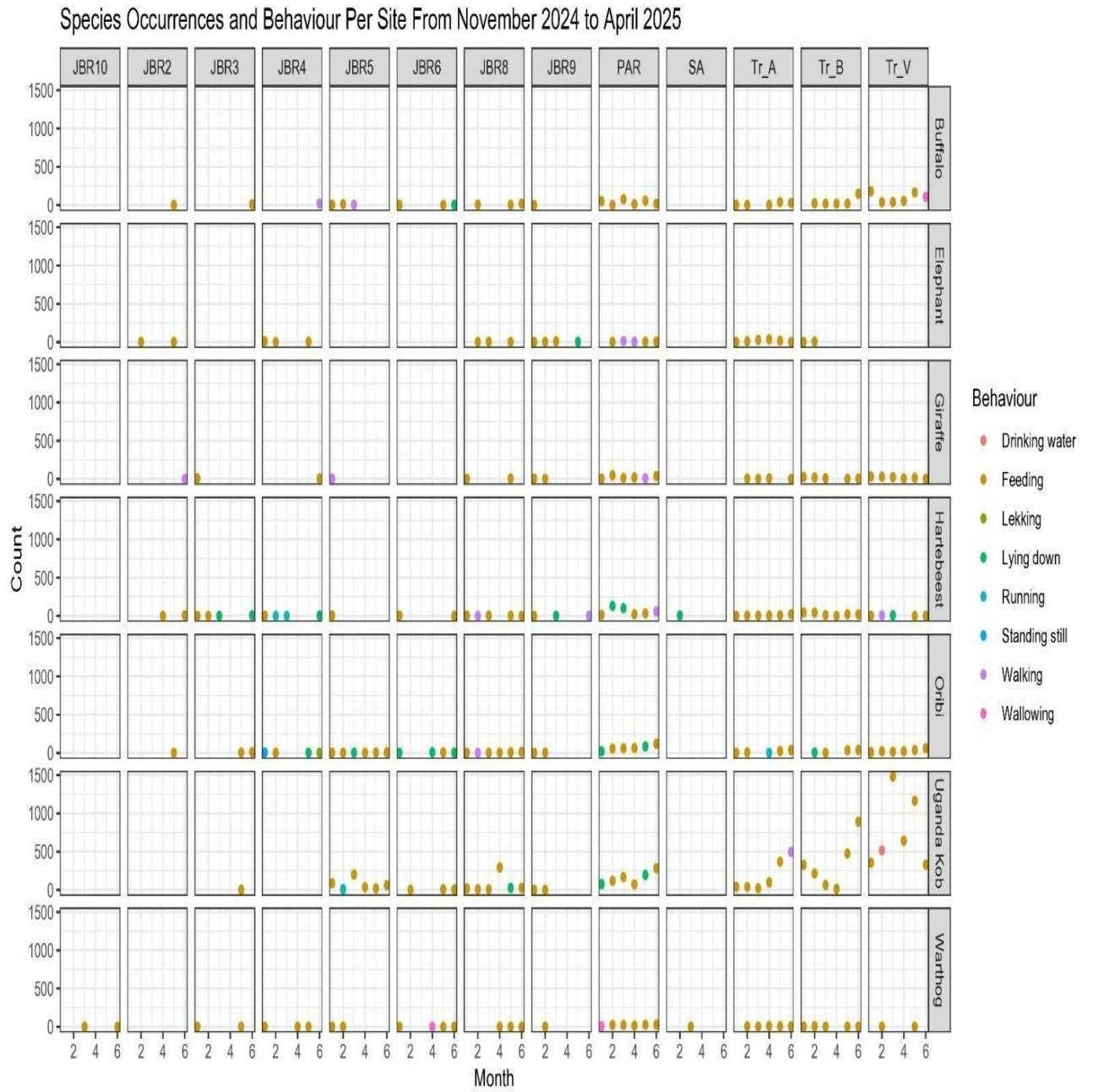
Lioness at JBR6



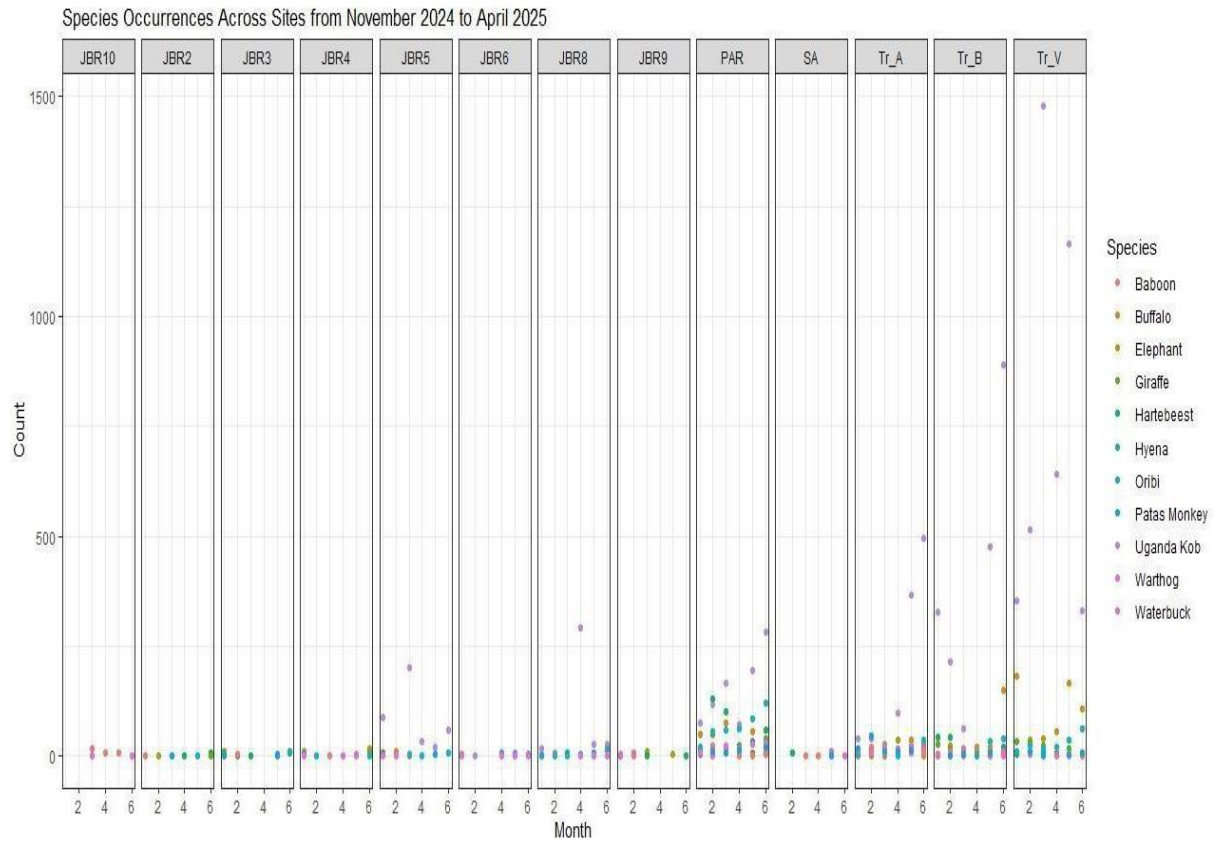
Lion at JBR6



Appendix IV: Species occurrences and behaviour across sites



Appendix V: Species Occurrences across Sites



Digitisation and Self-Archiving Consent Agreement: Theses

Agreement between Makerere University & Students (Authors of Theses / Dissertations / Reports)

1. The author is a student of Makerere University and author of the thesis / dissertation entitled:

Abundance and Distribution of wild animals around
oil and gas facilities and infrastructure in
Murchison falls national park Uganda.

2. The author grants to the University:

- The right to deposit the electronic version of the Thesis / Dissertation into Makerere University Institutional Repositories (Mak IR) or (Mak UD); and
- The right to store the thesis / dissertation in Mak IR / Mak UD and make it permanently available to the general public via the Internet at no cost to the general public after a grace period (if any is specified). Choose one of the two options below:
- The Author may opt for immediate open access to the public
- Or Restrict access indefinitely or for the specified number of years:

3. The author warrants that to the best of the authors knowledge and belief:

- The thesis / dissertation is an original work;
- The author is the owner of all the intellectual property in the thesis / dissertation;
or
- The Author is entitled to deal with the intellectual property in the thesis / dissertation by publishing it on the Internet
- The Author has the right, power and authority to enter into this Agreement and to grant the University the rights contained in this Agreement; and
- The University's use of the thesis / dissertation pursuant to this Agreement will not infringe the intellectual property rights of any third party.

4. The Author acknowledges and agrees that the University is not responsible or liable for any breach of the intellectual property rights in the thesis / dissertation, in particular any breach of copyright, as a result of the use of the thesis / dissertation pursuant to this Agreement.

5. The University acknowledges that the rights granted by the Creator in clause 2 of this Agreement, do not cause any transfer or assignment of any proprietary rights in the intellectual property in the article to the University.

Signed by the Author as confirmation that the Author has read and accepted the terms of this Agreement:

Name: MAHABWE ENOS

College/School: SVAR Department: MAAR - COVAB

(Tick) Type of Degree: (Undergraduate / PGD / Masters / PhD), Reg. No.: 2023/HD17/3301U

Tel No.: 0781809747 E-Mail: enahabwe99@gmail.com

Signature:  Date: 29th Dec - 2025

Supervisor's endorsement: 