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Economic Consequence of Human - Hippopotamus (*Hippopotamus amphibious*) Conflicts on Farming Livelihood in Rural Adamawa State, Nigeria

Abstract. Human-animal conflict is posing a severe threat to wildlife conservation as well as the long-term viability of farming communities. This study assessed the economic consequence of human-hippopotamus (*Hippopotamus amphibious*) conflicts on rural livelihoods in Adamawa state, Nigeria. The study had the following specific goals; describe the direct effects of Human Hippopotamus Conflict (HHC) on livelihoods in the study area, and estimate the agricultural economic losses incurred in the area as a result of HHC. A mixed research method was used to collect primary data from 371 crop farmers. The study relied on descriptive statistics in the analysis of the data collected between February to May 2019. The study found that Groundnut, Cowpea, and maize were among the most severely damaged crops at their mid-stage of development based on land size. In terms of the monetary value of the damages, sweet potato is the most affected. The study concluded that farmers should work as a team and adopt measures like fencing, scare tactics, or deterrents that will minimize significant crop losses. Also, there is the need for local awareness on the importance of Hippopotamus conservation in the area.

Key words: human-hippopotamus, conflict, economic losses, Adamawa State

JEL Classification: Q1, Q18, Q12, J18

Introduction

Human-Hippo conflicts are recurrent issues in wildlife conservation throughout affected areas worldwide, and have negative impacts on both human and wildlife populations (Dossou et al., 2019). Human-Hippo conflict denotes any instance in which the resource demands of humans and Hippos overlap, spurring competition for food, space, and water and thus creating tension between people and Hippos (Messmer, 2000; Seoraj-Pillai & Pillay, 2017). Hippopotamus (*Hippopotamus amphibious*) are among Africa's most destructive crop raiders (Lamarque et al., 2009; Baker et al., 2020). In Adamawa state, while the exact population of Hippopotamus in the riverine communities is not exactly known, (Baker et al.2020) it is estimated to be about 45 animals around Kiri dam reservoir. The conflicts emerge as a result

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of direct and indirect negative interactions, resulting in agricultural losses due to crop destruction, human fatalities and injuries, livestock predation, and retaliatory wildlife murders (Chardonnet et al., 2010). These conflicts hamper the peaceful habitation of humans and wildlife and constitute major threats to the survival of many wildlife species. According to Kahler & Gore (2015), these conflicts include how people perceive risks associated with negative interactions with wildlife. The conflicts have resulted in the destruction of food crops or harm by hippopotamuses, thereby affecting rural livelihoods or injury/ killing of the hippopotamuses by affected persons, which then also affects wildlife conservation. Such conflicts not only endanger the hippopotamus population but also have a severe impact on the local economy and people's livelihoods owing to crop loss (Dossou et al., 2019). According to Backer et al. (2022), between 2012-2017, about 6 persons were killed by hippopotamus in Adamawa state.

This challenge varies with location in terms of its nature and severity, based on human population growth rates, conservation measures, and scarcity of essential natural resources – particularly land and water resources available for wildlife (Conover, 2002; Institute of Policy Analysis and Research, 2005; Akinsorotan et al., 2020). Equally, the issue of climate change is one of the leading causes of human-Hippopotamus conflicts (Ba et al., 2014). Generally, hippopotamuses require large areas of savannah grasslands, where they feed on stems of herbaceous species, and in times of food stress, they will also feed on cultivated crops (González et al., 2017). However, due to these outlined factors, there have been pressures on land resources that have resulted in a reduction of core habitats for hippopotamus, curtailed hippopotamus movements, and accessibility to feed resources (Conflict-sensitive approaches, 2009). This has led to a substantial decrease in the quantity and quality of hippopotamus feed resources while exacerbating human-hippopotamus conflicts in terms of crops damage, killing of domestic animals, hippopotamus, and humans (Thornton et al., 2008; Madden, 2008; Joseline, 2010; Manga et al., 2013; and Ertiban, 2016).

Damage by wildlife could significantly affect the livelihood of the affected households both directly and indirectly (Akinsorotan et al., 2020). The conflicts have a wide variety of direct implications on human livelihoods, from nuisance behavior like reduced leisure opportunities to crop damage, livestock depredation, fatal human attacks, and zoonotic disease transfer to humans or cattle (Michel and Bengis, 2012). According to the International Union for Conservation of Nature (IUCN) Redlist, hippopotamus populations have fallen by 7% to 20% in the last decade as a result of habitat degradation and illicit and uncontrolled meat and ivory poaching (Lewison & Oliver, 2008; Igidi, 2014). Its indirect consequence is that it has a negative impact on the afflicted individuals' psychological health and social well-being by instilling fear and restricting movement (Barua et al., 2013; Brashares et al., 2014; Mukeka et al., 2019). Understanding risk perception is important in tackling Human-Hippo conflict because it can impact the behavior of key participants in conflicts, including farmers and conservationists (Kahler & Gore, 2015; Ertiban, 2016). In Adamawa State, human-hippopotamus conflicts have been found to impact negatively on conservation and jeopardize human livelihoods and safety. This has been witnessed in the southern and central part of Adamawa State where human-Hippopotamus conflicts have persisted over the years (Daily Trust, 2014). Over the years, there has been increasing effort by conservators to effectively resolve human-hippopotamus conflicts (Linnell et al., 2010). Most of these efforts tend to concentrate on hippopotamus management without regard to the community's opinions. The lopsided nature of these efforts is contributory to the persistence of human-hippopotamus conflicts in most areas (Masumbuko and Somda, 2014). The riverine communities in

Adamawa State engage in a variety of livelihood activities such as fishing, farming, and trade. These activities are essential for their survival and provide a source of income for the people in the area (Abubakar et al., 2020).

In analyzing the impact of wild animals on human interests, it is important to consider the species involved and the scale of damage caused (Chomba et al., 2012). Such information can significantly contribute to the development of a strategy that will comprehensively address human-wildlife conflict. In the last century, there was a decrease of about 7-20% in the number of common hippopotamuses. This decline was attributed to human activities, consequences, mainly habitat loss as wetlands are converted or impacted by agricultural development (Dossou et al., 2019). It is critical to understand the economic effects of these conflicts on the livelihoods of those affected in order to properly protect wildlife resources and minimize crises. As a result, the goal of this study was to address a vacuum in the literature on human-hippopotamus conflict in rural Adamawa State. The study's specific objectives were to:

- i. describe direct effects of Hippopotamus activities on livelihoods of farmers in the study area;
- ii. estimate the agricultural economic losses incurred in the area as a result of the conflicts.

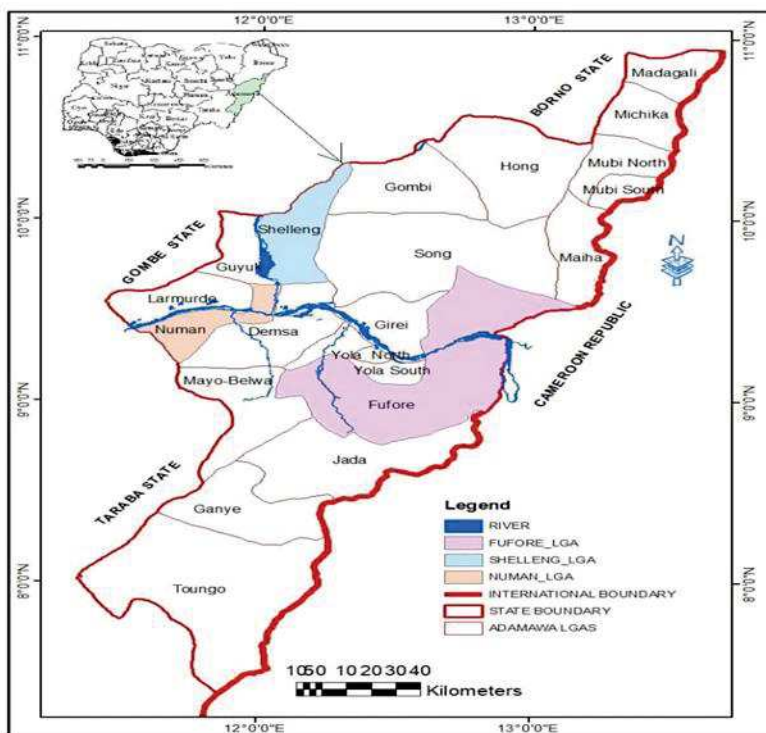


Fig. 1. Map of Adamawa State showing the Study Area

Source: GIS Lab, Modibbo Adama University Yola, 2019.

Methodology

The study was conducted in communities affected by hippopotamus activities in Adamawa State as shown in Figure 1. Geographically, the State is located between 7° and 11° north latitude and 11° and 14° east longitude of the Greenwich Meridian. As a result, the state is claimed to be in Nigeria's Northeastern region, with Taraba State to the south and west, Gombe State to the northwest, and Borno to the north. Along its eastern border, it also shares an international border with the Republic of Cameroon (Adebayo and Zemba, 2020). The state has a landmass of around 38,741 km² and a population of 4.254 million people (National Bureau of Statistics, 2021). Hippopotamus activity is abundant in the area's primary water bodies, Benue, and Gongola. The Gashaka Gumti National Park, in the extreme south of the state, is home to significant numbers of wild species (Briggs, 2018). In terms of livelihoods, the state is agro-based, with the entire economy depending mostly on crop and livestock production. Along the riverbanks, fishing and dry-season farming are common.

Data Collection

The study adopted a mixed research method in collecting the data. Firstly, seven communities across the three most affected Local Government Areas were purposively selected. Namely, Babbandaba, Gonlong, Talum, and Gundo in Shelleng LGA; Gurin and Ribadu in Fufore LGA; and Imburu in Numan LGA. Following Kagiri (2005), the direct observation method was adopted for this study. This involved the identification of all protected crop farms of not less than 1 hectare and an equal number of unprotected ones within each location. A total of 371 crop farmers were purposively selected because of the effects of hippopotamus activities on their farms. The farms were actively monitored throughout the growing season and the following were recorded: type of crops damaged, the stage of growth of the time of damage, and part of crops damaged. Similarly, economic losses were estimated using the method outlined by Jones et al. (2008) which were as follows:

- i. the crops that were damaged were identified,
- ii. the yield of each crop per hectare in the absence of damage by hippopotamus was obtained,
- iii. the total yield of each crop as a result of the damage was obtained,
- iv. the prevailing market price of the produce from each crop was also obtained from the nearby market. and
- v. the monetary loss on each crop was then obtained based on the difference in the amount realizable from the produce under optimum yield without damage and that obtained after damage.

Data Analysis

Data on conflict areas, crop damage, stage of growth of damaged crops, parts of crops damaged, and monetary losses in Naira and Dollar were analyzed using appropriate descriptive statistics such as tables, percentages, and charts. The direct observation method (Kagiri, 2005) was used to assess the conflict areas and determine the economic losses incurred by the participants in the period under review.

Results and discussion

Demographic characteristic of the respondents

In Table 1, the respondents' demographic characteristics were described. Based on the respondents' age breakdown, 15.77% were below 30 years, 31.02% were between 30 and 39, and 28.51% were between 40 and 49. The proportions of respondents aged 50 to 59 years and 60 years and older were 15.40% and 9.30%, respectively. According to the results, 18.76% of respondents were female, compared to 81.24% of males. This shows that the majority of local farmers are men. 20.14% of people were single, compared to 79.86% who were married. According to the household sizes of the respondents, homes with 1 to 5 people made up 20.39%, while households with 6 to 10 people, 11 to 15 people, and more than 15 people made up 33.75%, 28.08%, and 17.78%, respectively. This result shows a rather sizable household that can provide family labor for farming tasks. The distribution of respondents' educational levels shows that those with no formal education made up 28.22% of the sample, those with primary education made up 34.82%, and those with secondary and tertiary education made up 26.14% and 10.82%, respectively. Similarly, the respondents' farm size revealed that the majority (79.23%) of them cultivate between 1 and 5 ha, while just 20.77% of them cultivate more than 5 ha. In terms of farming experience, 37.96% had 1-10 years' experience in farming, while those with 11-20 years and more than 20 years constituted 35.76% and 26.28% respectively.

Table 1. Description of the Respondents Socio-Demographic Characteristics (n=371)

Variable	Frequency	Percentage	Variable	Frequency	Percentage
Age (years)			Educational Attainment		
<30	59	15.77	No formal education	105	28.22
30-39	115	31.02	Primary	129	34.82
40-49	106	28.51	Secondary	97	26.14
50-59	57	15.40	Tertiary	40	10.82
≥60	35	9.30	Farm size (ha)		
Gender			1-5	294	79.23
Female	70	18.76	6-10	72	19.46
Male	301	81.24	>10	5	1.31
Household Size (number of people)			Farming Experience (years)		
1-5	76	20.39	1-10	141	37.96
6-10	125	33.75	11-20	133	35.76
11-15	104	28.08	>20	97	26.28
≥15	66	17.78	Marital Status		
			Married	296	79.86
			Unmarried	75	20.14

Source: Field survey 2019.

Direct effects of human-hippo conflict on livelihoods

The distribution of the effects of Hippopotamus activities on the respondents is presented in Figure 1. Findings of the study across communities revealed that crop damage was the most common (averaged 79.1%), followed by livestock predation (9.6% on the average), and attack on human beings (2.4%).

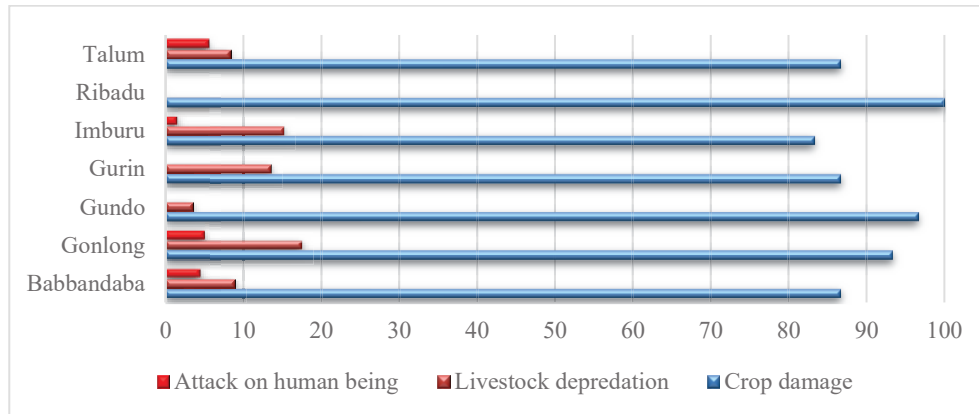


Fig. 1. Effects of hippopotamus activities in the study area (n=371)

Source: Field survey 2019.

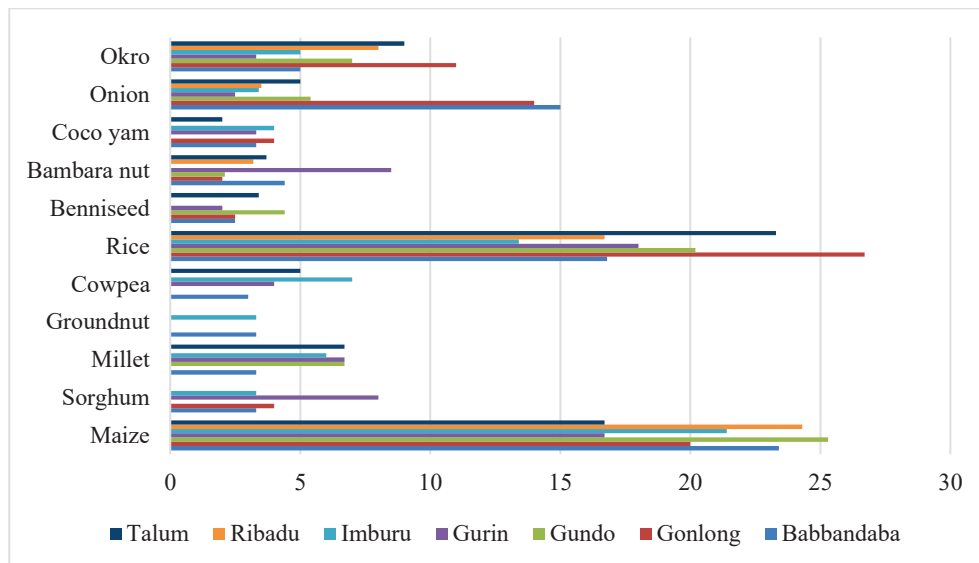


Fig. 2. Major crops damaged by hippopotamus in the study area (n=371)

Source: Field survey 2019.

The distribution of the major crops damaged by hippopotamus in the study area is shown in Figure 2. The findings of the study indicated that across the communities, maize was the most (21.9%) affected crop on average. This was followed by rice (18.6%), onion (7.3%), and okro (6.6%). Similarly, millet (3.8%), Bambara nut (3.4%), sorghum (3.1%), and cocoyam (2.4%) were also destroyed by the hippopotamus. Equally, the respondents reported that cowpea (2.3%), benniseed (1.9%), and groundnut (1.1%) were also destroyed in the area. This finding lends credence to the submission of Adeola et al. (2022) who also reported that Maize, Beans, Millet, Guinea corn, Rice and Groundnut are affected by Hippopotamus in Selected Communities around Kainji Dam in New-Bussa, Niger State, Nigeria.

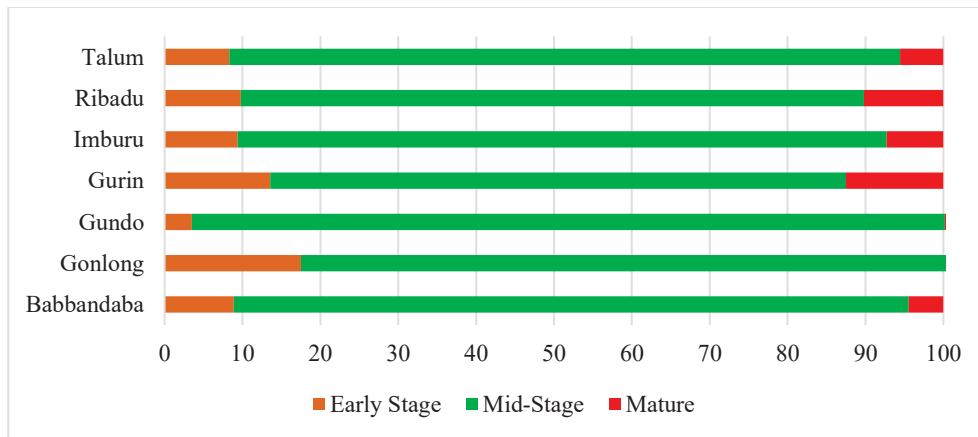


Fig. 3. Stages at which crops were damage by hippopotamus in the study area (n=371)

Source: Field survey 2019.

This study also assessed the level at which the crops were damaged by the hippo and the result is presented in Figure 3. The finding of the study revealed that the majority (85.7%) of the crops were damaged at their mid-stage of development, while 10.1% and 7.9% of the crops were damaged at early and mature stages of development respectively. However, it is worth noting that the extent of crop damage caused by hippos can vary depending on the specific circumstances, including the availability of other food sources, the proximity of water bodies, and the effectiveness of deterrent measures implemented by farmers or local communities (Bayani et al., 2016). The finding of this study is in line with that of Dossou et al. (2019) who revealed that the main damage caused by common hippopotamus was crops raiding, which occurs in farmlands during the whole year in central Benin Republic.

Estimate of economic losses due to crop damage as a result of human-hippo conflict

The result of economic losses due to crop damage by hippopotamus is presented in Table 2. The respondents were grouped into three categories based on their farm sizes, and the economic losses incurred were computed based on the average size of farm destroyed and the average market price of the affected commodity. Among small-scale farmers, sweet potato and coco yam were the most affected crops based on market value of ₦241,115.0 and

₦105,000.0 respectively. Hippos are primarily herbivorous animals and feed on various types of vegetation, including aquatic plants, grasses, and even crops in some cases. However, hippos are not known to specifically target tubers like sweet potatoes or cocoyam as a significant part of their diet. However, while roaming for feed, when hippos trample on these tubers, they cause considerable damage to the product physically, thereby reducing the shelf-life and market value of the commodity. Equally, cereal crops like maize, rice, and sorghum are also affected by hippos in the study area. The economic losses averaged ₦38,025.0, ₦33,540.5, and ₦103,873.0 respectively for the crops. Furthermore, among medium-scale farmers, Maize, Rice, Groundnut, Onion, and Sweet Potato were the affected crops.

Table 2. Estimate of economic losses due to crop damage in the area (n=371)

Crop	Expected output without damage (kg/ha)	Average size of farm destroyed (%)	Average yield damaged	Average market price/100kg (₦ ⁵)	Total estimated loss (₦)
Small-Scale Farmers (1-5 ha)					
Maize	1500-3000	65	1462.5	2600	38,025.0
Rice	2000-5000	37	1295.0	2590	33,540.5
Sorghum	800-1500	44	2090.0	4970	103,873.0
Groundnut	800-1500	69	793.5	1380	10,950.3
Cowpea	500-1500	65	650.0	6000	19,200.0
Bambara nut	500-1500	32	320.0	6500	21,450.0
Benniseed	300-800	60	330.0	5400	17,982.0
Okro	800-2000	30	150.0	1200	1,800.0
Onion	1500-3000	57	1282.5	2850	36,551.3
Sweet Potato	5000-15000	53	8300.0	2905	241,115.0
Cocoyam	8000-20000	50	7000.0	1500	105,000.0
Medium-Scale Farmers (6-10 ha)					
Maize	1500-3000	28	630.0	2600	16,380.0
Rice	2000-5000	31	1085.0	2590	28,101.5
Groundnut	800-1500	29	333.5	1380	4,602.3
Onion	1500-3000	21	472.5	2850	13,466.3
Sweet Potato	5000-15000	24	2400.0	2905	69,720.0
Large-Scale Farmers (>10 ha)					
Maize	1500-3000	17	382.5	2600	9,945.0
Rice	2000-5000	15	525.0	2590	13,597.5
Groundnut	800-1500	21	241.5	1380	3,332.7
Sweet Potato	5000-15000	19	1900.0	2905	55,195.0
Onion	1500-3000	12	270.0	2850	7,695.0

Source: Field survey, 2019.

However, sweet potato and rice were the most prominently affected to the tune of ₦69,720.0 and ₦28,101.5 on the average respectively. In terms of the large-scale farmers also, sweet potato and rice were the most prominently affected. The migration or movement patterns of hippos in Nigeria may vary depending on factors such as the availability of water and food resources, as well as human activities in the area (Baker et al., 2022). In Adamawa State, it is generally known that hippos tend to move around more during the dry season, and early parts of the rainy season (February-July) when water sources become scarce and competition

⁵At the time of the study, \$1 USD was worth 360 Naira, according to the official exchange rate of the Central Bank of Nigeria.

for resources increases (Radda, 2015). During this time, hippos may travel long distances in search of new water sources or better grazing areas. As they move, they may come into contact with human settlements, which can lead to human-wildlife conflicts and potential attacks (Baker et al., 2020).

HWC (human-wildlife conflict) is fast becoming a critical threat to the survival of many globally endangered species (Distefano, 2005; Croomsigt et al., 2013; Manral et al., 2016). While it is still difficult to reliably estimate the socio-economic and financial implications of human-wildlife conflicts on affected livelihood (Mhuriro-Mashapa et al., 2018), there is a need for actors to have a sound understanding of the level of impacts and drivers (White & Ward, 2010). Knowing this will substantially impact conservation policies and human wellbeing in affected communities (Barua et al., 2013). This study has established a multidimensional consequence of Human-Hippo Conflict between crop farmers and hippopotamus in the study area. This study revealed that crop damage was the major conflict in the area. This finding lends credence to the submission of Kanga et al. (2011) who reported similar outcomes in a study carried out in Kenya, which investigated human-hippopotamus conflict within support zones of the park. The damage done to crops by hippopotamuses in the study area has a significant effect on household livelihood as they attack most economic crops cultivated by the residents in the area. As opined by Barua et al. (2013), crop damage is the most prevalent form of human-wildlife conflict in Africa, and this impoverishes economically depressed households that rely on farming for sustenance.

Investigation into crop damage by hippopotamus in all the study locations within the study area revealed that rice and maize suffered the highest raiding. Hippopotamus raided other crops such as guinea corn, millet, groundnut, and beans. This finding is not unexpected as it aligns with the feeding habit of the hippopotamus. It also agrees with the report of Shefferly (2001) that the hippopotamus is a grazer, preferring short grasses. Rice, maize, guinea corn, and millet are cereals and therefore types of grass. The preference shown for rice and maize may not be unconnected with their palatability since guinea corn and millet are equally accessible and available in the study area, and yet not preferred. This result is similar to the findings of Shalangwa et al. (2014).

Investigation into crop-raiding in relation to stages of development of the crops indicated that the pattern of crop-raiding varied with the stage of growth of the crops. The findings showed that the mid-stage of crops was the most raided stage by hippopotamus in all the locations of the study area. The mid-stage growth consumption was followed by the consumption at the early-stage growth, while the mature stage growth was the least consumed. Observations of the crops on the farms showed that the mid-stage growth provided succulent stems and leaves in addition to relatively higher biomass than the early-stage growth. Besides, the succulent nature of the crops at the mid-stage growth is higher than at the mature stage of development. The implication is the availability of more palatable and higher biomass crops at the mid-stage growth. This situation might have influenced the preference shown by the hippopotamus towards crops at the mid-stage development. Similar findings were made by Wilbrod et al. (2011) and Gross et al. (2015).

Further findings from the investigation into the pattern of crop-raiding showed that hippopotamuses prefer the stems and leaves of the crops to their fruits, bulbs, and seeds. The findings also showed that they do not damage the roots. The selection of stems and leaves and the preference for mid and early stages of the crops by the hippopotamus may not be unconnected with the relatively high protein and low fiber content of the freshly sprouting

crops. This observation agrees with the report of Martin (2005) on the feeding habit of hippopotamus in the Caprivi region of Namibia.

The human-hippopotamus conflict investigated in this study involved food crop-raiding, hence most of the economic losses were on food crops. A total of twelve (12) food crops were raided by the common hippopotamus. The food crops included maize, rice, millet, sorghum, cowpea, benniseed, Bambara nut, cocoyam, groundnut, onion, okra, and sweet potato. Losses incurred as a result of the conflict have a monetary implication on the household economy. This implied that the hippopotamus could induce both food insecurity and poverty in the study area. Food and economic losses will continue to plague the rural population if indeed the issue persists unabated. With the rapid reduction of hippopotamus grazing land, this is likely to intensify. Mulu (2010) made a similar observation in similar research in Kenya.

According to Treves et al. (2006), where multiple stakeholders are affected in different ways by HWC, the conflict situation becomes more complex, since a desirable outcome requires an understanding of the impacts on the different stakeholder groups and an appreciation of the different attitudes that these groups may hold regarding both the level of impacts and the focus and outcome of management to reduce them. As a result, when wildlife roams freely on crops, harms livestock, or somehow threatens human security, conservationists must examine the economic and socio-political repercussions. This is because apart from the visible impacts of this conflict, other associated or hidden costs include opportunity and transaction costs that occur as a result of conflict, as well as health impacts that impair people's physical and mental wellbeing (Barua et al., 2013).

Conclusions and recommendations

In conclusion, the conflict between humans and hippopotamuses has a considerable and detrimental impact on farming in Adamawa state. The findings revealed that crop raiding is the major cause of conflict between humans and hippopotamuses in the study area. Crop loss, livestock raiding, hippo mortality, and habitat disturbance are the main repercussions of the presence of high conflicts in the study area. Crops raided by hippopotamus included both food and cash crops (maize, rice, millet, groundnut, guinea corn, and cowpea). Further investigation showed that the conflict has induced both food insecurity and poverty in the study area. Effective hippo management techniques and community-based interventions that give farmers and other stakeholders the capacity to safeguard their livelihoods and lower the risks associated with living near waterways will be necessary to address these disputes. As a result, determining feasible methods to decrease Human-Hippo conflict in the research region is essential for human- Hippo cohabitation. The following points in the study region are proposed based on the findings of this study:

- i. Farmers should work together to protect their farmlands from crop raiders, using the most effective means available in their area like fencing, scare tactics using noise and light, or deterrents like scarecrows, reflective materials or even employing guards to deter the animals and protect agricultural areas.
- ii. There is the need to educate local communities about the importance of hippo conservation and the potential risks and benefits. Coexistence can foster understanding and support for conservation efforts. Encouraging responsible

land use and promoting sustainable farming practices can also contribute to reducing conflicts.

- iii. Human settlements around water sources where these animals live should be removed by the authorities.

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