

The Effect of Armed Conflict on Biodiversity and its Implication on Wildlife: A Case Study on the Lebialem Highlands, South-West Region, Cameroon

Enokenwa Allen Tabi^{1*}, Mfonkwet Njiaghait Youchahou², Abhijit Mohanty³

^{1,2,3}Environment and Rural Development Foundation, Buea, Cameroon

*Corresponding Author: enokenwatabiallen@gmail.com, Tel.: +237677037976

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Abstract—The armed conflict in the Anglophone regions of Cameroon surged in 2016. In this conflict, many villages have been razed and hundreds of thousands of people displaced. In the South West Region, Lebialem is one of the hot zones of the conflict. Here, many displaced persons have found refuge in the forest; their impact on biodiversity cannot be undermined. The goal of this research paper is to highlight the impact of the armed conflict on the biodiversity and its implications for wildlife. In order to achieve this goal, the land cover of the study site was analyzed using satellite imagery. Two Landsat 8 OLI_TIRS satellite images taken in 2015 and 2020 were downloaded through the United States Geological Survey (USGS). These two images were processed using ENVI 5.3. Maps were produced by importing vectors derived from digital processing ENVI into Arc Map 10.5 software. A wildlife survey was conducted using the guided reconnaissance (recce) method. The results indicate that there was a slight change in dense forest cover of 0.26% (152 ha) and a general decrease in the relative abundance of Nigeria-Cameroon chimpanzee (from 2.964 in 2015 to 0.321 in 2018), Cross River gorilla (from 1.857 in 2015 to 0.107 in 2018), African forest elephants, and other species whose populations are vulnerable to human disturbance. Though armed conflict might have its own impacts on biodiversity and wildlife species, a strong conservation program is needed for the development of local professionals to continue even during socio-political instability.

Keywords- Conflict, Biodiversity, Wildlife, Habitat-loss, Lebialem Highlands

I. INTRODUCTION

In 2001, the United Nations (UN) General Assembly declared November 6th as the International Day for Preventing the Exploitation of the Environment in War and Armed Conflict. On May 27th, 2016, the UN Environment Assembly adopted a resolution which recognized the role of healthy ecosystems and resources that are managed sustainably to reduce the risk of armed conflict. They reassured their commitment in the implementation of the sustainable development goals. According to [1], armed conflicts have occurred in more than two thirds of the world's biodiversity hotspots over the past six decades. Human warfare has been documented by ([2], [3]) as having a significant influence on the biosphere across a range of ecological scales. Reference ([4], [5], [6], [7]) explained that armed conflict negatively impacts biodiversity through habitat fragmentation and destruction, direct loss of animals from land mines and poaching, degradation of natural resources, over-exploitation and increases water and land pollution. [8] collected data between 1946 and 2010 and the analysis showed that more than 250 populations of 36 species of large herbivorous mammal such as antelopes, elephants, rhinos, hippos and giraffes are distributed across 126 protected areas in Africa. In their research, more than 70 percent of the African parks were affected by armed conflicts. They also

found that as the number of conflicts increased, wildlife populations declined was due the frequency of war, not the intensity of war was the single most important factor in explaining the trends in wildlife populations relative to all others they had studied.

Armed conflict in the South-West and North-West Anglophone regions of Cameroon surged in 2016 when protests arose over perceptions that the central, francophone-dominated government was discriminating against English-speakers. Due to the conflict, many villages have been razed, causing the displacement of hundreds of thousands of people into safer zones such as Nigeria, francophone regions of Cameroon, and forest areas. In the South-West Region, Lebialem is one of the hot zones of the armed conflict. Here, many displaced persons have found refuge in the forest. The Lebialem Highlands are considered as one of the biodiversity hotspots in Cameroon. The area is the habitat of the critically endangered Cross River gorilla (*Gorilla gorilla diehli*), endangered Nigeria-Cameroon Chimpanzee (*Pan Troglodytes ellioti*), endangered Drill (*Mandrillus leucophaeus*), African forest elephant (*Loxodonta africana cyclotis*), and several other species of threatened fauna and flora. While people have sought for refuge in the Lebialem Highlands forest area, their impact on biodiversity cannot be underestimated.

Considering the escalating Anglophone crisis, many of the officials from Forestry and Wildlife department, Cameroon, have deserted their posts to safer areas. The Lebialem Division of South-West Cameroon has been deserted by most wildlife conservation officials for over one year. In fact, most conservation stakeholders who escaped to various destinations following an attack on the Senior Divisional Officer of Lebialem, and the killing of the Lebialem Divisional Delegate of Land Tenure on March 22, 2018, have not gone back to their duty posts. Conservation activities in most of these protected areas in the landscape have equally been affected. This has accelerated illegal hunting of wildlife and habitat degradation.

Knowledge on the consequences of armed conflict on the ecological changes of biological systems is known but in the Anglophone regions of Cameroon, this has yet to be conducted. The goal of this research paper is to highlight the impact of the armed conflict on the biodiversity and its implications for wildlife in the Lebialem Highlands forest, South-West Cameroon. This will go a long way to help conservationist and managers to put in place proper strategy for the management of biodiversity and its wildlife during conflict period.

Section I contains the introduction of armed conflict on biodiversity and the goal of this research paper, Section II contains related work of the subject under studies, Section III contains methodology used for this research work, Section IV is made up of the results and discussion, Section V describes the conclusion of the research work with future directions.

II. RELATED WORK

Research on effect of armed conflict on forest conservation has been done in Rwanda. The aim of this study was to examine forest loss or gain in protected areas in order to measure their effectiveness during and post conflict period. Other studies by Samuel Kanyamibaw highlighted the consequence of war with particular focus on conservation bodies and protected areas. To my knowledge known of these studies have been conducted in the war troubled Anglophone regions of Cameroon, the rationale for our research particularly in the Lebialem Highlands forest to provide conservationist and managers the situation of biodiversity and wildlife during the conflict.

III. METHODOLOGY

Description of Study Site

The Lebialem Highlands is a mountainous landscape located in the South-West region of Cameroon. It is bordered to the east by the West region, to the west and southwest by the Banyang-Mbo Sanctuary, to the north Momo Division and to the south by Sanchou game reserve. Geographically situated between latitudes 5° 11" and 5° 45" and longitudes 9° 50" and 10° 00" and falls in the range of 180m to about 2510m above sea level. The

highlands have a humid tropical climate with average annual rainfall of about 3500mm with peak in the month of August as described by [9]. The period from November to February is considered dry season meanwhile the months of March to October is rainy season. The Lebialem Highlands which is situated within the Cameroon-Nigeria cross-border has a daily temperature that varies between 20°C and 35°C, with the peak in March. According to [10], it is known to have exceptional diversity and degree of endemism with a floristically diverse cross-border area. The dense forest of the highlands falls in the Guineo-Congolian region which according to [11] has 80 % of known African primates, 70 % of known African passerine birds and African butterflies. Flagship species such as the critically endangered Cross River gorilla (*Gorilla gorilla diehli*) has population less than 300 individuals in the wild, the most threatened chimp subspecies endangered Nigeria-Cameroon chimpanzee (*Pan Troglodytes ellioti*) numbering fewer than 6,000 individuals in the wild (Blanc J. 2008).

Data Collection and Analysis of Land Cover (Forest Cover)

The conflict period in the study included forest cover change from the pre-armed conflict baseline of 2015 to the conflict present date of 2020. Due to the risks posed by the ongoing conflict, our analysis was based on satellite imagery. Assessment of land cover change was made using two Landsat 8 OLI_TIRS satellite images taken in 2015 and 2020 respectively, and downloaded through USGS (United State Geological Survey) web. Images were acquired during the dry season (December 2015 and January 2020) to make sure that the phenological stages of plant cover were not too different between dates. We used the ENVI 5.3 to process the images. In order to enhance the images, Landsat images were subjected to pan sharpening, layer stacking, color composition and normalized difference vegetation index calculations. A geo-rectified vector map (UTM 32 WGS 84) was used to extract the study zone. Ground-truth points were collected using Google-Earth. The image classification was done using the Super Vector Machine Classifier [12]. The maps were produced by importing Vectors derived from digital processing in ENVI into Arc Map 10.5 software. We determined the change in forest cover during the conflict period by calculating the difference in surface area of forest cover in the pre-conflict period and during the current conflict period. The percentage change was obtained using difference in surface area of forest cover (gain or loss/initial surface area of forest cover x100). Change in other features such as settlement, farmland, and grassland were also determined.

Wildlife Survey and Data Analysis

The wildlife survey in the Lebialem Highlands forest was conducted yearly in 2015 (November, December, June), 2016 (June, August, December), 2017 (January, June) and 2018 (June and July) inclusive during dry and rainy periods. No data was recorded in 2019 and 2020 because of the present insecurity in the area. 1km by 1km grid with

lay down recce of different lengths was designed in the survey area. The guided recce walks method ([13]; [14]; [15]) was used because it was faster and easy with little resources available. All waypoints of recces were determined using a GPS unit model GPSmap 62 GARMIN. Survey starts at 8 am and ends at 6 pm by a team of 3 persons made up of a leader who is wildlife biologist, one assistant and a guide from the community. The Wildlife Biologist was responsible for orientation and navigation through the recces, looking for wildlife and human signs and recording them in a designed data sheet. The assistant was in charge of reading the coordinates from the GPS as well as searching for animals and human signs and cutter of minimum vegetation to facilitate passage and identification of starting point was the guide. During the period of survey 224 km distance of recces were covered. Data collected includes great ape nests, nest type, vegetation type, species, slope, canopy type, food type, undergrowth of vegetation, and elevation. Slopes were classified into the following categories; flat (0°), slight (1-5°), moderate (5-10°) and steep (>10°). Feeding remains, scat, foot prints and direct sightings of other mammals were also recorded.

Great apes nest was identified and categories into different ages as described by [16]. We defined a nest site as all nests ≤ 50m apart from each other that were created by the same ape species. In this survey, only fresh nests were considered. All arboreal nest sites with tree nests higher than 10m above the ground level were attributed to chimpanzee. Gorillas were attributed with ground nest and tree nest of less than 10m high. No data was collected in 2019 or the beginning of 2020 due to the intensity of the armed conflict in the area.

The relative abundance (encounter rates) of species before and during the armed conflict was calculated to determine the implications of the armed conflict on wildlife species in the target area, this formula was used: Encounter Rate (ER) = Number of observations/ Distance covered (Km). Statistica 12 was used to determine the level of significance for encounter rates.

IV. RESULTS AND DISCUSSION

Spatial Pattern of Armed Conflict Induced Settlement and Forest Loss

The maps in Figure 1 and Figure 2 depict the situation of forest cover before the conflict in 2015 and during the conflict from 2016 to 2020. In 2015 and 2020 the forest cover was 58,514.840 ha and 58,362.809 ha respectively. There was a slight change in forest cover during the period of armed conflict.

The results of this study indicate that settlements in the Lebialem Highlands forest have increased over the years of the conflict. The change stands at 88.23%. The gain in settlements in the forest area can be explained by the fact that the conflict might have pushed people to abandon their villages and seek refuge in the forest while cutting down of trees and other forest materials for the construction of temporal shelters. There was also a slight change in dense

forest cover of 0.26% (152 ha) within the period. This loss in forest cover might not necessary be the impact of the armed conflict entirely, but a combination of other factors such as the decrease in law enforcement and conservation activities in the area during the period.

The creation of farmlands has decreased over the conflict period. The percentage change is 23.88% (1699 ha). This decrease co-occurs with an increase in grassland cover (from 29257.62 ha in 2015 to 30451.83 ha in 2020). This might be a result of the reality that many villages in the area have been deserted and people have moved to secured areas, abandoning their farmlands that have given way to grassland.

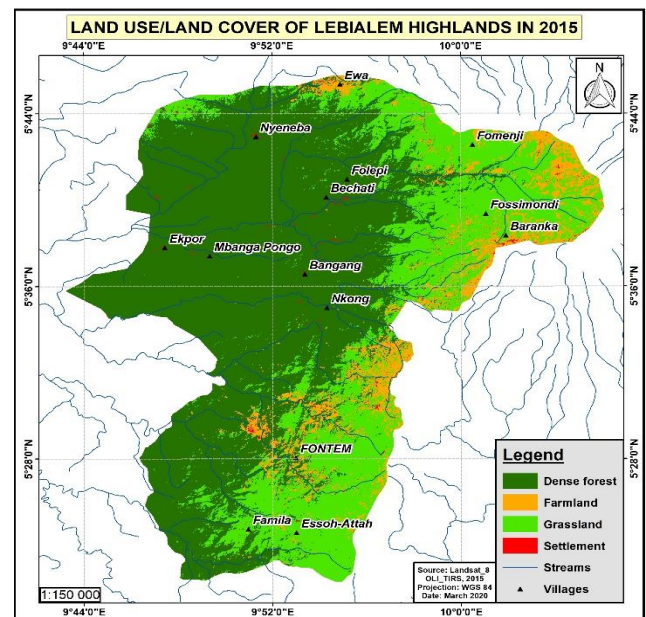


Figure 1. Map of 2015 Land Use/Land Cover of Lebialem Highlands

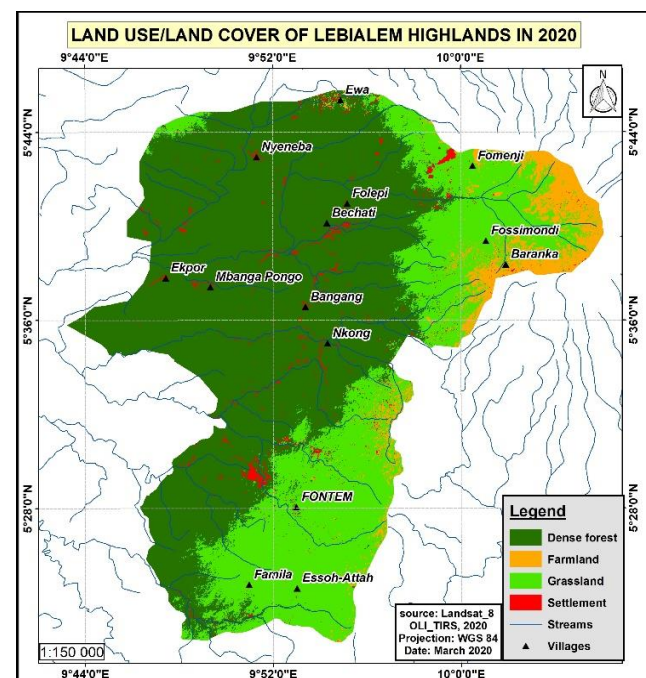


Figure 2. Map of 2020 Land Use/Land Cover of Lebialem Highlands

Implications of Armed Conflict on Wildlife

Eleven wildlife species were recorded before and during the period of armed conflict in the Lebialem Highlands forest area. These include: Cross River gorilla, Nigeria-Cameroon chimpanzee, duiker species, galago, civet, bush pig, Mona monkey, Preuss’s monkey, porcupine, forest elephant, and pangolin (see Table 1). Figure 3 shows the relative abundance (encounter rate) of these wildlife species. The highest encounter of wildlife species was recorded in 2017 (ER=2.60) and the lowest in 2018 (ER=1.54).

Table 1 shows the encounter rates of wildlife species recorded before the armed conflict in 2015 and during 2016, 2017 and 2018. Duiker species (*Cephalopus sp*) had the highest average encounter rate (ER=8.803) and pangolins (*Manis temminckii*) had the lowest (ER=0.027). Bush pigs (*Potamochoerus porcus*) were the most encountered (ER=12.429) in 2017. The two great apes in the study area, the Cross River gorilla (*Gorilla gorilla diehli*) and Nigeria-Cameroon chimpanzee (*Pan Troglodytes ellioti*) have their highest encounter rates respectively (ER=1.857 and ER=2.964) in 2015 and lowest encounter rates respectively (ER=0.107 and ER=0.321). The African forest elephant (*Loxodonta cyclotis*) was recorded only in 2015 (ER= 0.25) and 2017 (ER=0.0714). The statistical analysis reveals that there is no significant difference between the encounter rate of wildlife from 2015 to 2018 (ANOVA one-Way: F (3, 40) = 0,245, p = 0,863). However, there has been decrease in the population of wildlife species in the Lebialem Highlands forest area from 2015 to 2016 and in 2018 (ER=1.98 to ER=1.59 and ER=1.54). This decrease might be due to the armed conflict that has prevented law enforcement and conservation activities in the area. During these periods the local forestry and wildlife staff left the area in fear of their security, giving way for illegal hunting of wildlife species and the destruction of their habitats. There was also decreased funding from conservation partners supporting activities in the area. ERuDeF which is the sole conservation non-governmental organization in the Lebialem Highlands experienced about 20% decrease in funding from 180,890 USD in 2015 to 144,710 USD in 2018 (ERuDeF, 2019).

There was an abnormal increase in the encounter rate of wildlife species in 2017 (ER=2.60). This could be explained by the fact that there was a very high encounter rates of *Potamochoerus porcus* (ER=12.429) and *Cephalopus sp* (ER=10.357), which inflated the encounter rate value. These two wildlife species have high birth rates and large populations in the area.

It should be noted that the Lebialem Highlands forest landscape includes one protected area, the Tofala Hill Wildlife Sanctuary, and a proposed protected area called the Njoagwi-Fotabong III –EssohAttah Wildlife Sanctuary. These protected areas harbors threatened wildlife species that are negatively impacted by the armed conflict. There was a general decrease in the relative abundance of

Nigeria-Cameroon chimpanzees from 2.964 in 2015 to 0.321 in 2018 and of the Cross River gorilla from 1.857 in 2015 to 0.107 in 2018. The relative abundance of other large mammals such as the African forest elephant also decreased. These wildlife species have large body size and are the most vulnerable to human disturbance such as hunting and deforestation. This has been demonstrated in research conducted by [17]. Lack of wildlife law enforcement and conservation activities in the area, and with the continued loss of forest cover, the survival of wildlife species are at risk.

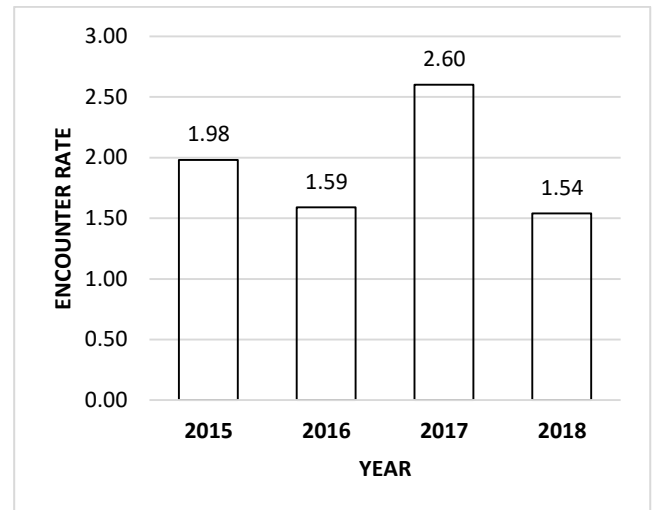


Figure 3. Yearly encounter rates of wildlife species recorded in Lebialem Highlands Forest

Table 1. Encounter rates of individual wildlife of species recorded in 2015, 2016, 2017 and 2018.

Species		Year			
		2015	2016	2017	2018
Common Name	Scientific Name	ER	ER	ER	ER
Nigeria-Cameroon Chimpanzee	<i>Pan Troglodytes ellioti</i>	2.964	2.2	1.1	0.321
Cross River gorilla	<i>Gorilla gorilla diehli</i>	1.857	1	0.1	0.107
Duiker	<i>Cephalopus sp</i>	9.535	8.3	10	6.9
Galago (Bush Baby)	<i>Galagoides sp</i>	0.321	0	0.5	0.8
Civet	<i>Nandinia binotata</i>	0.107	0	0	0
Bush Pig	<i>Potamochoerus porcus</i>	5.3	5.4	12.429	4.6
Mona Monkey	<i>Cercopithecus mona</i>	1.2	0.4	3.7	3.7
Preuss's Monkey	<i>Allochrocebus preussi preussi</i>	0.1	0	0	0
Porcupine	<i>Atherurus africanus</i>	0.0	0	0.1	0
Pangolin	<i>Manis temminckii</i>	0	0	0.1	0
African Forest Elephant	<i>Loxodonta cyclotis</i>	0.25	0	0.0714	0

V. CONCLUSION AND FUTURE SCOPE

This study assessed the effect of armed conflict on biodiversity and its implication on wildlife in the Lebiale Highlands Forest Landscape. After analysing the forest cover using satellite imageries of the forest area, we determined that there was a slight reduction in forest cover. The study concluded that the displacement of people across the landscape and other factors, like absence of conservation and law enforcement activities, over the conflict years might have exacerbated pressure on the already fragile biodiversity and wildlife species. These wildlife species are keystone species with large body size that are very sensitive to hunting and deforestation and are likely to go locally extinct. Dialogue among conflicting parties would be essential element in addressing these problems.

Myers explained that “In some respects, indeed, wildlife benefits from warfare: combatant armies effectively designate war zones as ‘off limits’ to casual wanderers, thus quarantining large areas of Africa from hunters and poachers. The site-effect of conflict on biodiversity and wildlife are not planned but are rather accidental, inadvertent and incidental benefits. Though conflict is necessary to identify error, it is essential for corrections but detrimental to the long-term cooperation for sustainability [18]. A solution to bounded conflict is possible only in societies where the exist political completion. [19], suggested that “the best preparation for conservation in the face of regional instability is the professional development of national staff and strong site-based conservation programs”. The need for increase wildlife monitoring and law enforcement will go a long way to enhance conservation outcomes in the armed conflict zone of Lebiale Highlands forest.

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AUTHORS PROFILE

Enokenwa Allen Tabi is a Wildlife Biologist and has worked with the Environment and Rural Development Foundation between 2011 to 2020 in different management positions. He holds a Master of Science in Ecology and Wildlife Management from the University of Dschang, Cameroon. Currently the and Founder of the Association for Biodiversity Conservation and Rural Development (ABCARD). Arthur of 2 papers on ecology of Cross River gorilla and Nigeria-Cameroon chimpanzee.



Mfonkwet Njiaghait Youchachou

is a GIS specialist with the Environment and Rural Development Foundation. He has a Forest Engineering and Master of Science Degree in Natural Resource Management in the University of Dschang.



Abhijit Mohanty is an International Consultant, work with the Environment and Rural Development as Director of Development and Fundraising. He has an MBA from Amity University and Bachelor of Sociology Honours from Utkal University. Currently he works as a



partnership Management Officer at United Nations Development Program in India.
