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Examining the Influence of Climate Change on Human Wildlife Conflict in Mosi-Oa-Tunya and Sioma Ngwezi National Parks

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Abstract

This study examined the impact of climate change on human-wildlife conflict (HWC) in two ecologically distinct protected areas in Zambia: Mosi-Oa-Tunya National Park (MoTNP) and Sioma Ngwezi National Park (SNNP). Utilizing a mixed-methods approach, data were collected from 171 households around MoTNP and 250 around SNNP through semi-structured questionnaires, complemented by 10 key informant interviews (KIIs) and 2 focus group discussions (FGDs) per site. Secondary data on climate and wildlife were obtained from the Zambia Meteorological Department (ZMD) and the Department of National Parks and Wildlife (DNPW). Quantitative data were analyzed using Microsoft Excel and SPSS Version 30.The findings revealed significant climate variability, including declining rainfall trends (59 mm/year/decade in MoTNP and 43 mm/year/decade in SNNP) and rising temperatures, contributing to prolonged dry seasons and droughts. These climatic changes correlated with increased HWC incidents. SNNP reported a higher prevalence of HWC (92%) compared to MoTNP (79.5%). Four primary HWC types were identified: crop damage, property destruction, livestock depredation, and human attacks, predominantly occurring during the dry season and daylight hours. In MoTNP, elephants, baboons, monkeys, and buffaloes were the key conflict species, while SNNP also reported significant conflict with hippopotamuses, crocodiles, hyenas, lions, and leopards. Communities employed deterrents such as physical barriers and fireworks, while park management focused on education and sensitisation. The study recommends a context-specific, adaptive HWC mitigation strategy that addresses climatic, socio-economic and ecological drivers. These findings provide critical insights for wildlife managers and policymakers to develop sustainable and inclusive climate-resilient HWC mitigation.

Keywords: *Climate Change, Climate Variability, Human-Wildlife Conflict, Mitigation.*

Introduction

Climate change has become one of the most pressing global challenges, with widespread implications for both the environment and human societies. Among its many ecological impacts, climate change is significantly influencing the dynamics of human-wildlife interactions. As ecosystems shift due to rising temperatures, altered rainfall patterns, and increased frequency of extreme weather events, wildlife species are forced to adjust their behaviors and movement patterns, often bringing them into closer contact with human populations [1]. These shifts disrupt traditional ecological balances and have intensified the frequency and severity of human-wildlife conflict (HWC), particularly in regions where

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humans and wildlife coexist in shared landscapes [2].

Human-wildlife conflict arises when the behavior or needs of wildlife directly interfere with human livelihoods, safety, or property, or conversely, when human activities negatively affect wildlife habitats and survival. In sub-Saharan Africa, where many communities live near protected areas and wildlife corridors, such conflicts are increasingly common and pose a threat to both biodiversity conservation and local socioeconomic development. In Zambia, for instance, between 2002 and 2008, an estimated 347 people were killed by wildlife, with crocodiles, elephants, and hippos accounting for most fatalities [3]. These figures highlight the magnitude of HWC in the country and underscore the urgent need for effective mitigation strategies.

Despite growing awareness of the links between climate change and HWC, comparative research that examines how these dynamics vary across different protected areas remains limited. This study addresses that gap by focusing on two ecologically and socio-economically distinct national parks in Zambia: Mosi-Oa-Tunya National Park (MoTNP) and Sioma Ngwezi National Park (SNNP). These two parks offer a unique opportunity for comparative analysis due to their contrasting settings. MoTNP is located within the urbanized environment of Livingstone, a city with significant infrastructure and tourism activity in southern Zambia. In contrast, SNNP lies in the remote Sioma District in the western region of the country, characterized by rural settlements, low population density, and communities that depend heavily on natural resources for sustenance.

These differing settings reflect unique pressures on wildlife and human populations and thus generate distinct human-wildlife conflict dynamics. The absence of comparative studies addressing how climate-induced changes interact with these localized pressures limits the formulation of responsive and context-specific mitigation strategies.

This study aims to fill this research gap by conducting a comparative assessment of climate-related human-wildlife conflict across these two national parks. It will:

1. Investigate the frequency, patterns, and spatial distribution of human-wildlife conflict incidents in both Mosi-Oa-Tunya and Sioma Ngwezi
2. Examine the socio-economic determinants influencing conflict in the surrounding communities, such as livelihoods, land use, and household vulnerability
3. Assess the perceptions, attitudes, and adaptive responses of key stakeholders, including local communities, park management, and conservation authorities, towards HWC.

By analysing how climate variability influences wildlife behaviour and resource competition, and by evaluating the effectiveness of current mitigation efforts, the study seeks to inform the development of adaptive and inclusive conflict management strategies. These insights will be crucial for shaping conservation policies that enhance resilience, safeguard biodiversity, and support sustainable livelihoods and development for communities co-existing with wildlife.

Methods and Materials

Study Area Location and Description

Sioma Ngwezi National Park (5,276 km²) lies in Western Zambia, bordering Namibia and Angola, and includes part of the West Zambezi GMA. Mosi-Oa-Tunya National Park (6,600 ha) is Zambia's second smallest park, located in Livingstone and uniquely surrounded by communities without a buffer zone. Both national parks are within the KAZA TFCA.

Research Design

This study employed a comparative case study design to examine the influence of climate change on human-wildlife conflict in

Mosi-Oa-Tunya and Sioma Ngwezi National Parks. A mixed-methods approach integrated quantitative analysis of climate trends, conflict records, and socio-economic data with qualitative insights from interviews and focus group discussions. This combination enabled a comprehensive understanding of context-specific human-wildlife interactions, adaptive responses, and the socio-ecological dynamics at play. Triangulation of data sources ensured methodological rigour, allowing for both statistical assessment and nuanced interpretation of the impacts of climate change and variability on conflict patterns [4].

Population Study

The target population consisted of all households around Mosi-Oa-Tunya National Park and Sioma Ngwezi National Park, as well as the involved wildlife management personnel. There are 53,394 people in Sioma Ngwezi and 43,181 people around Mosi-Oa-Tunya National Park, giving a total of 96,575 people.

Sampling Frame

The study's sampling frame comprised populations living near Mosi-Oa-Tunya and Sioma Ngwezi National Parks, totalling 43,181 and 53,394 individuals, respectively. It included key villages, wards, and chiefdoms within and around park boundaries, capturing areas most affected by human-wildlife conflict. For SNNP, five core villages Dihehe, Imusho, Ngweze, Mbao, and Mbala were central, alongside others in the surrounding Game Management Area. In MoTNP, settlements such as Chief Mukuni's village, Simonga (Sekute Chiefdom), and wards like Zambezi, Shungu, and Dambwa Central were included. This comprehensive geographic sampling frame ensured representation across diverse socio-ecological contexts, supporting robust qualitative and quantitative data collection.

Sample Size

Selecting the appropriate sample size from a large population was critical to avoiding research and/or inference bias. To obtain statistically acceptable results, the required sample size for questionnaire surveys was based on the following calculations:

The sample size was obtained using the Taro [$n = N/1 + N(e)^2$] formula as follows:

$n = N/1 + N(e)^2$

Where n = the required sample of study.

N = total population of study.

e= (0.05 marginal error).

Therefore:

$n = 96,575/1 + 96,575(0.05)^2$

$n = 383$

Table 1. Sample Size Determination for MoTNP and SNNP

National Park	Population	Sample Size Calculation	Sample Size
Sioma Ngwezi	53,394	(63,038/ 96,575) *383	250
Mosi-Oa-Tunya	43, 181	(43,181/ 96,575) *383	171

At 95% level of significance and 5% margin of error, sample size was 212 for SNNP and 171 for MoTNP residents.

Sampling Procedure

The study employed a systematic random sampling technique to select households near the national parks, with stratification to ensure representation across diverse communities and demographic groups. Additionally, purposive sampling was used to identify key informants from park management, government agencies, community leadership, and conservation NGOs, ensuring inclusion of expert perspectives on human-wildlife conflict and climate change.

Data Collection Methods

Primary data were collected through semi-structured questionnaires, focus group discussions, and key informant interviews. A total of 171 respondents in MoTNP and 250 in

SNNP were purposively selected using a homogenous sampling technique between 2023 and 2024. Additionally, 10 key informant interviews were conducted in each park. Random sampling was applied for household surveys, while non-probability sampling guided key informant selection. Secondary data included 24 monthly HWC reports from 2023-2024 under the Department of National Parks and Wildlife (DNPW), alongside data on wildlife corridors and hotspots from DNPW and partners. Climate trends and projections were sourced from meteorological reports and regional/global climate literature.

Data Analysis

Microsoft Excel (2019) and SPSS (Version 30) were used to analyse quantitative data. To investigate conflict species, HWC types, climate variables, and mitigation strategies, pivot tables, descriptive statistics, frequency distributions, and cross-tabulations were used. Pie charts and bar charts were among the visualisations used to highlight important trends and patterns. Excel was used to transcribe, code, and thematically analyse qualitative data from focus groups and key informant interviews to find themes of climate change, adaptive responses, and human-wildlife conflict. Combining qualitative and quantitative data improved the study's validity and gave researchers a thorough grasp of the dynamics between HWC and climate change.

Ethical Considerations

Ensuring respondent confidentiality and anonymity was fundamental to maintaining the ethical integrity of this study. By established research ethics [5], all sensitive data were handled with strict confidentiality and accessed only by the core research team. Participants were assured that their responses would remain anonymous and would be used solely for academic purposes. No personally identifiable information was recorded or disclosed to third parties, thereby safeguarding participant privacy and upholding the credibility of the research process.

Results

Frequency, Patterns, and Spatial Distribution of Human-Wildlife Conflict Incidents in Mosi-Oa-Tunya and Sioma Ngwezi National Parks

In Sioma National Park, a vast majority of respondents (92.0%) reported having personally experienced human-wildlife conflicts in the past years. Only 8.0% of respondents indicated that they had not experienced such conflicts. While in Mosi-Oa-Tunya National Park, a slightly smaller majority of respondents (79.5%) reported experiencing human-wildlife conflicts in the past years. A notable 20.5% of respondents stated that they had not experienced such conflicts (Table 2).

Table 2. Distribution of Whether Respondents Personally Experienced any Human-Wildlife Conflicts in the Past Years

	MoTNP		**SNNP**	
Description	**Frequency**	**Percent**	**Frequency**	**Percent**
Yes	136	79.5	230	92
No	35	20.5	20	8
Total	171	100	250	100

In Sioma Ngwezi National Park, the survey revealed a few human-wildlife conflicts, particularly centred around crop damage and raiding by elephants and hippos, as well as livestock depredation by hyenas, crocodiles, and lions. Respondents vividly described the challenges they face, with one lamenting, *"Elephants trampled over my maize field,*

leaving nothing but destruction in their wake." Another respondent poignantly expressed, "The hippos threaten our lives whenever we try to tend to our fields near the river."

Additionally, incidents of wildlife attacks on humans were reported, including encounters with crocodiles and hippos. One respondent recounted a harrowing experience, saying, *"I narrowly escaped a hippo attack while I was fishing along the riverbank. It was a terrifying ordeal that I never want to experience again."* These direct quotes provide a glimpse into the real and immediate dangers faced by individuals living near wildlife habitats.

In Mosi-Oa-Tunya National Park, similar conflicts were reported, including elephant attacks, property damage by elephants, and crop raids by elephants and baboons. One respondent shared, *"The elephants destroyed our crops overnight, leaving us with nothing to harvest."*

Additionally, incidents of wildlife attacks on humans were reported, including encounters with crocodiles and hippos. One respondent recounted a harrowing experience, saying, *"I narrowly escaped a hippo attack while I was fishing along the riverbank. It was a terrifying ordeal that I never want to experience again."* These direct quotes provide a glimpse into the real and immediate dangers faced by individuals living near wildlife habitats. In Mosi-Oa-Tunya National Park, similar conflicts were reported, including elephant attacks, property damage by elephants, and crop raids by elephants and baboons. One respondent shared, *"The elephants destroyed our crops overnight, leaving us with nothing to harvest."* Another highlighted the issue of wildlife intrusion, stating, *"Baboons frequently break into our homes, causing damage and stealing food."*(Figure 1).

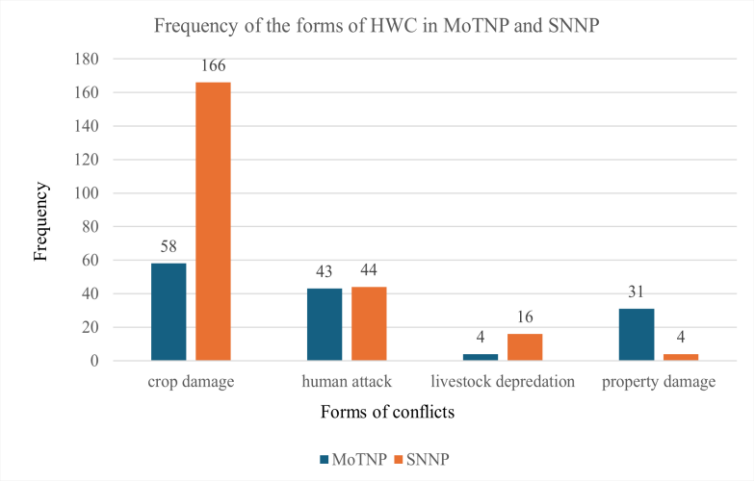

Figure 1. Frequency of the Different forms of Human Wildlife Conflicts Experienced in Mosi-Oa-Tunya and Sioma Ngwezi National Parks

Wild animals are responsible for different forms of conflicts and their threat levels in the two landscapes vary significantly. In SNNP, elephants were the most problematic species accounting for 68.2 % of the recorded HWC cases. The elephant conflicts were broken down into the following forms of conflicts; crop damage (63%), Human attacks (3.9%) and Property damage (1.3%). Hippos were the second most problematic species in SNNP, accounting for 14.4% of the recorded conflicts. Hippo conflicts were segmented as human attack (8.3%) and crop damage (6.1%). The third most problematic animal in SNNP was the crocodile, representing 5.7% of the recorded conflicts in SNNP. crocodile conflicts were segmented as human attack (3.5%) and livestock depredation (2.2%). Other notable conflict causing species in SNNP were the Eland (3.2%), Hyena (2.6%), Lions (2.6%),

Buffalo (1.7%), Leopard (0.8%) and Baboons/Monkeys (0.8%) (Figure 2).

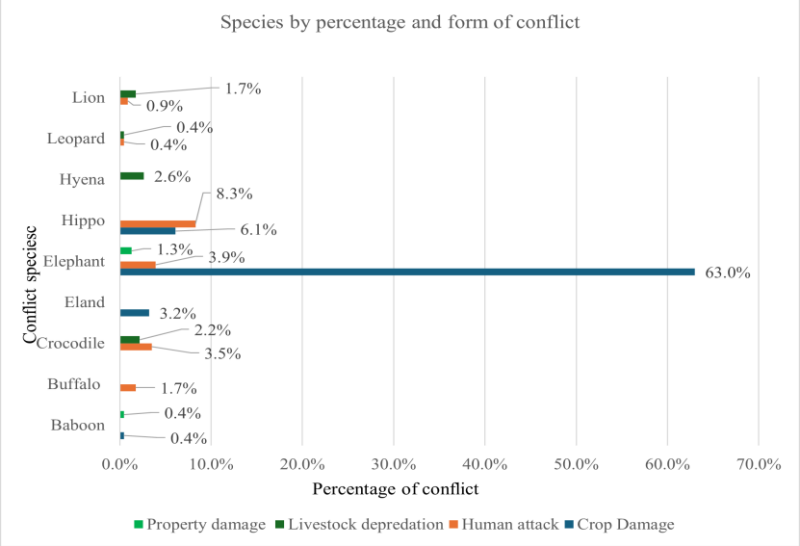

Figure 2. Frequency Percentages for the Various Forms of Human Wildlife Conflicts per Specie in Sioma Ngwezi National Park

In MoTNP, elephants were the most problematic species, accounting for 68 % of the recorded HWC cases. The elephant conflicts were broken down into the following forms of conflicts; crop damage (33%), Human attacks (19%) and Property damage (16%). Baboons and Monkeys were the second most problematic species in MoTNP, accounting for 20% of the recorded conflicts. Baboons and Monkey conflicts were segmented as human crop damage (8%), property damage (7%) and Human attack (5%). The third most problematic animal in MoTNP was the Buffalo, representing 5% of the recorded conflicts. Other notable conflict-causing species in MoTNP were the Hippo (3%) and Crocodile (3%). Despite MoTNP having no resident carnivores, sightings of carnivores have been confirmed, with hyena accounting for (1% of recorded conflicts through livestock depredation (Figure 3).

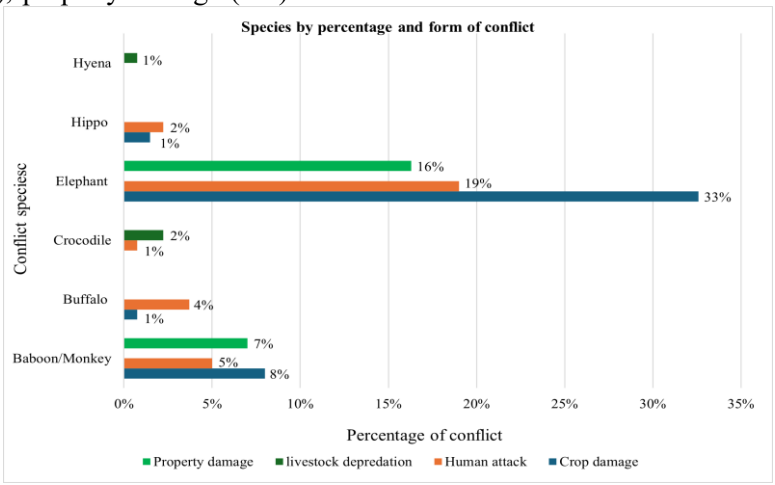

Figure 3. Frequency Percentages for the Various Forms of Human Wildlife Conflicts per Specie in Mosi-Oa-Tunya National Park

The temporal patterns of human wildlife conflict were observed in terms of time (day or night) and season (wet or dry) in which the incidents occurred. Results indicated that the

majority (57%) of human wildlife conflicts incidents in Sioma Ngwezi National Park occurred during the day compared to those that occurred during the night (43%). This trend was also seen in Mosi-Oa-Tunya National Park, though with a higher percentage of conflicts that occurred during the day (70%) compared to those that occurred during the night (30%) (Figure 4).

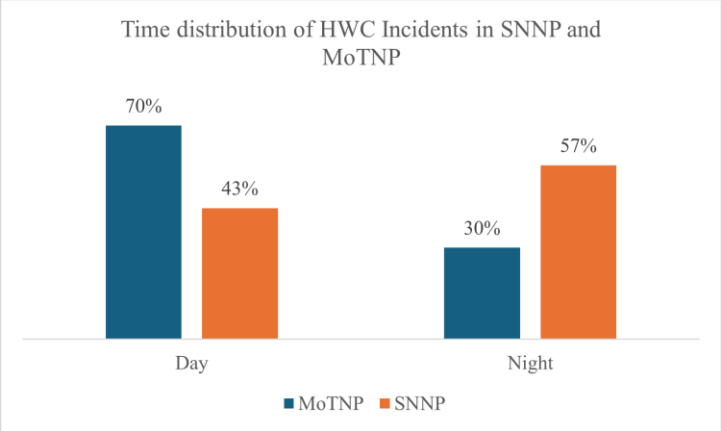

Figure 4. Proportion of Conflict Incidents that Occur during Daytime and Nighttime in Mosi-Oa-Tunya and Sioma Ngwezi National Parks

The results obtained on the seasonal distribution of HWC incidents indicated that the majority (67%) of human wildlife conflicts incidents in Sioma Ngwezi National Park occurred during the dry season compared to those that occurred during wet season (33%). A similar trend was also observed in Mosi-Oa-Tunya National Park, though with a higher percentage of conflicts that occurred during the dry season (80%) compared to those that occurred during the wet season (20%) (Figure 5).

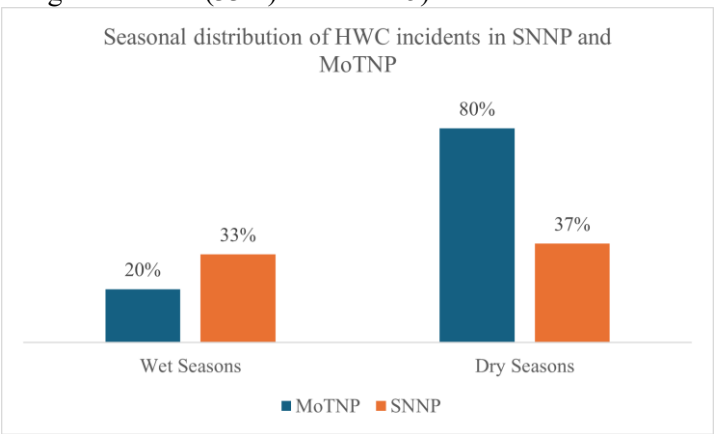

Figure 5. Proportion of Conflict Incidents that Occur During Wet and Dry Season of the Year in Mosi-Oa-Tunya and Sioma Ngwezi National Parks

From the key informant interviews and focus group discussions, the participants were asked to name and locate the areas where most of the conflicts occur within the study areas. The areas were marked by taking coordinates (Table 3 and Table 4) and located on a map of human-wildlife conflicts (Figure 6 and Figure 7). The map shows the human-wildlife conflict hotspots (or areas where a lot of conflicts occur). The hotspots were located both inside and outside the park boundaries.

Table 3. Summary of Identified Communities that are HWC Hotspots with GPS Coordinates and the most Prevalent Form of Conflict in MoTNP

SN	LATITUDE	LONGITUDE	COMPOUND	FORM OF HWC
1	-17.917912	25.893658	Nsongwe	Human Elephant Conflict
2	-17.917927	25.893625	Simasiku	Human Elephant Conflict
3	-17.930831	25.902325	Mukuni	Human Elephant Conflict
4	-17.902718	25.939903	Dambwa, Mukuni	Human Elephant Conflict
5	-17.871534	25.959313	Chise	Human Elephant Conflict
6	-17.870009	25.981795	Muchinga	Human Elephant Conflict
7	-17.86999	25.981793	Mukalahani	Human Elephant Conflict
8	-17.900142	25.975674	N'gandu	Human Elephant Conflict
9	-17.944686	25.955478	Machenje	Human Elephant Conflict
10	-17.903142	25.911858	Siamapa	Human Elephant Conflict
11	-17.874828	25.837916	Sewerage	Baboon and Elephant Conflict
12	-17.868148	25.84915	Cold storage	Human Elephant Conflict
13	-17.860985	25.851509	217	Human Elephant Conflict
14	-17.860963	25.851496	Simoonga	Human Elephant Conflict
15	-17.808681	25.716612	Sinde	Human Elephant Conflict
16	-17.661893	25.905846	Sons of thunder	Human Elephant Conflict
17	-17.661847	25.905852	Musokotwane	Human Elephant Conflict
18	-17.618848	25.837868	Sinde mission	Human Elephant Conflict
19	-17.618868	25.837751	Kananga	Human Elephant Conflict
20	-17.851457	25.818776	Parklands	Human Elephant Conflict
21	-17.854553	25.819636	Nakatindi	Baboon and Elephant Conflict
22	-17.859015	25.826668	Morelight	Human Elephant Conflict
23	-17.863889	25.831781	INDECO	Human Elephant Conflict
24	-17.863885	25.831818	DVS Extension	Human Elephant Conflict
25	-17.866761	25.839311	Maloni	Human Elephant Conflict
26	-17.883345	25.874659	Linda	Baboon and Elephant Conflict
27	-17.863463	25.858443	Railways	Human Elephant Conflict
28	-17.85735	25.879739	Libuyu	Human Elephant Conflict
29	-17.857356	25.879727	Kalaluka	Human Elephant Conflict
30	-17.855306	25.910237	Silozi	Human Elephant Conflict
31	-17.886472	25.859034	Maramba bridge	Human Elephant Conflict
32	-17.928011	25.864870	Victoria border	Baboon conflict
33	-17.924937	25.867957	Zesco station	Baboon conflict
34	-17.874972	25.851803	Foleys land rover	Buffalo conflict
35	-17.878474	25.858628	Elephant view/Munga	Baboon and Elephants
36	-17.883694	25.842795	Gate 1 area	Baboon/Monkey conflict
37	-17.911121	25.863739	Dry Manzi	Human Hippo Conflict
38	-17.821261	25.796492	Airport	Buffalo conflict

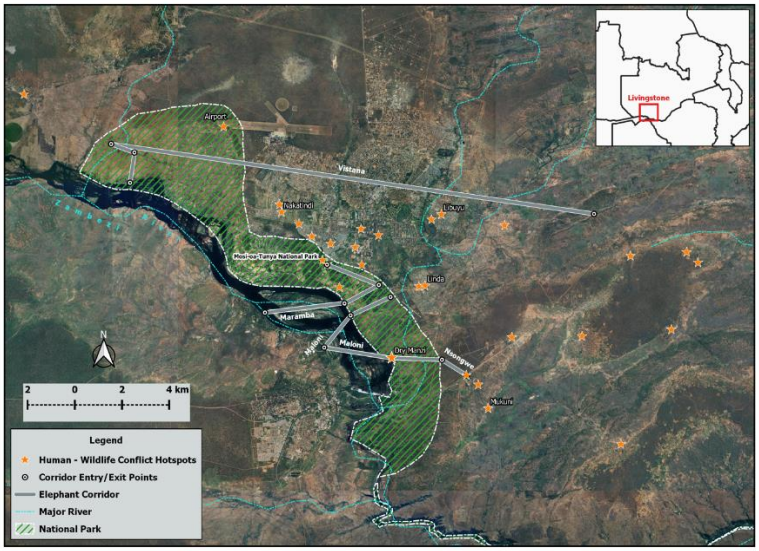

Figure 6. Map of HWC Hotspots in MoTNP

Table 4. Summary of Identified Communities that are HWC Hotspots with GPS Coordinates and the most Prevalent Form of Conflict in SNNP

SN	LATITUDE	LONGITUDE	COMMUNITY	FORM OF HWC
1	-17.01474	23.9607	Kalobolelwa	Human Elephant Conflict
2	-16.990501	23.951212	Kalobolelwa	Human Elephant Conflict
3	-17.23728	24.11474	Mutemwa Lusu	Human Elephant Conflict
4	-17.15797	24.05826	Mutemwa Lusu	Human Elephant Conflict
5	-17.38381	24.17863	Silolo	Human Elephant Conflict
6	-16.79216308	23.74784519	Kaale	Human Elephant Conflict
7	-17.018667	23.96456	Kalobolelwa	Human Elephant Conflict
8	-16.48349	23.24035	Nangweshi	Human Elephant Conflict
9	-16.41166	23.33824	Nangweshi	Human Elephant Conflict
10	-16.46509	23.3952	Kaanja	Human Elephant Conflict
11	-16.4747	23.40561	Kaanja	Human Elephant Conflict
12	-16.52009	23.4521	Kaanja	Human Elephant Conflict
13	-16.48574	23.41527	Kaanja	Human Elephant Conflict
14	-16.600523	23.499746	Malombe	Human Elephant Conflict
15	-16.60369	23.51259	Malombe	Human Elephant Conflict
16	-17.5339	23.25109	Imusho	Human Elephant Conflict
17	-17.5159	23.21008	Imusho	Human Elephant Conflict
18	-17.57464	23.38688	Mbala	Human Elephant Conflict
19	-17.61877	23.42844	Mbala	Human Elephant Conflict
20	-16.61764	23.52988	Malombe	Human Elephant Conflict
21	-16.86098	23.18677	Sipangule	Human Carnivore Conflict (HCC)
22	-16.88764	23.25069	Sipangule	Human Carnivore Conflict (HCC)
23	-17.59412	23.41261	Mbala	Human Carnivore Conflict (HCC)
24	-16.79203299	23.75121304	Kaale	Human Crocodile & Hippo Conflict
25	-17.46889899	24.24302003	Silolo	Human Crocodile & Hippo Conflict
26	-16.600523	23.499746	Malombe	Human Crocodile & Hippo Conflict

27	-16.37848	23.31594	Nangweshi	Human Crocodile & Hippo Conflict
28	-16.39609401	23.33107199	Nangweshi	Human Crocodile & Hippo Conflict
29	-17.23188	24.1089	Mutemwa Lusu	Human Crocodile & Hippo Conflict
30	-16.49151502	23.422725	Kaanja	Human Crocodile & Hippo Conflict
31	-17.23538	24.11334	Mutemwa Lusu	Human Crocodile & Hippo Conflict
32	-16.61837596	23.53643096	Sikuka	Human Crocodile & Hippo Conflict
33	-17.1553	24.06485	Mutemwa Lusu	Human Crocodile & Hippo Conflict
34	-17.48036	24.296656	Sililo	Human Crocodile & Hippo Conflict
35	-17.42123	24.19851	Sililo	Human Crocodile & Hippo Conflict
36	-16.79203299	23.75121304	Kaale	Human Crocodile & Hippo Conflict
37	-16.49289	23.41876	Kaanja	Human Crocodile & Hippo Conflict
38	-16.40051	23.31803	Nangweshi	Human Crocodile & Hippo Conflict

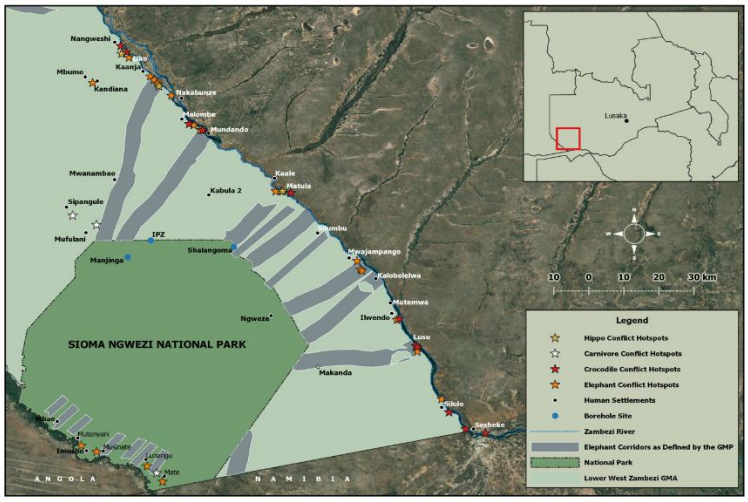

Figure 7. Map of HWC Hotspots in SNNP

Socio-economic Determinants of Human-Wildlife Conflict in Communities Surrounding Mosi-Oa-Tunya and Sioma Ngwezi National Parks

Human-wildlife conflict (HWC) is a pressing issue faced by communities living at the human wildlife interphase, often arising from competition for resources. In the context of Mosi-Oa-Tunya and Sioma Ngwezi National Parks, socio-economic factors are multifaceted and rooted in the complex interactions among human communities, wildlife populations, legislation and governance. Therefore, understanding how climate change variables are influencing the incidents of HWC can be better understood by incorporating these complex socio-economic determinants that have a bearing on HWC. This holistic approach is crucial for developing effective and adaptive management strategies that prioritize both wildlife conservation and community livelihoods, thereby helping to foster coexistence between humans and wildlife.

The socioeconomic determinants of HWC were collected from the 171 respondents in Mosi-Oa-Tunya National Parks and the 250 respondents in Sioma Ngwezi National Park. The responses were sorted and analysed revealing that 52% of respondents in Sioma Ngwezi National Park indicated poverty and lack off alternative livelihood options as one of the crucial drivers off HWC in the landscape. additionally, 32 % of respondents cited the lack of compensation legislation in conflict incidents as a serious socioeconomic factor that

influenced some conflicts. 12% of respondents indicated land use planning and land use changes while 4% indicated the status of people living alongside wildlife (co-existence) as a contributing factor to the prevailing HWC in Sioma Ngwezi National Park (Figure 8).

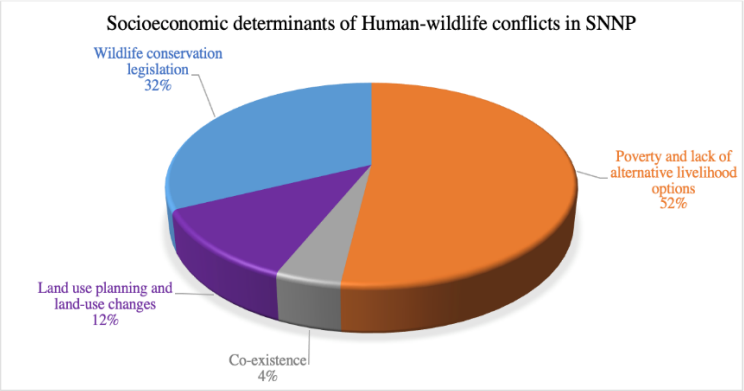

Figure 8. Chart Indicating the Proportions of Socioeconomic Determinants of HWC in Sioma Ngwezi National Park

In Mosi-Oa-Tunya National Park, respondents indicated that rapid urbanisation (33%), agriculture and human settlement expansion (29%), land use planning and land use changes (26%) and wildlife conservation legislation (12%) were the main social economic factors that influenced HWC (Figure 9).

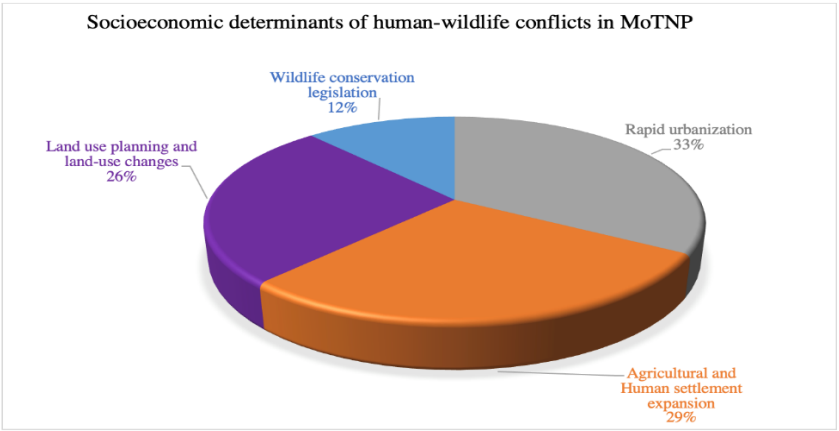

Figure 9. Chart Indicating the Proportions of Socioeconomic determinants of HWC in Mosi-Oa-Tunya National Park

Perceptions, Attitudes and Adaptive Responses of local Communities, Park Management Authorities, and other Stakeholders Regarding Human-Wildlife Conflict

Participants were asked to describe how severe they perceived the issue of human-wildlife conflicts in their community. The responses were divided into three categories: "Not severe at all," "Somewhat severe," and "Very severe (Table 5). Majority of respondents in Sioma Ngwezi National Park perceive the issue of human-wildlife conflicts as very severe, with 80.4% of respondents holding this view while a small proportion of respondents, 4.8%, viewed the issue as not severe at all. On the other hand, in Mosi-Oa-Tunya National Park, a similar trend was observed, albeit with slightly different percentages. Here, 67.8% of respondents perceived the issue as very severe, while 28.1% viewed it as somewhat severe and 4.1% of respondents felt that the issue was not severe at all (Table 5).

Table 5. Perception of the Severity of the Issue of Human-Wildlife Conflicts in the Community

	MoTNP		SNNP	
Description	**Frequency**	**Percent**	**Frequency**	**Percent**
Not severe at all	7	4.1	12	4.8
Somewhat severe	48	28.1	37	14.8
Very severe	116	67.8	201	80.4
Total	171	100	250	100

In Sioma Ngwezi National Park, the average perception of the severity of human-wildlife conflicts, measured on a scale of 1 to 3, is 2.76. This indicates that, on average, respondents perceive the issue to be closer to "very severe" than "somewhat severe." The median score of 3.00 and the mode of 3 further support this, suggesting that the most common perception among respondents is that the issue is "very severe." The standard deviation of 0.531 indicates that responses are relatively clustered around the mean, with little variation (Table 6).

In Mosi-Oa-Tunya National Park, the median and mode are both 3, indicating that the most common perception among respondents is also that the issue of human-wildlife conflicts is "very severe." The average score is 2.64, slightly lower than in Sioma Ngwezi National Park. The standard deviation of 0.561 suggests that there is slightly more variability in perceptions among respondents in Mosi-Oa-Tunya National Park compared to Sioma Ngwezi National Park, although both parks show a strong consensus that the issue is perceived as very severe (Table 6).

Table 6. Central Tendencies of the Perception of the Severity of the Issue of Human-Wildlife Conflicts in the Community

	N	Mean	Median	Mode	Std. Dev	Skewness	Kurtosis	Min	Max
MoTNP	171	2.64	3	3	0.561	-1.268	0.65	1	3
SNNP	250	2.76	3	3	0.531	-2.114	3.547	1	3

Respondents were asked if they had noticed any changes in wildlife behaviour around national parks recently. 82.8% of respondents in Sioma Ngwezi National Park indicated that they had noticed changes in wildlife behavior, while 5.2% said they had not noticed any changes, and 12% were not sure (Table 7). On the other hand, 73.1% of respondents in Mosi-Oa-Tunya National Park reported noticing changes in wildlife behavior, 14.6% said they had not noticed any changes, and 12.3% were not sure (Table 7).

Table 7. Distribution of Whether Respondents Noticed Changes in Wildlife Behaviour around the National Parks

	MoTNP		SNNP	
Description	**Frequency**	**Percent**	**Frequency**	**Percent**
Yes	125	73.1	207	82.8
No	25	14.6	13	5.2
Not sure	21	12.3	30	12
Total	171	100	250	100

Furthermore, the respondents were asked whether they believed the observed changes in wildlife behaviour were linked to climate change. In Sioma Ngwezi National Park, the majority of respondents (80.8%) believe that the changes in wildlife behavior, such as increased aggression and encroachment into human settlements, are linked to climate change. A smaller proportion of respondents (8.0%) do not believe there is a link, while 11.2% are not sure (Table 8).

In Mosi-Oa-Tunya National Park, a slightly lower percentage of respondents (63.7%) believe that the changes in wildlife behavior are linked to climate change. 15.2% of respondents do not believe there is a link, and 21.1% are unsure (Table 8).

Table 8. Respondents' Perception of Wildlife Behaviour being Linked to Climate Change

	MoTNP		**SNNP**	
Description	**Frequency**	**Percent**	**Frequency**	**Percent**
Yes	109	63.7	202	80.8
No	26	15.2	20	8
Not sure	36	21.1	28	11.2
Total	171	100	250	100

Participants were also asked to describe how they perceive the response of the national park management to human-wildlife conflicts. The responses were categorized into four groups: "Very effective," "Somewhat effective," "Not effective," and "Not sure." Table 9 below summarizes the responses. In Sioma Ngwezi National Park, 61.6% of respondents believed that the response of National Parks Management was not effective. Additionally, 16.8% of respondents found the response somewhat effective, while only 19.6% considered it very effective. In Mosi-Oa-Tunya National Park, the perceptions of the national park management's response were slightly different indicating that 57.9% of respondents believed that the response was not effective, 32.2% of respondents believed the response by national parks management was somewhat effective and 7.0% of respondents considered the response very effective (Table 9).

Table 9. Perception of Responses of National Park Management to Human-Wildlife Conflict Incidents

	MoTNP		**SNNP**	
Description	**Frequency**	**Percent**	**Frequency**	**Percent**
Very effective	12	7	49	19.6
Somewhat effective	55	32.2	42	16.8
Not effective	99	57.9	154	61.6
Not sure	5	2.9	5	2
Total	171	100	250	100

In Sioma Ngwezi National Park, the mean response to the perceived effectiveness of the national park management's response to human-wildlife conflicts was 2.46, with a median of 3.00 and a mode of 3. The standard deviation was 0.827, indicating a relatively high level of variability in responses. The distribution was negatively skewed (-0.818), suggesting that more respondents rated the response as not effective compared to those who rated it as very effective or somewhat effective. The kurtosis was -0.694, indicating a relatively flat distribution with fewer extreme responses (Table 10).

In Mosi-Oa-Tunya National Park, the median response was also 3.00, with a mode of 3. The standard deviation was 0.669, indicating a moderate level of variability in responses. The distribution was slightly negatively skewed (-0.667), suggesting a similar pattern to Sioma Ngwezi National Park, where more respondents rated the response as not effective. The kurtosis was 0.078, indicating a relatively normal distribution with no significant outliers (Table 10).

Table 10. Central Tendencies of the Perceptions and Responses of National Park Management to Human-Wildlife Conflicts

	N	Mean	Median	Mode	Std. Dev.	Skewness	Kurtosis	Min	Max
MoTNP	171	2.57	3	3	0.669	-0.667	0.078	1	4
SNNP	250	2.46	3	3	0.827	-0.818	-0.694	1	4

Perceptions and responses towards human-wildlife conflicts vary among stakeholders, reflecting a complex interplay of cultural, socioeconomic, and conservation values. DNPW Principal Ranger with more than a decade of experience, acknowledges, *"Communities living near Mosi-Oa-Tunya are divided in their perceptions of wildlife, with some fearing and resenting them, while others actively participate in conservation efforts."*

Respondents were asked whether they preferred to co-exist with wildlife in both Mosi-Oa-Tunya and Sioma Ngwezi National Park, 87% of respondents were for the idea of co-existence while only 13 % did not want humans to co-exist with wildlife in Mosi-Oa-Tunya. A way less proportion of 39% were for co-existence in SNNP with a higher proportion of respondents (61%) being against co-existence (Figure 10).

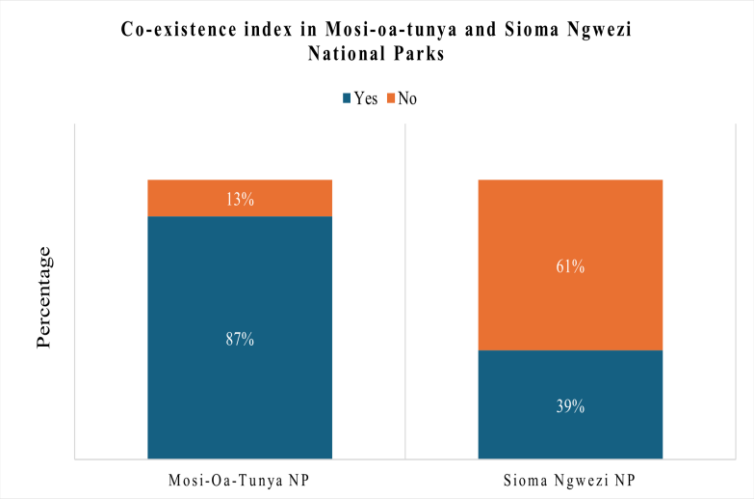

Figure 10. Showing the Wildlife Tolerance Level through the Co-existence Index in Mosi-Oa-Tunya and Sioma Ngwezi National Parks

Furthermore, the attitude of respondents towards wildlife was guaged through HWC retaliatory actions. Respondents were asked to give their experienced opinion and 93% of respondents in Mosi-Oa-Tunya national park perceived retaliatory killing not an ideal response to HWC. Conversely, retaliatory killing was a popular option in Sioma Ngwezi with 56% of respondents leaning towards its use (Figure 11)

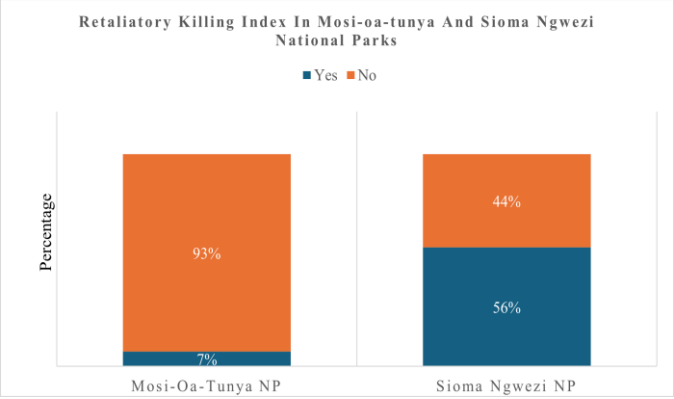

Figure 11. Showing the Wildlife Tolerance Level through the Retaliatory Killing Index in Mosi-Oa-Tunya and Sioma Ngwezi National Parks

Discussion

More people (92%) have experienced human-wildlife conflict in Sioma Ngwezi National Park than in Mosi-Oa-Tunya (79.5%). Human-wildlife contact grew in SNNP when settlements were legalised. Population density may enhance human-wildlife interactions in the two research regions. Despite having more people than SNNP, MoTNP has less wildlife-human conflicts[6]. reported similar results to current literature on cohabited human-wildlife conflicts in Tanzania's Ngorongoro Conservation Area.

In many instances, MoTNP and SNNP worried about wildlife-induced crop and property damage, livestock predation, and human attacks [7]. Population growth and urbanisation, agriculture, and commercial development have increased elephant, baboon, and buffalo interactions in MoTNP. Most MoTNP responders said elephants and baboons cause the most trouble. Due to biological diversity and an increasing legal human population in SNNP, elephants, hippos, hyenas, lions, and crocodiles assault crops, prey on livestock, and attack humans. In SNNP, elephants, hippos, crocodiles, elands, hyenas, lions, buffalo, baboons/monkeys, and leopards create the greatest conflict. These findings differed from [3], who identified animal species responsible for human injuries and deaths in Zambia from 2002 to 2008. Five common wildlife conflict species include Nile crocodile, elephant, hippopotamus, lion, and buffalo.

Crop destruction dominated human-wildlife conflict in Mosi-Oa-Tunya and Sioma Ngwezi National Parks, despite livestock depredation, injuries, and deaths. Agriculture was along the park boundaries. Farm proximity to protected areas dramatically increased crop loss [8]. Crop damage caused by wildlife is a common human-wildlife conflict [9, 10]. The cost of human wildlife conflict on both humans and wildlife remained unmeasured [11]

Conflicts between humans and predators detected four apex predators in SNNP: Nile crocodile, spotted hyena, lion, and leopard. The Zambezi River features crocodiles but no carnivores, hence MoTNP has negligible cattle depredation. Elephants dominated MoTNP animal conflicts (68%). More human-elephant conflicts (HEC) injuries and deaths confirmed this. Elephants damaged homes by breaking fences and falling into septic tanks. Wildlife-motorist RTAs have occurred due to road fragmentation in MoTNP. Road traffic killed giraffes, elephants, hippopotamuses, and buffalo in Mosi-Oa-Tunya National Park.

Dry season HWC disputes were more likely in MoTNP and SNNP (May-October) than wet season (November-April). In the wet season, restored seasonal rivers and pans provided feed and water, concentrating wildlife in core regions with little human interaction and shaping patterns. In contrast, the dry season

witnessed mature crops, lower feed mass, and desiccating seasonal rivers and pans, which caused elephants to encroach on agricultural and human habitation areas seeking food and water [12]. Elephants in SNNP migrated across Zambia, Namibia, Botswana, and Angola during wet and dry seasons, while the elephants in MoTNP migrated across Zambia, Zimbabwe, and Botswana. Elephants stayed in Mosi-Oa-Tunya National Park in the dry season and went to Zimbabwe and Botswana in the wet season, indicating how climate variability and change affect migration and activity patterns, increasing human-wildlife interactions [13].

Most HWC incidents in Sioma Ngwezi and Mosi-Oa-Tunya national parks occurred during the day and this was influenced by the involved animal species, species behavior, species adaptation, human activity cycle and the existing mitigation measures. Daytime confrontations increased among elephants that were both diurnal and nocturnal. Light pollution in the city of Livingstone acted as a deterrent that led to an increased shift to crepuscular or daylight activities by elephants. Baboons and vervet monkeys were primarily diurnal, contributing to the high HWC incidents experienced in broad daylight, particularly when human surveillance was low. Daytime human-wildlife conflict escalated in Mosi-Oa-Tunya National Park as human activity increased during day.

Unlike Mosi-Oa-Tunya National Park, Sioma Ngwezi National Park hosts nocturnal carnivore species such as lions and hyenas. Despite this, the park showed a similar temporal pattern and recorded more daytime conflicts attributed to the increased number of hippo and crocodile conflicts that occurred during the day as people were fishing and herding cattle, respectively. Additionally, Crocodiles are also targeted during daytime water-fetching missions by community members.

The interactions between human communities, wildlife populations, legislation, and governance present complex socio-economic issues affecting MoTNP and SNNP. Communities near wildlife in the two research sites suffer social and economic turmoil from HWC, and their adaptive capacity is lessened because the Zambian Wildlife Act No. 14 of 2015 does not provide for compensation of wildlife-induced damages and losses. [14] found that socio-economic dynamics affect global human-wildlife conflict patterns and intensity.

Both parks have lost tolerance for HWC and the problematic species, but SNNP, where residents have lived with animals for years, more so. This signifies a growing frustration arising from the incurred socio-economic losses that resulted in negative feedback on both humans and wildlife. The adaptive capacity and resilience of communities were reduced while retaliatory actions increased. Community members often pressured wildlife management authorities to kill problematic animals so that they could benefit in the sharing of the meat in MoTNP. In retribution, SNNP residents poached conflict species, impacting wildlife populations while undermining conservation efforts.

Rapid urbanization, agricultural expansion, human settlements and land-use planning and land use changes emerged as key socio-economic determinants of HWC in MoTNP. The rapid urbanization was responsible for habitat fragmentation, increased human-wildlife interactions, and altered ecosystems due to noise, traffic, and light pollution, disrupting wildlife behaviour. The lack of a MoTNP wildlife management plan caused considerable land-use changes from wildlife habitat to commercial or tourism infrastructure. While land use planning may reduce human-wildlife conflicts in MoTNP and SNNP, it was viewed to cause restrictions on communities from their ancestral land in SNNP. Human development and agriculture have disrupted wildlife habitats and increased human-wildlife interactions. This shows how urbanisation and development strain wildlife habitats and the

functions of ecosystems in supporting humans and wildlife. [15] observed that laws and land-use rules affect MoTNP communities, emphasising sustainable land management and community involvement.

Human-wildlife interactions are hurting conservation and development. Human-wildlife conflict in the two settings was exacerbated by negative effects on humans and their livelihoods. Most respondents in MoTNP and SNNP indicated that HWC was very severe and was a humanitarian crisis that caused injuries, deaths, economic losses, and generally affected the poorest and most marginalized communities living at the human-wildlife interface.

Wild animals are becoming more hostile and invading human habitats, causing conflicts and jeopardising lives and livelihoods. Both national parks' participants saw a major effect of climate change on animals. To understand the issue, both negative and positive interactions between humans and wildlife, HWC drivers, impacts, and the broader societal and political context [16] in the selected sites had to be identified.

Climate change was linked to wild animals' conflict-causing behaviour, although additional factors compounded human-wildlife conflict scenarios. Human settlements, agriculture, and commercial development strained MoTNP, while agricultural growth and timber harvesting affected SNNP fauna. Encroachments have fragmented wildlife habitats and blocked wildlife corridors that have existed for centuries, justifying some of the observed changes in wildlife behavior and space utilization patterns as wildlife adapted to the changing climate and environment.

The two parks viewed habitat fragmentation and conflict differently. Commercial infrastructure in MoTNP reduced wildlife utilization areas and escalated conflicts. These findings matched [17]. Lack of a buffer between human settlements and the park enhanced conflicts in MoTNP. The lack of adequate forage in MoTNP attributed to low precipitation, soils and vegetation, drove elephants into human settlement areas where they threatened humans, raided crops and destroyed property.

In contrast, SNNP demonstrates climate-induced behavioural changes in wildlife species due to water constraints, generating feed and water insecurity for the recovering wildlife population. Wildlife in SNNP exploit climate-sensitive seasonal water pans since the park did not have permanent rivers. Illicit timber cutting in SNNP negatively affected precipitation, temperature, leading to ecosystem degradation. Dry spells and extreme temperatures caused swift water and food depletion, thereby driving wildlife, including problematic species like elephants, closer to human settlements that are near existing natural water bodies such as the Zambezi and Kwando rivers around SNNP.

The locals understood that wildlife is wild and can threaten humans and property. SNNP dwellers were less willing to bear direct and indirect costs and risks of wildlife existence than MoTNP residents. These beliefs were impacted by human-wildlife coexistence's costs and advantages [18, 19]. Most MoTNP enterprises promoted human-wildlife co-existence through wildlife-based tourism, employing thousands of locals. While wildlife provided no benefits, SNNP people bore the brunt of human-animal conflict. Rural poor farmers regularly battled, aggravating their economic situation.

A majority of SNNP respondents were unhappy with the DNPW's response to HWC incidents. Response reduces HWC incidents during or after them [20]. Human-wildlife disputes can be resolved quickly to protect both people and wildlife. The response was inadequate because many HWC problems remained unresolved or worsened despite interventions. The fact that management activities deviate from community expectations supports [21]. who stress the need to understand human-wildlife conflict perceptions and

prioritise community issues to build effective co-existence strategies.

Unresolved conflicts changed people's attitudes and stimulated poaching or retaliation. Retaliators may be considered as "local heroes" in communities plagued by human-wildlife conflict (HWC) because they eradicate the source of conflict. These supports [22]. who observed that many SNNP community members recommended killing conflict predators to alleviate human-wildlife conflict. Because it focused more on HWC incidents, DNPW in MoTNP was deemed to perform better than SNNP. MoTNP's compact size allowed HWC response teams to reach most conflict zones within hours, improving human-wildlife conflict response. Despite the recorded HWC incidents in MoTNP, respondents commended managements' conflict resolution. This example shows how park administration struggles to resolve context-specific disputes [23].

The study results in both parks demonstrated that human-wildlife conflict management must acknowledge the many negative impacts of HWC on humans and wildlife and implement comprehensive mitigation techniques to decrease these impacts. Human-wildlife conflict resolution requires context-specific and site-specific mitigation measures. Park management can reduce conflict and promote sustainable human-wildlife co-existence by incorporating community feedback and customising mitigation measures to local needs [24].

Conclusion

The findings indicate that Mosi-Oa-Tunya National Park (MoTNP) and Sioma Ngwezi National Park (SNNP) are facing considerable impacts of climate change, evidenced by a decrease in annual precipitation rates of 59 mm/year/decade and 43 mm/year/decade, respectively. Temperature trends indicate a rise in both average and maximum temperatures, with a more significant increase observed in MoTNP (0.14°C/decade) compared to SNNP (0.08°C/decade). The observed changes have led to extended periods of dryness, postponed precipitation, and reduced rainy seasons, especially noted during the drought years of 2015/16, 2017/18, 2019/20, and 2023/24, increasing the vulnerability to drought in both areas. The wildlife-based economy that underpins local livelihoods in MoTNP is experiencing heightened pressure as wildlife behaviour adapts in response to climate stressors. Conversely, the residents of SNNP, primarily consisting of impoverished rural farmers, endure the significant impacts of HWC, with ongoing conflicts leading to economic difficulties. To tackle this intricate interplay, a comprehensive and adequately funded approach is essential, one that harmonises environmental conditions with socioeconomic demands, thereby fostering both the preservation of biodiversity and the well-being of local communities.

Limitations of the Study

This study had a relatively small sample size, which limits to generalizability of the findings. The study relied on self-reported data, which may be subject to social desirability and recall biases. Finally, limited community participation in identifying, validating, and mapping human-wildlife conflict (HWC) hotspots and wildlife corridors may hinder effective conflict resolution, corridor management, and long-term conservation planning.

Conflict of Interest

The author(s) declare that they have no competing interests.

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Recommendations

Based on the study findings, several key recommendations are proposed to strengthen human-wildlife conflict (HWC) management. First, the Department of National Parks and Wildlife (DNPW) should develop and implement Game Management Plans (GMPs) for Sioma Ngwezi and Mosi-Oa-Tunya National Parks to promote sustainable resource use and minimize conflict through effective zonation. Second, the Wildlife Act No. 14 of 2015 should be amended to incorporate compensation mechanisms for HWC-related losses, which could enhance community tolerance and reduce retaliatory actions against wildlife. Third, community participation in conflict mitigation should be scaled up by promoting locally led strategies that integrate indigenous knowledge. A holistic, multi-dimensional approach to HWC management is also recommended, incorporating ecological, social, and climate-responsive measures. Finally, DNPW should establish a comprehensive monitoring and evaluation system to assess the effectiveness of mitigation strategies, enabling continuous refinement and evidence-based improvements in the field.

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