THE EFFECT OF BUSHFIRES ON ABUNDANCE AND DIVERSITY OF MAMMALS IN MIOMBO WOODLANDS UNDER DIFFERENT FOREST TENURE, KILOMBERO DISTRICT TANZANIA

LUKELO MATIMBWI

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ABSTRACT

Miombo woodlands are the largest savanna in the world and dominate southern Africa. They support the livelihoods of over 100 million people and are strongly influenced by anthropogenic fires. This study was conducted with the overall objective of determining the effect of bushfires on mammals in miombo woodlands under different forest tenure systems. Household questionnaires, checklist of probe questions for key informants, participant observation, PRA techniques and field inventory were employed in data collection. Data collected during PRA were analyzed with the help of the local communities. Content and structural-functional analysis techniques were applied to qualitative data and information. Statistical Package for Social Sciences (SPSSs) software was used to analyze quantitative data. Microsoft excel software tools were used to analyze mammals stocking data collected through inventory. Analysis of Variance (ANOVA) was used to test whether there were significant differences between the mean numbers of mammals obtained from different forest tenure systems. Shannon - Wiener Index (H') was used to determine species diversity of mammal species from different forest tenure systems. The results indicated that the main causes of bushfires in miombo woodlands was due to farm preparation 44.5%, charcoal making 21.1% and hunting wild animals 18.9%. Illegal timber harvesting and honey harvesting were considered as minor causes. In most cases the total numbers of mammals in a given area were higher in Central Governmental Forest Reserve followed by Local Government Forest Reserve and the least in Village Forest Reserve. However for the diversity indices, the mildly burned blocks in the Central Governmental Forest Reserve were 3.2 while in the Village Forest Reserve it was 2.0 and in the Local Government Forest Reserve it was 1.6. For moderately burned blocks the diversity index value for the Central Governmental Forest Reserve and Village Forest Reserve were similar which were 2.0 while it was 1.6 in the

Local Government Forest Reserve. For the severely burned blocks the diversity values were 1.5 for the Central Governmental Forest Reserve, 1.4 in the Village Forest Reserve and 1.2 in the Local Government Forest Reserve. Mammals with low fire escape rate such as rock hyrax were more severely affected by bushfires. It is, therefore being recommended that the current Local Government Authority management regimes should be strengthen to ensure increased local community participation with more effective law enforcement measures so as to rescue the forests from degradation. Communities should, similarly be empowered with credit facilities and support on income generating activities so as to reduce dependence on miombo woodlands.

DECLARATION

I, Lukelo E. Matimbwi, do hereby declare to neither the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution

_____ _____

Lukelo E. Matimbwi Date

(MSc. MNRSA)

The above declaration is confirmed

_____ _____

Professor Madoffe, S.S. Date

(Supervisor)

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DEDICATION

This work is dedicated to my parents and my family: My late father Ezekiel Faluhenga Matimbwi and my mother Tulayaga Kyunga for laying a strong foundation for my education.

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LIST OF ABBREVIATIONS AND ACRONYMS

CBFM	Community Based Forest Management
CGFR	Central Government Forest Reserve
FAO	Food and Agriculture Organization
FR	Forest Reserve
LGA	Local Government Authority
LGFR	Local Government Forest Reserve
PFM	Participatory Forest Management
SPSSs	Statistical Package for Social Sciences
VFR	Village Forest Reserve
VG	Village Government
VNRC	Village Natural Resources Committee

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

It is estimated that, Tanzania mainland had 38.8 million hectares (ha) of forests representing about 41% of the total land area in 2011 (FAO, 2011). The total forest area includes natural forests, plantations and woodlands. Miombo woodlands are amongst the largest continuous dry deciduous forests in the world (Desanker *et al.,* 1997). The contribution of these forests to the national economy is very high even though currently data on the provision of products and services is underestimated due to unrecording of other forest products, apart from timber, such as wild fruits, vegetables, herbs, thatch grasses and other services such as catchments and biodiversity values (URT, 2001). According to MNRT (1998), it is estimated that over 75 million people in Africa live within the Miombo ecoregion and that the woodlands directly support the livelihoods of over 40 million people.

Despite the importance of the miombo to livelihoods, bushfires is a serious threat in this ecosystem (Chidumuyo, 2002). Fire is serious threat in most of the natural and plantation forests which destroy from small organisms to larger ones depending on its magnitude and coverage. In the Miombo woodlands, most species suffer reduction in populations during or immediately after fire. Many individual mammals and plants are killed through burning or suffocation (UNEP_SARDC, 2009). Others may survive the fire, but die shortly afterwards due to predation by other species and/or through shortages of food and habitat (UNEP_SARDC, 2009). However, some mammals survive and, like plants, using various survival techniques in their response to fire (Davies, 2011). Even though fire is believed to have adverse effect to flora and fauna. Low fire intensity burning of litter and

undergrowth under mild weather conditions offers the only practical way of reducing fuels in forests and woodlands (Viklund, 2011). Other approaches have been suggested such as mechanical removal of litter and undergrowth, but have not proved to be practical or cost-effective. Fire also acts as a preventive land management tool through fuel reduction. Vegetation thinning and related activities such as maintenance of access trails. Fire breaks can have a beneficial impact in reducing the likelihood and severity of natural bushfires (Stephens, 2010). Some plants actually need heat and smoke to release their seeds. This suggests that fires are critical to the successful reproduction of certain plant species (Davies, 2011).

Tanzania, like other eastern and southern African countries, is significantly affected by wildfires. Though estimating the spatial distribution and size of wildfires in Tanzania is currently hampered by the absence of a long-term fire monitoring programmes, the limited number of existing information sources suggests that fire is a widespread phenomenon.

The fire affected area in Tanzania is about 12% yearly during the period from 2001 to 2007 (Archibald *et al.,* 2010), thereby ranking fourth within the SADC region. Forest fires destroy about 65 000 ha of forests of different tenure regimes and other wooded areas annually (MNRT, 2009). More than 75% of these fires occur in Miombo woodlands, followed by forest plantations (20%) and least in nature reserves (5%) (MNRT, 2009).

Forestry in Tanzania are managed under fire management regimes namely Central Government, Local Government and Village Government (MNRT, 2009). It is envisage in current study to identify the effect of bushfires on mammals in miombo woodlands

under different forest tenure regimes such as the Central, Local and Village Government Authorities in order to generate some information which could facilitate management decisions.

1.2 Problem Statement and Justification

It is widely acknowledged that increased immigration of cattle herders and farmers from other areas in search for pastures and farming land has increased incidences of bushfires in Kilombero District. Fire has direct effects which are negative and positive with regard to conservation by modifying both the post fire microclimate and the activity of soil biota. Organisms differ widely in their response and tolerance to fire and in their capacity to recover afterwards (Zohlo, 2005).

Mammals respond differently to fire. For example some mammals run away from fire, others hide from fire while others are directly affected. The effect on plants could have indirect effect on mammals because mammals do depend on plants for food and habitat. It is widely known that in Kilombero District, bushfires have high negative effect on the diversity of flora and fauna under different forest tenure regimes, but the recognition of the magnitude of its effects has been understudied and or overlooked and burning still continues due to inappropriate policies and weak law enforcement systems.

Despite the fact that several studies have been conducted in Kilombero Forest Reserves under different forest tenure regimes, little is known about the effect of bushfires on mammals. In Kilombero District, there are three main forest tenure systems namely Central Government, Local Government and Village Government forests.

Understanding the intensities and effects of bushfires on the loss of diversity and abundance of mammal species in th forests under different forest tenure systems will facilitate conservation and management efforts in Kilombero forest reserves and similar other sites in Tanzania.

Findings from this study are also expected to contribute in improving the envisaged Fire Reduction Strategy for the Miombo woodlands and also the National Forest Policy.

1.3 Objectives

1.3.1 Overall objective

The general objective of this study was to determine the effect of bushfires on abundancy of mammals in miombo woodlands under Central Government, Local Government and Village Government Authorities forest tenure systems.

1.3.2 Specific objectives

i. To determine the main causes of bushfires and their intensities in different forest tenure
ii. To assess the effects of bushfire on the mammals diversity and abundance in the study forests.
iii. To evaluate and document the effectiveness of applied fire management strategies in each of the study forests.

1.4 Hypotheses

This study was guided by two main hypotheses:-

HO_1: Bushfires has similar effects on mammals abundance and diversity in miombo woodlands under different forest tenure systems.

HO_1: Bushfires have different effect on mammals abundance and diversity in miombo woodlands under different forest tenure systems.

HO_2: Fire management strategies are similar in all the miombo woodlands under different management regimes.

HO_2: Fire management strategies are different in all miombo woodlands under different management regime.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Miombo Woodlands Distribution and Tree Species Abundances

Miombo woodland cover a large area of central Africa, South of the equator and they cover about 3.6km^2 (Lawton, 1982; Milington *et al*., 1994). The area of the woodlands extends from Tanzania to the Democratic Republic of Congo in the North, through Angola, Zambia in the east to Malawi, Zimbabwe and Mozambique in the South (Frost, 1996). In Tanzania, the miombo woodlands are estimated to cover about 75% of the total forest area and about 40% of the Tanzania mainland (Fyhrquist *et al*., 2002) compared with about 2% of the closed canopy forests (Rodgers, 1996). These forests which are found on diverse vegetation types including the Miombo Woodlands, Montane, mangrove and lowland rain forests, provide both services and products to the adjacent communities (Malimbwi *et al.*, 2004). Miombo woodlands occur in soils with generally low levels of organic matter and low nutrients as a result of the abundant activities of insects and frequent fire incidences (Lawton, 1982).

2.2 The effect of Wildfires in the Miombo Woodlands

The long term impact of frequent fires may result in changes in productivity and population structure of the plant and animal species (Zolho, 2005). Forest fires reduce plant biomass and litter, thereby altering the energy, nutrient and water fluxes between the soil, plants and atmosphere. These changes in turn may affect the long term nutrient status and productivity of the system and consequently population structure of a community, the composition and ultimately, the probability and characteristics of future fires (Frost and Robertson, 1977). Fire also kills animals that are unable to escape or avoid excessive heat and smoke (Frost, 1996). The ranges that have burned are habitats of different species

with restricted home range. Herbivores and birds are also specifically affected by fire through changes in their habitat (used for cover, shelter and structure and breeding conditions), food supplies and increased risk of predation due to loss of vegetation (WCS, 2009). The effect of fire frequency on organisms is mostly related to its impact on the soil, water, atmosphere and their interconnectedness. Also frequent fires reduce mammal's densities, and can influence changes of floristic and structural composition by killing or suppressing individuals in the smaller diameter size classes (Zolho, 2005).

In developing countries land and forest resources are the most basic for social and economic development of the people. However, with high population growth rates, total demands of these resources is increasing, exerting increasing pressure upon the natural resources base and productive land resources are increasing becoming scarce in most of the countries (FAO, 2005). As a result, some forests are being degraded in both quality and quantity. To streamline the social and economic activities both in and outside the forests, government has often promulgated laws to protect, manage and guide the use of forests (URT, 2002). Even though the laws for managing the forests exist, forest reserves in Tanzania for example continue to be degraded through encroachment for permanent settlement, timber and wood fuel harvesting, livestock keeping, bushfires and farming (MNRT, 1998). Uncontrolled burning is usually carried out in the forests and woodlands by pastoralists as a way of inducing growth of fresh grass and eradicating tsetse flies. Moreover, farmers also use fire in clearing farm – lands while honey collectors and hunters also cause forest fires. Fires are common in the dry season and cause great losses in terms of vegetation burned. The loss of vegetation has resulted in exposing the topsoil and has resulted in soil erosion in various places (FAO, 2011).

2.3 Forest Management Regimes in Tanzania

In terms of ownership, Tanzania's forests are classified as government (Central and local) forests reserves, general land forests, community/ village, and private forests (MNRT, 1998). Forests provide wildlife habitats, unique natural ecosystems and biological diversity and water catchments (Dugilo, 2009). Although it has been observed that security of tenure is an essential instrument in sustainable forest management, in Tanzania about 50% of forestland is in general land and is more or less under open access regime (Singo, 2007).

Until the 1990's most forests in Tanzania were managed centrally through ''top down'' approach where the Government policed the forest. In the late 1990's the forest policy however changed and the concept of ''bottom up'' (participatory) approach was introduced (MNRT, 1998). Experience in Tanzania shows that centralized ''top – down'' conservation is only effective with large expenditure on law enforcement and that is why in the forest policy of 1998, the Tanzania government gradually released itself from direct management of the resources, thus Participatory Forest Management (PFM) emerged (MNRT, 1998). PFM makes people living adjacent to the forests the guardians of the forest resources which appear to be the most viable, effective, cheaper and long lasting way to manage natural forest resources (Kajembe *et al.*, 2003).

Participatory Forest Management (PFM) is a strategy to achieve sustainable forest Management through encouraging collaborative management of forests and woodlands. The concept of PFM has grown to form two concepts of Community Based Forest Management (CBFM) and Joint Forest Management (JFM). Joint Forest Management is a collaborative management approach which divides forest management responsibility and returns between the forest owners (usually central or local government but occasionally

the private sectors) and the local communities. It takes place on land reserved for forest management such as National Forest Reserves for Catchments, Mangroves or production purposes. It is formalized by signing of Joint Management Agreement between Village Representatives and the government (either District Council or Ministry of Natural Resources and Tourism). On the other hand CBFM takes place in forests on village land, land which has been surveyed and registered under the provisions of the Village *Land Act* (1999) and managed by the Village Council. Under CBFM, villagers take full ownership and management responsibility for an area within their jurisdiction and it is ‘’declared’’ by the village and the District Government as Village Land Reserve (MNRT, 1998).

2.4 Causes of Fire in Miombo Woodland

Forest fire (also known as bushfire) is a moving combustion reaction, spreading outwards in a band from its ignition point, leaving a burned out forest behind it (FAO, 2011). Common causes of bushfires include lightning, arson, accidental ignition from agricultural clearing, campfires, cigarettes and dropped matches, machinery, and controlled burn escapes (Walles, 2011). Fire control is the major consideration in the management of natural regeneration in miombo woodlands in Africa. Fires may be natural, but deliberate man - made burning is common in the miombo woodlands. Bushfires are often deliberately started to facilitate hunting, pasture and clearance of tsetse flies from settlements. Intense dry fuels are a characteristic feature of the miombo woodlands (Nyondo, 2002).

Fire and forest clearing is considered to be the chief agents of deforestation and degradation in the Miombo woodlands of Tanzania (Fyhrquist *at el.,* 2002). Most of these wildfires occur in Miombo woodlands (75%), followed by forest plantations (20%)

and least in the high forests (5%) (FAO, 2007). These percentages indicate that forest degradation from uncontrolled fires alone contribute significantly to the total causes of forest land degradation in Tanzania mainland.

2.5 Forest Fire Intensities and Ecosystem Maintenance

Fire and forests go back to the prehistoric era; they have been with each other for millions of years. Fire as a preeminent partner, a re-generator, a rejuvenator plays a greater roles in the development of the temperate world's forest ecosystems (Nix, 1977). Species such as Silver Wattles (*Acacia dealbata*) and Blackwood Wattles (*A. melanoxylon*) may survive due to regrowth from root suckers, and/or soil stored seeds after roots get exposed to fire (DSE, 2011). Fire was reported to be a major ecological factor, which led to the development of the Miombo woodlands (Lawton, 1978: Zahabu, 2001). The impacts of fire in Miombo depend on time and frequency of burning and on the flammable biomass. Based on burning experience Compyby (2011) reported that repeated late and hot fires may destroy about 50% of the trees and mammals after eleven years of late fires. While early burning if allowed could maintain regeneration, complete protection leading to the development of a more closed, partly evergreen forest.

Fire has been part of Miombo since the early Stone Age, about 60,000 years ago and it has been associated with the development and maintenance of tropical savannas (Zohlo, 2005). Fire has a direct effect by modifying both the post fire microclimate and the activity of soil biota. Plants in Miombo woodlands differ widely in their responses and tolerance to fire and in their capacities to recover afterwards (Zohlo, 2005). Much of the fire occurs regularly and frequently during the dry season from May to November with most occurring during the hot dry season from August - October and mainly in the

understory of the Miombo woodlands (Chidumayo, 1997). Fire burning in the early dry season (May-June), when the ground layer is still moist tends to be very low in intensity and limited in extent (Frost, 1996). Kall (2006) pointed out that early dry season fire affects grasses and mammals negatively while woody plants are less affected. As season progresses and the ground layer dries out, the fire intensity increases. Late season fires often completely burn up ground layer vegetation, cause substantial leaf scorch in the canopy and cover large areas (Frost, 1996). Cauldwell (2000), explained that late season burning inhibits regeneration of trees, leading to overtime loss of the tall canopy forming trees of the genera *Brachystegia spp, Julbernardia spp,* and *Isorberlnia spp*. and most mammals found in Miombo woodlands.

2.6 Forest Fire Management Initiatives and Strategies in Tanzania

Efforts to combat forest fires in Tanzania in general are hindered by lack of fire management policies and legal instruments to support fire prevention and suppression. Furthermore, technical and professional human resources are also inadequate at all levels. It is for this reason that collective efforts involving local communities in fire management should be encouraged. The local communities have their own management systems and forest fire management strategies that complement the local ecology and traditions. For example, the Sukuma people traditionally reserved Ngitili (a Sukuma term meaning "enclosure") (Nssoko, 2013). This area within the village is closed off from livestock grazing at the beginning of the wet season and opened during the dry season. This traditional practice has protected many areas from fires. Therefore, Joint Forest Management (JFM) efforts and strategies need to be implemented, considering that the government does not have sufficient resources to combat forest fires (FAO, 2011). Timing of fires is a major problem in the management of natural regeneration in the

woodlands in Africa. Miombo woodlands will regenerate if the grass is burnt during the cool season (prescribed burning) because the grass is still moist and therefore burns less fiercely. Many ecologists and forest managers use fire as a management tool following strict and predetermined fire management regimes as dictated by forest management objectives (Nyondo, 2002).

WWF (2006) recommended that in order for fire management to be successful, local communities need to be empowered through awareness raising, environmental education, and where necessary to support them in terms of firefighting gears and through legal enforcement by respective authorities; furthermore introducing more promising and acceptable alternative economic activities, which are environmentally sound like modern beekeeping, zero grazing for dairy cattle and goats, fish and butterfly farming is recommended. These would act as incentives for the community to effectively participate in implementing the proposed sustainable forest fire management plans. There should be proper enforcement and monitoring in respect of the agreed community based by-laws, fines and penalties for the uncontrolled forest and bush fires. In some cases where the offenders are not members of the communities, culprits should be referred to the courts of law, all the prerequisites for successful controlled burning should be thoroughly followed up as per the agreed Community - Based Fire Management Plans, the responsibility for fire management should be given to the Village Environmental Committee in order to avoid unnecessary clashes in the course of executing their responsibilities and the committees need to be supported in terms of fire management plan and by-laws development and enforcement, awareness raising of the problems, damages of uncontrolled fires and training on sustainable fire management approaches.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

3.1.1 Location

This study was conducted in three miombo woodland reserves with different land tenure in Kilombero District. These reserves were namely Nyanganje FR (under Central government) located between latitude 07^{o} 56' and 8^{o}4' South and longitude 36^{o}39' and 36^{o} 50', East 15 km North East of Ifakara town, Ihanga FR (under District council) which is found between latitude 08^{0} 25’ South and longitude 36^{0}20’ East, and Itundufura FR (under Village government) which is located between longitude 08^{0}18’ south and latitude 36^{0} 06’ East. The district has a total area of 14 918 km^{2} and it lies between 300 – 1700 metres above sea level.

3.1.2 Climate

Kilombero District receives rainfall averaging between 1200mm to 1850mm per annum. The District has bimodal rainfall pattern falling between March to May (long rainy seasons) and October to December (short rainy seasons), and the mean daily temperature ranging between 26°C to 32°C.

3.1.3 Flora and fauna

Species composition generally depends on the environmental factors like soil conditions and dynamic factors like fire (Frost, 1996). The common species found in the miombo woodland includes tree species like *Brachystegia boehmii, Brachystegia bussei, Julbernardia globiflora, Brachystegia spiciformis, Pseudolachnostylis maprouneifolia, Pterocarpus angolensis and Dalbergia melanoxylon* (Backe´us *et al.*, 2006). Wildlife

such as elephants (*Loxodanta africana*), buffaloes (*Syncerus caffer*), Lion (*Panthera leo*) Spotted hyena (*Crocuta crocuta*), Rock hyrax (*Procavia johnstoni*), White and Black colobus monkeys (*Colobus angolensis sharpie*) Greater Kudus (*Tragelaphus strepsiceros*), rodents and variety of birds are also found in the same woodland area in Kilombero District (Frontier Tanzania, 2003).

3.1.4 Human population and economic activities

According to population and housing census of 2012, Kilombero District had a population of 321 611 people of which 169 397 were males and 162 214 females. The growth rate is 3.4% which is above the National annual average of 2.1%. The main ethnic groups are Wapogoro, Wandamba, Wabena, and Wambunga and several others in small proportions. On the other hand, the main economic activities conducted by majority of the local people include crop farming, livestock keeping and petty trading.

3.2 Methods

3.2.1 Reconnaissance survey

Before actual data collection process, a reconnaissance survey was conducted in the area so as to pre – test the data collection tools and modifications done accordingly so as to suit the prevailing local conditions.

3.2.2 Data collection

Biophysical and socio economic data were collected from different areas namely:-

The Kilombero District Catchment Project Office, Kilombero District Council Officials and forests adjacent villagers of Kiberege, Lungongole and Ihanga and NGO's. Additional secondary information was obtained from different sources.

3.2.2.1 Biophysical data

Assessment of mammal species composition and distribution between forests under Central government forest (Nyanganje Forest Reserve), Local government forest (Ihanga Forest Reserve) and Village forest (Itundufura Forest Reserve) was carried out through field inventories. The survey team composed of district game officer, myself and two local experts with some knowledge on wildlife of Kilombero. Each forest tenure was divided into three blocks with different intensity of burning. The blocks were namely mild incidences of fire, moderate burnt areas and severely burned areas. The former was dominantly semi – evergreen forest with less than 25% of the area burned. Moderately burned area was dominated by closed Miombo and had about 25 – 50% of the area burned and the later had lost more than 50% of the area through fires and the dominant vegetation was open Miombo and grasslands. These areas were identified by the help of historical bushfire trends from villagers, information from the District Forest Officer, District Game Officer and own field observations.

The number of plots was obtained by the following formula:-

N = (TA*Si)/ (Ps*100), Where: N=number of sampling plots, TA=total area of the forest/block, Si=Sampling intensity and Ps=plot size. A sampling intensity of 0.01% was considered for each study forest.

Strips (plots) of 10 x 30 m were established along the transect running along the contour of each block. Each transect was estimated to be 6km. In each transect a starting point was established at random and geo-referenced with the help of a GPS for subsequent reassessment and a compass was used to facilitate in finding the directions. The distance between plots was 200m and distance between transects was 200m. In each block plots were distributed equally at the middle and the edges.

In each plot the diversity and abundances of mammal species was assessed by direct observations of mammals in the field and indirectly by looking at faeces, foot prints, mammal's damages, sounds of different mammals (indices). Live trapping method (Sherman trap) was used for small mammals such as rodents to provide the most reliable and informative data about the population. The traps were baited with peanut butter to attract rodents. The team walked quietly along the transects and counted all mammals or indices on the both sides along the transects. Experience and care were taken to avoid double counting. Counting along each transect was done in the morning and evenings in order to obtain a good average and repeated fortnightly. Experienced wildlife experts and villagers were instrumental in identifying the mammal species. Specifically heaps of droppings of mammals and mammal damages facilitated in estimating the number of mammals. It was assumed that the higher the number of mammals dungs and the higher the damage level the higher the number of mammals. Higher numbers of foot prints and/or nosier environment were indicators of higher number of mammals.

3.2.2.2 Socio-economic data

Social economic data was collected from the villages adjacent to the study forests. The selected villages were Ihanga, Sagamaganga and Kiberege which are adjacent to Ihanga, Nyanganje and Itundufura forest reserves respectively. Furthermore, data were obtained from government offices and NGOs working in Kilombero District. Participatory Rural Appraisal (PRA) was employed prior to questionnaire survey. Focus group discussions were used as PRA methods for data collection and each PRA was composed of 7 – 8 respondents (Lusambo, 2009). Focus group discussions were purposely chosen so as to explore information from respondents of different ages, sexes, and occupation (Appendix 2). As a research tool, the PRA serves the purpose of opening

up discussions with villagers on particular topics of interest as recommended by Kessy, 1995.

Structured questionnaires with both open and close ended questions were administered to the heads of the selected households within the study villages so as to get information like species abundances, reasons for bushfires, area burned, frequencies of fire occurrences, control/ measures taken and fire reduction strategies (Appendix 1). A total of 30 households from each village were selected at randomly. According to Bailey (1994) a sub sample size of 30 from one observation unit is considered adequate provided that the characteristics of the study population were well excluded.

3.3 Data Analysis

3.3.1 Biophysical data

Microsoft excel software tool was used to analyze data for abundances and diversity of mammals collected through field inventory. Table 4 was used to present the summarized numbers of mammals by species of the forest reserves. Analysis of Variance (ANOVA) was used to compare mammal abundances in the different forest reserves example Nyanganje Forest Reserve, Ihanga Forest and Itundufura Forest Reserve.

Shannon Wiener Index (H') was used to determine the diversity of mammal species from each forest tenure regime. The value usually lies between 1.5 and 3.5 although it can occasionally exceed 4.5 (Kent and Coker, 1992). The index is determined by the following formula:

$$H' = -\sum_{i=1}^{s} pi * \ln pi \qquad \text{.....(1)}$$

Where;

H' Diversity index

n_i The number of individuals in species i; the abundance of species i.

S The number of species also called species richness.

pi = Proportion of individual species i^{th} and

ln = Natural logarithm

3.3.2 Socio economic data

Both descriptive and inferential statistics were carried out. The descriptive statistical analysis carried out through cross tabulation where by arithmetic mean, standard error, frequencies and percentages were computed. Statistical Package for Social Sciences (SPSS) was used in the data analysis. Socio economic data from household questionnaires survey was coded and transformed into a form amenable for analysis.

Content analysis method was used to handle qualitative data or information. The component of verbal discussion were analysed in detail with the help of content analysis method in which recorded dialogue with respondents was broken down into smallest meaningful units of information or themes and tendencies. This helped in ascertaining values and attitudes of respondents. Kajembe (1994) explained that structural functional analysis entails to explain social facts that are related to each other within the social system and by manner in which they are related to the physical surroundings.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Social Characteristics of the Respondents

The social economic characteristics of the respondents specifically age, gender, ethnicity, sex, marital status, family size, residence status and education level were used to assess the status of the respondents and how they relate and/ or influence fire occurrences and conservation practices in the study area.

4.1.1 Age distribution, gender and marital status of the respondents

The majority (49%) of the respondents were in the age group of 31-40 years, followed by the age group between 18 to 30 years (22%) (Table 1). The domination of the respondent's 31-40 years age category indicates that the community comprised of higher percentage of energetic people who can contribute to household income. Age affects experience, wealth and decision which ultimately contribute to income generation activities. Respondents aged over 60 years rarely participate in income generation activities probably because they are considered as economically not active (Ishengoma, 1998). In pursuing economic activities such as farming and hunting incidences of forest fire could also increase.

Gender identifies the social relationship between men and women. It refers to the relationship between them and the way this relationship is socially constructed (Balton, 1994). Gender is a cultural construction related to the behavior learned by men and women. It affects what they do and how they do within a specific social group (Katani, 1999). Thus, gender as a social relation has a profound influence in the role of men and women play in the management and conservation of natural resources (Balton, 1994).

The study revealed that 74.4% of the respondents were male while 25.6% were female (Table 1). This implies that majority of households in the study area were male headed and this is the typical characteristics of traditional African societies.

Majorities of the respondents corresponding to 84% married the rest 16% were either widowed, separated, divorced or single (Table 1). This is an indication of the African belief that four hands can produce better than two hands and married couples are likely to be more productive than single persons due to labour supply, hence household well-being (Muywanga, 2004). However, both married and unmarried respondents represent the mature people as far as the households are concerned.

4.1.2 Level of education, residence duration of the respondents and economic activities

Education plays important roles in socio-economic development of a particular society as a tool of transferring knowledge and experience. Education tends to create awareness, self-reliance, stimulate self-confidence, motivation and positive attitudes. Increase of education level was assumed to increase the possibility of respondents in adoption of sustainable land use practices advocated by Participatory Forest Management in the study area, since educated people have more access to technical information that enable them to participate in new innovations compared to illiterates ones. Education level was recorded with respect to the number of years that a respondent has spent in schooling. Results in Table 1 show that 83% of the respondents have attained primary level education, 12% had secondary education and about 4% of the respondents had no formal education. Given that the majority of the respondents having attained primary education as their highest education level could imply that they are knowledgeable regarding conservation issues.

Furthermore, the results revealed that about 46% of the respondents had stayed in the study area for more than 20 years followed by 38% and 17% of respondents who had stayed for up to 10 years and 11-20 years respectively (Table 1). This implies that most of the respondents have enough knowledge on the status of fire and even on its effects and ways of reducing the occurrence of forest fires in the area.

The main occupation of the respondents was farming and small business with small proportion of other employment opportunities (Table 1). The majorities were doing farming (86.7%) followed by small business like selling of crops and vegetables (5.6%), Livestock keepers contributed 3.3%. Because of the floristic composition of miombo woodlands, livestock keepers esteem Miombo woodlands as grazing area for their livestock which led to deforestation (Kajembe and Kessy, 2000; Abdallah, 2001). Livestock keepers commonly use fire in miombo to induce grass growth. Similarly farmers use fire to reduce biomass during preparation of farms and occasionally fire escapes from the farm and cause forest fires. Records from the District forest office (DNRO, 2011), show that most of fires in the District are caused by farmers followed by livestock/ pastoralists keepers.

Table 1: Characteristics of respondents in Ihanga, Kiberege and Sagamaganga Villages, Kilombero District

Characteristics/ variable	Frequency			Percentage
	Kiberege	Ihanga	Sagamaganga	
Gender				
Male	27	21	19	74.4
Female	14	8	7	25.6
Age group (in years)				
18-30	7	6	7	22.2
31-40	11	30	13	48.9
41-50	5	6	4	16.7
51-60	2	2	1	5.6
Above 60	3	2	1	6.7
Marital status				
Single	3	4	2	10.0
Married	26	30	20	84.4
Divorced	0	2	1	3.3
Widow	2	0	0	2.2
Education level				
Non formal education	2	1	1	4.4
Primary Education	15	40	20	83.3
Secondary Education	1	3	7	12.2
Residence duration				
1 – 10	4	16	14	37.8
11 – 20	5	5	5	16.7
Above 20	22	11	12	45.6
Occupation				
Farmers	18	25	25	86.7
Petty trade	2	1	2	5.6
Livestock keeping	1	1	1	3.3
Others	2	1	1	4.4

4.1.3 Ethnicity and Household size of Respondents

Table 2 shows that 19% of the interviewed households belonged to Ngindo ethnic tribe followed by Ngoni (12%) and Ndamba (11%) while other tribes accounts for (58%). It was observed that the Ngindo, Ngoni and Ndamba tend to settle in village centers while the agro-pastoralists tend to confine themselves in the periphery of the villages so as to

get grazing and farm lands, they usually start fire for increasing palatability of grazing land and farm preparation.

About 45.6% of the households had more than five individuals which is larger than national average of five people (URT, 2012) followed by categories of one to two individuals per household (37.8%). A group of three to five individuals made 16.7% of the household. Family size is an important factor for determining the extent at which labour is available in household income generation to improve livelihood however, big family sizes could contribute to the destruction of forest ecosystem services.

Table 2: Ethnicity and Household sizes of Respondents

Characteristics/ variable	Frequency	Percentage
Ethnicity		
Ngindo	21.1	19
Ngoni	13.3	12
Ndamba	12.2	11
Other tribes	43.4	58
Size of the household		
1-2	34	37.8
3-5	15	16.7
Above 5	41	45.6

4.2 Causes of Bushfire in Miombo Woodlands

Fig. 1 shows that the main causes of bushfires in Miombo woodlands includes farm preparation 44.5%, charcoal making 21.1%, hunting of wild animals 10%, cigarette remains 5.6%, illegal harvesting of logs 4.4%, local believes 4.4%, honey harvesting 1.1% and others causes was 8.9%. Low per capita income and high population growth rates in Southern Africa imply that the subsistence slash-and-burn within the Miombo zone is predominant (Chidumayo, 1997; Luoga, 2000).These results are in line with the finding of FAO (2011) which indicate that most bushfires in the Miombo and grassland

ecosystems are a result of uncontrolled human activities particularly preparation of cropping fields. Other major causes include game hunting, who either deliberately set fire on biomass in order to drive wild animals to intended destinations or to attract them later to the re-growing grass on burnt areas for an easy catch. Furthermore, honey hunting and collection are other causal factors for wild fires on the Tanzania mainland. Some beekeepers, in the process of harvesting honey, use smoke to drive away bees but often do not extinguish the fires, which lead to accidental or unwanted fires. For livestock keepers, deliberately setting fires in grasslands is meant to improve pasture quality and in some areas to eradicate parasites such as ticks or tsetse flies.

Charcoal making in miombo woodlands is also noted as a serious human activity that leads to forest degradation especially within 200-300 km radius around the major urban areas. Other activities like mining and pit sawing as well as controlled burning (prescribed biomass burning) especially in forest plantations including game reserves and national parks, at the beginning of the dry season, is done to reduce the amount of biomass and therefore, maintain conditions that could not lead to accidental fires from pedestrian smokers and arson.. On the other hand, in most incidences fires are usually started by some people for reasons known to them as mentioned above but some do cause fires to amuse themselves (cultural believes e.g. *in Tanzania some tribes believe that if one starts the fire and it ends up gutting and spreading to a large extent such a person is bound to live a long life*).

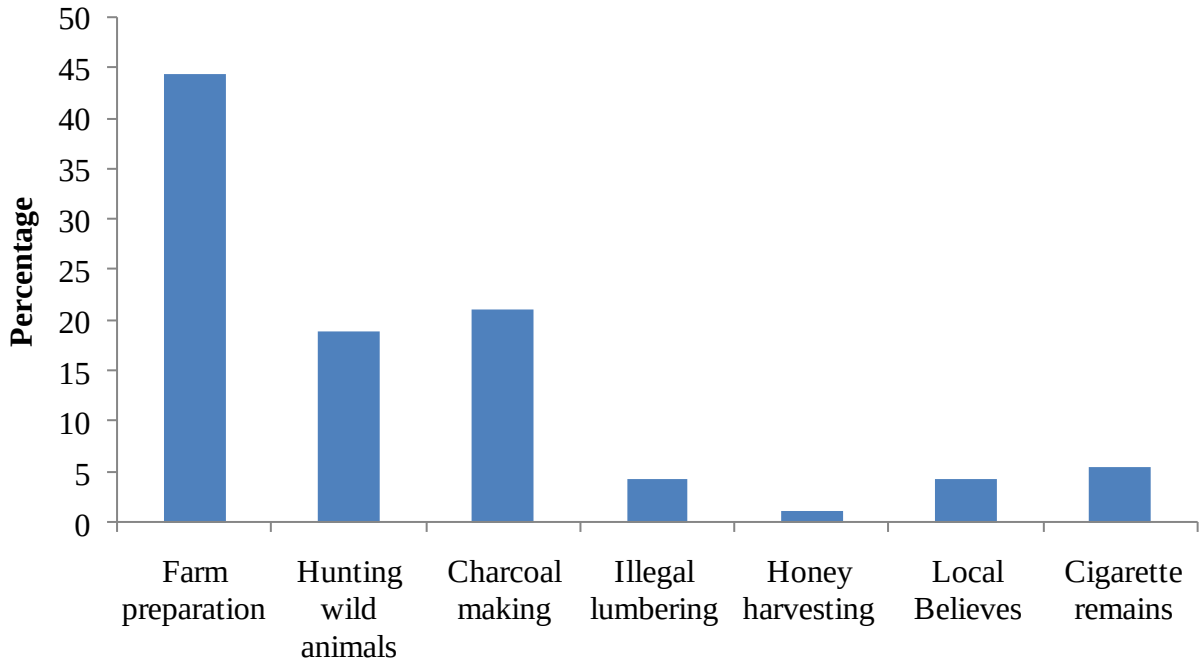

Figure 1: Causes of bushfire in Miombo woodlands

4.3 Bushfire Occurrence and Intensities in Miombo Woodlands

Table 3 shows wildfire occurrence for the past seven years from 2005 to 2011. Results showed that burning frequencies and intensities fluctuate yearly, this is because the bushfire occurrences depends on a number of factors such as amount of biomass in the forest, reasons for starting fire and weather conditions. On the average VFR had the lowest numbers and intensities of fire while LGFR had the highest number of fires. CGFR was moderate in terms of numbers and intensities.

Fire intensities and frequencies might have been attributed by the sense of ownership (tenure and incentives) which had showed an effect on fire incidences. According to FAO (2010), various factors influence a government's decision to embark on tenure reform. It is increasingly recognized that a shift towards more diverse tenure arrangements, is necessary for creating better conditions for the achievement of forest management

objectives. These objectives refer to Sustainable Forest Management and enhanced economic outcomes by rescuing the abundances and diversity of mammals.

Table 3: Bushfire intensities in Miombo woodlands

Year	Management regime	Number of fire occurred	Fire intensity
2005	Nyanganje FR	1	Low
	Ihanga FR	2	Moderate
	Itundufura FR	1	High
2006	Nyanganje FR	2	High
	Ihanga FR	5	High
	Itundufura FR	1	Moderate
2007	Nyanganje FR	3	Moderate
	Ihanga FR	6	High
	Itundufura FR	1	Moderate
2008	Nyanganje FR	1	Low
	Ihanga FR	3	High
	Itundufura FR	2	Moderate
2009	Nyanganje FR	2	High
	Ihanga FR	1	High
	Itundufura FR	1	Moderate
2010	Nyanganje FR	2	High
	Ihanga FR	4	High
	Itundufura FR	2	Low
2011	Nyanganje FR	1	Low
	Ihanga FR	2	High
	Itundufura FR	2	Low

The results showed statistical significant differences between means of bushfires occurrences between CGFR versus VFR and LGFR versus VFR as 0.956 ± 0.337 and 1.556 ± 0.334 respectively ($p < 0.05$) which signifies the higher number of bushfire occurrences in these forest reserves. Thus, efforts intended to overcome bushfire occurrences should be equally implemented in all the forest reserves because of their effect on mammal's species abundances and diversity in Miombo woodlands. It is important to encourage local and higher government authorities to adopt community development plans and enforce regimes that emphasize risk mitigation and fire smart principles because they have better strategies in managing wildlife and ultimately reduce its negative effect to natural resources (British, 2010).

4.4 Bushfire Management Strategies in Miombo Woodlands

Even though in Miombo woodlands there are a number of bushfire management strategies which are being used in combating occurrences of bushfires, fire is still a threat to the existence of mammals in these woodlands. Results showed that, these strategies include conducting forest patrols (34.4%), followed by VNRC's members selection who acts as key implementers of participatory forest management (25.6%), use of by-laws (23.3%), conducting bushfire campaigns (6.7%), and the use of fire management teams (10%) (Figure 2). In order to manage bushfires now and in the future, including potentially catastrophic events, the Strategic Bushfire Management Plan (SBMP) sets out the strategies and the specific actions by which the communities and the Government can better manage bushfires and reduce their consequences to life, property and the environment (Corbell, 2009).

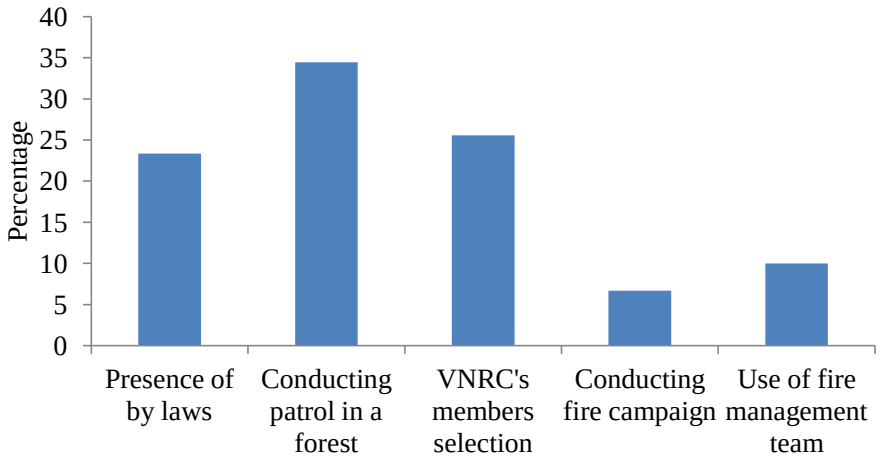

Figure 2: Bushfire management strategies in Miombo woodlands

In this study 65.6% of the respondents indicated that there are fire management strategies in the area while 34.4% reported of no fire management strategies in their villages. This shows that the strategies are not well implemented at the local forest adjacent communities and hence poor forest conservation.

Results of PFM as fire management strategies in Miombo woodland indicated that 63.3% of the households said that PFM had significant contribution on alleviation fire problems in Kilombero Forest Reserves. According to FAO (2011), inadequate institutional capacity in terms of technical and professional staff as well as financial resources, leds to failure in managing the fires accordingly. In that context: engagement, collaboration and involving local communities in integrated fire management should be encouraged. About 32.2% of the households responded that PFM does not contribute in reducing fire incidences while about 4.4% had no clue on PFM (Fig. 3).

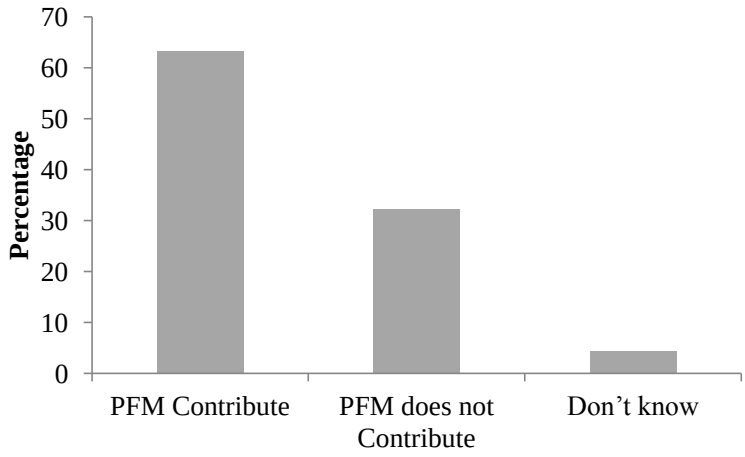

Figure 3: Contribution of PFM in alleviating bushfire problems

Statistically, results showed that there is no significant difference ($p < 0.05$), between the fire reduction strategies in the forest under CGFR versus LGFR (0.00 ± 0.125) and VFR versus CGFR (0.033 ± 0.125). This shows that the fire management strategies for forests under different management regimes are different.

4.5 Status of Mammals Due to Forest Fire

About 71% of the respondents reported that mammal species in the Miombo woodlands have disappeared due to fire and 29% said that mammal species have remained the same. Forest fires reduce plant biomass and litter, thereby altering the energy, nutrient and water fluxes between the soil, plants and atmosphere. These changes in turn may affect the long term nutrient status and productivity of the vegetation and hence destroying the habitat of other mammals (Frost, 1996). Fires also kill individual organisms, damage or destroy unprotected living tissues, modify growth and reproductive rates, change the availability and use of resources and alter competitive and other relationships between organisms. The other reason for disappearing of mammals is due to hunting and some of them free away from their niche.

4.6 Effect of Fire Regimes on Mammal's Species Diversity in Different Forest Tenure

Shannon Wiener diversity index value in the moderately burned forest blocks diversity was 2.0 under the Central Government (Nyanganje Forest Reserve) and those under the Village Government Authority (Itundufura Forest Reserve) while value for Forest Reserve under Local Government Authority (Ihanga Forest Reserve) was 1.6 (Fig. 4). For severely burned blocks diversity values were 1.5, 1.4 and 1.2 for CGFR (Nyanganje forest Reserve), Village Government Authority (Itundufura Forest Reserve) and Local Government Authority (Ihanga Forest Reserve) respectively. For mildly burned blocks the Shannon Wiener index were 3.2, 2.0 and 1.6 for the CGFR (Nyanganje forest Reserve), under VFR (Itundufura Forest Reserve) and Forest Reserve under Local Government Authority (Ihanga Forest Reserve) respectively

Overall, the Shannon Wiener index values of diversity (H') revealed that, the CGFR had highest diversity followed by that of VFR with the LGFR having the least (Fig. 4). These findings are in line with those observed by Zahabu (2008), which also, had a clear indication of higher species diversity in the managed forests than in unmanaged one. In Tanzania, the Central Government forests are generally better managed than LGFR. Species diversity is higher in the forests under the Central Government because there is a combination of law enforcement and involvement of adjacent local communities involvement in the management of the forest resources. Madoffe and Munishi (2005) identified wildfire as the biggest single threat to the Eastern Arc Mountain forests causing devastating effects to biodiversity and water conservation. Shannon Index showed no significant difference ($p < 0.05$) between effects of bushfires on mammal species, found in different forest tenure regimes. The fire regimes lines are almost parallel to each other indicating that bushfire have moreless similar effect on mammals in Miombo woodlands under different forest tenure.

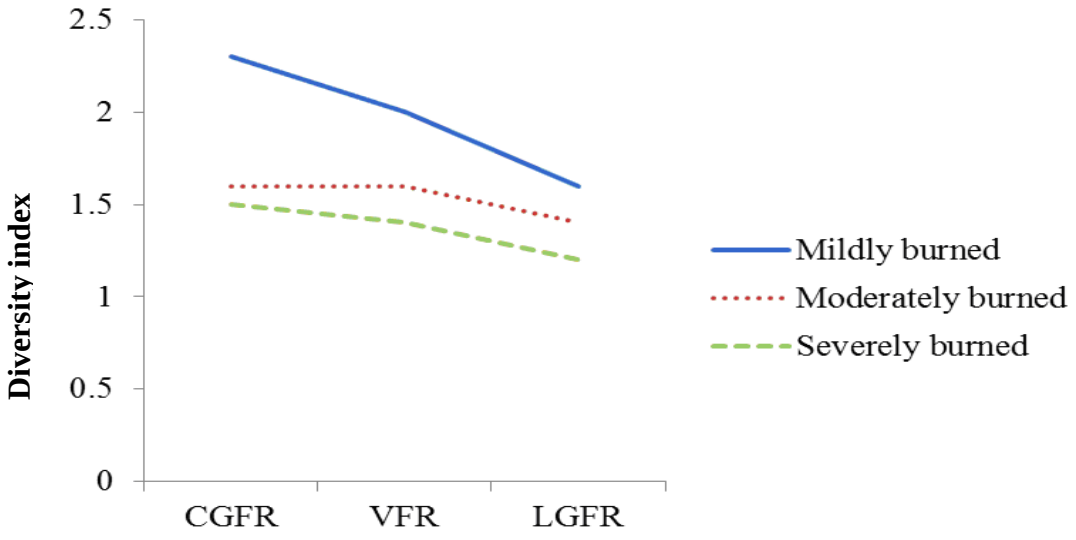

Figure 4: Effect of fire regime on mammal species diversity in different forest tenure, Kilombero District

4.7 Effect of Fire Regime on Mammals Abundance under Different Forest Tenure

Fig. 5 shows the abundance of mammal species present in the forests under different tenure. Forest tenure and fire management regimes have direct effect on the abundance of mammals. Distribution of mammals in terms of numbers per hectare showed that in the mild burned site the numbers were 45, 22, and 20 for CGFR, LGFR and VFR respectively. For moderate burned site the numbers were 28, 23, and 24 for CGA, LGA and VFR respectively. For severe burned site numbers of mammals were 25, 23, and 10 for CGFR, VFR and LGFR respectively. Generally, the numbers of mammals in the VFR and LGFR were much lower than those of forests under Central Government ownership. The number could be higher due to better habitats in the CGFR as a result of better management. Central Government has regular budget, more patrol and laws are better implemented (Madoffe and Munishi, 2005).

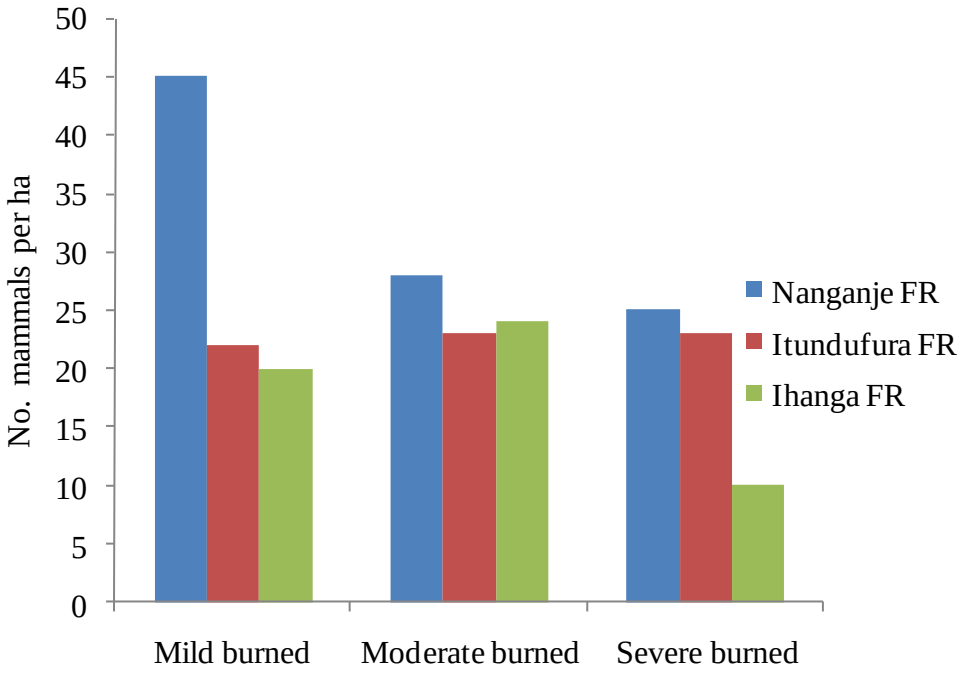

Figure 5: Mammals abundance in forests under different tenure

The Local Government forest are heavily encroached by the local communities and the mammals don't feel secure consequently they free from LGFR for safety. Forest protection helps to ensure the long-term survival of the mammals and trees which are the habitats for mammals and address rural poverty (Penn, 2010). In this study, a total of 16 mammal species were identified in the three forests. Dominant mammal species identified are listed in Table 4, which includes *Kobus vardoni, Madoqua kirki, Colobus angolensis sharpie, Phacochoerus africanus* and Rodents. The *Colobus angolensis sharpie* species dominate the forests of CGFR, LGFR and VFR with about 43.3% of all counted individual species.

The study showed that distribution of mammal species varied widely in forest management regimes. The wide distribution of these species could have been attributed to wildfire occurrences which do not favour the perpetuation of these species. Mammals with high fire escape rate such as rodents and monkeys were not significantly affected by fire while slugsh/ slow mammals such as rock hyrax, could been more affected by fire. Fire could also have some indirect effect to mammals particularly opening up areas and destroying their niches and feeds. Some mammals such as lions need tall grass to conceal from their preys while elephants and giraffe need tall tree/ vegetation to feed on and also for shade. Conversely mild forest could have green grass growth consequently creating a good environment for population growth.

Table 4: Mammals species in different forest tenure, Kilombero District

Forest tenure	Fire regime	Common name	Mammal Spp.	Number of mammals
CGFR	Mild	Puku	*Kobus vardoni*	1
		Buffalo	*Syncerus caffer*	5
		Elephant	*Loxodanta africana*	3
		Reedbuck	*Redunca arundinum*	2
		Eland	*Taurotrugus oryx*	1
		Colobus monkeys	*Colobus angolensis sharpie*	12
		Hartebeest	*Alcelaphus bucelaphus lichensteinii*	3
		Sable antelope		1
		Waterbuck	*Kobus ellipsiprymnus*	1
		Zebra		1
		Rock hyrax	*Procavia johnstoni*	2
		Dik dik	*Madoqua kirki*	4
		Lion	*Panthera leo*	1
		Warthog	*Phacochoerus africanus*	2
		Rodent		5
		Greater Kudus	*Tragelaphus strepsiceros*	1
	Moderate	Elephant	*Loxodanta africana*	2
		Colobus monkeys	*Colobus angolensis sharpie*	5
		Waterbuck	Kobus ellipsiprymnus	1
		Rodents		3
		Rock hyrax	*Procavia johnstoni*	2
		Dik dik	*Madoqua kirki*	1
	Severely	Elephant	*Loxodanta africana*	2
		Colobus monkeys	*Colobus angolensis sharpie*	37
		Waterbuck	Kobus ellipsiprymnus	8
		Rock hyrax	*Procavia johnstoni*	6
		Dik dik	*Madoqua kirki*	4
		Warthog	*Phacochoerus africanus*	6
		Rodents		12
VFR	Mild	Elephant	*Loxodanta africana*	2
		Reedbuck	*Redunca arundinum*	2
		Colobus monkeys	*Colobus angolensis sharpie*	7
		Hartebeest	Alcelaphus bucelaphus lichensteinii	2
		Rock hyrax	*Procavia johnstoni*	2
		Dik dik	*Madoqua kirki*	2
		Lion	*Panthera leo*	1
		Warthog	*Phacochoerus africanus*	2
	Moderate	Colobus monkeys	*Colobus angolensis sharpie*	7
		Waterbuck	*Kobus ellipsiprymnus*	3
		Rock hyrax	*Procavia johnstoni*	4
		Dik dik	*Madoqua kirki*	5
		Warthog	*Phacochoerus africanus*	4
	Severely burned	Colobus monkeys	*Colobus angolensis sharpie*	12
		Waterbuck	Kobus ellipsiprymnus	1
		Dik dik	*Madoqua kirki*	2
		Rodents		4
		Rock hyrax	*Procavia johnstoni*	2
		Warthog	*Phacochoerus africanus*	2
LGFR	Mild burned	Colobus monkeys	*Colobus angolensis sharpie*	7
		Hartebeest	*Alcelaphus bucelaphus lichensteinii*	4
		Rock hyrax	*Procavia johnstoni*	2
		Dik dik	*Madoqua kirki*	2
		Warthog	*Phacochoerus africanus*	4
		Rodents		9
	Moderate	Hartebeest	*Alcelaphus bucelaphus lichensteinii*	2
		Waterbuck	*Kobus ellipsiprymnus*	3
		Warthog	*Phacochoerus africanus*	2
		Rodents		3
	Severely	Colobus monkeys	*Colobus angolensis sharpie*	9
		Hartebeest	*Alcelaphus bucelaphus lichensteinii*	3
		Waterbuck	*Kobus ellipsiprymnus*	2
		Rodents		10

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study assessed the effect of bushfires on abundancy of mammals in miombo woodlands under different forest tenure systems. Based on the findings from this study, the following conclusions are made:-

i. The study clearly showed that the main causes of bushfires in miombo woodlands include farm preparation, charcoal making and hunting of wild animals. Cigarette remains, illegal harvesting of logs, local believes and honey harvesting also contribute to some fire incidence.

ii. It was revealed that, CGFR had higher mammal diversity followed by VFR and the least was LGFR similarly mammals were abundant in mildly burnt areas followed by moderately and least was the severely burnt area.

iii. Difference in the local community involvement and strong law enforcement are the reasons for the differences in the numbers of mammals present in the different forest regimes. That means conservation is more effective in CGFR followed by the VFR and least in the LGFR.

iv. In the study area there are several fire management regimes strategies such as law enforcement, PFM and patrol which are implemented in the CGFR and not in other regimes.

v. Moreover, social economic factors specifically education level of the respondents, gender and residence duration had a positive significant influence on forest conservation specifically reducing fire incidences.

5.2 Recommendations

Based on the findings and my own experience, the following recommendations are put forward: -

i. The Current LGA forest management regimes should ensure strong local community participation and law enforcement so as to rescue the forests from encroachment and hence reduce bushfire incidences.

ii. Illegal extraction of woodland products such as charcoal, timber, honey and wild animals as a source of income should be viewed as management challenges to VG, CG and LGA management. Thus initiatives that focus on livelihood empowerment such as credit provision and support in income generating activities are proposed to be initiated in using participatory management as one of the possible livelihood enhancement strategies.

iii. Communities should be trained on the effect of fire in forestry and the environment in general and this should be an agenda in all the villages and districts.

iv. The government in collaboration with the NGOs should emulate the informal sectors in fire management and successful models from North Pare and Mufindi could be given priority.

v. Further study should be conducted to examine the effects of bushfire on other living organisms apart from mammals so as to know their diversity and abundances for conservation purposes.

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APPENDICES

Appendix 1: Households Interview Schedule

A. General information.

1. Name of enumerator …….
2. Date of interview …….
3. Village name ……..
4. Sub village name …….
5. Ward name …….
6. Division name …….
7. House identification No ……..

B. Characteristics of Respondents

1. Name of head of household (respondent) ……..
2. Sex 1 Male
   2 Female
3. Age …….. Years
4. Ethnic group ……
5. Marital status:
   1 Single ……..…….
   2 Married ……
   3. Divorced ……
   4 Widowed ……
6. Highest Education level reached
   1. Non formal education
   2. Adult education
   3. Primary education
   4. Secondary education
   5. Others (specify) ……..
7. Are you born in this village? 1. Yes. …… 2. No …
8. Number of household members……. ……
9. What is your main occupation? ……
10. How long have you stayed in this village ……

C. Social economic activities

1. What are the main household income activities?

   (1) Agriculture crops

   (2) Livestock farming

   (3) Mixed farming

   (4) Wage employment (5) Small business

2. Others (specify) ……

3. How much do you obtain per annum?

4. Do you own land?..... What is the size of your land? …….

5. Is the size of land you have enough ……

6. If not why? ……

7. How was the land acquired? (1) Inheritance (2) Bought (3) Village offers (4) Clearing natural forest

8. Others specify ……..

D. Miombo species diversity

1. Is there any fire incidences which occur in the forest within past 3years?

   1. Yes …. 2. No …….

2. If yes, which year has it occurred?

   1…….2 ……..3 …… 4 …… 5…….

3. When did Participatory Forest Management stated in your village? …….year

4. What are the main activities your doing in PFM ……

5. Does the PFM bring any changes in alleviating bushfire problems?

   1. Yes ...2.No…..

4 What is the present state of the forest cover near the village 1 Good 2 Bad?

5 If Bad why? …….

9. If Yes, Mention tree species which has been lost from your forest due to fire incidences

Tree species	Uses
1. ……	…….
2. ……	…. ……..
3. ……	…… ……..……

E. Factors which is mostly causing forest disturbances

1. Among the factors which are causing forest degradation, what is the first one?.....
2. What are the control measures taken by your Village to alleviate bush fire problems?..
3. Do you have fire reduction strategies in your village? 1 …. Yes ……2 No ……
4. If yes for question 3, what are they?.....
5. What are the main reasons of bushfire in the forest reserve……

‘’Thank you so much for your corporation’’

Appendix 2: Checklist for key informants

Name ……Title ……

Organization ……Respondents no……

A. Is there any PFM activity conducted in your forests?

1. Is PFM important in conserving the forests in the district/ village? 1 Yes..2 No
2. Why ……
3. When did PFM activities started in the District/ Village …… Year
4. Does District receive any fund from donors to support PFM?
   1 Yes …….
   2 No ……..
5. If yes who are they? 1…… 2……..3 ……..
7. Is there any illegal activities occurs in forest in absence of PFM?
   Yes …… 2 No ……
8. If yes, why do you think PFM is important in conserving forest…….
9. Currently how much forest area is frequently burned…….. ….hectare.
10. What is the ownership pattern of forests in your village/ district?
11. What is the present state of bushfire is it increasing or decreasing? Why
12. If there any changes in plants species composition, can you list tree species which is mostly affected?
13. What might be the causes of all these changes?
14. Is there any regeneration in fire prone sites 1Yes ……. 2 No ……..
15. If yes, what types of tree do regenerate?
16. What are the management strategies to combat burning and associated impacts?
17. What are your opinion/ comments regarding management strategies to alleviate problems associated with burning activities in respect to:-

- ✓ Forest policy
- ✓ Environmental policy
- ✓ Land policy
- ✓ Other specify……

''Thank you so much for your corporation''