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Atmospheric Changes on the Activity of African Elephants (*Loxodonta cyclotis*) in the Farming Area of Mount Cameroon National Park, Southwest Region, Cameroon

Melle Ekane Maurice[1]*, Tadida Elvis Chembonui[1], Fominka Tajoacha Nestor[1], Agbor James Ayamba[1], Kamah Pascal Bumtu[1], Esther Eyong Mbi Arrabi[2], Che Scholastica Nchang[2], Aganya Benedatte Eyama[2], Tashe Vanesa Nwah[2]

[1]Department of Forestry and Wildlife, University of Buea, Buea, Cameroon
[2]Department of Environmental Science, University of Buea, Buea, Cameroon

Research Article

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***For Correspondence:**
Melle Ekane Maurice, Department of Forestry and Wildlife, University of Buea, Buea, Cameroon
E-mail: melleekane@gmail.com

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ABSTRACT

The atmospheric condition is very important to wildlife management and conservation since the animal location and survival are mainly determined by this factor. Extreme atmospheric condition such as temperature for example has caused the migration of huge population of elephants and other wildlife species to areas with moderate temperature ranges. This study was aimed at determining the influence of some atmospheric conditions on the activity of African elephants in mount Cameroon national park. Data collection was done for four months within the national park area. Hence, the atmospheric conditions such as sunshine, rainfall, and cloud were taken into consideration alongside the activities of the elephants in crop-farms. The study showed a significance of atmospheric conditions, X^2=85.49 df=4 P=0.000, X^2=47.17 df=8 P=<0.05, and X^2=12.57 df=8 P<0.05 on the elephant-conflict villages, crop-farm, and farm destruction level respectively. More so, atmospheric factors revealed a significance, r=0.104 P<0.05, X^2=166.78 df=4 P=0.000, and X^2=10.61 df=2 P=0.005 on farm destruction level, photo-period, and elephant habitats respectively. Additionally, the atmosphere recorded a significance, X^2=5.17 df=4 P<0.05, X=10.97 df=4 P<0.05 and X^2=58.51 df=10 P=0.000 on landscape, elephant trails and crop destruction proximity to human homes respectively. Crop-farms of distance >100 meters 28%, 10 m-20m 19% , recorded the highest activity rate compared to other farming distances from human homes. However, the destructive crop-feeding and foraging activities of elephants were more observed during the sunny

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atmosphere. Among the three atmospheric conditions considered in this study, elephant activity was highest on the moderate sunshine 45%, followed by cloud 36%, and then rainfall 15% respectively. The study revealed that the moderate sunshine in Mount Cameroon national park is conducive to a smooth elephant activity, especially feeding and foraging that elephants spend most of their daily time budget on. The sunny atmosphere in mount Cameroon national park has been a key driving force to the feeding and foraging activities of elephants in the area. Unfortunately, this period coincides with crop-farming activities of subsistence farmers who depend on farm-crops for feeding and income generation to support family welfare. Farming is a survival strategy to the inhabitants of this area; hence, elephant crop-raiding needs a national mitigation attention.

Keywords: Atmospheric conditions; Elephant activity; Crop-farms; Crop-feeding; Crop-raiding

INTRODUCTION

Despite high rainfall in tropical forests, forest elephants, like savannah elephants, might also be limited by water [1,2]. As large-bodied mammals living in a tropical climate, forest elephants likely use a substantial amount of water in thermoregulation [3] and employ similar range of physiological and behavioral mechanisms as their savannah counterparts [4,5]. Moreover, proximity to wetlands often predicts elephant presence, and seasonal habitat occupation has been more closely linked with permanent wetlands than fruit availability [6]. In Congo, forest elephants are hypothesized to have two distinct modes of ranging with dry season movements concentrated around rivers or swamps and wet season movements tracking the irregular distribution of fruit [7]. Amongst these key environmental factors, the degree to which water availability, temperature and resource availability interact to shape forest elephant movement behavior is yet to be explored at the landscape scale.

Understanding the environmental factors that influence animal movements is fundamental to theoretical and applied research in the field of movement ecology [8]. Studies relating fine-scale movement paths to spatiotemporally structured landscape data can shed light on the determinants of movement, such as resource availability and the relative importance of different resources [9]. The relationship between landscape dynamics and movement is particularly important to wide-ranging species, like elephants, whose mobility can be critical for persistence in the face of high temporal variability of local food resources [10].

The African forest elephant (*Loxodonta cyclotis*) is a wide-ranging mega herbivore and keystone species for Afro-tropical rainforests that influences the composition and structure of the ecosystem through movement and browsing [7,11-13]. Forest elephants can move over 2800 km annually with average home ranges of ~700 km^2 [2]. Like savanna elephants (*Loxodonta africana*), forest elephants show patterned preferences for various habitats, potentially moving to fulfill their energy and nutrition needs [14]. The ranging behavior of forest elephants has been linked to resources such as browse abundance,

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mineral deposits, water resources and the physical and seasonal distribution of ripe fruit [2,6,7,15], but the relative importance of these resources on their movements is largely unknown.

Although forest elephants have broad diets, they are highly frugivorous and foraging decisions likely track fruit resources [16-18]. The distribution of forest elephant trails, for example, is associated with high-nutrient food sources such as fruit and mineral deposits [15] and elephant trails frequently lead to important fruiting trees [19,20]. Although rainforests are often viewed as lush, productive ecosystems, ripe fruit is often patchily distributed and seasonally scarce [21-23]. Consistent with this, Central African forests demonstrate distinct fruiting fluctuations, linked with both annual and seasonal patterns [23-26]. Peak fruit production consistently falls within the wettest months of the year across geographic locations, particularly for fleshy fruits [27-30], at least in the forest interior [13]. Studies of other frugivores (e.g., primates) have highlighted that the spatial distribution and temporal periodicity of flowering and fruiting often drive their ranging behavior and habitat use [31,32], and that frugivores can show marked seasonal dietary shifts by switching to alternative diets when particular energy resources are scarce [21,32]. These dietary shifts lead to behavioral shifts and changes in activity budgets, including when, where, and how individuals move [32,33].

The endemism of any wildlife species in any part of the world is climate dependent, one of the reasons many wildlife species in the tropics are not in the polar or temperate regions. Some wildlife species can withstand extreme cold climatic or atmospheric conditions while others can survive in extreme sunny conditions. African elephants are very sensitive to atmospheric changes such as temperature, hence, their feeding might be weather influenced. The sunny atmosphere in mount Cameroon national park has been a key driving force to the feeding and foraging activities of elephants in the area. Unfortunately, this period coincides with crop-farming activities of subsistence farmers who depend on farm crops for their feeding and income generation for family survival, creating a conflict relation that sometimes results to casualties.

MATERIALS AND METHODS

Description of the study area

Mount Cameroon national park lies at the coast of Gulf of Guinea, between latitude 3°57'N - 4°27'N and longitude 8°58'E - 9°24'E (Figure 1). Climatically, the area is dominated by equatorial climate of high rainfall and moderate tropical temperature. Average monthly temperatures are like any other part of the region, with the hottest month recording a monthly temperature of 33°C (February-March) and the coldest months recording as low as 23°C (June–October) (Limbe City Council 2014). Two major seasons exist in the area, the rainy and the dry seasons. In the past, the rainy season occurred from March, extending to October and the dry season from November to February each year. But due to the present climatic changes, the rainy season extends up to October and December. Biodiversity richness of mount Cameroon national park area has been threatened over the years mainly due to the rich volcanic soils which attract the development of agro-businesses [34].

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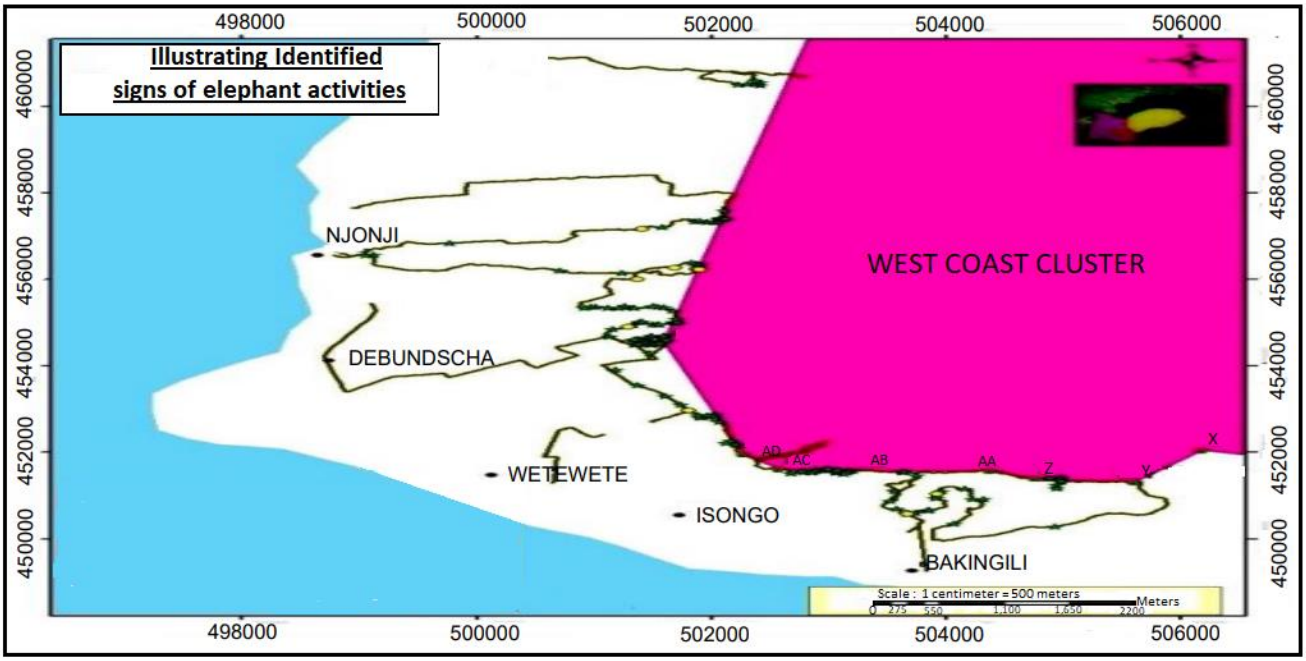
Figure 1. Map of the study area in Mount Cameroon national park. **Note**: ( ) West coast cluster; ( ) Signs of elephant activities; ( ) Trails/elephants tracks, ( ) Last farms to PA boundary; ( ) Settlements; ( ) Atlantic ocean.



Mount Cameroon national park is a home to a wide range of wildlife species such as drill (*Papio leucophaeus*), chimpanzee (*Pan troglodytes*), putty-nosed monkey (*Cercopithecus nictitans*), mona monkey (*Cercopithecus mona*), red-eared monkey (*Cercopithecus erythrotis*), red-cap mangabey (*Cercocebos torquatus*), Preuss's guenon (*Cercopithecus preussii*) and crowned guenon monkey (*Cercopithecus pogonias*). However, the population of drills and chimps is fast dwindling due to hunting pressure and habitat loss. The forest elephant (*Loxodonta africana*) is one of the keystone species of the area. A survey carried out in 2003 indicates a population of 176 elephants in the national park [35].

Methods of data collection

The field data collection started with a pilot study to test the methods to be used during the program. The exercise witnessed adjustment of some variables on the check-sheet not feasible for data collection [36]. Hence, the data collection program started in the month of February and ended in May. Three villages severely crop-raided by the elephants were chosen for research data collection and the crop-farms raided were maize, cassava, banana, oil palm, and plantain. The elephants were monitored at a distance of about 100 m during crop-feeding periods and data recorded. Data recording was also carried out on elephant trails, photo-period, habitat, landscape, crop destruction distance from human homes, human-elephant conflict villages, and the cropland destruction rate. The four months data collection period witnessed a two-week-data collection program, each month from 8:00 pm-6:00 pm each day.

Data analysis

The research data was analyzed using SPSS version 25, and all the variables and sub variables tested against others by using exploratory and inferential statistics models such as chi-square (X^2) and correlation. Ecological parameters such as

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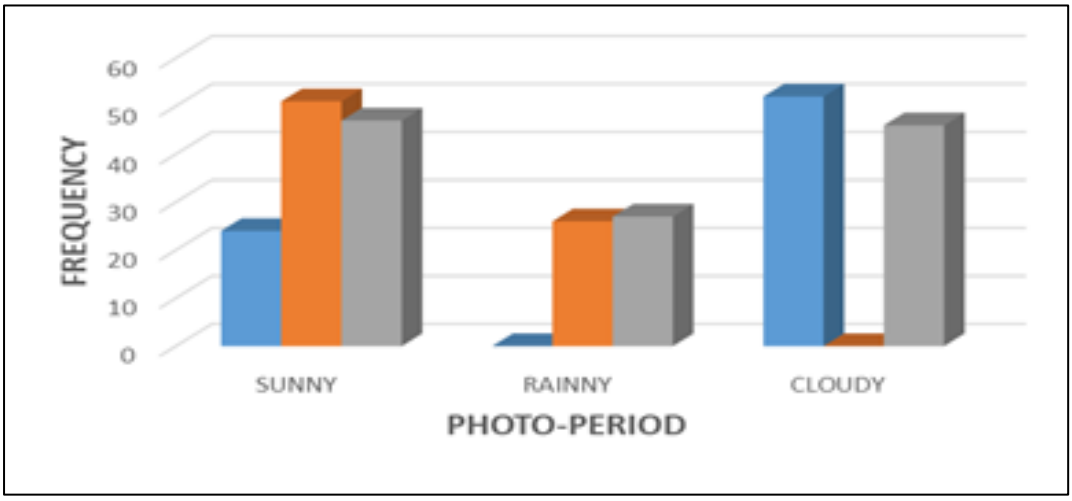
photo-period, elephant trails, landscape, distance of crop destruction by the elephants from human residential houses, and the rate of cropland destruction were tested on crop-raided activity of the elephants in the sample area.

RESULTS

In the study, atmospheric conditions showed a significance, X^2=85.49 df=4 P=0.000, X^2=47.17 df=8 P=<0.05, and X^2= 12.57 df=8 P<0.05 on elephant conflict villages in Figure 2 and crop-farm in Figure 3, and farm destruction level Figure 4 respectively. The atmosphere is a key contributor to the welfare of forest vegetation wildlife depends on for population increase and distribution in a wide range of habitats. Some atmospheric factors like the rain or rainy season contributes immensely to female fecundity and reproduction enhancement due to abundant food availability to herbivorous wildlife species. During the rainy season, herbivores would spend less energy locating food sources compared to the dry season where they spend much time in movement to local distance feeding areas. The rainforest of Mount Cameroon national park produces a very green canopy and forest understory vegetation year round due to its coastal lowland location with very heavy rainfall during the wet season of the year. Human population increase in most villages around the foot of Mount Cameroon is principally caused by migration of people from distance places to access the rich coastal environment; together with the socio-political crisis in the English-speaking regions of Cameroon, crop-farming expansion in this area has been witnessed recently. Poverty has pushed many people into crop-farming practice, a family survival strategy for sustainable income generation. Mount Cameroon National Park has a good population of African forest elephants (*Loxondonta cyclotis*) concentrated at the foot of the mountain where a huge human population is cultivating crops for family up-keep. Unfortunately, the crop-farming exercise is seemingly fueling the conflict between farmers and the elephants. However, the sunny atmosphere received the highest elephant activities in all the three villages compared to the cloud, and rain.

Figure 2. Atmospheric condition and the elephant conflict villages. **Note**: (▬) Bakingili; (▬) Njonji; (▬) Debundscha.



Maize (*Zea mays*), cassava (*Manihot escaulenta*) and banana (*Musa acuminata*) were dominant crops fed upon by the elephants in all the villages while plantain (*Musa sapientum*) and oil palm (*Elaeis guineensis*) showed the least elephant feeding interest. Forest elephants feed very much on plantain stems, leaves, and bunch but are seemingly shifting their cultivation strategy to other crops in order to reduce the conflict on elephants. All the atmospheric factors, however,

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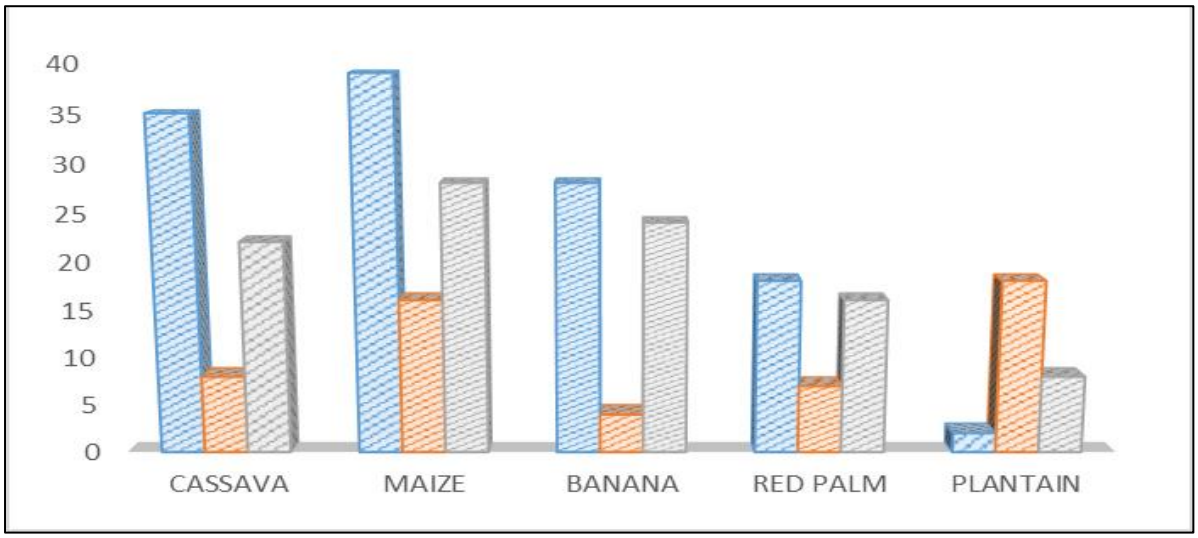
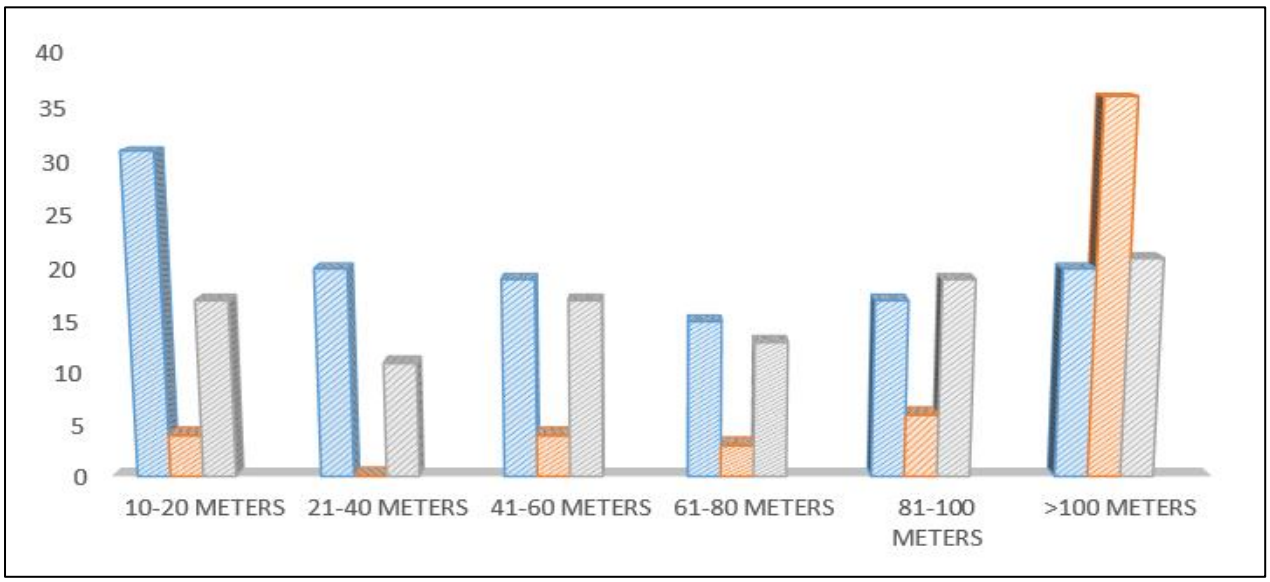
provided a healthy elephant-feeding environment except for the rain, which is sometimes very severe and might restrict elephant feeding and movement.

Figure 3. Atmospheric conditions and crop-farm. **Note:** ( ) Sunny; ( ) Rainy; ( ) Cloudy.



There was more conflict at 10 m-20 m distance from human residential homes, a situation that has paved a pathway to both human and elephant casualties. Elephants are massive body mammals feeding frequently and heavily to secure sustainable metabolic energy dynamics. Unfortunately, the vegetation at the slope of mount Cameroon in most areas is seemingly inaccessible to elephant feeding due to ascension challenges caused by their huge body. Any deterrent efforts made by the local farmers might just take the elephants 100 meters away from farms, a distance not still good enough for human cultivation safety in the elephant territory.

Figure 4. Atmospheric conditions and crop-farm size estimate. **Note:** ( ) Sunny; ( ) Rainy; ( ) Cloudy



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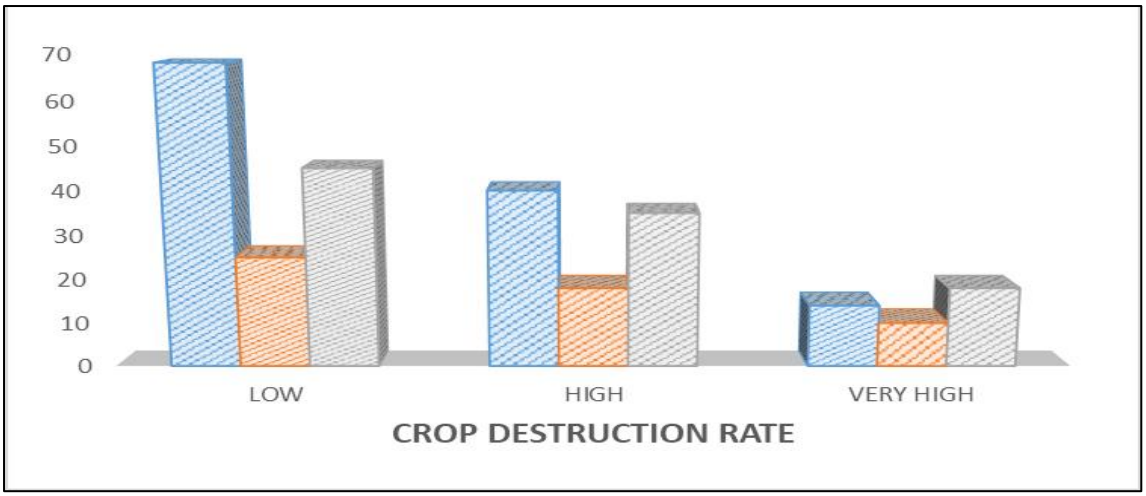
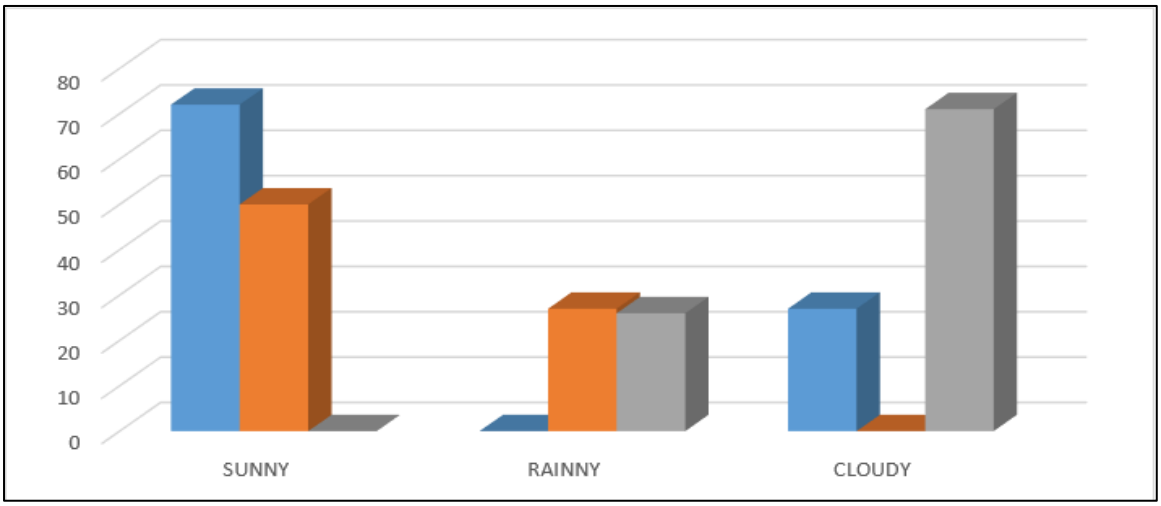
More so, atmospheric factors revealed a significance, r=0.104 P<0.05, X^2=166.78 df=4 P=0.000, and X^2=10.61 df=2 P=0.005 on farm destruction level in Figure 5, photo-period in Figure 6, and the elephant habitat in Figure 7 respectively. Elephant-crop feeding, as any other wildlife species is very much dependent on the dynamics of the atmospheric conditions. The sunny atmosphere in a coastal forest area, together with cold wind blowing from the ocean provide minimal feeding stress to the elephant population which much depend on the crop-farms. The elephant deterring strategies such as shouting, stone-through, chasing, and metal-hitting objects made so far by the people, have all been adapted by these mammals, rather, they look more radicalized and hostile to the human population.

Figure 5. Atmospheric condition and farm destruction level. **Note:** ( ) Sunny; ( ) Rainy; ( ) Cloudy



Furthermore, the morning and afternoon periods received the highest elephant activity in the farms while the evening period, comparatively little, except for the sunny atmosphere. Elephants are diurnal in feeding and foraging, though, in some areas nocturnal activity has been observed on them, it's not common in mount Cameroon national park periphery. The elephant nocturnal activity absence in the area might have influenced the diurnal confrontations with farmers who depend on the dawn period for cultivation.

Figure 6. Atmospheric condition and photo-period. **Note:** ( ) Morning; ( ) Evening; ( ) Afternoon.



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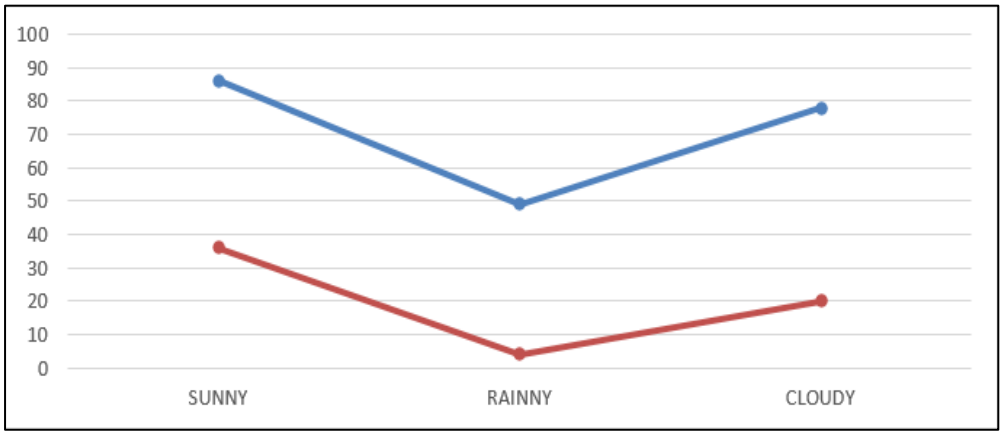
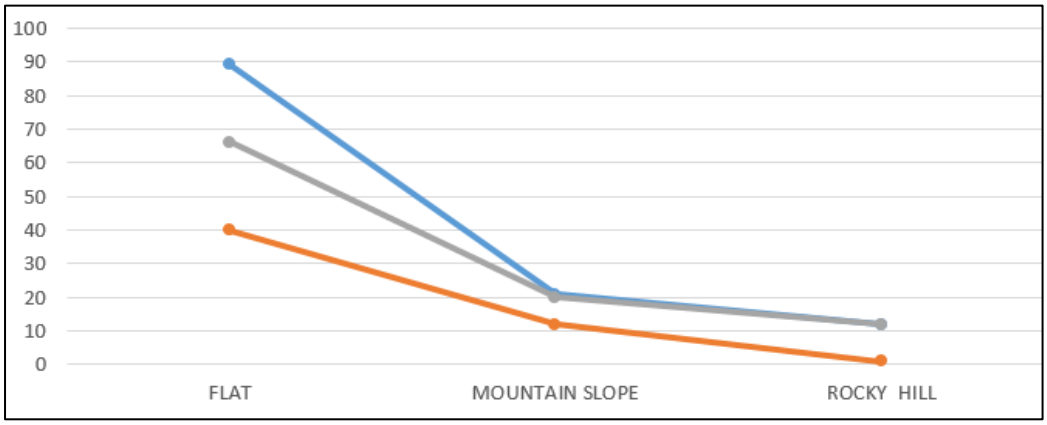
More time was budgeted by the elephant population on crop-raiding during the sunny atmosphere compared to the rainforest habitat which is their endemic home, generating violent and dreadful episodes of clashes with their human neighbors on farmland. The national park management authorities and other conservation stakeholders are very much aware of the crisis but no concrete solution has been made for mitigation. There have been reported cases of elephant shot far from cropland, signifying a multi-dimensional conflict that might constitute poverty, bush-meat-consumption interest, and elephant tusk-trade for income.

Figure 7. Atmospheric condition and habitat. **Note:** (—●—) Cropland; (—●—) Rainforest.



Additionally, the atmosphere recorded a significance, X^2=5.17 df=4 P<0.05, X^2=10.97 df=4 P<0.05, and X^2=58.51 df=10 P=0.000 on landscape in Figure 8, elephant trails in Figure 9, and crop destruction proximity to human homes Figure 10 respectively. Landscape is an ecological factor that can determine the activities of wildlife such as elephants with huge body sizes. The montane forest of Mount Cameroon national park is sloppy and rocky, a challenge to ascension, sometimes even to humans. The flat landscape of the national park is fertile and favourable to cultivation, and its rich vegetation density also supports a huge elephant population, believed to be one of the main causes of conflict. Human population migration in these area cannot happen without poaching, a heavy conservation cost on wildlife, especially the elephants. Mountain slopes and rocky landscape areas received the least elephant activity.

Figure 8. Atmospheric condition and landscape. **Note:** (—●—) Sunny; (—●—) Rainy; (—●—) Cloudy.



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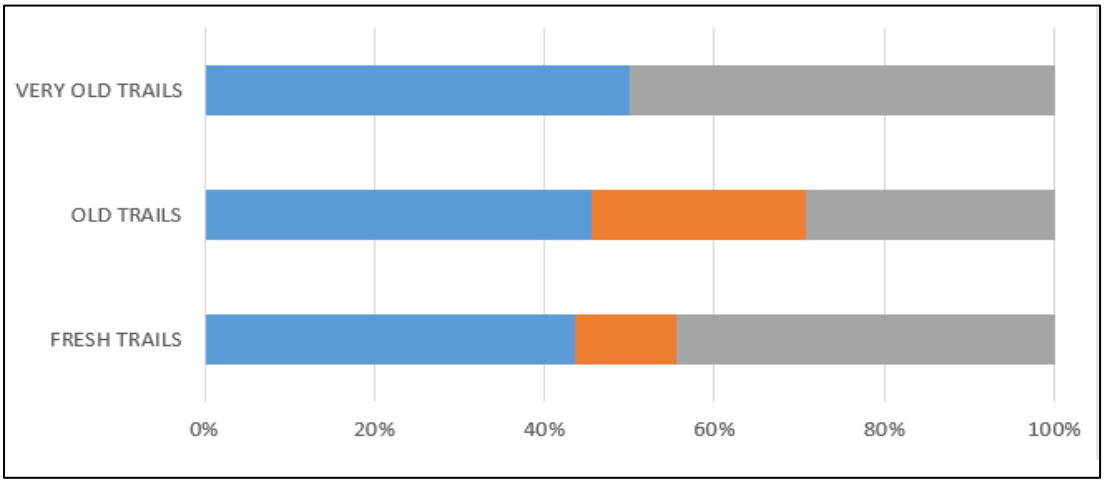
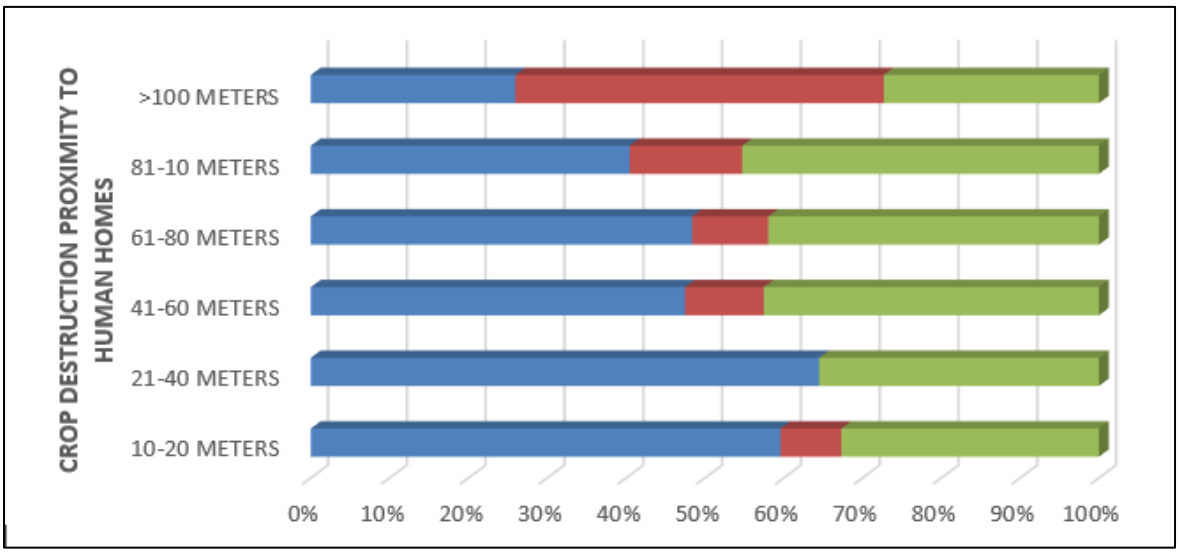
Elephant footprints were the major factors used to estimate the duration of the trails wherever and whenever the animals were not met by the research team. Nonetheless, the sunny weather still played and eminent role to estimate activity duration, while heavy rain and cloudy atmospheric conditions created some visibility challenges.

Figure 9. Atmospheric condition and elephant trail type. **Note:** (▬) Sunny; (▬) Rainny; (▬) Cloudy.



Crop-farms of distance >100 meters 28%, and 10 m-20 m 19% , recorded the highest activity rate compared to other farming distances from human homes. The morning and afternoon periods of a bright atmosphere was much conducive to farmers' energetic output, meaning, any imposed change to farming activity caused by elephants' presence might rather aggravate the crisis, hence the elephant population management would be far from reaching a conservation benchmark.

Figure 10. Atmospheric condition and crop destruction proximity to homes. **Note:** (▬) Sunny; (▬) Rainy; (▬) Cloudy.



Among the three atmospheric conditions considered during this study, elephant activity was highest during moderate sunshine 45%, followed by cloud 36%, and then rain 15% respectively Figures 11 and 12. The sunshine in mount

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Cameroon national park area is moderate conducive to a smooth elephant activity such as feeding and foraging, elephants spend much of their time budget on.

Figure 11. Crop-farm destruction distance human residence. **Note:** (▬) >100 m; (▬) 81 m-100 m; (▬) 61 m-80 m; (▬) 41 m-60 m; (▬) 21 m-40 m; (▬) 10 m-20 m.

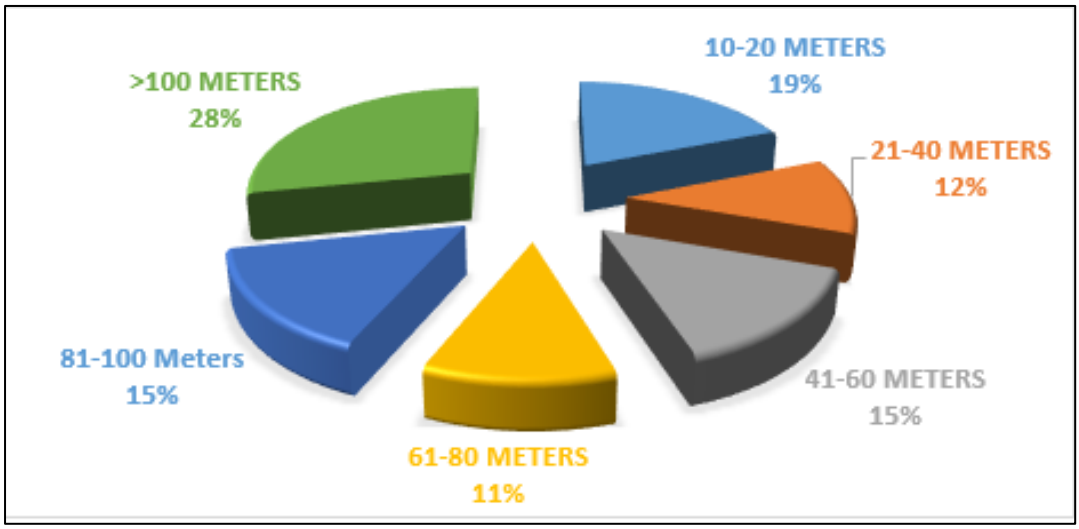
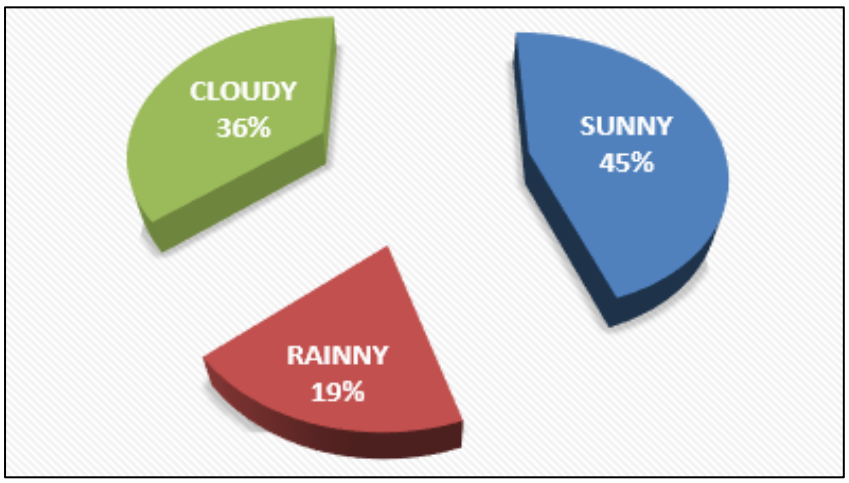


Figure 12. Atmospheric conditions. **Note:** (▬) Sunny; (▬) Rainy; (▬) Cloudy.



DISCUSSION

Weather, especially temperature plays a major role in influencing whether animals can survive and be healthy in certain habitats. Fluctuations in temperatures in certain regions can result in the deaths of entire populations. Cold-blooded animals (fishes, amphibians, reptiles, and invertebrates) are particularly susceptible to sudden changes in temperature. Young animals that cannot migrate or live in shallow waters that get cold more quickly are especially at risk. When weather conditions are sufficient to maintain a certain population of animals, they can reproduce for generations until conditions

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become unfavourable for survival [37]. Even though an environment may meet animals' survival needs, they can still experience extreme discomfort. Let's consider a scenario in which some animals can only survive if the temperature remains between 40°F (4°C) and 90°F (32°C). If the temperature stays within this range, the animals will continue to live and reproduce. However, if the temperature fluctuates too much above or below that range, they might survive but will suffer from the extreme heat or cold [38].

Many factors other than extremes of temperature can affect animal populations. Some animals require a certain level of humidity to thrive and can suffer a great deal in arid regions. For others, too much humidity or rain can be harmful. Although there are many animals who are not affected by rain, or who actually like rain, there are others who are bothered by it or have illnesses or physical conditions that are worsened by it. Just as rain, snow, and strong wind can negatively impact human wellbeing, they can cause similar discomfort and stress to animals living in the wild. Even if these uncomfortable weather conditions don't kill them, just as they usually don't kill us, they can still cause suffering for nonhuman animals. Without access to adequate shelter or medical care, complications that would be minor for humans can be severe for animals living in the wild.

Several other weather phenomena can have a huge impact on animals, and can wipe out entire populations. Their effects can combine with other factors such as the availability of food and water, the presence of predators, and diseases. Consider, for example, droughts, heavy snows, and flooding. These extreme conditions can kill animals directly, for example by drowning, or indirectly, for example by damaging the food supply. Weather conditions can also cause diseases or trigger epidemics among animals. Many animals get weaker during the winter due to the harsh weather, which makes them more susceptible to becoming sick. For example, many birds carry avian cholera that is inactive. Very cold weather or high water forcing birds to leave their habitats are common stressors that can activate the disease in infected birds. Lobsters living in warmer water are more susceptible to lobster shell disease, which weakens their shells and makes them more susceptible to injury and predation. Other animals suffer from diseases that are transmitted by flies when certain weather conditions occur [39].

Effects of rainfall on elephant–vegetation interactions around water sources are currently not well understood. Results from empirical studies lead to contradicting hypotheses [40] found that during droughts the destruction of woody plants by elephants was increased. Although they did not investigate vegetation dynamics in areas close to water sources, their finding supports the hypothesis that decreasing rainfall leads to increased vegetation destruction by elephants around waterholes. However, current knowledge of piosphere dynamics supports the contradictory hypothesis that decreasing rainfall does not lead to increased vegetation destruction in areas close to water. Specifically, studies by [41,42] revealed that the main effect of decreased rainfall in piospheres is a decrease of the upper asymptote of the vegetation gradient and not a spatial expansion of the piosphere, which would indicate increased vegetation destruction in areas close to water.

Vegetation growth in arid and semi-arid regions is mainly limited by water availability [43-45]. Reduced vegetation growth usually leads to limited forage availability for herbivores in the dry season [46,47], and herbivore access to forage during this time can also strongly depend on surface water availability. Many herbivores depend on drinking water to fulfill their daily water requirements, which forces these animals to forage in the vicinity of permanent water sources [48,49]. The provisioning of artificial waterholes is, therefore, an important and widely applied management option to promote herbivore viability in arid and semi-arid regions [50]. The ecological system of herbivore–vegetation interactions around a single waterhole is often called piosphere [51].

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CONCLUSION

The human population increase in sub Saharan African countries without family planning strategy is the major root of poverty, unemployment, crime, corruption and lower life expectancy. Surviving with a spectrum of these problems, people had to come out with a strategy, the rainforest cultivation and wildlife hunting for sustainable feeding and income generation. Nonetheless, this achievement would be a far-fetched dream in the foot of Mount Cameroon without encroachment, leading to a perpetual conflict with a hostile elephant population stranded by inaccessible vegetation lying on the slope of the mountain. Human population survival and safety cannot be compromised by elephant crop-raiding activity. However, the ecological and recreational role played by elephants is contributing to forest regeneration and national economy of many countries in sub-Saharan Africa. Enhancement of elephant activities in the villages at the foot of mount Cameroon depends on the atmospheric changes. Therefore, this study recommends translocation of some elephants to other protected areas in the southwest region or beyond, a mitigation strategy that has been successfully used in Kenya, Botswana, and South Africa. Before embarking on this conservation strategy, a population census of the elephants within the national park should be done. This would help us understand the status of the elephant population and their distribution pattern in the national park.

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