Characterization of Human-Elephant Conflicts in and Around Ma Mbed Mbed National Park, Far North Cameroon

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Abstract: The clandestine occupation of national parks by some farmers does not fail to expose their lives dangerously. Elephants in these protected areas, no longer knowing where to go, pop up in plantations and camps and claim victims. A study was carried out from June 2023 to February 2024 and from June 2024 to November 2024 with the aim of characterizing Human-Elephant Conflicts (HEC) in and around the Ma Mbed Mbed National Park (MMMNP) in the Far North of Cameroon. To this end, a questionnaire was used to collect the opinions of farmers in villages located in and around the MMMNP. Survey data were supplemented by direct observations in the field. Of the 380 households surveyed, 277 were involved in HEC and 103 were not. Cereals, houses and sheds were the main crops and goods destroyed, with around 251 tonnes, one shed and six huts for the 2023-2024 season alone. The monetary loss of these destroyed cereals was estimated at 94,012,600 FCFA. The local population has adopted a range of rudimentary equipment to drive back these animals. The method used by the authorities to reduce HEC was the administrative drive. HEC occurs almost every year, with the peak of hostilities in October. The level of compensation was still zero. Given that the MMMNP shares a boundary with the Binder Léré forest reserve in the Republic of Chad, the possibility of cross-border poaching should not be overlooked. The park's bright future was threatened by low incomes and the population's heavy dependence on natural resources, which leads to farming and the collection of firewood in the park. The study recommends that the MMMNP should be well developed in terms of ponds, or that micro-projects such as pepper growing and bee-keeping, which are practices that repel elephants, should be developed. It would also be desirable to set up a rain-fed rice project. On the whole, this area is ideal for rice-growing.

Keywords: Human-elephant Conflict; Damage; Compensation; Ma Mbed Mbed National Park

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1 Introduction

Central Africa has long been home to the continent's highest human population density with a high growth rate [2]. This continuous human population growth leads to considerable pressure on land and a decline in soil fertility due to over exploitation [5, 22]. Anthropogenic pressures, dominated by clearing, hunting, fishing and charcoal mining, have degraded the natural state of the forests. Habitat loss remains a major long-term threat to wildlife in general and to the survival of the African elephant in particular [2, 18]. Elephants are the largest terrestrial mammals and, because of their large size, require a vast home range and a large quantity of food to satisfy their nutritional and reproductive need [8, 16]. Protecting them indirectly protects many animal species that live in the same environment [2]. However,

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more than 75% of their home range lies entirely outside the protected area networ [6, 7]. Also, it seems that tree fruiting in natural forests has fallen dramatically over the last 30 years, which may have pushed elephants 'out of the forest [5, 6]. They occasionally enter areas of human habitation and destroy crops, prey on food supplies and damage water sources, fences or other human structures, occasionally killing or injuring inhabitants [9]. The presence of elephants in transition zones unfortunately results in a deplorable phenomenon for farmers [4]. This phenomenon gives rise to negative interactions between humans and elephants, which have come to be known as Human-Elephant Conflict (HEC) [9]. Human-elephant conflicts can have direct consequences (injuries and deaths from contact with wild animals) and indirect consequences in the form of crop or livestock losses or damaged infrastructure [5, 19]. In Cameroon in general, and in the Ma Mbed Mbed National Park in particular, elephants are increasingly trespassing on crops, houses and plantations, causing discontent among farmers. This was the case in 1998, when [26] stated in his studies carried out in the Waza-Logone region that elephant damage to rainfed sorghum, groundnuts, cotton and dry season sorghum could be estimated at 1,003 tonnes, 336 tonnes, 165 tonnes and 150 tonnes respectively in 1994, 1995, 1996 and 1997, and that the total area devastated by elephants during this period was as follows over the same period would not exceed 1080 ha. This lost production would represent total annual financial losses of around $206,000,000. Meanwhile, [4] showed in their studies carried out in the village of Mi é ékouka in the north of the Odzala Kokoua National Park (Congo) that losses caused by elephant attacks on banana, avocado, papaya, taro, cassava, squash, sugar cane, pineapple and cocoa crops were estimated at 1,915,215 CFA francs, in fields totalling 13.68 ha [27]. also found in his studies carried out in Kalfou, Extreme North Cameroon, that elephant damage to rainy season sorghum (commonly known as Ndjigarri), groundnuts, cotton, cowpeas and rice was estimated at 221 tonnes over an area of 246 ha. The monetary loss associated with this destruction was estimated at 65,145,500 FCFA. On the other hand, in the same context, [11] found in their studies in the peripheral zone of the Abokouam é kro Wildlife Reserve (central C ôte d'Ivoire) that elephants caused damage to maize (100%), taro (92.86%), cassava (81, 53%), yams (79.32%) and plantain bananas (77%), 34.03% of cashew trees and 32.35% of cocoa trees in this area, for an estimated monetary value of 205,941,600 FCFA, deducted from the loss of 343.69 ha of land. Similarly, [21] concluded from his studies carried out on the outskirts of the Nouabal é-Ndoki National Park, Congo, that elephants had destroyed cassava (37%), banana (25.7), maize (5%), pineapple (14%) and other crops such as papaya, aubergine and sugar cane, covering an area of 9.69 ha. All this production was estimated to have a monetary value of FCFA 2,907600. What results would we get from HEC characterised in and around the MMMNP? Current knowledge of conflicts between humans and elephants in Central Africa remains limited, [11, 12]. Most studies have focused on the savannahs of southern and eastern Africa (in particular on savannah elephants, Loxodonta africana africana), from which various lessons can be drawn [5]. Certainly, in recent years, many complaints against these animals marauding in the rural area regularly reach the conservation of the MMMNP. After several unsuccessful attempts to drive them back due to limited resources, these animals end up in the villages of the study area, more specifically in the departments of Mayo-Kani and Mayo-Danay [2, 28]. They cause damage to crops, arousing the anger and complaints of many farmers [2, 27]. The general objective of this study is to take stock of human-elephant conflicts in and around the Ma Mbed Mbed National Park. Specifically, the aim was to: (i) determine the origins of the conflicts, (ii) identify the nature of the damage caused by elephants in the area, and (iii) estimate the cost of this damage.

2 Materials and Methods

This study was carried out in and around the MMMNP (Figure 1).

The study area is located in the sub-prefectures of Ka é é, Guidiguis and Taïbong between 9°40'and 13°05' North Latitude, and between 12°15'and 16°45' East Longitude. Over 90% of the population is indigenous (mainly Toupouri, Moundang and Peuhl), with a mix of people from Chad and Nigeria. The climate in this area has two seasons, a short rainy season (June to September) and a long dry season (October to May), with an average annual rainfall of 800 mm and relative humidity of less than 60% [13, 29].

The vegetation is characteristic of the Sahelian region and is sparse. It is thorny. There are periodically flooded grasslands (Yaérés) and shrub and tree savannahs. These plant formations have been severely degraded, mainly as a result of the intensification of agricultural activities, overgrazing and excessive logging for domestic and commercial purposes [14]. It has a fairly uniform relief, a vast flood plain, sloping slightly towards the south-west of the park where the park waters flow into the Mayo-Kani. The texture of the soil is such that it is very difficult for rainwater

to penetrate, making access to certain localities very difficult during the rainy season. However, there are no hills on this stretch of plain. In this region, farming is the main activity for local people. The main cash crops are cotton, rainy season sorghum or 'Ndjigari', off-season sorghum or 'Mouskwari', cowpeas, onions, maize, groundnuts, potato peas and sesame.

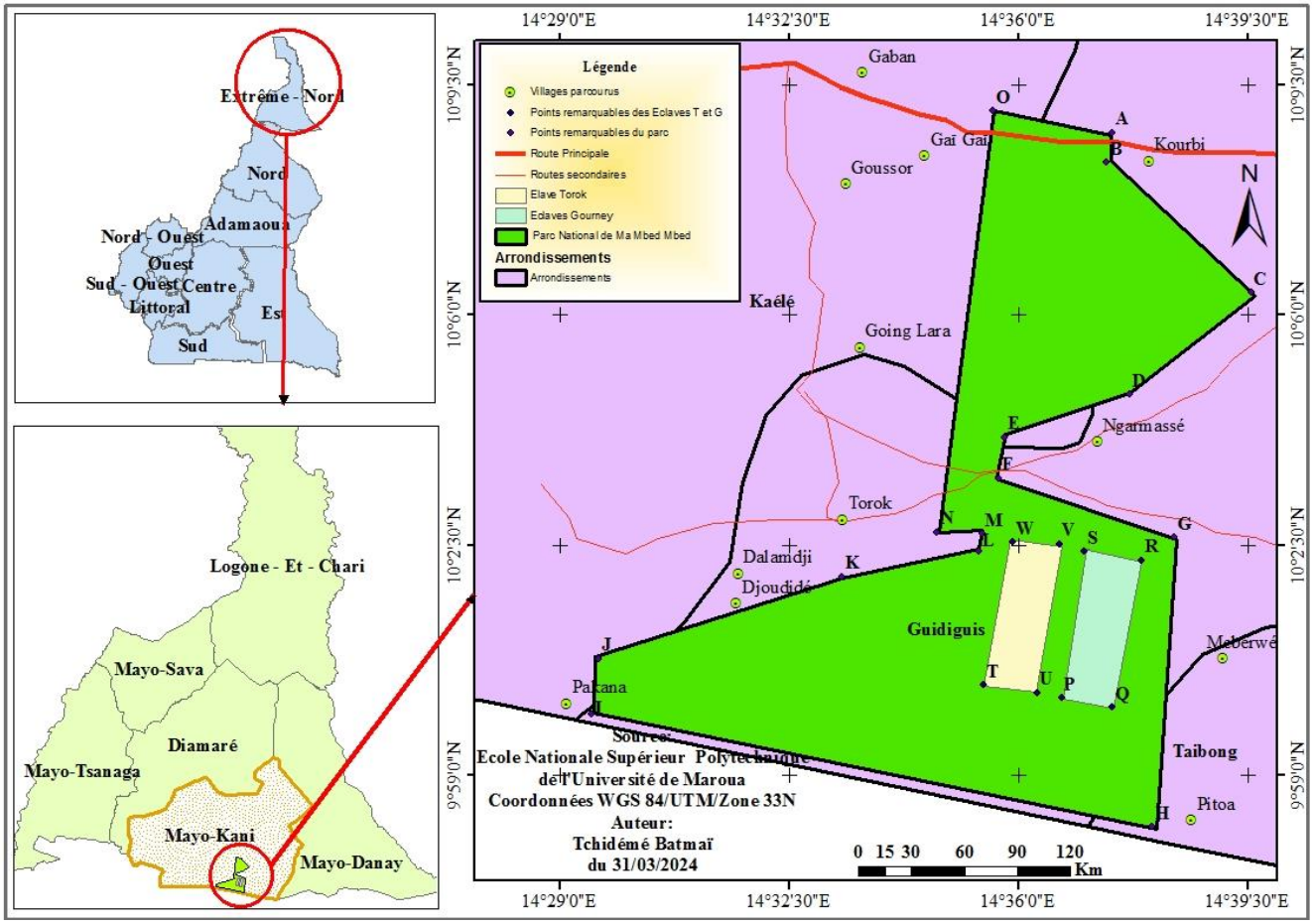

Figure 1 Location of the Ma Mbed Mbed National Park

3 Methodology

Surveys and direct observations were used to study human-elephant conflicts in and around MMMNP [14]. Information on the size of animal populations, crop damage, phenological stages of damaged plants and the period of damage was collected using a questionnaire developed from that of a group of African elephant specialists [9, 17]. The interviews were carried out in the villages of Dalamdji, Djoudidé, Gaban, Gaï Gaï, Going, Goussor, Meberwé, Kourbi, Pakana, Pitoa and Torock between June 2023 and February 2024 and from June 2024 to November 2024, in two stages. The first stage consisted of arriving in each village and finding out from the chief the number of neighbourhoods that make up the village. The neighbourhoods in which the surveys were to be carried out were selected by simple random sampling using scraps of paper in a basket at a rate of 50%. In concrete terms, this involved writing the names of all the neighbourhoods that make up each village on small pieces of paper, folding them and putting them in a basket. 50% of these pieces of paper were drawn to form the study sample in each village. Once this operation of identifying the sample neighbourhoods in which the surveys were carried out had been completed, the second stage was devoted to identifying the sample households. On arrival in each neighbourhood, with the help of the neighbourhood leader, the next stage of the operation consisted of identifying and numbering all the households in each neighbourhood on small pieces of paper as well. Once these two exercises, i.e. the identification and numbering of each household, had been completed, the next exercise

involved selecting the households in which the surveys were to be conducted using systematic sampling with a calculated step size of three. As regards the people to be interviewed in the households, priority was given to the head of the family because of the traditional culture of the study area. If the head of household was absent, the housekeeper was interviewed. If both were absent, the choice was given to the family's eldest son or daughter aged fifteen or over. At the end of this survey, 380 people were interviewed. The second stage was devoted to visiting the fields. Each field was visited to see where the elephants had been and what damage had been caused. The devastated fields were then traced using the GPS 76 tracking system. At the end of each plot, the data collected (latitude, longitude) was transferred to Qgis 10.3 software, and the surface area of each field was calculated. For each field, the following information was recorded: the area threatened, the owner of the field and the crops damaged. In addition, plants damaged (uprooted, broken, organs consumed, etc.) by elephants were also counted. The phenological stage of perennial crops (mango, papaya, etc.) and food crops (cotton, rainy season sorghum (Ndjigari), off-season sorghum (Mouskwari), maize, onions, cassava, cowpeas, groundnuts) destroyed by elephants was recorded [25]. Production and income per hectare of each crop were estimated on the basis of each household's declaration. The average cost on the local market (in CFA francs) was also estimated. The calculation of losses was simplified by reducing the production of each crop to one hectare. Finally, after the investigation, the data was entered and coded in an Excel matrix (questionnaires and field trip observation tables). The various frequencies were calculated using Excel 2010 and the crop losses caused by elephants were calculated using the following formula: Prp= ((Pt-Pve)/Pt)×100 with Prp: Proportion of losses; Pt: Total production; Pve: Production after elephant visit. Elephant damage in terms of extent was classified into three categories:

1) [0-25%[was low-level damage;
2) [25-75%[was categories of major damage;
3) [75-100%[was catastrophic damage.

Statistical analyses were carried out using non-parametric ANOVA tests to compare the proportions of damage between the different crops in order to determine whether or not significant differences exist. The distances between the villages surveyed and the park are listed in Table 2.

4 Results

4.1 Origin of Conflicts

The respondents showed that the causes of HEC have been exacerbated over the last ten years with the creation of the MMMNP in the study area through the movement of elephants in search of water and food. However, as [5] suggest, this can be explained by the fact that elephants avoid areas of high poaching intensity or elephants that have the massacre of their fellow elephants take refuge in witnessed areas where they feel safe. This results in high local abundance (due to the gathering of animals and not to an increase in population) and potentially high impacts of attacks on crops in these areas where they are rarely hunted [5]. All these elephants used to live in the Waza National Park, but today, with the insecurity created by Boko Haram since 2013, the positions of these pachyderms are becoming unstable. For 73% of the people interviewed, the elephants came from the Binder Léré Forest Reserve in Chad, settled for some seven months in and around the MMNP, and then left for the Kalfou Forest Reserve in Cameroon. 22% of those interviewed thought that the elephants came from Moulvoudaï, and 5% had no opinion. These elephants damage crops in groups of four, eight, 16 or even 300 elephants, depending on the village [27]. These elephants are close to the savannah ecotype, Loxodonta africana Africana, characterised by their long, forward-curving tusks and larger, wider ears with a very pointed lower lobe that cross on the midline of the neck when they are pressed against the body.

4.2 Nature of the Conflicts

The HEC recorded in and around the MMMNP are incursions into crop fields and plantations, incursions into concessions, destruction of water points and property, and attacks on humans. Elephants, wherever they migrate, have always caused significant losses to certain farm managers, exposing them to famine and poverty. Following the field surveys, 482 cases of human-elephant conflict were recorded between June 2023 and February 2024 and between June 2024 and November 2024. Three categories of response were recorded during the interviews: damage to crops, human attacks and damage to property. Crop damage (73%) is the main cause of conflict, accounting for most of the damage recorded. Human attacks are less significant (1%), and the latter accounts for 26% (Figure 2).

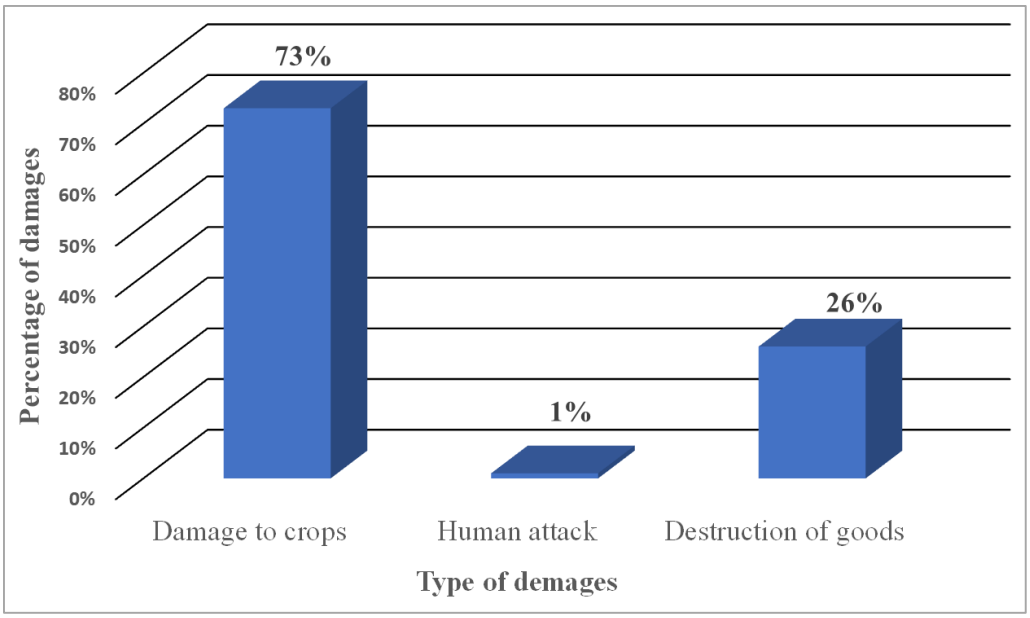

Figure 2 Level of knowledge of damage caused in the study area

Although human attacks are less frequent, they are considered to be the most severe form of HEC. In all twelve localities, the damage recorded mainly concerned crops. The food crops grown in the study area are: rainy season sorghum, known locally as 'Ndjigari', off-season sorghum or 'Mouskwari', cowpeas, groundnuts, onions, potato peas, sesame and rice. They are used for food and are sometimes marketed. Cotton is the food crop grown mainly for marketing. All these crops have been damaged by elephants, either through grazing or trampling. The ANOVA test on crop damage by elephants in the villages indicated that there was a significant difference between damage in the different localities on the basis of crop type (P = 6.6367E-10). In the localities surveyed during the present study, 1% of mango plants and 1% of water installations and sheds were destroyed by elephants. The highest rate of damage was observed in food crops, namely Ndjigari (37%), which belongs to the category of major damage, followed by Niébé(16%), Mouskwari (22%), Onions (7%) and Maize (6%), which belong to the category of minor damage (Figure 3).

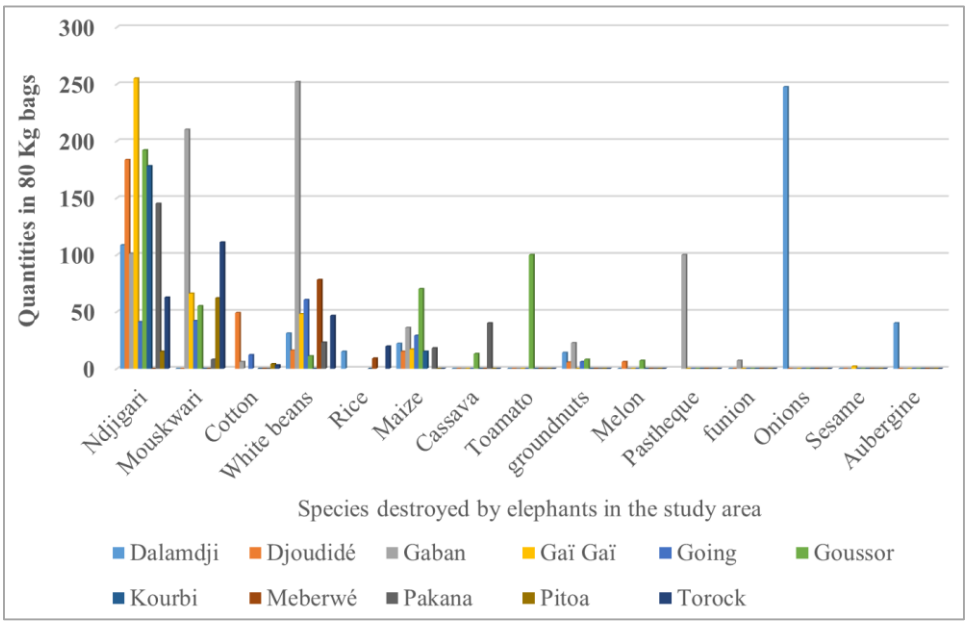

Figure 3 Level of knowledge of quantities of species destroyed

Damage is much more concentrated in areas close to water points. Damage to perennial trees (mango, papaya and doum palm) generally consists of broken branches or, rarely, the uprooting of young plants. Even in new plantations, young plants are trampled by elephants. What's more, elephants eat the bark of mango trees and mangos in busy areas.

4.3 Estimation of Damage Costs

Table 1 shows the quantities in 80 kg bags of crops damaged and losses (in CFA francs) caused by elephants in the study area.

Table 1 Monetary value of the various crops destroyed by elephants in the study area in 2023

Villages	Speculations	Quantities (in bags of 80 kg)	Unit Price	Total price (en FCFA)	Number of households involved in HEC
Dalamdji	Ndjigari	108,5	23000	2495500	50
	Maize	22	35000	770000	
	Niébé	31	34000	1054000	
	Rice	15	40000	600000	
	Onions	247,5	35000	8662500	
	Groundnuts	14	30000	420000	
	Aubergine	40	7000	280000	
	Total	478		14282000	
Djoudidé	Ndjigari	183,5	23000	4220500	22
	White beans	16	34000	544000	
	Maize	15	35000	525000	
	Melon	6	1000	480000	
	Groundnuts	5,5	30000	165000	
	Cotton	49	285 /Kg	1117200	
	Total	275		7051800	
Kourbi	Ndjigari	178	23000	4094000	15
	Maize	15	35000	525000	
	Total	193		4619000	
Gaï Gaï	Ndjigari	255	23000	5865000	25
	White beans	48	34000	1632000	
	Maize	17	35000	595000	
	Mouskwari	66	32000	2112000	
	Sesame	2	40000	80000	
	Total	388		10284000	
Going	Groundnuts	6	30000	180000	21
	Cotton	12	285/Kg	273600	
	Maize	29	35000	1015000	
	Mouskwari	42	35000	1368000	
	Ndjigari	41	23000	943000	
	White beans	60,5	34000	2057000	
	Total	190,5		5836600	
Goussor	Ndjigari	192	23000	4416000	32
	Mouskwari	55	32000	1760000	
	Maize	70	35000	2450000	
	White beans	11	34000	374000	
	Melon	7	1000	560000	
	Cassava	13	12000	156000	
	Tomato	100	8000	800000	
	Groundnuts	8	30000	240000	
	Total	456		10756000	
Gaban	Groundnuts	22,5	30000	675000	67
	Cotton	6	285/Kg	136800	
	Funion	7	28000	196000	
	Maize	36	35000	1260000	
	Mouskwari	210	35000	6795000	
	Ndjigari	101	23000	2323000	
	White beans	252	34000	8568000	
	Pastheque	100	800	800000	

Villages	Speculations	Quantities (in bags of 80 kg)	Unit Price	Total price (en FCFA)	Number of households involved in HEC
	Total	734,5		20753800	
	Cotton	33	285/Kg	752400	
Pakana	Maize	18	35000	630000	22
	Cassava	40	12000	480000	
	Mouskwari	8	35000	280000	
	Ndjigari	145	23000	3335000	
	White beans	23	34000	782000	
	Total	267		6259400	
	Cotton	3	285/Kg	68400	
	Mouskwari	111	35000	3885000	
Torok	Ndjigari	62,5	23000	1437500	
	White beans	46,5	34000	1581000	
	Rice	19,5	40000	780000	8
	Total	242,5		7751900	
	Ndjigari	15	23000	345000	
Meberwé	White beans	78	34000	2652000	8
	Rice	9	40000	360000	
	Total	102		3357000	
	Cotton	4	285/Kg	91200	
Pitoa	Mouskwari	62	35000	2170000	
	Ndjigari	15	23000	345000	7
	Total	81		2606200	
	5 Boxes		15000	75000	
	03 Drinking troughs		10000	30000	
Others	04 Mango trees		50000	200000	
	30 bags of de mangoes		5000	150000	
	Total autres			455000	
Total Général		251 tonnes		94 012 600	277

Table 1 shows an overall monetary evaluation of the damage caused to crops and property by elephants in and around the MMMNP. Analysis of the table shows that: 176 fields measuring 5 m x 5 m were visited during direct observations, resulting in a loss of 251 tonnes of cereals and a monetary value of approximately 94,012,600 CFA Francs, all of which went up in smoke due to HEC. Moreover, if we plot the damage-distance data in Excel, we find that the coefficient of determination is R2 = 0.493 (damage-distance level) and the regression line is $y = 17.701x^2-6.1507x+156.15$ (Figure 4).

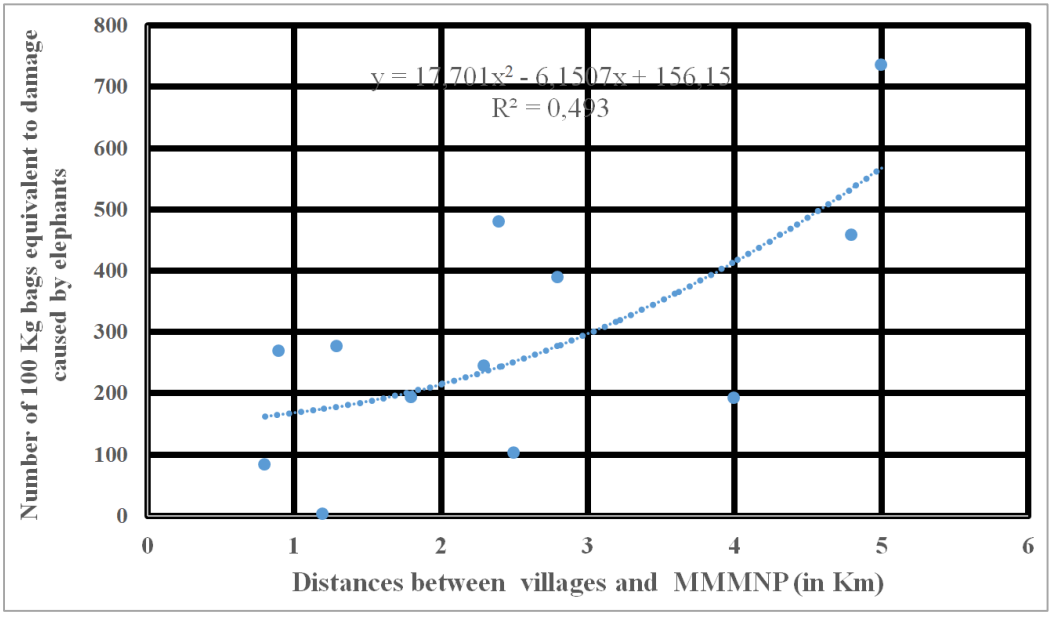

Figure 4 Correlation between quantity destroyed and distance from villages in and around Ma Mbed Mbed National Park

This means that the damage caused by elephants to farmers' crops around MMMNP is perceived as a function of distance (R^2 tending towards zero). In other words, elephant incursions into farmers' fields in and around MMMNP are not a function of distance (Table 2).

Table 2 Level of knowledge of the distances between the villages surveyed and the Ma Mbed Mbed National Park

Various villages	Number of 100 kg bags equivalent to elephant damage	Distances between each village and the MMMNP (in km)
Dalamdji-PNMMM	478	2,4
Djoudidé-PNMMM	275	1,3
Gaban-PNMMM	734,5	5
Gaï Gaï-PNMMM	388	2,8
Going Lara-PNMMM	190,5	4
Goussor-PNMMM	456	4,8
Kourbi-PNMMM	193	1,8
Maberwé-PNMMM	102	2,5
Ngarmassé-PNMMM	0	1,2
Pakana-PNMMM	267	0,9
Pitoa-PNMMM	81	0,8
Torok-PNMMM	242,5	2,3

This study also shows that several factors can encourage the movement of these elephants in rural areas: the lack of water inside the park, the intensification of human pressure due to several threats (poaching, bush fires, logging and the corollary of insecurity caused by Boko Haram in the Waza area). Wherever there is a human presence and elephants, in the same area, there are always conflicts between humans and elephants (destruction of crops, injury or even death to humans, attack on livestock). Table 2 shows that the ANOVA test applied to determine whether the quantities of cereals lost are a function of distance or not. P= 8.69E-5< 0.05, which means that the losses suffered are not a function of distance.

5 Discussion

Conflicts between elephants and humans are due to several factors: the expansion of human settlements (including linear infrastructures such as roads) and the growing need of populations for agricultural land and pasture. The consequence of this development is the loss and increasing fragmentation of elephant habitat and increasing areas of conflict [10]. The origin of HEC is also linked to the movement of these pachyderms, which move every year in search of food and water in their usual ecological environment [23]. The presence of elephants in the localities visited is reflected by the presence of populations on their usual travel corridors or their proximity to their habitat. Elephants have also found these favorable environments to be their preferred crops. According [11, 20, 24], several factors encourage elephant movements in rural areas. The most important of these are: the lack of water inside the park, the intensification of human pressure (poaching, bush fires and logging) and changes in the nutritional situation in savannah areas such as the MMMNP. Wherever crops and elephants are found in the same area, there are always conflicts between humans and elephants. The types of farming practices in the savannah zone of Cameroon create a mosaic of vegetation that elephants are particularly fond of [3]. In the localities of the MMMNP, agriculture was the main activity of the local population. The crops grown by the farmers attract elephants. In many cases, only a combination of different crops was grown. In terms of the landscape, the areas occupied by food crops are small. Although the correlations are not significant at crop level, in the field elephants seem to have a preference for certain crops such as Ndjigari, Maize, Mouskwari, Aachides, Cassava, Onions and Rice. They stay in these food crops and eat most of them, trampling on the rest. This finding is consistent with the work of [14], who found that elephants were much more likely to consume food crops. According to [17], food crops are rich in mineral salts, and it was these salts that attract animals, in this case elephants. [15] stated that the risk of crop damage increases with the number of food crops grown. All phenological stages of crops were affected by elephants in the study area. Damage to cotton occurred mainly at the pod formation stage, which elephants are particularly keen on, according to growers. In the case of Mouskwari, Ndjigari and Maize, the heading stage was much more attractive to elephants because of the strong odours given off and quickly picked up by these pachyderms. There were also early peaks in damage to Mouskwari, Ndjigari, Maize and Arachis at the bolting stage, which could be explained by the fact that the foliage

was always young, which can attract elephants. These results are at variance with those of of [5, 14, 15] who reported that crops are attacked at critical stages such as the ripening and intermediate stages. In general, the stages most affected by damage are the ripening and intermediate stages and, to a lesser extent, the young stage. Elephants consume a lot of mature crops. These crops contain far more nutrients than the other stages. These results confirm those of of [19] who also reported that elephants prefer mature crops to immature ones. Also, [5], the maturity of crops has a strong impact on incursions into fields. When crops are mature, they attract elephants because of their high nutritional value. They can also provide additional benefits to elephants, such as rare nutrients. According to [1], damage was greatest when crops are mature, of good quality and ready for harvest. It should be noted that stocks are also consumed by elephants simply because of the installation of granaries and the display of cereals in concessions located on their travel corridor. In the study areas where elephants are present, the threats are real. Indeed, the quantities of vegetation (120 to 150 kg per day per animal) consumed by these animals cause major losses to farmers, as has been observed elsewhere) [15]. Elephants cause major losses to farmers by eating and trampling their crops. They have become very fond of these products. They destroy crops as they pass by, trampling them underfoot. Their presence in plantations or near villages causes great fear among the population, preventing them from going about their business in peace. The losses caused by elephants in the research area are enormous. Most of the farmers living in these areas have seen their crops completely destroyed by elephants. Compensation or partial compensation for victims of crop damage is desirable to avoid impoverishment and famine in some households. This could lead to participatory management by farmers to ensure good conservation of elephants. Elephants are not very aggressive, but become a danger to na ïve and curious humans. These animals can react unpredictably. The human injuries reported were caused by the carelessness, curiosity and provocation of these animals by humans.

6 Conclusion

The study of human-elephant conflicts in the localities of the study area showed that the incursions of elephants into crops are well-founded and are at the origin of these rififis. Human-elephant conflicts arise from the movement of elephants, their palatability and the nutritional value of cultivated plants. There are two types of conflict: damage to plantations and human attacks. As a result, 247 hectares of crops were ravaged by elephants, at an estimated cost of 94,012,600 CFA francs. Compensation or partial compensation for victims of crop damage is desirable to avoid impoverishment and famine in some households. Today, more than ever, we need to change the paradigm of HEC management. We need to make it easier for local people to access funding for projects such as beekeeping and pepper growing. Or the rain-fed rice-growing project, which is very favorable to the study area.

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