Human-Wildlife Conflicts in a Changing Climate Regime: A Multidimensional Perspective In Swagaswaga Game Reserve, Tanzania

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Abstract

This study examines the influence of climatic and non-climatic factors on human-wildlife conflicts in Swagaswaga Game Reserve, Tanzania. A mixed research design employing both qualitative and quantitative data collection methods—including semi-structured interviews, focus group discussions, and key informant interviews—was used. Rainfall and temperature data for the past 30 years were obtained from the Tanzania Meteorological Authority. Quantitative data were analysed using IBM SPSS (V26), in which the Chi-square test was performed to test the association between predictors and the status of human-wildlife conflicts. A binary logistic regression model was used to determine the extent to which independent factors were associated with human-wildlife conflicts. Meteorological data on rainfall and temperature were analysed using Excel to perform a simple regression analysis. Qualitative data were analysed using the content analysis technique. The study revealed that both climatic and non-climatic factors influenced conflicts. As temperature increased significantly, evapotranspiration and scarcity of resources also increased, leading to a decline in crop yield, accelerated human-wildlife conflicts due to resource competition between wildlife and communities around protected areas. Rainfall distribution, onset, and cessation were unpredictable. Additionally, human-wildlife conflicts are significantly associated with human population growth, while encroachment and reserve expansion influenced human-wildlife conflicts, though their impacts were not significant. Conclusively, climate change and rapid human population growth accelerated encroachment, causing wildlife survival threats and intensifying human-wildlife conflicts. The study recommends that the government should develop a comprehensive land use plan involving local communities in decision-making to adapt to the impacts of climate change on wildlife habitats and livelihoods.

Keywords: *climate change, human-wildlife conflicts, resource scarcity, population growth*

Introduction

Climate change poses a significant threat to natural resource management, biodiversity, and the livelihood of communities (Otiang'a et al., 2011; Abrahms, 2021). According to reports from Switzerland, population growth and climate change interact to accelerate scarcity of water supply (Beniston, 2010; Gross et al., 2016). Climate change threatens food security through temperature and

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precipitation changes, agricultural land losses due to sea-level rises, erosion, pests, and disease, and human-caused deforestation and desertification, reducing global agricultural potential and raising resource scarcity (Beniston, 2010). Human-induced land-use change, including deforestation and desertification, has significantly reduced the agricultural potential in numerous regions worldwide. Southeast Asia, including Indonesia, is predicted to experience rising temperatures and precipitation by the end of the century, with temperatures expected to rise by 0.72% to 3.92°C, and precipitation potentially falling by 2%, or increasing by up to 12%. Rising temperatures could lead to extended droughts (Case et al., 2007). Droughts exacerbate resource scarcity and conflicts in terrestrial systems. In India, a severe drought from 1986 to 1988 caused food loss and migration of elephants, resulting in increased crop destruction and fatal attacks (Otiang'a et al., 2011).

In Africa, which is particularly vulnerable to climate change (Alexander, 2016; Masson-Delmotte et al., 2018), the dependence of livelihoods on natural resources like water and land makes many regions susceptible to climate change and variability. The unpredictable trends in key climatic elements intensify risks, leading to severe weather extremes that affect both human and natural resources (IPCC, 2020). For instance, Eastern Africa is predicted to experience temperature increases of 0.2°C to 0.5°C per decade in the 21st century (Case, 2006). This could result in prolonged droughts, increased rainfall, floods, and reduced river flow: all affecting biodiversity and causing famine (Sintayehu, 2018; IPCC, 2020). The changing climate also threatens wildlife resources through extreme events like floods and droughts, triggering behavioural and geographical responses, and increased competition for resources (Aryal et al., 2014; Abrahms, 2021; Mmbaga et al., 2021).

In Tanzania, community dependence on natural resources leads to resource-use conflicts between wild animals and communities living close to protected areas (Yanda et al., 2010; Abrahms, 2021). Increasing human populations near protected areas intensify the effects of climate change on wildlife conflicts as people seek additional resources in response to climate change consequences (Otiang'a et al., 2011; Magige, 2012). Consequently, this leads to threats to wildlife resources due to the expansion of cropland at the expense of wildlife habitats (Magige, 2012; Caro et al., 2009; Newmark, 2008). Human population growth also contributes to the encroachment on migratory wildlife areas, overutilization of resources such as forests, and intensifying human-wildlife conflicts (Campbell et al., 2009; Ogutu et al., 2012; Mmbaga, 2022).

Moreover, other non-climatic factors—including changing land use, habitat loss, degradation, fragmentation, and high livestock population density—contribute to human-wildlife conflicts (HWCs) (Mukeka et al., 2018). Such conflicts arise when human goals negatively impact wildlife needs or vice versa, leading to negative economic, cultural, and social impacts (Magige, 2012; Aryal et al., 2014;

Ringo, 2016). In the Swagaswaga Game Reserve (SGR) in central Tanzania, reported HWCs include livestock predation by carnivores like lions and spotted hyenas; and crop destruction by elephants, warthogs, and bush pigs. The frequency of these conflicts is increasing, but the complex interplay between climatic and non-climatic stressors contributing to heightened conflicts is not fully understood. This study sought to uncover the causes of HWCs by considering both ongoing climate change and related non-climatic factors (Liwenga & Silangwa, 2020; Hariohay et al., 2020; IPCC, 2020; Dickman, 2008; Mmbaga et al., 2021; Otiang'a et al., 2011; Magige, 2012; Campbell et al., 2009; Mukeka et al., 2018).

2. Literature Review

2.1 Climatic and Non-Climatic Factors Influencing Human-Wildlife Conflicts

Changes in temperature and rainfall patterns, including other climate-related events, together with anthropogenic stressors, affect the quantity and quality of habitat and distribution of wildlife species. This intensifies competition for natural resources, and results in conflicts (Karl et al., 2009; Kerkeni et al., 2016). A study by Mukeka et al. (2020) in Kenya also reported that climate change, particularly involving lower rainfall and increasing temperatures, exacerbates wildlife food and water scarcity. Remarkably, temperatures in Africa are rising faster than the world average. As a result, climate change may have long-term effects on the frequency and intensity of HWCs in Africa. These conflicts constitute a big problem for most people who live close to protected areas. Although such conflicts have existed since the dawn of time (Mekonen, 2020); however, these conflicts have become severe in many places in recent times as a result of human population growth and the resulting expansion of agricultural and industrial activity in many locations. Climate change intensifies conflicts by increasing competition for resources such as water and habitats, among other things (FAO, 2015).

HWCs are identified as one of the major threats to the survival of many species in different parts of the world. For example, 48 people were killed by elephants in 2005 after these elephants entered human settlements in India (Johansson, 2008). In Sri Lanka, about 50–70 humans and 150 elephants died in 2002 when elephants attacked crops in a village close to a national park. In Tanzania, many communities are being affected by wild carnivores through attacks on livestock, mainly in villages found close to protected areas (Mayengo et al., 2017). Also, rodents invade farmlands and damage crops as was the case in western Serengeti, Tanzania, because the agricultural areas were close to the protected area (Magige & Senzota, 2006). Crops were also destroyed by elephants, hippos and pigs (FAO, 2015). Climate change and unpredictability are causing a decline in wildlife food and water supplies, leading to resource scarcity (Mukeka et al., 2018). Droughts and rising temperatures produce frequent shortages of foods and water for herbivores, and increases migration and risks of interaction between wildlife, people, and livestock.

Diverse information exists in various studies about the causes and effects of HWCs (Mukeka et al., 2019; Mayengo et al., 2017). However, most of the studies have not addressed how non-climatic factors intensify climate change impacts, hence increased HWCs. Understanding how factors driven by changing climate and non-climatic factors, such as rapid increase in human population, contribute to HWCs is crucial for successful mitigation and biodiversity conservation.

2.2 Theoretical Review

This article is guided by the eco-violence theory proposed by Homer-Dixon (1994). It examines the connection between environmental scarcity of major resources such as farmland, water, and forests with violent conflicts, insurgencies, and ethnic confrontations in emerging nations. The theory connects population pressure to potential resource shortage (Homer-Dixon, 1999). It states that conflicts among groups sharing common natural resources are generated by the shrinkage of natural resources. The theory implies that natural resource scarcity is caused by both population growth and environmental or climate factors, which decrease the quality and quantity of renewable resources, resulting in the shift of resource distribution. It also explains how environmental degradation—such as decreased land resources for wild animals, agricultural land, and water—could create a condition of simple scarcity and raise violent conflicts (Obioha, 2008).

According to Homer-Dixon (1994), increasing resource scarcity tends to have social consequences that enhance the possibility of internal violent conflicts within a society. Because of resource scarcity, agricultural and economic output might be severely restricted, resulting in widespread poverty (Petter et al., 2016). Migration occurs either because the environmental quality of a habitat has deteriorated to the point that it is uninhabitable (push factors), or because the migrants' economic prospects are anticipated to be better in places with more resources (pull factors) (Obioha, 2008; Wilk, 2018). Generally, the theory emphasizes the importance of successful conservation measures that balance the demands of both human and wildlife populations in the context of wildlife management. These could include measures like sustainable land use planning, resource management, and wildlife conservation programmes. Wildlife managers must work to conserve and preserve wildlife habitats while managing the increasing resource needs for human populations.

3. Methodology

3.1 The Study Area

This study was conducted in Swagaswaga Game Reserve (SGR), which is located in Kondoa and Chemba districts. Kondoa District is one of the seven districts of Dodoma Region, in Tanzania. It is bordered to the south by the Dodoma Rural District, and to the southeast by the Kongwa District. The Chemba District was formed in 2010 after it was split from the Kondoa District (Figure 1).

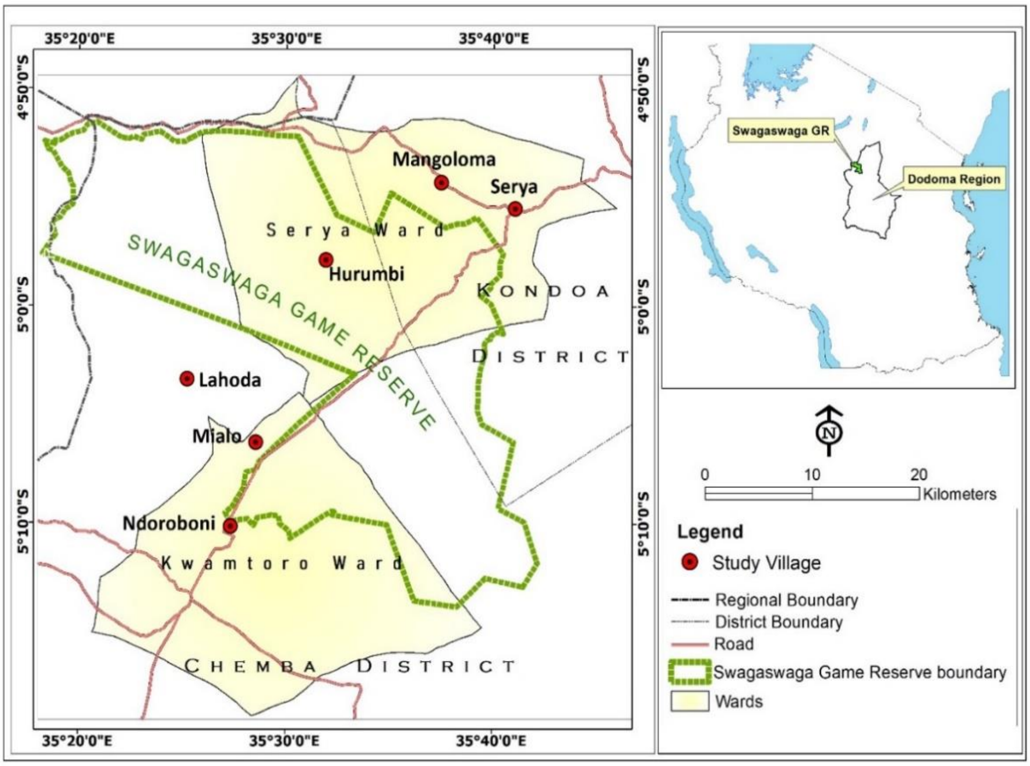

Figure 1: Study Area Location Map
Source: GIS Lab, Institute of Resource Assessment - University of Dar es Salaam, 2021

The district is bordered to the north by Kondoa District, to the east by Manyara Region, to the south by Chamwino District as well as Bahi District, and to the west by Singida Region. The Swagaswaga Game Reserve borders Hanang in Arusha and Singida districts (URT, 2012). The reserve has an area of about 871km^2. It connects the former Songa Forest Reserve (187km^2) and the Handa forests (400km^2), and other forest areas adjacent to these forests (Nyamasija et al., 2020). The study area is located between latitude -4° 54′ 0.00′′ S and longitude 35° 46′ 59.99′′ E. It is characterized by a long dry season between April and December, and a short wet season between December and April. The average rainfall is between 400mm in the plateau, and 1000mm in the highlands. Temperature ranges between 15^{0}C and 20^{0}C. By 2012 the Kondoa District had a total population of 210,682 people, of whom 107,341 were males, and 103,341 were females (URT, 2012). Moreover, the Chemba District had a population of 235,711; of whom 117,585 were males, and 118,126 were females (ibid.). Data collection involved 6 villages bordering the Swagaswaga Game Reserve: Serya, Mongoroma and Urumbi in Kondoa District, and three villages of Mialo, Ndoroboni, and Lahoda in Chemba District. All six villages are found close to the protected area.

3.2 Sampling Design and Data Collection Methods

This study used a cross-sectional research design to assess the prevalence of an outcome of interest for a given population at a single time, or over a short period. Both probability (simple random) and non-probability (purposive) sampling were used to obtain the sample. Simple random sampling was used to select households where questionnaires were administered, and the respondents involved in FGDs. Purposive sampling was also used to select districts, wards, villages, and KIIs for members; with specific information on the accomplishments of the study objectives. For example, the two districts, wards and villages were purposively chosen because they were close to the protected area, and exceeded 10% of the population since only three districts are located close to the game reserve (Kothari, 2004; Cresswell & Cresswell, 2018). The sample size was 252 at a 5% confidence interval. The methods for primary data collection were focus group discussions (FGDs), household survey, key informant interviews (KIIs) and a questionnaire for the quantitative approach.

3.2.1 Household Interview

The questionnaires for the household interview were administered to 252 households randomly selected, of which 5% of the total households were interviewed. The questions were both close- and open-ended; and were designed to answer the research questions and extract respondents' ideas. The questionnaires were prepared in English, but administered in Kiswahili. The questions were about HWCs and climatic trends in the current and previous years, people's perception of climate change, trends of human-wildlife conflicts, and activities mostly affected by HWCs. Heads of the household, wives, or resident adults (>30 years) were interviewed to collect information on climate change for the past 30 years.

3.2.2 Focus Group Discussion (FGDs)

Six FGD groups were selected from Chemba and Kondoa districts, and semi-structured questions were administered to selected group members aged 30 years and above as they had to recall some climatic events that had occurred 10 to 20 years earlier. Each group consisted of 6–12 people, and comprised of both males and females. FGDs were conducted in each village for 1–2 hours.

3.2.3 Key Informants (KIIs)

The key informant interviews aimed to verify and supplement the information gathered through the questionnaires and FGDs. A total of 18 key informants were interviewed, and these consisted of government leaders such as village executive officers, ward executive officers, ward extension officers, and wildlife and climate change experts. Using a face-to-face interviewing approach, the researcher used a checklist containing semi-structured questions that were purposively designed to gather information on socioeconomic activities, climate patterns, and the current status of HWCs compared to the previous years.

3.2.4 Secondary Data

The secondary data were obtained by reviewing published and unpublished materials, including journal articles, books, and relevant reports from the Internet. Other secondary datasets included information about rainfall and temperature data obtained from the Tanzania Meteorological Authority, within a time range of 30 years from 1991 to 2020. The data disclosed the trends of rainfall and temperature relative to what was reported by the respondents.

3.3 Data Analysis

The data collected through questionnaires were classified, coded and analysed using IBM SPSS, V25. Descriptive statistics was used for categorical data to describe the characteristics of the respondents; and presented through graphs, charts, frequencies and percentages. Inferential statistics was done using a chi-square test and binary logistic regression at $p < 0.05$ level of significance to show the association between dependent and independent variables, as well as indicate the extent to which the outcomes (conflicts) were associated with the independent variables (climatic stress factors and non-climatic stress factors). The outcome variables of this study were conflicts (0=No, 1=Yes); while the independent variables consisted of district, number of household members, land expansion, migration status, human population, climatic change, and encroachment.

The general logistic regression model used is given as:

$$\text{log}it[\pi(x)] = \log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p$$

Where, $\pi(x)$ is the likelihood of status of conflict is 'Yes'; x_p are sets of independent variables; and β_p are their respective parameters.

Meteorological data—rainfall and temperature—were analysed using Excel to perform simple regression analysis. The y-dependent variables were rainfall and temperature (maximum and minimum), while the x-independent variables comprised of year or number of seasons. Then R^2 for linear relationship between variables, p-value and β values were also calculated. Moreover, the content analysis technique was utilized to codify, analyse, and summarize field notes, and also verbal and visual data (Swai et al., 2012). In-depth, face-to-face interviews—such as KIIs and FGDs—were the tools used to gather qualitative data, which were then subjected to content description, grouped into themes, and finally analysed with some degree of interpretation (Cresswell, J. W. & Cresswell, J. D., 2018).

4. Results

4.1 Mean Minimum and Mean Maximum Temperature Trends for Kondoa-Chemba Districts (1991–2020)

The findings revealed that, for the past 30 years (1991–2020), the average temperature of the investigated areas significantly increased by 0.92^{0}C. Besides, the annual average temperature was found to have increased by 0.31^{0}C per decade, with some degree of variation. Statistical analysis revealed that the overall average temperature variations for a period of 30 years are significant, with $p < 0.0001$. The results are precisely summarized in Figure 2 and Table 1, where the results for the average temperature variation are $R^2 = 0.5432$, while $\beta = 0.03066$, and $p < 0.0001$.

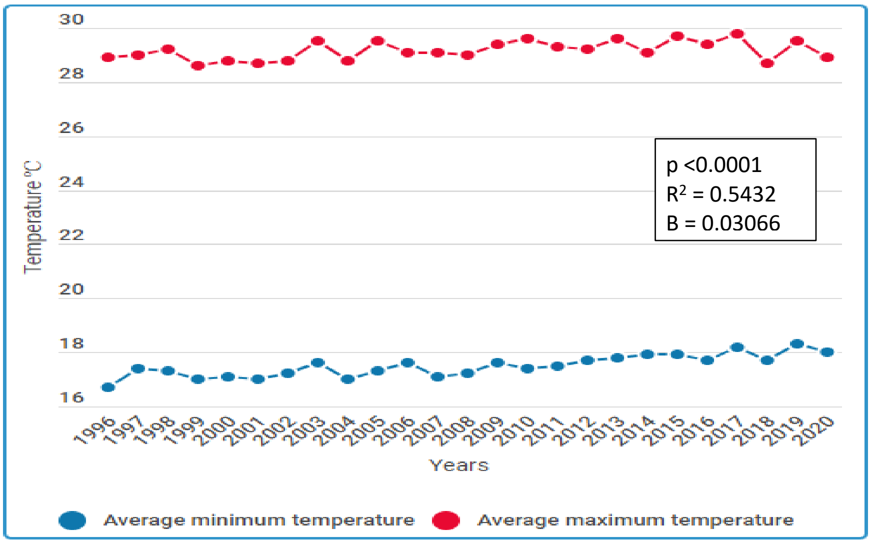

Figure 2: Average Temperature from 1991 to 2020
Source: Tanzania Meteorological Agency (TMA), 2021

Furthermore, the results revealed that the average minimum and maximum temperatures have been significantly increasing for the past three decades. The statistical analysis in Table 1 show that the mean minimum temperature results were $R^2 = 0.714$; while $\beta = 0.044$ and ($p < 0.0001$). Additionally, the lowest mean minimum temperature was 16.4^{0}C in 1993; followed by a slight increase and decrease patterns of temperature with an interval of either one or two years. The highest mean minimum temperature was 18.3^{0}C in 2019. Generally, the results show that, in the last three decades, the mean minimum temperature has increased by 1.32^{0}C and 0.44^{0}C per decade.

Table 1: Simple Linear Regression Analysis for Temperature and Rainfall Changes Over Time

Variable	Parameter Estimate	P-value	R-square
Maximum temperature	0.01697	0.0200	0.4787
Average temperature	0.03066	< 0.0001	0.5432
Minimum temperature	0.04436	< 0.0001	0.7143
Average rainfall	0.39686	0.3229	0.0349

Source: Tanzania Meteorological Agency (TMA), 2021

Moreover, the observed results for the mean maximum temperature show that there was an increase in the mean maximum temperature by 0.51^{0}C in three decades' time. This is testified by a statistical calculation, which reveals that R^2 = 0.1787, β = 0.01697 and ($p < 0.0200$), as shown in Table 1. Furthermore, the results show that the mean maximum temperature fluctuated inconsistently within an interval of one or two years. The study observed that the lowest mean maximum temperature in 1999 was 28.60^{0}C, while the highest mean maximum temperature in 2017 stood at 29.8^{0}C. Besides, it was observed that the mean minimum temperature was basically increasing at a fast rate compared to the mean maximum temperature (Figure 2). As said earlier, an increase in temperature creates water and food shortages due to heavy evaporation and water scarcity, thus increasing competition for resources for wild animals and humans.

4.2 Mean Annual Rainfall Trends for Kondoa-Chemba Districts: 1991–2020

Figure 3 illustrates a 30-year annual mean rainfall trend in the study area (1991–2020). The data demonstrates that the annual mean rainfall has been increasing with fluctuation patterns for the period of three decades. However, based on statistical analysis, the change observed was insignificant, with results showing that R^2 = 0.3349, β = 0.39686, and p = 0.3229, as illustrated in Table 1. The results show that, in the past three decades, the average rainfall has increased by 3.96mm per decade.

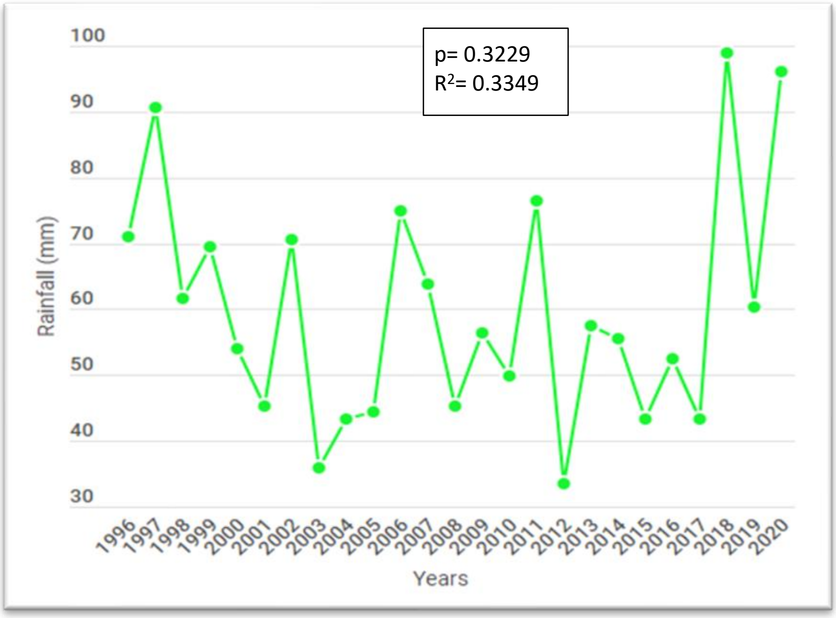

Figure 3: Average Rainfall from 1991 to 2020
Source: Tanzania Meteorological Agency (TMA), 2021

Although the change in rainfall was not significant, the study observed that the rate of evaporation of soil and water bodies, as well as the rate of transpiration of plants, was increasing as the rate of temperature rose. Generally, the findings revealed that the area was not affected by increasing rainfall; but by its onset, cessation and distribution.

4.3 Respondents' Perceptions of the Trends and Drivers of Human-Wildlife Conflicts

Respondents were asked if they had experienced any human-wildlife conflicts (HWCs) in the study area. Findings revealed that most of them (86.5%) acknowledged having experienced HWCs. In contrast, only a few respondents (13%) reported not having experienced any human-wildlife conflicts. These respondents had no experience with HWCs because, as the researchers observed, their residential areas were located far away from the game reserves. On the other side, findings concerning the main drivers of prevailing human-wildlife conflicts in the study area revealed that more than half of the respondents (64.8%) considered the main driver of HWCs to be the ever-increasing human population. In comparison, 36.6% attributed them to the expansion of the game reserves, and 31.9% considered people's expansion of their farmlands to be the key reason in the encroachment of the reserved territory (see Table 2).

Table 2: Respondents' Perception on Experience and Drivers of Human Wildlife Conflicts

Variables	Frequency	Percent
Experiencing any Human-wildlife conflicts in the study area		
Yes	218	86.51
No	34	13.49
Main drivers of existing HW conflicts in your area (Multiple responses)		
Human population	138	64.79
Expansion of reserve area	78	36.62
Expansion of land/Encroachment	68	31.92

Source: Field survey, 2021

A statistical analysis revealed that human-wildlife conflicts were significantly associated with location (district) ($p = 0.0131$), and human population growth ($p = 0.0032$; see Table 3). The study observed that a large proportion of the respondents who experienced wildlife conflicts due to the location of their residents being closer to the game reserves came from Kondoa District (91.94%), compared to those from Chemba District (81.25%), as one village (Hurumbi) in Kondoa is found inside the reserve. On the other hand, Serya village encroaches on the Mnang'ana wildlife migratory corridor. Besides, areas which experienced a rise in human population were also reported to have experienced significant upsurge in HWCs (97.18%), compared to areas where the population growth was steady (87.21%). Other predictors—such as migration status, expansion of game reserves, and encroachment of the reserved areas by the nearby residents—were not significantly associated with HWCs (see Table 3).

Table 3: Factors Associated with Human-Wildlife Conflicts Experience Based on Chi Square Test

Variable	Yes N (%)	No N (%)	Chi-square	p-value
District			6.1615	**0.0131**
Chemba	104(81.25)	24(18.75)		
Kondoa	114(91.94)	10(8.06)		
Migration status			3.2046	0.0734
Born	79(91.86)	7(8.14)		
Migrated	139(83.73)	27(16.27)		
Human population			8.6691	**0.0032**
Yes	138(97.18)	4(2.82)		
No	75(87.21)	11(12.79)		
Expansion of reserve			3.3362	0.0678
Yes	78(97.50)	2(2.50)		
No	135(91.22)	13(8.78)		
Expansion of land/ Encroachment			2.8609	0.0908
Yes	118(83.10)	24(16.90)		
No	96(90.57)	10(9.43)		

Source: Field survey, 2021

As presented in the methodological section, unadjusted and adjusted binary logistic analysis was used to assess the extent to which the independent factors could be associated with HWCs, as shown in Table 4. Based on an unadjusted analysis, HWCs were significantly associated with geographical location (p=0.0156) and human population growth (p=0.0070). Nevertheless, after adjustment, the results showed that the conflicts were significantly associated with only human population, implying that the respondents who reported an increment of human population in their areas were more likely to have experienced HWCs compared to those who did not, as revealed by the statistical analysis (AOR=5.700, p=0.005).

With regard to the expansion of the reserves, the results show that the respondents from the areas where the game reserve was expanded were more likely to have experienced HWCs compared to their counterparts, even though they were not significant, as testified by the statistical analysis (AOR=3.729, p=0.1063). Similar results were found with respect to geographical location, where it was found not to be a significant contributor to HWCs. However, the study observed that respondents from Kondoa District were more likely to have experienced HWCs due to this factor, compared to those from Chemba District (AOR=1.274, p=0.6834), as the statistical analysis testified.

Table 4: Factors Associated with Human-Wildlife Conflicts in the Study Area

Variable	Unadjusted logistic		Adjusted logistic	
	OR[95%CI]	*P-value*	*AOR[95%CI]*	*P-value*
District				
Chemba	Reference		Reference	
Kondoa	2.631[1.201, 5.763]	0.0156	1.274 [0.398, 4.077]	0.6834
Migration status				
Born	Reference		Reference	
Migrated	0.456[0.190, 1.095]	0.0791	0.367 [0.095, 1.414]	0.6834
Human population				
Yes	5.060[1.557, 16.441]	0.0070	5.700 [1.692, 19.205]	**0.0050**
No	Reference		Reference	
Expansion of reserve				
Yes	3.756[0.826, 17.078]	0.0868	3.729 [0.755, 18.419]	0.1063
No	Reference		Reference	
Expansion of land/ Encroachment				
Yes	0.512[0.234, 1.123]	0.0949	0.659 [0.210, 2.066]	0.4740
No	Reference		Reference	

Source: Field survey, 2021

It was also observed that the poaching rate (as an indicator of HWCs) had been increasing year after year for a period of ten years (Figure 4), while the most prevalent illegal activity in the investigated areas was the introduction of livestock into the game reserve, with cows and goats being the most frequently captured livestock in the game reserve. Moreover, the other illegal activities observed were timber harvesting, followed by honey hunting. This was substantiated by the game manager, who reported during KIIs that the amount of the fines paid kept increasing, year after year, as the number of culprits caught for poaching offences also kept rising. Nevertheless, the researchers observed that investigations on long-term patterns of HWCs for many species were quite rare due to the scarcity of data. Besides, a lot of research that had been conducted on the subject of HWCs tended to rely on survey questionnaires, which are susceptible to bias. For example, it has been observed that livestock owners tend to overestimate livestock losses due to large carnivore depredation more than the actual incidences of the HWCs (Yirga et al., 2013; Mukeka et al., 2019).

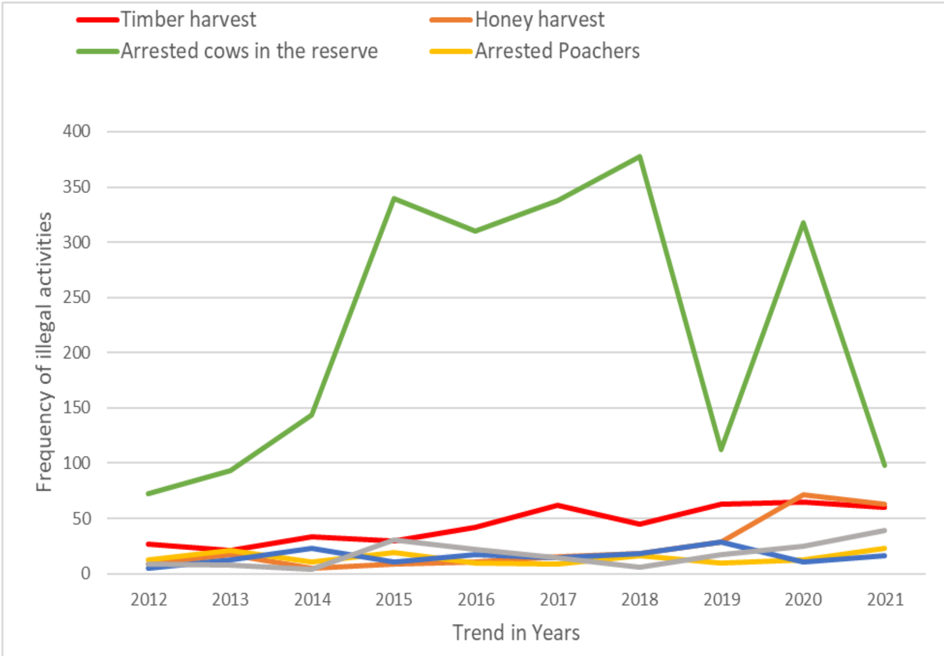

Figure 4: Frequency Oo Occurrence of Illegal/Poaching Activities in the Reserve for 10 Years as an Indicator of HWC
Source: Swagaswaga Game Reserve (TAWA), 2021

Table 5 shows that the number of illegal logging and honey hunting cases were significantly positively correlated with years, as the p-values are 0.0004, 0.005 and 0.014, respectively. This implies that the encroachment rate towards wildlife habitats increased. This also happened due to poor land use plans that led people to invade wildlife reserve areas to cultivate and graze livestock. In contrast, the number of cases in relation to captured cows and goats due to intrusion in the game reserve, and those of arrested poachers, were not significantly correlated with years, although positively associated.

Table 5: Pearson Correlation of Illegal Activities Yearly

Number of cases in illegal activity	Years	
	Correlation	p-value
Timber harvest	0.89999	0.0004
Honey harvest	0.79852	0.0056
Axe and sword	0.14968	0.6798
Arrested cows in the reserve	0.26224	0.4642
Arrested goats in the reserve	0.09578	0.7924
Arrested Poachers	0.07588	0.8350

Source: Swagaswaga game reserve (TAWA), 2021

5. Discussion

5.1 Influence of Climatic Stress Factors on Human-Wildlife Conflicts

This paper has explored the impact of climatic stress factors and non-climatic elements on the dynamics HWCs in the Chemba and Kondoa Districts. The rise in temperature is evident in both temperature data from the TMA, and the testimonies of the respondents during interviews and FGDs, which testifies that 2017 was a year that witnessed the worst famine, compared to all other years, with the highest mean maximum temperature of 29.8^{0}C. The increased temperature led to a drought, resulting in food scarcity due to evaporation and water shortages. In turn, this intensified the competition for resources between wild animals and humans, particularly in areas near protected game reserves.

Moreover, the temperature increase and the ensuing drought contributed to decreased crop production, creating a scenario where HWCs become prevalent due to heightened resource competition. Similar observations were noted in other studies by Swai et al. (2012), Aryal et al. (2014), and Mmbaga et al. (2021), which noted the link between temperature rise, declining vegetation productivity, and increased competition for food and water resources. Similarly, Psenner and Sattler (2012) attested to the fact that warmer temperatures tend to lower plant and vegetation productivity in semi-arid habitats; hence making animals in those surroundings more likely to compete with domestic livestock for food and water than in other scenarios.

Rainfall patterns also play a role in HWCs, with respondents highlighting challenges in determining optimal crop planting times. Farmers complained that they were unable to determine when to plant water-intensive crops (poor drought-resistant crops such as rice, maize, and sorghum), and when they should sow drought-resistant ones (e.g., sunflower) in their fields. The fluctuating annual mean rainfall trends indicated an unstable pattern, impacting seasonal crops and wildlife movements. During KIIs, game rangers noted that heavy rains disperse ungulates, making them harder for predators to catch. This leads predators to seek easier targets, including livestock and humans in nearby villages. For example, it was observed that during the El-Nino Oscillation in Tanzania in 1997, there was a surge in lion attacks. Nevertheless, in 1999, after the floods had diminished, the ungulates returned to their normal range (Otiang'a et al. 2011), which also diminished lions' attacks on humans and livestock. Chen et al. (2012) assert that rainfall seasonality is a key driver of HWCs, and climate change further exacerbates this by altering the irregularity of rainfall patterns. A significant change in rainfall seasonality can intensify competition for food and water resources among livestock, wildlife, and humans (Sintayehu, 2018; Mukeka et al., 2019).

5.2 Influence of Non-climatic Factors on Human-Wildlife Conflicts

Non-climatic factors, notably population growth, are identified as crucial influencers of HWCs. According to the Tanzania National Bureau of Statistics (2020), the populations of Chemba and Kondoa Districts have been increasing significantly. For instance, while the population of Kondoa was 210,682 in 2012, it reached 259,963 in 2020; and that of Chemba increased from 235,711 in 2012 to 293,619 in 2020. This population increase led to the conversion of agricultural land to settlements, and encroachments into wildlife habitats. Villagers reported that immigrants from other areas—e.g., Hanang and Singida, driven by the search for pasture and cultivation areas—contribute to this population growth. This demographic shift results in closer interaction between humans and wildlife, escalating competition for resources such as land and water, and consequently more HWCs.

Nyhus (2016) supports the foregoing finding, linking population growth to increased demand for land for agricultural activities. As farmers encroach upon animals' migratory corridors, crop destruction by wildlife becomes common, undermining food security, and fostering human intolerance towards wildlife. This situation was also observed by Mukeka et al. (2018), who pointed out that an increase in human population is linked to increased use of natural resources and habitat, hence forcing wildlife to graze close to humans. Additionally, population growth is associated with habitat destruction of wild animals' homes. Habitat disturbance in the study area was a combined result of settlements in and around the reserve, overgrazing, bush encroachment, as well as tree cutting for charcoal and construction of houses (Baral et al., 2021). This aligns with the study findings by Mukeka et al. (2018) in Kenya, which revealed that human population growth and habitat fragmentation were the leading contributing factors to HWCs.

The expansion of game reserve boundaries—a point of contention between the community and reserve management—adds another layer to the conflicts. While the management contends that the boundaries were officially demarcated within legal parameters, community members claim that the reserve's land was encroached upon. These disputes have contributed to prolonged HWCs since 2018.

6. Conclusion and Recommendations

Following the findings of this study, it could be concluded that rapid population growth in most SSA countries, as well as climate change and human-wildlife interactions, underscore the significance of HWCs in determining the future survival of wildlife resources. Given the reliance of the local population on agriculture and livestock, addressing HWCs becomes critical. Therefore, the government should implement a comprehensive land use strategy that incorporates the active participation of the local communities in the planning and decision-making processes. This approach will help in addressing the impact of climate change on both wildlife habitats and human livelihoods, thereby promoting sustainable well-being for all.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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