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Impact of Managing Selous-Niassa Wildlife Corridor on Socio-Economic Activities

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Abstract

Management of wildlife corridors in Eastern and Southern African countries plays a critical role in maintaining connected ecosystems and promoting both ecological and socioeconomic benefits. However, these corridors often face challenges due to various socio-economic activities that degrade and fragment wildlife habitats, leading to suboptimal corridor management. This study focuses on examining the impact of socio-economic activities on the management of the Selous-Niassa Wildlife Corridor (SNWC). Cross-sectional study design employed. Data for this study were collected through a questionnaire survey, key informant interviews, focus group discussions, direct field observations, and a review of secondary materials. The collected data were analysed both qualitatively and quantitatively. The results revealed that a significant proportion (86.7%) of respondents reported inadequate land allocation for settlement, agriculture, and livestock keeping, resulting in increased human-wildlife conflicts within the corridor. Furthermore, the study found that local communities had limited involvement (81.7%) in the management of protected areas within the SNWC due to a lack of sense of ownership over natural resources in these areas. Based on the findings, the study concludes that the management of the SNWC is relatively sustainable, but there are areas for improvement. The study recommends a deeper understanding of the resource use values to local communities, as this can inform more effective management strategies. Additionally, it emphasizes the importance of providing adequate manpower, field gear, and financial support to the SNWC for the effective management of biodiversity and the preservation of ecosystem services.

Keywords: Wildlife corridors, Selous-Niassa wildlife corridor (SNWC), Socio-economic activities affecting SNWC, Managing SNWC

1. Introduction

The establishment of wildlife corridors has been widely recognized as an effective conservation strategy to reduce the negative effects of habitat fragmentation (Harris, 1984; Forman and Godron, 1986; Noss, 1987; Bennett, 1990; Saunders and Hobbs, 1991; Laurance and Laurance, 1999; Mpanduji, 2004). Habitat fragmentation, whether natural or human-induced, has numerous consequences including increased external influences, altered microclimates, and isolation from similar habitats (Andren, 1994; Saunders et al., 1991; MacDonald, 2003). Furthermore, the destruction or fragmentation of corridors poses a threat to the persistence and viability of protected species by limiting their mobility (Mpanduji, 2004). In contrast, properly managed wildlife corridors offer ecological benefits such as maintaining connected landscapes, facilitating species migration, promoting gene flow, and reducing inbreeding (Schmitt and Seitz, 2002; Suter *et al.*, 2008). Corridors also provide opportunities for species to escape predation, respond to stochastic events like fire, and adapt to long-term climatic changes (Andreassen et al., 1996; McEuen, 1993; Suter *et al.*, 2008). Protected areas (PAs) are established based on pragmatic, ecological, and socioeconomic reasons (Mpanduji, 2004). In Eastern and Southern Africa, the establishment of PAs, including wildlife corridors, has been driven by pragmatic and economic criteria (Sarunday and Ruzika, 2000 cited in Mpanduji, 2004).

The Selous-Niassa Wildlife Protection Corridor (SNWC) project, linking PAs in Tanzania and Mozambique, is one such corridor project aimed at conserving connected ecosystems. However, the SNWC is threatened by various socioeconomic activities that degrade habitats, including uncontrolled wildfires, unregulated resource use, and conversion of land for agriculture driven by a high human population growth (Baldus and Hann, 2009). These activities not only disturb wildlife movements but also lead to a significant reduction in wildlife populations and local extinctions of some species (Baldus and Hann, 2009). Before the enactment of the Tanzania Wildlife Conservation Act No. 5 of 2009, there were no legal mechanisms to protect the SNWC, leaving it vulnerable to encroachment and conversion for cultivation (Baldus and Hann, 2009). The lack of information on the root factors influencing encroachment further compounds the challenge of managing the corridor effectively.

To address these issues, participatory management strategies for wildlife corridors are essential for achieving sustainability and maintaining the livelihoods of local communities (Reid *et al.*, 2004; Roe *et al.*, 2007; Harris, 1984; Andren, 1994; Saunders and Hobbs, 1991; MacDonald, 2003; Suter *et al.*, 2008). This

study aims to analyse the impact of managing the Selous-Niassa wildlife corridor on socio-economic activities. It aligns with the conservation principle that effective management of protected areas requires an understanding of the threats they face (USAID, 2005). The findings of this study will serve as an environmental management tool to raise awareness among the general public, policymakers, and decision-makers regarding current land uses and their impacts on the SNWC. Additionally, it provides valuable information to SNWC managers on the factors influencing the encroachment of the corridor, allowing for improved management strategies to ensure its long-term sustainability.

2. Methodology

2.1 Study Area

The study was conducted in the Selous-Niassa Wildlife Corridor (SNWC), which spans across Southern Tanzania into Northern Mozambique, between 10°S to 11°40'S, with a North-South length of 160 to 180 km (Figure 1). The SNWC is divided into two parts, the Western part administratively passing through Namtumbo and Tunduru Districts in Ruvuma Region -Tanzania, and the Eastern part passing through Liwale, Nachingwea, Masasi, and Nanyumbu Districts. This study focused on the Eastern part of the SNWC.

The SNWC includes the Selous-Masasi corridor, which consists of the Msanjesi Game Reserve (2,125 ha) and the Lukwika-Lumesule Game Reserve (44,420 ha) in Masasi and Nanyumbu Districts respectively, as well as areas within Liwale, Nachingwea, Masasi, and Tunduru Districts. The study area also includes the Wildlife Management Areas (WMAs) that border the Selous, Msanjesi, and Lukwika-Lumesule Game Reserves, namely the MAGINGO WMA, NDONDA, and MCHIMALU proposed WMAs, which are located within Liwale, Nachingwea/Masasi, and Nanyumbu Districts. For this study, two villages, namely Mpigamiti and Mpombe within the MAGINGO WMA and MCHIMALU proposed WMA, were purposively selected for the study because of their location on the start and destination of SNWC.

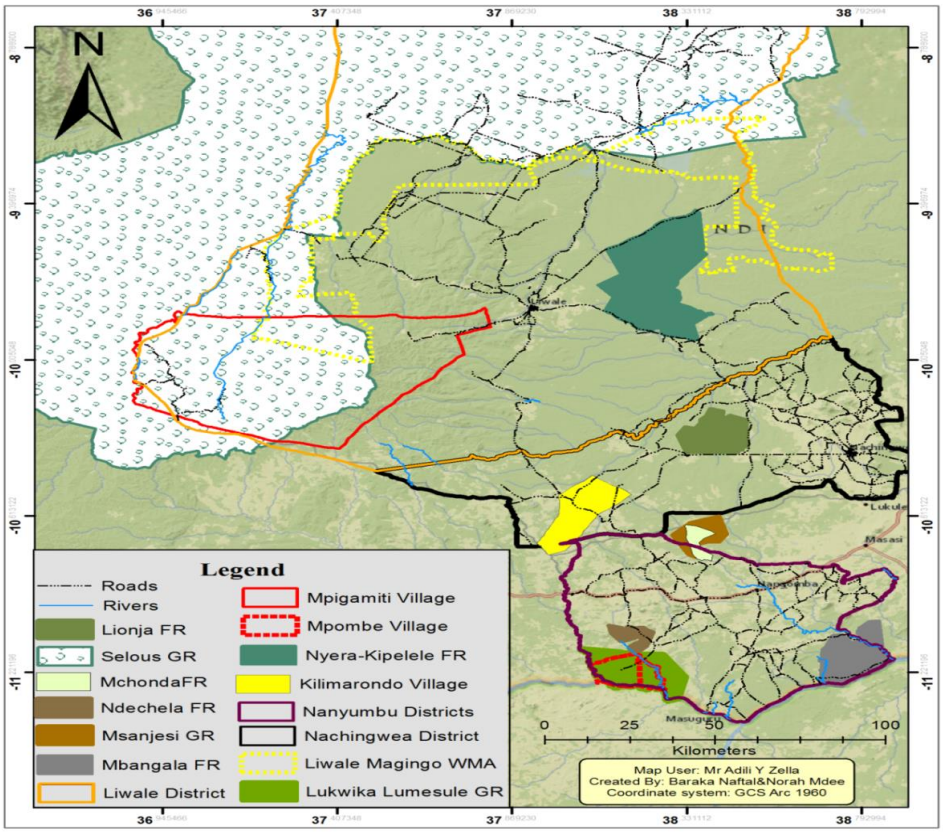

Figure 1: The Map showing the Selous-Niassa Wildlife Corridor

2.2 Research Approach and Design

A cross-sectional survey design with a pragmatic approach was employed for this study. This research design involves studying different groups of people who vary in the variable of interest but share other characteristics, such as socioeconomic status, educational background, and ethnicity (Kothari, 2004). The cross-sectional survey design offers several advantages. Firstly, it is conducted at a single point in time, providing a snapshot of the population at that particular period. Secondly, it does not involve manipulating variables, allowing researchers to observe and measure the variables as they naturally exist. Thirdly, this design allows researchers to examine multiple factors simultaneously, such as age, income, and gender, providing a comprehensive understanding of the population being studied. Lastly, the cross-sectional survey design is often used to determine the prevalence of a specific characteristic or phenomenon within a given population (Kothari, 2004).

2.3 Sampling Procedures and Sample Size

The villages of Mpigamiti and Mpombe in the Liwale and Nanyumbu Districts were purposively selected for this study due to their location within the Eastern

wildlife corridor of the Selous-Niassa ecosystem. The selection of these villages was based on several factors: (i) both villages are situated within the corridor, (ii) both villages are members of wildlife management areas (Mpigamiti – MAGINGO WMA and Mpombe – MCHIMALU proposed WMA), and (iii) Mpigamiti represents the starting point of the corridor in Tanzania while Mpombe represents the destination within the country. The sampling frame for this study was generated from an updated village register book containing a list of all households in the selected villages. The sampling unit for this study was the household, defined as a group of individuals living together under the authority of one person, the household head, who acts as the decision-maker for the household (Katani, 1999). To select the sample units, a simple random sampling method was employed, ensuring that every household had an equal chance of being selected. In cases where multiple candidates were identified within the household, only one individual was included in the sample, as recommended by Bouma (2000), Henn *et al*. (2006), Veal (1997), and Kaswamila (2009).

Each study village had a sample size of 30 households (Table 1), with 10 households drawn from each income group (low, medium, and high) as described in the village's fact sheet. The decision on the sample size in socio-economic studies can vary depending on the nature of the study, but it is recommended to have at least 30 units, as supported by various scholars (Bailey, 1994; Boyd et al., 1981; Kajembe and Luoga, 1996; Mbwambo, 2000; and Kaswamila, 2009). In addition to the household survey, a judgmental/purposive sampling technique was employed to select 12 key informants.

Table 1: Respondent sample composition

Category of respondent	**District**	**Villages**		
		Mpigamiti	**Mpombe**	**Total**
Households	-	30	30	60
Village Executive officers (VEOs)	-	1	1	2
Village Natural Resources Officers(VNROs)	-	1	1	2
Project Manager of LLM (PLLM)	1	-	-	1
District Game officers (DGOs)	2	-	-	2
Sector warden of SGR (SWS)	1	-	-	1
Village Development Officers (VDOs)	-	1	1	2
WMA Chairpersons (WCs)	2			2
Total	**6**	**33**	**33**	**72**

2.4 Pilot Study

Prior to the actual data collection, a pilot study was carried out to gain a better understanding of the study area and to test data collection tools to ensure that the tools were easily comprehensible to the respondents. The pilot testing of the tools was conducted in Majonanga village, which is situated within the Selous-Niassa wildlife corridor in the Ndonda proposed WMA of Nachingwea District. Majonanga village is adjacent to the Msanjesi Game Reserve. The main objectives of the pilot testing were to assess the wording, sequencing, and layout of the data collection tools, as well as to estimate response rates and the time required to complete the collecting data in each tool.

2.5 Data Collection

The research encompassed two phases of data collection, involving the gathering of primary and secondary data. The primary data for this study were collected through various methods, including household questionnaire surveys (60 respondents), key informant interviews (12 respondents), participatory rural appraisals (focus group discussions (4-6 participants)) and direct observations (Researcher with village leaders and some villagers)). On the other hand, secondary data was collected through a comprehensive literature survey. The data collected included both quantitative and qualitative information, providing a comprehensive understanding of the research topic.

2.6 Data Analysis

The quantitative data collected from the questionnaires were analysed using statistical techniques. On the other hand, the qualitative data obtained from focus group discussions (FGDs) and key informant interviews were analysed using content analysis. Content analysis is a valuable method for examining the details and components of verbal discussions held with key informants and during FGDs (Kajembe, 1996 cited by Kijazi, 2006). This approach allows for a systematic and thorough analysis of the qualitative data, providing valuable insights and interpretations.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) and Microsoft Excel were utilized for data analysis in this study. Descriptive statistical analysis was conducted to analyse the quantitative data, which included calculating frequencies, percentages, means, and standard deviations of variables such as age, marital status, sex, education level, household size, and income. Additionally, the relationship between two variables was examined using the

cross-tabulation method, allowing for a deeper understanding of the associations between different factors in the research.

3. Results and Discussion

3.1 Access to land and land tenure in the study area

The study findings revealed that the dominant land tenure system in the study area is individual land ownership obtained through inheritance, accounting for 83.3% of the respondents (Table 2). This was followed by rented land, which constituted 16.7% of the land ownership. It was observed that the majority of individuals who rented land were females who were either divorced or widowed. This can be attributed to the traditional rules for accessing land, which did not favour them. The minimum farm size owned by an individual farmer was one hectare, while the maximum farm size was 15 hectares. On average, each farmer owned 1.2 hectares of land. In terms of land area, 80% of the respondents had land parcels between 1-3 hectares, while 20% had more than three hectares. Despite this, 86.7% of the respondents claimed that land was not sufficient for their needs.

Regarding the possibility of obtaining more land for cultivation, 78.3% of the respondents believed that it was possible. The methods mentioned included formal application to the village government (81.7%), purchasing land from those with larger farms (10.0%), and renting land temporarily (8.3%) (Table 4). Although the majority of respondents (85%) indicated that obtaining additional land was possible, during the focus group discussions, it was revealed that there is a problem with fertile land for rice farming in Mpigamiti village, leading to conflicts over land use. The conflict arose in 2010 after the establishment of the MAGINGO WMA, as immigrants invaded the area and cultivated protected land without prior consultation or permission from the village, MAGINGO leaders, or district authorities. Additionally, the immigrants were using water from the source of Liwale River (Mpigamiti spring) without proper authorization. Importantly, the Liwale River is the only water source for Liwale District.

The conflict over land use and water resources was partly due to the division of the former Mpigamiti village into three separate villages (Mpigamiti, Namakololo, and Mitawa) while the formation of the WMA included the entire Mpigamiti village. As a result, the distribution of income from the WMA only benefits one village (Mpigamiti), while the other two remaining villages receive no benefits despite sharing their land with the WMA.

These findings underscore the existing challenges in land tenure and management within the study area. The dominance of individual land ownership through inheritance highlights the importance of addressing issues related to gender equity in land access and ownership. Furthermore, the conflicts over land use and water resources demonstrate the need for effective consultation and collaboration among stakeholders involved in the management of protected areas and WMAs. Additionally, efforts should be made to ensure equitable distribution of benefits and resources among all villages involved in the WMA, considering their contributions to land sharing.

Table 2: Land ownership in study villages

Information	**Villages**		
	Mpigamiti n=30	Mpombe n=30	Overall N=60
(a)Land ownership:	27(90.0)[1]		50(83.3)
Individual	3(10.0)	23(76.9)	10(16.7)
Rent		7(23.3)	
(b)Size of land owned hectares:	24(80.0)		48(80.0)
1 - 3 ha	6(20.0)	24(80.0)	11(18.3)
4 – 6 ha	0(0.0)	5(16.7)	1(1.7)
7 - 10 ha	0(0.0)	1(3.3)	0(0.0)
11-15 ha	0(0.0)	0(0.0)	0(0.0)
> 15 ha		0(0.0)	
(c)Land available:	2(6.7)		8(13.3)
Enough	28(93.3)	6(20.0)	52(86.7)
Not enough		24(80.0)	
(d) Possibility to get more land:	23(76.7)		51(85.0)
Yes	6(23.3)	28(93.3)	9(15.0)
No		2(6.7%)	
(d)Location of owned land:	2(6.7)		3(5.0)
Within migratory routes	2(6.7)	1(3.3)	3(5.0)
Five km from core PA	0(0.0)	1(3.3)	10(16.7)
Within the WMA	23(76.7)	10(33.3)	41(68.3)
In the planned area	3(10.0)	18(60.0)	3(5.0)
In wetland area		0(0.0)	

[1] Figures outside and inside the parentheses are frequencies and percentages respectively.

Table 3: t-test for possibility to get more land for cultivation by households in study villages

T	df	Sig. (2-tailed)	Mean Difference	95% CI of the Difference: Lower	Upper
-1.067E3	59	.000	-58.767	-58.88	-58.66

CI=confidence interval

The results of the t-test presented in Table 3 demonstrated statistical significance (p=0.05) regarding the possibility of households in the study villages acquiring more land for cultivation through various means, such as applying to the village government, buying, or renting.

Furthermore, the findings from the analysis of variance (ANOVA) conducted and displayed in Table 4 indicated a significant variation ($p<0.05$) in the means of acquiring land for cultivation among households in the study villages. This suggests that the methods used to obtain additional land differed significantly among households in the villages.

Table 4: One-way ANOVA for means to acquire land for cultivation by households in study villages

Source of variations	Sum of Squares	Df	Mean Square	F	Sig. Level
Between villages	1.067	1	1.067	2.994	< 0.05
Within villages (error)	20.667	58	.356		
Total	**21.733**	**59**			

*Statistically significant at 0.05 level of significance

Additionally, we obtained information from the MAGINGO and MCHIMALU WMAs offices, as well as the District Land Offices (DLOs), revealing that the study villages, which share borders with the Selous and Lukwika-Lumesule Game Reserves (GRs), have land use plans developed by the Tanzania Land Use Plan Commission (TLUPC) in collaboration with the Ministry of Land, Housing, and Settlement (MLHS), as well as the Liwale and Nanyumbu District Councils (LDC and NDC), in 2008 and 2010 respectively. It is worth noting that the planning process was funded by the WWF. However, these land use plans excluded the Selous and Lukwika-Lumesule Game Reserves, which, to some extent, have contributed to the ongoing conflicts between adjacent villages and protected areas. Moreover, we discovered that the land use plan maps of the study villages do not incorporate "buffer zones" as recommended by the Wildlife Conservation Act No. 12 of 1974 and its successor Act No. 5 of 2009.

Findings indicate that professionals involved in the land use planning process primarily focused on the perspectives of the villagers without adequately considering other relevant laws and policies regarding wildlife, environmental conservation, and forestry. For instance, during boundary conflict resolution between MAGINGO WMA and the Selous Game Reserve in 2015, a committee was formed by then Minister of MNRT, which included professionals from TLUPC, LDC, MLHS, MNRT, SGR, and village elders from the nine villages that formed the WMA, namely Mpigamiti, Ndapata, Barikiwa, Chimbuko, Kikulyungu, Kimambi, Mirui, and Naujombo (MWMA and SGR office reports, 2020). All villages except Kikulyungu agreed with Government Notice No. 275 of 1974, which defines the boundaries of the Selous Game Reserve. However, the zoned area for the WMA in Kikulyungu village is no longer conducive to wildlife conservation as it has been converted for agricultural activities.

Thus, our findings reveal that the study villages located in the Liwale and Nanyumbu Districts have land use plans developed by the TLUPC in collaboration with the MLHS and the respective district councils. However, these plans omitted the Selous and Lukwika-Lumesule Game Reserves, which has contributed to conflicts between neighbouring villages and protected areas. Additionally, the absence of "buffer zones" in the land use plans, as mandated by relevant wildlife conservation acts, indicates that the professionals primarily focused on the input of villagers without adequately considering other legal and policy frameworks related to wildlife, environment, and forest conservation. The resolution of the boundary conflict between MAGINGO WMA and the Selous Game Reserve further exemplified the need for better integration and adherence to existing laws and policies. It is crucial to ensure that land use planning processes comprehensively incorporate the guidelines and recommendations of relevant wildlife, environmental, and forest conservation acts. This would support the effective management and conservation of both protected areas and the sustainable livelihoods of local communities. The provided figures (Figures 2 & 3) offer a visual summary of the land uses in the study villages located within the Liwale and Nanyumbu Districts.

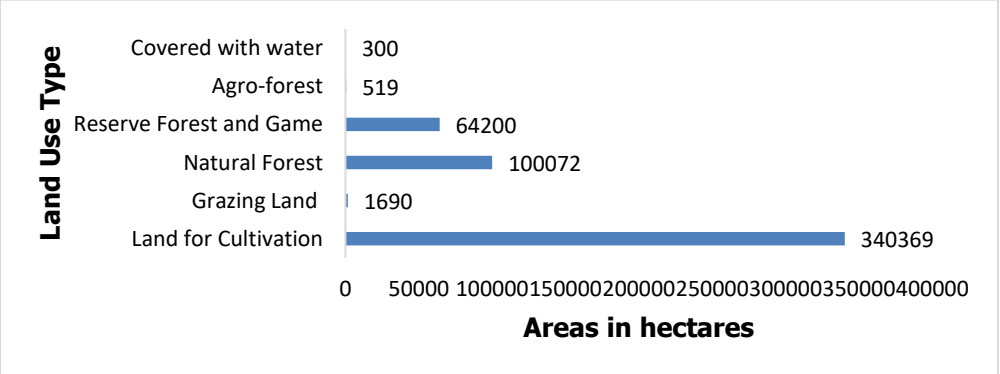

Figure 2: Land uses in Nanyumbu District

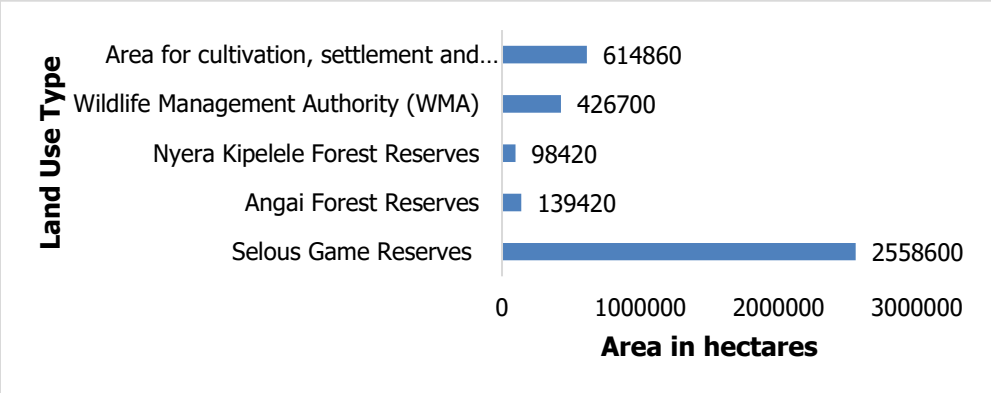

Figure 3: Land uses in Liwale District

3.2 Agriculture

Agriculture plays a vital role in the Selous-Niassa wildlife corridor, serving as a primary economic activity and source of income for the communities in the Liwale and Nanyumbu Districts (Table 5). However, many villagers in these districts practice shifting cultivation, which involves the clearance of Miombo forests. These forests serve as crucial habitats for wild animals, resulting in human-wildlife interactions and conflicts over crops. The prevalence of this behaviour is influenced by the population dynamics of the districts.

Table 52: Food and cash crop areas

Information:	**Area (hectares)**	
	Liwale District	Nanyumbu District
(a)Food crops:		
Cassava	12,809	27,558
Maize	14,464	16,450
Rice	5,998	2,154
Sorghum	11,741	10,280
Total	**45,012**	**56,442**
(b)Cash crops:		
Cashew nuts	13,943	105,820
Sesame	6,800	5,400
Cowpea	1,400	3,500
Pigeon	1,220	14,000
Gram	4,340	9,811
Groundnuts	870	15,120
Total	**28,573**	**153,651**

According to the 2012 census data, Liwale District has a population of 91,380 people, with an average of one person occupying 6.7 hectares of land suitable for agriculture outside protected areas. On the other hand, Nanyumbu District has a population of 150,857 people, with an average of one person occupying 2.3 hectares. This reveals that, without interventions, Nanyumbu District is likely to encroach further into protected lands for agricultural activities due to the higher population density and smaller land availability per person.

Shifting cultivation, although an important agricultural practice for local livelihoods, poses significant challenges to wildlife conservation and the preservation of habitat. The destruction of Miombo forests not only affects the natural environment but also leads to increased human-wildlife conflicts as animals venture into agricultural areas in search of food. These conflicts can result in crop losses and pose risks to both humans and wildlife. To address this issue and mitigate human-wildlife conflicts, it is crucial to implement strategies that promote sustainable agricultural practices and reduce reliance on shifting cultivation. This may include providing alternative income-generating activities, promoting improved farming techniques, and raising awareness about the importance of conserving natural habitats for both ecological and economic reasons. Moreover, population growth and land scarcity in Nanyumbu District highlight the urgency to find sustainable solutions that balance agricultural development with wildlife conservation. This may involve exploring methods to increase agricultural productivity within existing cultivated land while simultaneously preserving and restoring habitat for wildlife. Implementing effective land use planning, incorporating buffer zones, and establishing mechanisms for community-based natural resource management can contribute to the long-term sustainability of agriculture and wildlife conservation in the Selous-Niassa wildlife corridor.

Thus, addressing the challenges associated with shifting cultivation and its impact on Miombo forests and wildlife is essential for achieving a sustainable balance between agricultural activities and conservation efforts in the study area. By promoting sustainable agricultural practices, protecting critical habitats, and implementing holistic land management strategies, it is possible to mitigate human-wildlife conflicts and ensure the long-term coexistence of local communities and wildlife in the Selous-Niassa wildlife corridor.

In terms of land utilization, Liwale District utilizes only 62,065 hectares (10.1%) of its arable land for agriculture, settlement, and grazing. On the other hand, Nanyumbu District utilizes a larger portion of its land, with 210,093 hectares

(61.7%) being used for these purposes (Figures 2 & 3 and Table 5). The crops cultivated in the study area can be categorized into three main groups: annual, semi-perennial, and perennial crops. The major annual crops include maize (*Zea mays*), rice (*Oryza sativa*), and sorghum (*Sorghum vulgare*). Semi-perennial crops include cassava (*Manihot esculenta*), sugarcane (*Saccharum officinarum*), sesame (*Sesamum sp*), and various types of bananas (*Musa esente, Musa cavendishii*, and *Musa sp*). Cashew nuts (*Anacardium occidentale*) and coconut (*Cocos nucifera*) are examples of perennial crops. Minor cultivated crops in the area include groundnuts (*Arachis hypogaea*), melon (*Cucurbita mero*), and pigeon beans (*Cajanus cajan*). Fruits such as mango (*Mangifera indica*), orange (*Citrus sp*), and pawpaw (*Carica papaya*) are also cultivated in the study area.

While perennial and semi-perennial crops are grown on a small scale, all crops are cultivated for subsistence as well as for trade. Cashew nuts remain the principal cash crop, while sesame has emerged as a short-term cash crop, contributing to significant deforestation. The production trends vary from year to year, depending on inputs and the availability of equipment. Figures 4 & 5 provide an overview of the existing production levels in Liwale and Nanyumbu Districts during different years.

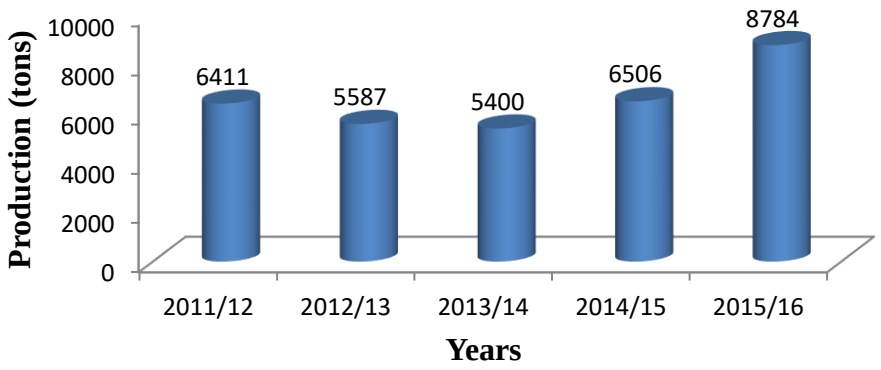

Figure 4: Liwale cashewnuts production (Tons) for the years 2011/12 up to 2015/16

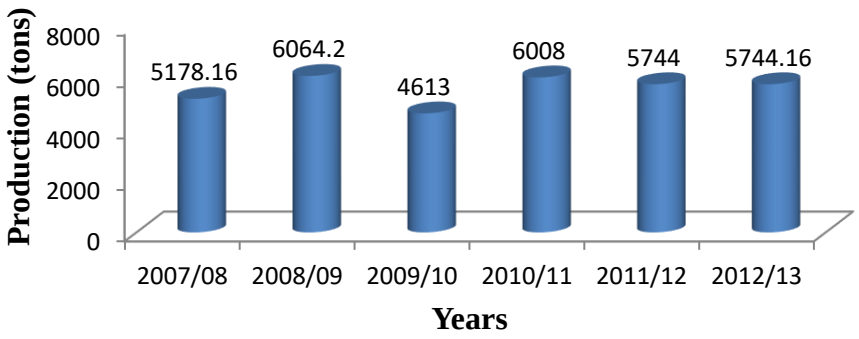

Figure 5: Nanyumbu cashew nut production (Tons) for the years 2007/08 up to 2012/13

It is important to note that sustainable agricultural practices and the preservation of forests and natural habitats are crucial in ensuring the long-term viability of agricultural production in the area. Balancing subsistence farming with economic development and environmental conservation will be vital for the communities in the study area to achieve sustainable and resilient livelihoods. This may involve promoting agroforestry practices, implementing soil conservation measures, and encouraging the use of efficient farming techniques that minimize the environmental impact. Additionally, diversifying crop production and fostering value chains for various agricultural products can help enhance food security and create economic opportunities for the local communities. Furthermore, supporting farmers with access to improved inputs, credit facilities, and market linkages can contribute to increased productivity and profitability. It is essential to balance the economic benefits of cash crops like cashew nuts and sesame with the need to protect and conserve the natural resources, including forests and wildlife habitats. This can be achieved through sustainable land management practices, promoting reforestation initiatives, and raising awareness about the importance of preserving biodiversity and ecosystem services.

Therefore, the findings highlight the diverse range of crops cultivated in the study area and the importance of agriculture as a source of livelihood. However, sustainable agricultural practices and conservation efforts are necessary to ensure the long-term viability of agriculture and preserve the natural resources and ecosystems in Liwale and Nanyumbu Districts. By promoting sustainable farming techniques, supporting crop diversification, and preserving forested areas, it is possible to achieve a balance between agricultural production, economic development, and environmental conservation, leading to improved livelihoods and the preservation of valuable ecosystems.

According to in-depth interviews with District agriculture officers, it was revealed that the reported production trends might not accurately reflect the actual situation due to the presence of illegal buyers known as "Chomachoma." These buyers operate outside the official channels, making it difficult to ascertain the number of agricultural products being purchased, which ultimately leads to a loss of income for the districts. Therefore, among other factors, the variation in production from year to year depends on the strength of district security on the exit routes during that particular year. One notable trend is the emergence of high production of simsim (*Sesamum sp*), which has surpassed cashew nuts as the leading source of revenue for districts and households. For example, in 2015/16, simsim production in Liwale District reached 7,925,157 kg, compared to 7,483,874 kg of cashew nuts. The revenue generated from simsim amounted to TZS 15,850,314,000, nearly double the revenue from cashew nuts, which amounted to TZS 8,980,648,800. However, it is important to note that most cashew nut trees are at least fifty years old and are owned through inheritance, which encourages conservation efforts. On the other hand, simsim production is an environmentally destructive activity that offers short-term income rewards. It was observed that a significant number of simsim producers invade and clear public Miombo forests for farming purposes, as reported by the "Makonde" community from Newala, Tandahimba, and Mahuta during focus group discussions. Unfortunately, there is no actual figure available regarding the land size used for simsim production due to these illegal encroachments.

Furthermore, the cultivation of both food and cash crops in the study area attracts wild animals, leading to conflicts of interest between conservation efforts and agriculture. The majority of respondents (88.6%) in the study villages reported experiencing wildlife-related problems, while only a small percentage (11.4%) had not encountered such issues (Table 6). These conflicts highlight the need for effective strategies and interventions to mitigate human-wildlife conflicts and find a balance between conservation and agricultural activities.

Thus, the presence of illegal buyers, the rise of simsim production as a leading revenue source, the invasion of public forests for agriculture, and the conflicts between wildlife conservation and agricultural practices all underscore the complexity of the agricultural landscape in the study area. Addressing these challenges requires a multi-faceted approach that includes improved market access, enforcement of regulations, sustainable land management practices, and effective measures to minimize human-wildlife conflicts.

Table 6: Problem animals destroying crops and human life

Information	Village		
	Mpigamit n=30	Mpombe n=30	Overall N=60
(a) Availability of problem animals:			
Yes	26(86.7)[1]	26 (86.7)	52(86.7)
No	4(13.3)	4(13.3)	8(13.3)
(b) Common problem animals:			
Elephant *(Loxodonta africana)*	26(86.7)	4(13.3)	30(50.0)
Bushpig *(Potamochoerus porcus)*	20(66.7)	11(36.7	31(51.7)
Vervet monkeys *(Chlorocebus aethiops)*	9(30.0)	24(80.0)	33(55.0)
Hippos (*Hippopotamus amphibius*)	6(20.0)	3(10.0)	9(30.0)
Olive baboon *(Papio anubis anubis)*	16(53.3)	12(40.0)	28(46.7)

[1]Figures outside and inside the parentheses are frequencies and percentages respectively.

The study revealed that elephants (50%), bush pigs (51.7%), velvet monkeys (55%), hippos (30%), and olive baboons (46.7%) were the main animals responsible for damaging crops in the fields (Table 6). Elephants were found to cause the most damage in Mpigamiti village (86.7%), while velvet monkeys were more prominent in Mpombe village (80%). These findings suggest that elephant poaching is a pressing issue in Mpombe village, highlighting the need for increased efforts to combat illegal hunting within the Selous-Niassa wildlife corridor.

Additionally, rodents, particularly rats, were reported to cause significant damage to stored cereal crops within households, surpassing the damage seen in field crops. The extent of crop damage varied across different villages and even within different plots within the study area. Maize, cassava, sugarcane, melon, and cashew nuts were identified as the crops most preferred by animals causing damage.

During focus group discussions, the community categorized the wild animals causing crop damage into three main groups:

a) Diurnal crop-damaging animals, including velvet monkeys (*Cercopithecus aethiops arenarius*), Rufiji blue monkeys (*Cercopithecus mitis monoldes*), and yellow baboons (*Papio cynocephalus*).

b) Nocturnal crop-damaging animals, including African elephants (*Loxodonta africana*), bush pigs (*Potamochoerus porcus*), buffalos (*Cyncerus caffer*), and hippos *(Hippopotamus amphibius*).

c) Minor nocturnal crop-damaging animals, including warthogs (*Phacochoerus aethiopicus*), elands (*Taurotragus oryx*), greater kudus (*Strepsiceros strepsiceros*), bushbucks (*Tragelaphus scriptus*), impalas (*Aepyceros melampus*), black-backed jackals (*Canis mesomelas*), reedbuck (*Redunca redunca*), porcupines (*Hytrix africae astralis*), and cane rats (*Thyronomys swinderianus*).

Elephants, bush pigs, and baboons were identified as the animals causing the most significant damage to maize farm plots during both the wet and dry seasons. Baboons were found to destroy maize seedlings immediately after germination, while elephants began feeding on maize seedlings around 3-4 weeks after germination and continued damaging the crops until harvest. The severity of elephant damage varied across the study area, depending on the field's proximity to feeding or migratory routes to or from core protected areas. Bush pigs were reported to use maize and sorghum stems at an early stage.

Farmers employed various non-lethal deterrents to control crop damage, such as using oil-chilled ropes and chilled elephant dung blocks. Farmers who implemented these measures around their farm plots experienced fewer crop losses and raids by animals, particularly elephants. Notably, in Mpigamiti village, peasants who applied elephant deterrents had larger farm plots and higher crop yields compared to those who did not use these deterrents (see plates 1-4).

Plate 1: Oil chilled ropes around farm Plot

Plate 2: Chill-elephant dung bricks

Plate 3: Harvested chillies used in HEC/HWC

Plate 4: Cultivation of non-palatable crops (Sesame, Sunflower etc.)

Therefore, as suggested by Kagaruki (2004), increasing efforts to prevent crop damage should focus on controlling weeds, crop diseases, and smaller species like bush pigs, baboons, rodents, or birds, as the impact of elephants is already significant in many areas within the corridor.

Thus, the study highlights the significant impact of elephants, bush pigs, velvet monkeys, and other animals on crop damage in the study area. Strategies to mitigate crop damage should take into account the specific animal species involved and their activity patterns. The use of non-lethal deterrents, such as oil-chilled ropes and chilled elephant dung blocks, shows promise in reducing crop losses. However, further research and effective management strategies are needed to address the complex issue of human-wildlife conflicts and ensure the sustainable coexistence of farmers and wildlife in the study area.

However, it is important to acknowledge that wildlife not only pose challenges for communities living near them, but they also hold a great deal of respect, affection, and positive cultural significance. Wild animals are deeply intertwined with people's lives, shaping their identities and creating a strong attachment to the land. There is often a significant trust in the ability of wildlife managers to address the problems faced by communities while simultaneously protecting natural resources. However, a major hindrance to sustainable wildlife conservation is the limited opportunities and alternatives available in areas characterized by widespread poverty and increasing population pressure within wildlife corridors. Therefore, the facilitation of community mobilization is crucial for the sustainable management of wildlife (Pinter-Wollman, 2012).

The population growth of humans and unsustainable land uses in the study villages exert pressure on the available resources, resulting in habitat destruction and environmental degradation. Field observations revealed that many farms are situated within the wildlife corridor and beyond the planned areas, suggesting that people are not solely focused on crop cultivation but also hold a strong interest in wild animals. Conflicts within the corridor stem from differing perspectives on resource utilization. The conservation objective is to conserve natural resources for long-term benefits, while the concern of corridor inhabitants is the need for livelihoods to ensure their survival. These divergent interpretations of the corridor's purpose contribute to varying degrees of conflicts experienced.

3.3 Poaching and law enforcement in the study area

The study findings indicate that hunting of wildlife has had detrimental effects on the populations of several resident herbivore species, as evidenced by various reports and studies (Campbell and Hofer, 1995; Campbell and Loibooki, 2000; Ngowe, 2004; TRAFFIC, 2012; TAWIRI, 2013; WWF, 2016). In addition, data from the SGR-South eastern sector and LLM highlights the prevalence of poaching, with only a small fraction of poachers arrested during the period from 2009 to 2014 being taken to court. Instead, a significant number of poachers were able to compound their charges by paying a fine of TZS 3,230,000.

Furthermore, poaching remains a chronic problem within wildlife corridors and protected areas. In the Selous-Niassa wildlife corridor and core protected areas, poachers primarily use firearms to target elephants, as the demand for elephant tusks in Asian markets drives up their price in the black market. The years 2011 to 2013 saw a surge in elephant trophy poaching in the study area, exemplified by the high price of elephant tusks in the Liwale and Nanyumbu Districts. Evidence of poaching is further supported by the discovery of 67 elephant carcasses in the SGR-South eastern sector, MWMA, and Liwale open area between 2010 to 2012 (Figure 6).

Additionally, there have been numerous seizures of elephant ivory in Asia, particularly in China and Vietnam, claiming that the ivory originates from Tanzania (Interpol reports, 2014). Other species such as hartebeest, buffalo, eland, and impala are also targeted using wire snares, with poaching activities driven by subsistence needs and the selling of the harvested animals within the districts. Poached elephant ivory is primarily transported through blind ports along the shores of the Indian Ocean in the Lindi and Mtwara regions. Recent data suggests that there are 16 blind ports identified for smuggling elephant

tusks as of September 2014, with the ivory being transported to Zanzibar and Dar es Salaam for eventual overseas transportation (Interpol reports, 2014).

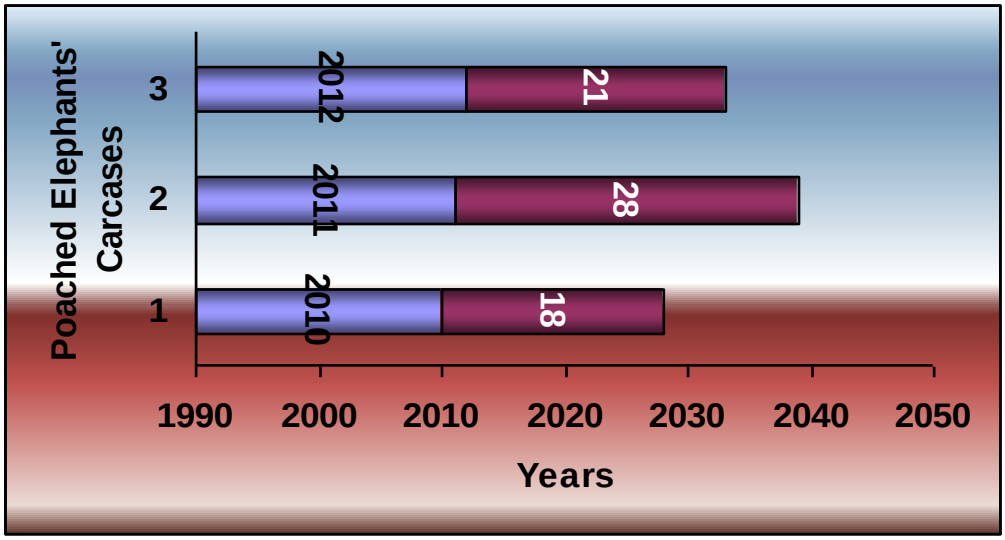

Figure 6: Poached elephants' carcasses from 2010 – 2012

Despite being classified as environmental crimes, poaching and other illegal harvesting of wild resources continue to increase. For example, between 2010 and 2015, a total of 487 elephant tusks were confiscated in Nachingwea and Nanyumbu Districts, equivalent to the killing of 244 elephants within the Selous-Niassa wildlife corridor. The value of these confiscated tusks amounted to $366,000 (TZS 732,000,000). When comparing the ratio of staff and anti-poaching equipment to the size of the area and the conservation regime, it is estimated that over 80% of illegal trophies are being exported from the corridor (personal observation).

During discussions with focus groups, the reported reasons for poaching were primarily rooted in historical cultural practices, where local communities have a preference for wildlife meat over livestock. Traditional weapons such as snares, arrows, traditional poisons, and local guns (gobore) are used for wildlife hunting, as evidenced by the arrest of 368 snares. The use of wire snares reduces the risk of poachers being apprehended by wildlife authorities, as it does not require the same amount of physical pursuit as traditional hunting methods. It is important to dispel the romantic myth that bush meat originates only from small-scale consumptive poaching, as it is less destructive than commercial trophy poaching.

Even though villagers are involved in wildlife management, illegal hunting is still observed in Wildlife Management Areas (WMAs) that cover a significant area in the Liwale and Nanyumbu Districts. The lack of capacity of village governments and WMAs to invest in anti-poaching activities is a contributing factor. For instance, the patrol budget for MAGINGO WMA was only TZS 59 million and TZS 60 million for the years 2013/14 and 2014/15, respectively. In comparison, the income generated from hunting quotas and shared with the Department of Wildlife was TZS 50 million and TZS 63 million for the same years.

Anti-poaching operations carried out by the Taskforce (National and Trans-National High Crimes Intelligence Unit - NTHCIU) have had some success in confiscating illegal weapons used in the killing of wild animals, such as the withdrawal of 147 guns and 600 ammunition in Liwale District in September 2012. However, poaching continues to persist, as evidenced by the seizure of 61 pieces of elephant tusks in October 2012, equivalent to 34 complete tusks and the killing of 17 elephants. Anti-poaching efforts are focused on the SGR, LLM, district authorities, and WMAs, with game scouts, wardens, and officers expected to patrol a minimum of 20 days per month to ensure thorough coverage of core protected areas and the wildlife corridor. However, it is important to note that while the number of poachers arrested has decreased over time, this does not necessarily indicate a decrease in poaching activities. The cases that are available for prosecution are mostly for poachers arrested outside the core protected areas, as inside the core protected areas there is an ongoing battle between poachers and game scouts. It is essential to address the root causes of poaching and ensure that every individual has a sense of ownership and responsibility towards the conservation of wildlife resources.

Interestingly, the study population exhibited low trust in the management of LLM and SGR. Figure 7 shows that 56.7% of the study population ranked their trust as very little, 25% ranked it as very poor, 10% considered it as considerable, and the remaining percentage ranked it as somewhat. This indicates that there is a need for LLM and SGR management to improve their strategies for the benefit of future generations.

Thus, despite efforts to address illegal wildlife activities such as poaching, the problem continues to persist and even increase. The high demand for wildlife products, such as elephant tusks, drives poachers to target and kill elephants within the Selous-Niassa wildlife corridor and other protected areas. The lack of sufficient anti-poaching measures and resources, combined with limited capacity among village governments and WMAs, contributes to the ongoing illegal

hunting. The use of traditional weapons and wire snares further complicates the control and apprehension of poachers. Efforts by the force and other agencies have led to some successes in confiscating weapons and ammunition used in illegal wildlife killing. However, poaching activities remain a significant challenge, as evidenced by the continuous seizure of elephant tusks and wildlife carcasses. There is a need for stronger and more effective anti-poaching operations, increased investment in patrol and surveillance, and improved collaboration between authorities, communities, and conservation organizations.

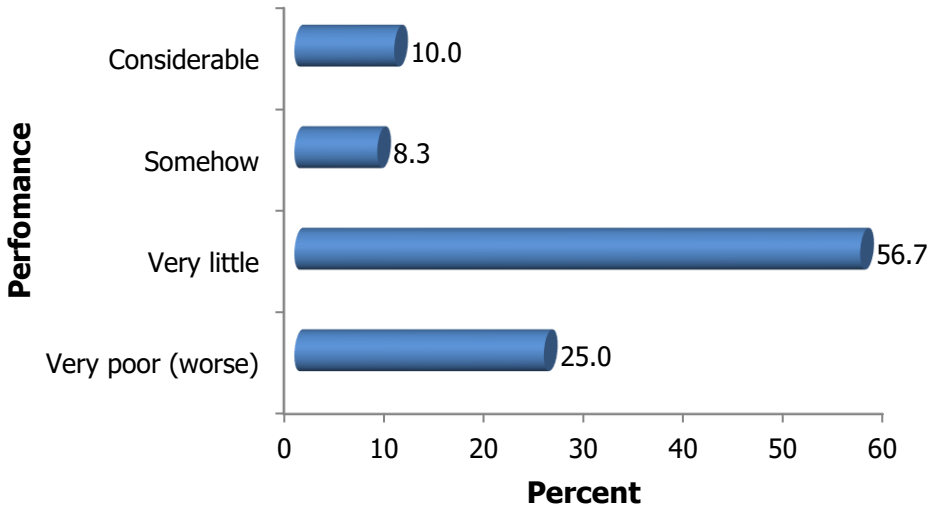

Figure 7: LLM and SGR Performance on Protection of Wildlife Resources

Additionally, building trust and enhancing the engagement of local communities in wildlife management is crucial. It is essential to address the socio-cultural reasons behind poaching and encourage alternative livelihood opportunities that reduce reliance on illegal hunting. Collaborative efforts should focus on empowering communities and promoting a sense of ownership and responsibility for wildlife conservation. Therefore, the findings highlight the urgent need for comprehensive and multi-faceted strategies to combat illegal wildlife activities and ensure the long-term protection of wildlife populations in the study area.

3.4 Encroachment for fuelwood, logging, and mining

The study findings reveal that encroachment for fuelwood, logging, and mining activities is increasing in the study area, as these activities serve as alternative sources of income for local livelihoods. Direct field observations and focus group discussions highlighted the presence of mining tunnels, particularly within rivers

located in wildlife and forest-protected areas. Focus group participants mentioned various minerals found in the study area, including white sapphire, green sapphire, blue sapphire, green tourmaline, and gold. This is further supported by the seizure of mining equipment, such as "gunia" bags, buckets, and pickaxes, which are commonly used for mining purposes as reported by the SGR-South Eastern sector Manager and Project Manager of LLM during the interview. However, the quantity of mines and revenues generated by these activities remains unclear, as reported by in-depth interviews with District Government Officials and records of revenue collections.

Illegal logging has also become a significant issue in the study area, particularly in forest reserves, WMAs, and the SGR and LLM Game Reserves. These areas are known to have valuable tree species suitable for logging and timbering. Between 2010 and 2015, a total of 1,953 timbers were confiscated by LLM in the Nachingwea and Nanyumbu Districts, while SGR confiscated 2,217 timbers in the Liwale District. The illegal harvesting of trees has intensified due to the widespread use of chainsaws, both in illegal and legal logging activities, which goes against the Forest Act of 2002. In 2014 alone, Tanzania Forest Service (TFS), in collaboration with SGR, arrested 26 individuals and seized over 4,000 illegally harvested timbers in MAGINGO WMA, Nyera/Kipele forest reserve, and other open areas. The increase in encroachments for fuelwood, logging, and mining activities is driven by the growing population in the study area, as well as the need for resources. This has led to a conflict between conservation and development, as various studies have highlighted (World Bank, 2008; Nelson, 2009 and 2010; Wilfred, 2010).

Furthermore, the study found that tree planting practices are not widely adopted in the study villages, despite the importance of tree planting in addressing fuelwood shortages and reducing the pressure on logging. Most households rely on the natural regeneration of trees, with only a few practising private tree planting, agro-forestry, and communal tree planting. This lack of tree planting exacerbates the issue of encroachments in the study area.

Therefore, the findings indicate that encroachments for fuelwood, logging, and mining activities are on the rise in the study area. These activities pose a significant threat to the area's forests, wildlife habitats, and natural resources, leading to conflicts between conservation efforts and the needs of local livelihoods. It is crucial to address these encroachments through stricter enforcement of regulations, promoting sustainable alternatives, and encouraging community participation in conservation and sustainable resource management.

3.5 Wildfires

The study findings indicate that there is a lack of adoption and implementation of wildfire control strategies and practices in the study villages. The study area serves as a migratory route for elephants and other wildlife species, making it particularly susceptible to wildfires. The occurrence of wildfires in the area is frequent, and they are primarily caused by activities such as honey gathering, charcoal production, land clearance for cultivation, and local beliefs.

In the Nanyumbu and Liwale districts, more than eight wildfires are reported each year in various villages within the Selous-Niassa Wildlife Corridor (SNWC). Figures 8 and 9 illustrate the reported incidences of wildfires from 2010 to 2015. The extent of damage caused by these wildfires to the SNWC ecosystem is immense, affecting the biodiversity and ecology of the area. However, the core protected areas of Selous Game Reserve, Msanjesi Game Reserve, Lukwika-Lumesule Game Reserve, and some forest reserves, such as Matandu, Liwale, Mbwemkulu, Lumesule, Lukwika, and Ruvuma, have natural firebreaks such as rivers and man-made breaks like roads. While many villagers are aware of the existence of by-laws to prevent wildfires, traditional methods of starting fires are still commonly practised, especially during nighttime hours. This poses a significant challenge to wildfire prevention efforts.

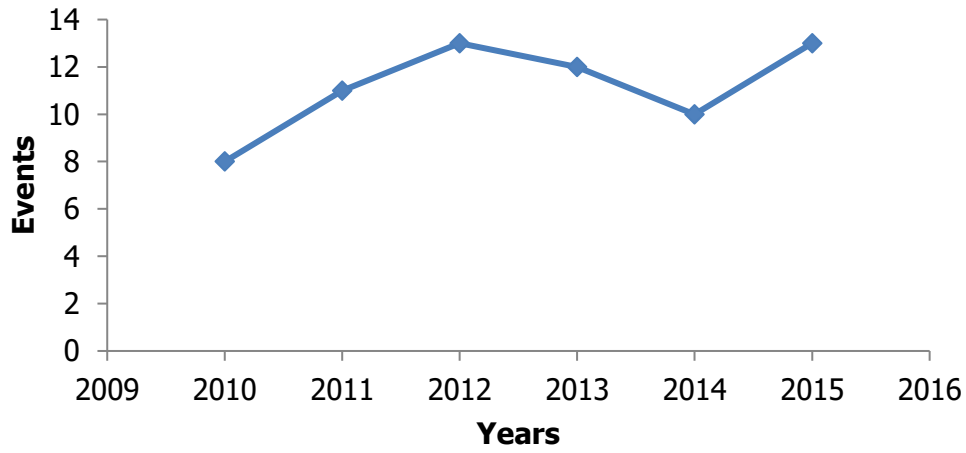

Figure 8: Incidence of Wildfires from the Year 2010 to 2015

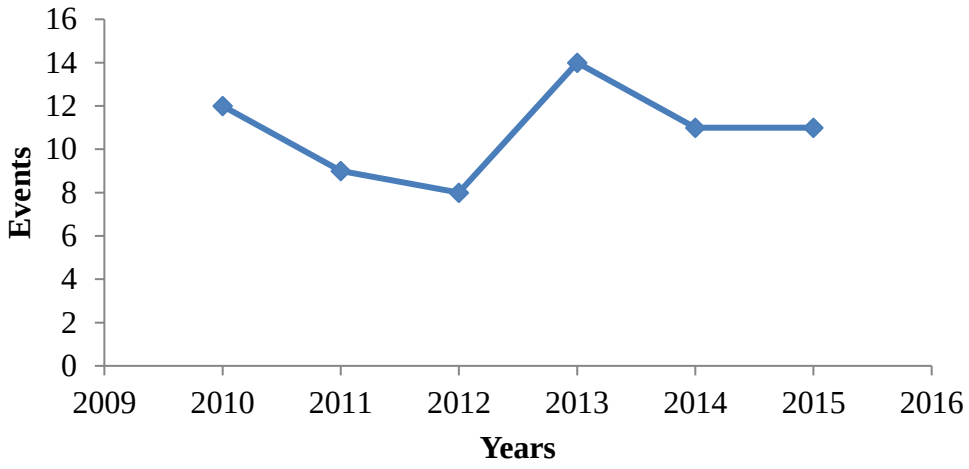

Figure 9: Incidence of Wildfires from the Year 2010 to 2015

Efficient and effective management of wildfires is crucial to protect the biodiversity and ecological integrity of the SNWC ecosystem. The study findings emphasize the need to raise awareness and promote the adoption of wildfire control strategies and practices among local communities. This includes educating villagers about the negative impacts of wildfires on wildlife resources, as well as encouraging alternative livelihood options that reduce reliance on activities that contribute to wildfires, such as honey gathering and charcoal production.

Additionally, it is important to strengthen the enforcement of existing by-laws and regulations related to wildfire prevention. Collaborative efforts between local communities, conservation organizations, and authorities can contribute to more effective fire management. This can involve implementing early warning systems, establishing firebreaks, conducting controlled burns, and training community members in fire management techniques.

Thus, addressing the challenges posed by wildfires requires the active participation and cooperation of all stakeholders involved. By implementing proactive measures to prevent and control wildfires, the study area can better safeguard its valuable biodiversity and wildlife resources.

4. Conclusions and Recommendations

4.1 Conclusions

To conclude, the study highlights the significant impacts of socio-economic activities on the management of the Selous-Niassa wildlife corridor (SNWC) and the effectiveness of existing wildlife management strategies. Community land

uses play a crucial role in the management of natural resources in the SNWC, with limited access to land and gender inequality issues being prevalent in the study area. Shifting cultivation practices and the need for improved agricultural practices are also identified. Moreover, wildlife-crop conflicts are a major challenge in the study area, and the adoption of non-lethal deterrents and conservation agriculture practices are recommended as effective control measures. The study emphasizes the importance of addressing poaching, encroachment for fuelwood, and wildfires, as these activities have a detrimental impact on wildlife habitats and populations.

The study stresses the need for an integrative and participatory approach to wildlife resources management, involving local communities and other stakeholders. Benefit-based approaches need further development to ensure they enhance the value of wildlife resources for local communities, guarantee equitable access, and promote sustainability. Additionally, the effectiveness of existing wildlife management strategies must be evaluated to provide sufficient incentives and motivation to adjacent communities. Thus, there is a need for comprehensive and collaborative efforts to address the impacts of socio-economic activities on the SNWC. By promoting sustainable land use practices, mitigating wildlife-crop conflicts, combating illegal activities, and involving local communities, it is possible to achieve a more harmonious coexistence between human livelihoods and wildlife conservation in the SNWC.

4.2 Recommendations

Based on these findings, the study offers the following recommendations to the government, stakeholders, and the public:

(i) Land tenure systems should ensure equal access for both genders, including divorced or widowed individuals who may be disadvantaged by customary laws. The invasion of reserved land for MAGINGO and MCHIMALU WMAs should be addressed by enforcing existing land use plans, which will contribute to the long-term survival of wildlife. Poor agricultural practices, such as shifting cultivation, should be reversed, as they lead to the destruction of important habitats for wildlife. Instead, cultivation on permanent farm plots with proper mechanization and the use of pesticides, herbicides, and fertilizers should be encouraged. Additionally, efforts should be made to combat elephant poaching by improving working facilities, increasing staff numbers, providing training in new techniques, and fostering collaboration with stakeholders such as the Tanzania Revenue Authority (TRA), Tanzania Ports Authority (TPA), Tanzania forces (Police, Military, and Migration), and local communities. Communities should also reject beliefs that contribute to

increasing wildfires to ensure their future livelihoods, which depend on the ecosystem services provided by the SNWC.

(ii)(ii) The involvement of local communities in SNWC management is crucial to effective conservation efforts. Excluding communities from protected area management can lead to negative outcomes. Indigenous technical knowledge (ITK) should be recognized and integrated into wildlife conservation strategies. Transparency regarding the benefits derived from the protection of wildlife in PAs within the SNWC is essential. Communities need to be aware of the 25% income generated from hunting blocks in the Liwale and Nanyumbu Districts. Hunting companies operating in these blocks should fulfil their obligations according to the Tourist Hunting Regulations of 2010, providing support to the adjacent communities in terms of social services and job opportunities. Furthermore, there is a need to prioritize efforts to control human-wildlife conflict (HWC) in Liwale and Nanyumbu Districts. Enhancing knowledge and promoting the use of non-lethal deterrents, such as oil-chilled ropes and chilled dung blocks, can be effective in mitigating conflict with elephants and problem animals. The Ministry of Natural Resources and Tourism (MNRT) should also establish a compensation or consolation mechanism for individuals who have been injured or have had their crops damaged or destroyed by problem animals. It is essential to address the lack of compensation or consolation that has persisted since 2010. Additionally, measures should be taken to enhance the routines of accessing ritual sites (Ngende) while considering the locations of camping sites used by Ngende groups. Changing the location of camping sites along rivers can facilitate the regeneration of vegetation that may have been destroyed. Finally, fishing activities in camping sites should be halted following the Wildlife Conservation Act No. 5 of 2009.

Implementing these recommendations will contribute to improved land tenure systems, community involvement, transparency, and the effective management of human-wildlife conflicts in the SNWC. Furthermore, recognizing Indigenous knowledge, providing fair compensation, and ensuring sustainable practices will enhance conservation efforts and protect the valuable biodiversity present in the area.

5. Compliance with Ethical Standards

5.1 Acknowledgments

Our frank appreciation to the management of Selous, Lukwika-Lumesule and Msanjesi game reserves; Liwale, Masasi and Nanyumbu Districts; Mpigamiti and

Mpombe villages for their kind acceptance and positive cooperation they provided to us.

5.2 Disclosure of conflict of interest

The authors have no conflict of interest in publishing this paper.

5.3 Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study.

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