

Diversity and Threats to Large and Medium-Sized Mammals in the Northeastern Part of the Mbangassina Council Forest, Centre Cameroon

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Abstract

The purpose of this study was to assess the diversity, abundance, and major threats to large- and medium-sized mammal species in the Mbangassina Council Forest in Centre region of Cameroon. The purpose was to assist the municipality in implementing its local strategy for sustainable development. The data were collected between March 6 and April 22, 2022, using the line-transects distance sampling method and reconnaissance walks (recce). A total of 33 transects were covered, for a completion rate of 97.45% in the study area. The results of the study confirm the presence of nine species of large and medium mammals belonging to four orders, four families dominated by Artiodactyles. The large- and medium-sized mammals recorded during our surveys included the black-backed duiker (*Cephalophus dorsalis*), yellow-backed duiker (*Cephalophus silvicultor*), pangolin (*Manis* sp.), moustached monkey (*Cercopithecus cephus*), sitatunga (*Tragelphus spekii*), civet (*Civettictis civetta*), blue duiker (*Philantomba monticola*), and red-flanked duiker (*Cephalophus rufilatus*). The diversity index was 0.99 for a total mammal Kilometric Abundance Index (KAI) of 0.51 indices/km. However, the study area recorded a total KAI of 0.31 individuals per kilometer for 21 indices of human presence. The high value of the observed diversity index reflects the ecological importance of this ecological entity for the Municipality of Mbangassina, and the authorities must intensify their protection effort to reduce illegal activities in these areas.

Keywords

Inventory, Mammals, Anthropogenic Activities, KAI, Mbangassina Council

1. Introduction

Tropical forests account for around 44% of global forest cover, and they are home to more than half of all global species [1]-[3]. They also serve as exceptional carbon sinks. Tropical forests are critical to addressing twenty-first-century ecological challenges such as biodiversity protection, climate change mitigation, and environmental preservation. The Congo Basin forest, the world's second biggest tropical forest ecosystem after the Amazon, is critical to preserving regional and global climatic balance [4]. These forests support a diverse and unique flora and fauna. They also serve important social and cultural functions and provide a means of subsistence for local communities thereby indirectly providing resources to approximately 40 million people living in cities near these forested areas [3] [5]-[8].

The forest ecosystems of Cameroon are ecologically diverse with nearly 90% of African ecosystems represented [9] [10]. These ecosystems are home to more than 409 species of Mammals, 183 species of Reptiles, 1000 species of Birds, 190 species of Amphibians, and 1050 species of Butterflies. With this diversity, Cameroon ranks fourth in Africa after the Democratic Republic of the Congo (DRC) [10].

Despite its remarkable diversity, Cameroon's Congo Basin forest is threatened by activities such as deforestation, fragmentation, and degradation caused by a variety of factors such as natural resource exploitation (timber, oil, minerals), agricultural production for domestic and export, land use changes, illegal hunting, and uncontrolled bush fires [4] [11] [12]. Indeed, the peasant agriculture and fuel wood collection are the primary causes of deforestation in the Congo Basin forest [13]. Only when demographic pressures surpass the sub-regions anticipated eight inhabitants/km², do peasant farming practices become the primary causes of forest degradation. Also, due to the ongoing population growth, farmers are being forced to increase cultivable plots and decrease fallow periods [4]. As a result, they are gradually transitioning from family farmers to non-industrial employer farmers, primarily engaged in the cultivation of oil palms, plantains, and cocoa [14] [15].

To address these threats, the Cameroonian government has chosen a sustainable management approach to natural resources following the 1992 Rio Summit, which launched multiple measures based on the principles of sustainable development as stated by Agenda 21. Cameroon has also ratified the United Nations Environment Convention and the United Nations Convention to Combat Desertification in response to these new global requirements, as well as formally adhering to the Millennium Development Goals in 2000 and the Johannesburg Summit Action Plan in 2002. Furthermore, the Cameroonian government has implemented policies and strategies based on institutional and legal frameworks to reduce deforestation and the degradation of forest ecosystems. These include the environmental management framework law (No. 96/12 of August 5, 1996), the forestry, wildlife, and fishing laws (No. 94/01 of January 20, 1994), and the law 2011/008 of May 06, 2011, that gives the orientation for the planning and sustain-

able development of local territories in Cameroon. It is within the context of the latter law that the Municipality of Mbangassina known nationally as a significant Cameroonian cocoa production basin is a priority landscape for creating a Local Land use Planning and Sustainable Development Plan (LLSPDP). Nevertheless, determining the site's High Conservation Values (HCV) is a prerequisite for implementing this local development plan. Thus, to assist in determining the High Conservation Values (HCV) of the municipality of Mbangassina, our study aims to update fundamental data on the quantity and distribution of populations of large and medium-sized mammals, as well as threats from anthropogenic pressures. We hypothesised that species richness and abundance of large and medium-sized mammals decrease over the anthropogenic pressure.

2. Method

2.1. The Study Area

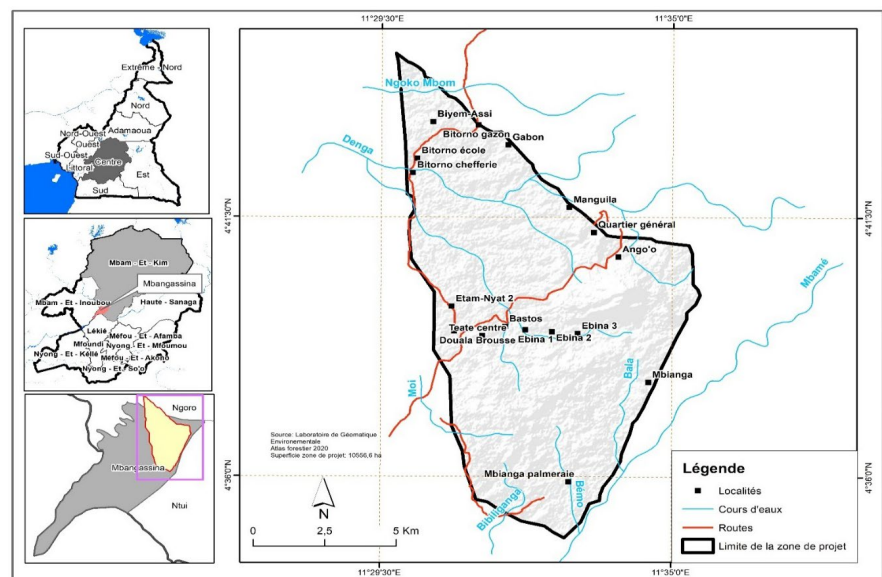


Figure 1. Localization of the north-west sector of the Mbangassina Council in Centre region of Cameroon.

This study was carried out in the northeastern section of the Municipality of Mbangassina (Figure 1). This municipality is located in the Central Region of Cameroon, in the Mbam and Kim divisions. It extends between $11^{\circ}1'$ and $11^{\circ}30'$ East longitude and between $4^{\circ}20'$ and $4^{\circ}40'$ North latitude [16]. The area has a tropical climate with a bimodal pattern of rainfall characterized by four seasons including two dry seasons and two rainy seasons. The long dry season is from mid-November to mid-March, the short rainy season is from mid-March to mid-June, the short dry season is from mid-June to mid-August, and the long rainy season is from mid-August to mid-November. The average temperature in the area is between 23°C and 25°C . The relief is not very rugged and consists of a succession of hills and plateaus for the most part. The Municipality of Mbangas-

sina is an agricultural zone. The fauna is characterized by the presence of rodents such as porcupines, palm rats, and cane rats. However, there are other species such as antelopes, civets, monitor lizards, crocodiles, and pythons. As for the flora, it includes forest formations and large expanses of wooded savannah. The main woody species are the “Baobab, Iroko, Fraké, Parasolier, Sapelli, Padouk, Bilinga, Ebènier, White Doussié, Ayous, Moabi, Sipo, Framiré, Okoumé, Movingui, Noi-setier, Bitter cola and Djangsang” [16].

2.2. Sampling Plan and Data Collection

The perpendicular distance sampling methodology [17] was used to carry out this study. This approach is based on walking line transects with a combination of recce or reconnaissance walking. We used the 2020 inventory completed in the Mpem and Djim National Park (Mbam and Kim division) to determine the sampling effort, rather than utilizing a pilot study. The precision required for density estimates of large and medium-sized mammals in this area has been set at coefficients of variation (CV) ranging from 15% to 25%. The sampling effort estimated according to equation (E1) proposed by Buckland *et al.* (2001), based on encounter rates from 2020 data and a desired level of precision of 20%, made it possible to retain 68 km of transects as the theoretical total effort to be carried out in the study area. This total effort consisted of 34 equidistant and parallel transects of 2 km each. The transects were generated with the Distance 7.3 software, following the inventory standards for large and medium-sized mammals in forest areas (**Table 1** and **Figure 2**).

$$L = \left(\frac{b}{[CV(\hat{D})]^2} \right) \left(\frac{L_o}{n_o} \right) \quad (1)$$

L = Total length of transect to be carried out (sampling effort);

b = Dispersion parameter set to 3;

CV = Coefficient of variation (accuracy) expected for the density to be estimated;

L_o/n_o = Inverse of the encounter rate of indices or individuals of the target species from a pilot study or a previous study (n_o = number and L_o = effort).

Table 1. Characteristics of the sampling plan in the North-East part of the territory of the Commune of Mbangassina.

Parameters	Value
Surface area	110 km ²
Quadrat surface area	4 km ²
Transect length	2 km
Number sampling unit	34
Total effort	68 km

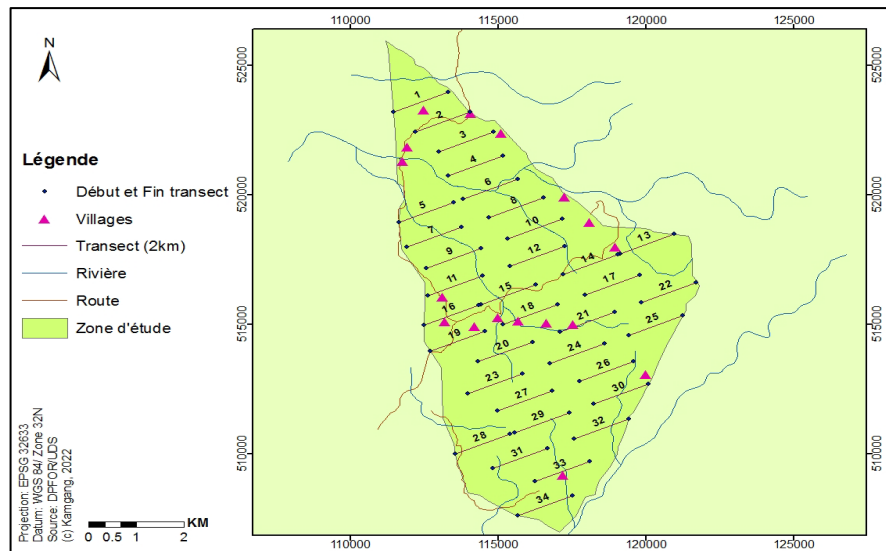


Figure 2. Map showing the spatial distribution of inventory line transects in the northeastern part of the territory of the Mbangassina Council.

2.3. Data Analysis

Based on the estimated effort, the sampling device was developed with the Distance 7.2 software [17] and equipped with the ArcGIS 10.2.2 mapping software. The system of random and systematic positioning of the transects was adopted to have better coverage of the study area [18] to limit variations around the estimates. The transects were oriented so that they were not only more or less perpendicular to the direction of the major watercourses and the main tracks but also to the contour of the relief of the area (Figure 2) [19].

The data was collected on large and medium-sized mammals as well as on human activities and environmental factors. A codification of the different species and their indices, human activities, and environmental factors was made to facilitate recordings on the field collection sheets. Data collection was done by four (04) teams trained for this purpose. Each team was made up of 08 people (compass operator, Global Positioning System (GPS)/compass operator, surveyor/topofil, tape measure/rangefinder operator, and four porters for the transport of camping equipment and food rations). The census of animals was done in two phases per day: a first phase in the morning which began between 6:30 and 8:00 a.m. and went until 11:00 a.m. at the latest; a second phase which began between 2 p.m. and 3:30 p.m. and ended at 5:30 p.m. [20]. These time intervals were chosen to avoid biases during sampling, cases during hot hours, and animals at rest or at water points, which biases their distribution and makes detections not independent [21].

The teams on the ground progressed at an average rate of 1 km every 2 hours. The transect's starting point was marked on the ground using a GPS, and the compass guided the team in the direction of the corresponding azimuth (ENE or WSW). The team members moved in the direction indicated one behind the other following the wire of the topofil while disturbing the habitat as little as possible.

The GPS operator monitored the constancy of the azimuth so that the team kept the direction of displacement until the end of the transect. The team walked the transect as quietly as possible while scanning both sides of the walking axis for any animals or clues to ensure that a good width of the strip (ESW) was effectively covered. When an index, an animal, or a group of animals is seen, the following information was recorded in the data collection sheets: time of observation; index type; species; length traveled on the transect; distances perpendicular to the transect (poop/nest sightings); GPS positions of the various observation points; type of habitat. Other information was also collected on the transect. These include ecological factors likely to influence the distribution of fauna such as the vegetation; topography; hydrography; and signs of human presence. To determine the relative number of humans in the area, data on human activities, ages, and GPS positions were gathered along the transects and recces (individual, noises, smoke, signs of passage, chopped machetes, exploitation, tracks, traps, pruning, camps) [22].

2.3.1. Species Richness

The specific richness noted S , is the total number of species recorded during the count in the study environment: $S = \Sigma$ species. Thus, the data collected were organized and explored using Excel software to highlight the specific richness of the mammals encountered in the northeastern part of the territory of the Municipality of Mbangassina. The diversity index [23] was calculated according to Equation (2) to assess the current specific richness and to be able to assess the biological importance of the North-East (NE) part of the territory of the Municipality of Mbangassina.

$$D = 1 - \sum_{k=1}^k \left(\frac{n_i(n_i-1)}{N_i(N-1)} \right) \quad (2)$$

where

N = number of animals observed, and n_i = number of animals of species i , i ranging from 1 to k .

2.3.2. Estimation of Densities

Estimates of species densities were not made as part of this study. Indeed, the observations made were small enough (less than 60 to 80 observations) to be analyzed using the Distance 7.2 program [18].

2.3.3. Kilometric Abundance Indices

The calculation of the Kilometric Abundance Index (KAI) was done following [22]. This is the ratio of the number of contacts made to the total length of the transects traveled (sounding effort made) in kilometers. It is calculated for a species or all the species observed. It is also the relative density and its formula is presented by the Equation (3).

$$\text{KAI} = \left(\frac{\text{Number of contacts made}}{\text{Transects traveled (km)}} \right) \quad (3)$$

2.3.4. Distribution Maps

The KAI obtained by transect made it possible to draw up spatial distribution maps using ArcGIS 10.2.2 software. They were made by interpolation with the IDW (Inverse Distance Weighted) tool, choosing 30 neighbors and a power of 2. The distribution maps of various anthropogenic activities were also made with the same software.

2.4. Conservation Status

The IUCN Red List of Threatened Species (<https://www.iucnredlist.org/>, accessed January 2022) was used to define the conservation status of the listed species. To determine the conservation status of species, the IUCN assigns one of eight threat categories to species based on whether they meet certain criteria related to the trend, size, and structure of their populations and their range. geographical. To better assess the status of a species at the local level, the national lists defining the protection classes were also consulted (Order No. 0053/MINFOF of April 01, 2020, setting the terms for the distribution of animal species into protection classes A, B, and C).

3. Results

3.1. Sampling Effort

Among the 34 transects (68 km) planned, 33 (66 km) were covered, thus indicating a completion rate of 97.45% in the northeastern part of Mbangassina municipality.

3.2. Species Richness and Diversity Index

Table 2. IUCN status and MINFOF category of species recorded in the North-East part of the territory of the Commune of Mbangassina.

Order	Family	Scientific name	IUCN status (Cameroon's protection category)
		<i>Cephalophus dorsalis</i>	NT (B)
Artiodactyles	Bovidae	<i>Cephalophus silvicultor</i>	NT (A)
		<i>Cephalophus rufilatus</i>	LC (B)
		<i>Tragelaphus spekii</i>	LC (B)
Cetartiodactyles		<i>Philantomba moticola</i>	LC (B)
Carnivores	Viverridae	<i>Civettictis civetta</i>	LC (B)
Primates	Cercopithecidae	<i>Cercopithecus nictitans</i>	NT (B)
		<i>Cercopithecus cephus</i>	LC (B)
Pholidotes	Manidae	<i>Manis</i> sp.	

The sampling carried out in the North-East part of the territory of the Municipality of Mbangassina confirmed the presence of 09 species of large and medium-

sized mammals, including the duiker with a black dorsal stripe, the yellow-backed duiker, the nodger, the pangolin, whiskered, sitatunga, civet, blue duiker, and red-flanked duiker. The species recorded are divided into 05 Orders and 04 Families with a preponderance of the order of Artiodactyla (Table 2). The value of the diversity index is 0.99, reflecting the ecological importance of the study area for the conservation of large and medium-sized mammals.

3.2.1. Encounter Rate and Distribution of Recorded Mammals

Encounter rate of recorded mammals

The total KAI of all recorded mammals is around 0.51 indices/km. This value varies depending on the species. Figure 3 presents the relative abundance of the different species and groups of species recorded in the study area. Signs of the presence of the blue duiker (*Philantomba monticola*) are the most frequently encountered (0.18 indices/km), followed by those of the black-backed duiker (*Cephalophus dorsalis*) (0.07 indices/km) and the sitatunga (*Tragelaphus spekii*) (0.04 index/km). The species encountered on average are the pangolins (*Manis* sp.) (0.26 index/km), the yellow-backed duiker (*Cephalophus silvicultor*) (0.03 index/km) and the red-flanked duiker (*Cephalophus rufilatus*) (0.03 index/km), while the rare species is represented by the civet (*Civettictis civetta*) (0.01 index/km) (Figure 3). For recorded species, only three observations direct tests were carried out (Table 3).

Distribution of recorded mammals

The spatial distribution of signs of mammal activity in the study area shows that their presence are highly concentrated in the South-East, North, and North-West parts ($0.00 \leq \text{KAI} < 3$), and tend from medium to high in the South-East, North-West and North parts ($1.20 \leq \text{KAI} < 3.00$). This distribution depends on the water points, tracks, housing, and human activities carried out in the area (Figure 4).

Table 3. Types and relative abundance of recorded species presence indices.

Scientific name	Indices					Total (n)	ERn (n/Lt)
	Droppings	Footprints	Direct observation	Trace	Vocalization		
<i>Cephalophus dorsalis</i>	/	4	1	/	/	5	0.07
<i>Cephalophus silvicultor</i>	/	2	/	/	/	2	0.03
<i>Cephalophus rufilatus</i>	/	1	/	1	/	2	0.03
<i>Philantomba monticola</i>	3	9	/	/	/	12	0.18
<i>Civettictis civetta</i>	/	1	/	/	/	1	0.01
<i>Cercopithecus nictitans</i>	/	/	1	1	1	3	0.04
<i>Cercopithecus cephus</i>	/	/	1	/	1	2	0.03
<i>Manis</i> sp.	/	/	/	2	/	2	0.03
<i>Tragelaphus spekii</i>	/	3	/	/	/	3	0.04
Undetermined	/	/	/	3	/	3	0.04
Total	3	20	3	7	2	35	0.51

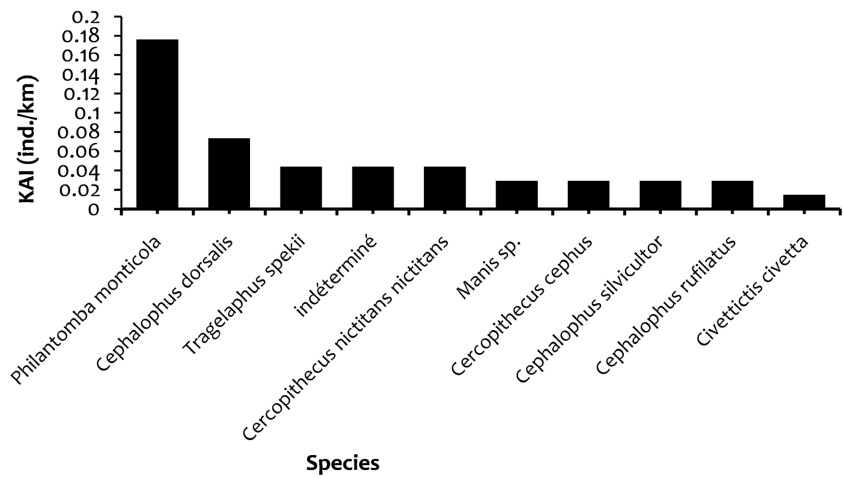


Figure 3. Species encounter rate in the North-East part of the territory of the Municipality of Mbangassina.

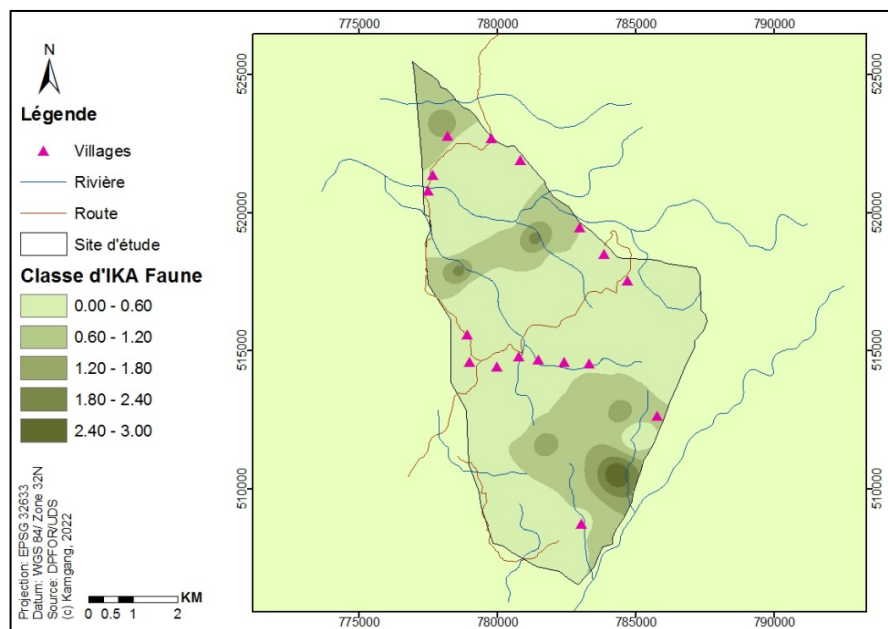


Figure 4. Spatial distribution maps of indices of large and medium-sized mammals in the study area

Spatial distribution of blue duiker indices

The spatial distribution obtained from the interpolation of the encounter rates of all blue duiker presence indices (**Figure 5**) indicates areas of high concentration located in the southeast and northwest part of the study area ($0.39 \leq KAI < 0.99$). However, pockets of average to low abundance are observed in places in the north-western part ($0 \leq KAI < 30.39$).

Spatial distribution of black-backed duiker

The spatial distribution obtained from the interpolation of the encounter rates of the black-backed duiker (**Figure 6**) indicates areas of high concentration located in the northern part of the sampled area ($0.59 \leq KAI < 0.99$). However,

pockets of average to low abundance are observed in places in the northern and southern parts ($0 \leq \text{KAI} < 0.39$).

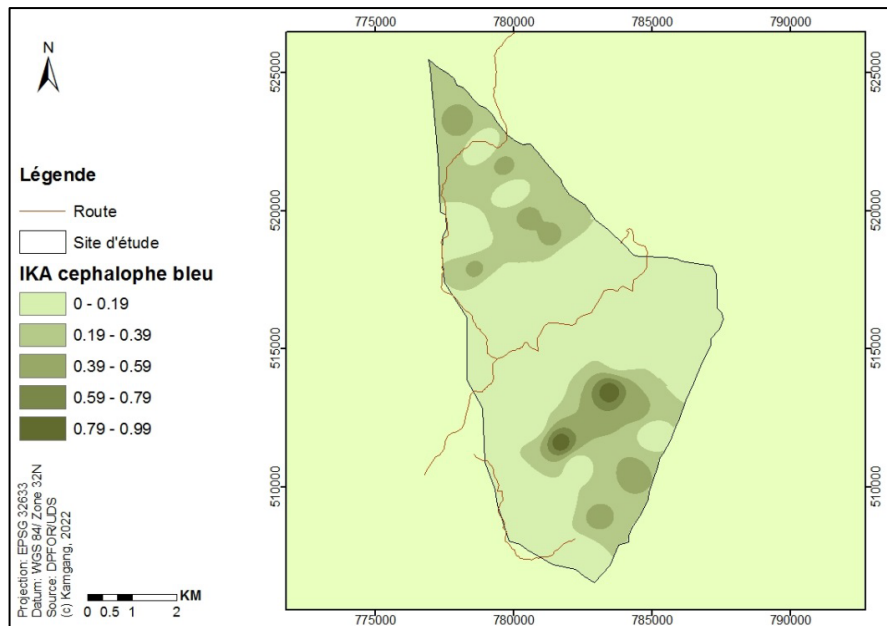


Figure 5. Distribution of blue duiker (*Philantomba monticola*) in the study area.

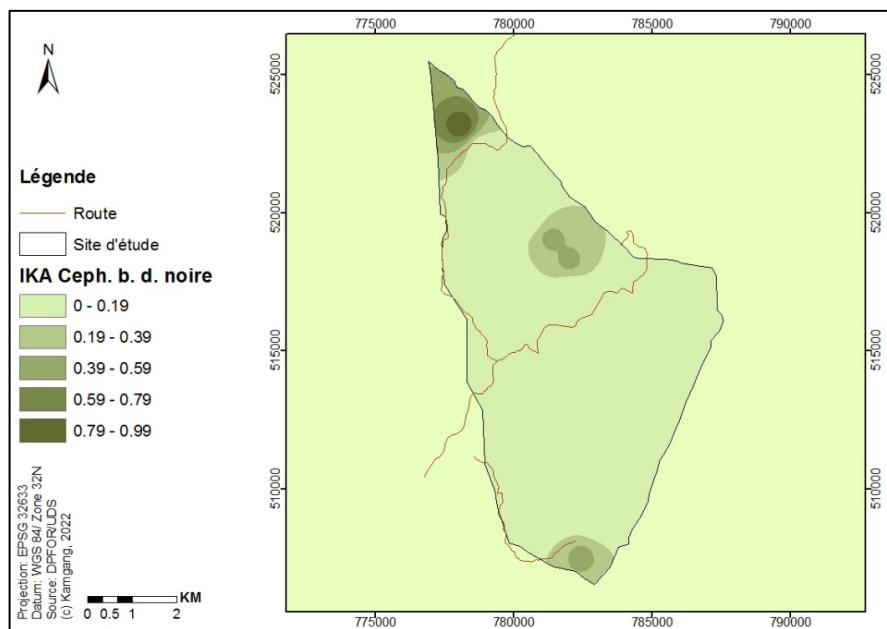


Figure 6. Spatial distribution maps of indices of black-backed duiker (*Cephalophus dorsalis*) in the study area.

The spatial distribution of situnga indices

The spatial distribution obtained from the interpolation of the encounter rates of situnga (Figure 7) indicates areas of high concentration located in the western part of the study area ($0.59 \leq \text{KAI} < 0.99$). In the northern part, pockets of average to low abundance are also observed in places ($0 \leq \text{KAI} < 0.39$).

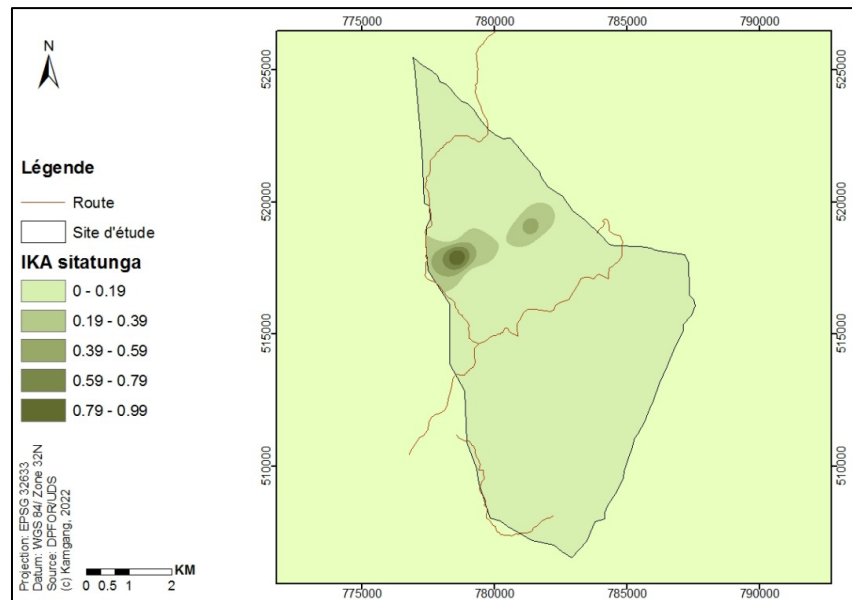


Figure 7. Spatial distribution maps of indices of sitatunga (*Tragelphus spekii*) in the study area.

Spatial distribution of the yellow-backer duiker

The Spatial distribution of the yellow-backed duiker does not differ from the overall distribution pattern of fauna in the area. Indeed, the pockets of high concentration are located in the southeast of the study area ($0 \leq \text{KAI} < 0.49$) (**Figure 8**).

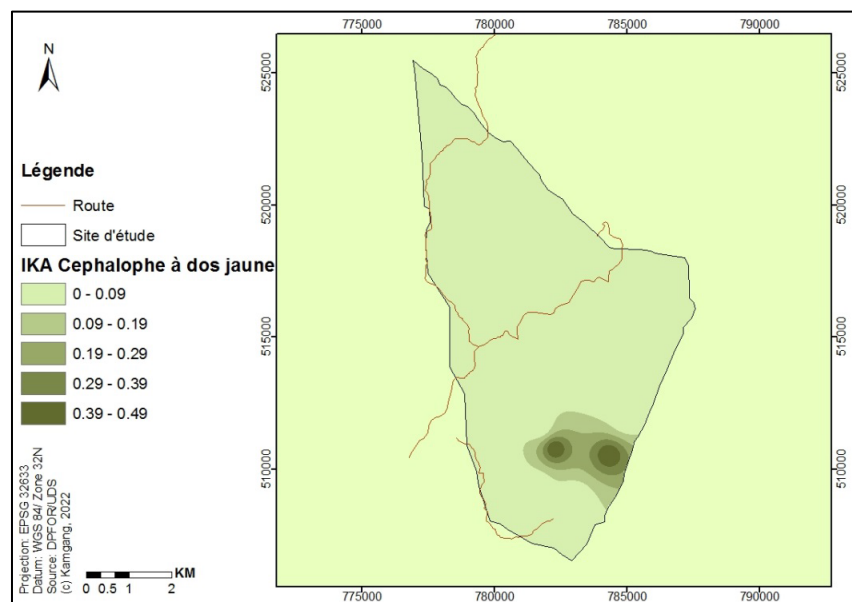


Figure 8. Spatial distribution maps of indices of yellow-backer duiker (*Cephalophus silvicultor*) in the study area.

Spatial distribution of red-flanked duiker indices

The spatial distribution obtained from the interpolation of the encounter rates of the red-flanked duiker (**Figure 9**) indicates areas of high concentration located

in the southern part of the study area ($0.29 \leq \text{KAI} < 0.49$). In the same area, pockets of average to low abundance are also observed ($0 \leq \text{KAI} < 0.19$).

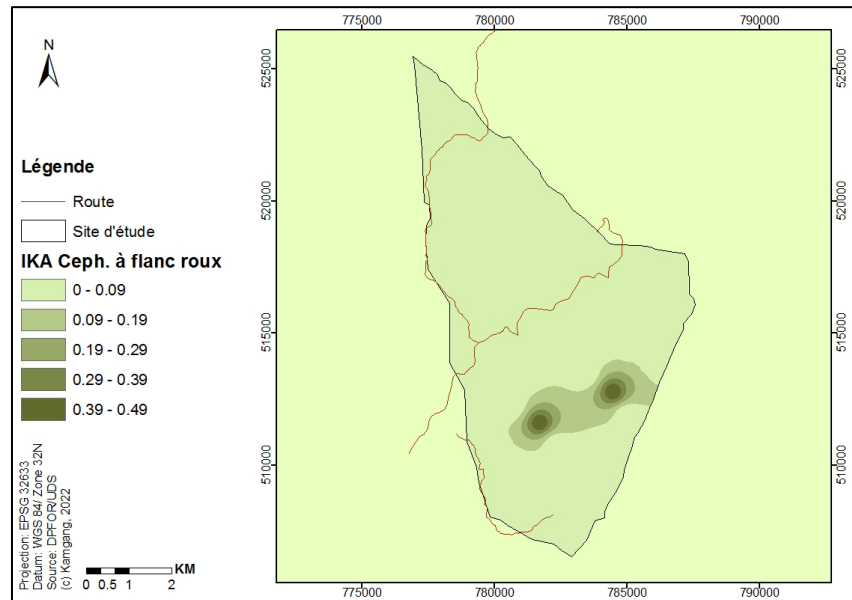


Figure 9. Spatial distribution maps of indices of red-flanked duiker (*Cephalophus rufilatus*) in the study area.

Spatial distribution of putty-nosed monkey

The spatial distribution obtained from the interpolation of the encounter rates of the putty-nosed monkey (**Figure 10**) indicates areas of high concentration located in the eastern and southeastern parts of the study area ($0.29 \leq \text{KAI} < 0.49$). In this area, pockets of average to low abundance are also observed ($0 \leq \text{KAI} < 0.29$).

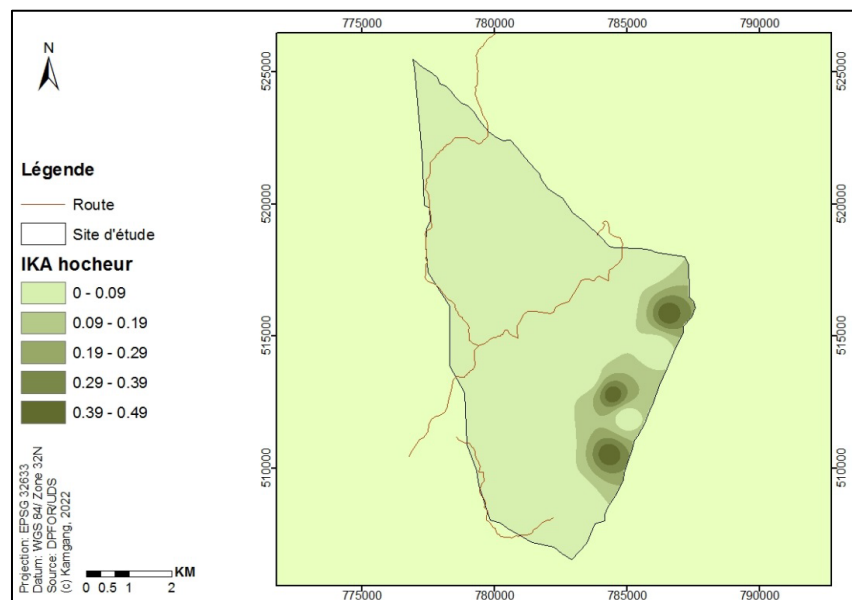


Figure 10. Spatial distribution maps of indices of putty-nosed monkey (*Cercopithecus nictitans*) in the study area.

Spatial distribution of moustached monkey indices

The spatial distribution of the moustached monkey obeys the global faunal distribution pattern. Indeed, the pockets of high concentration are located in the Southeast ($0 \leq \text{KAI} < 0.49$) and West ($0 \leq \text{KAI} < 0.49$) of the study area (Figure 11).

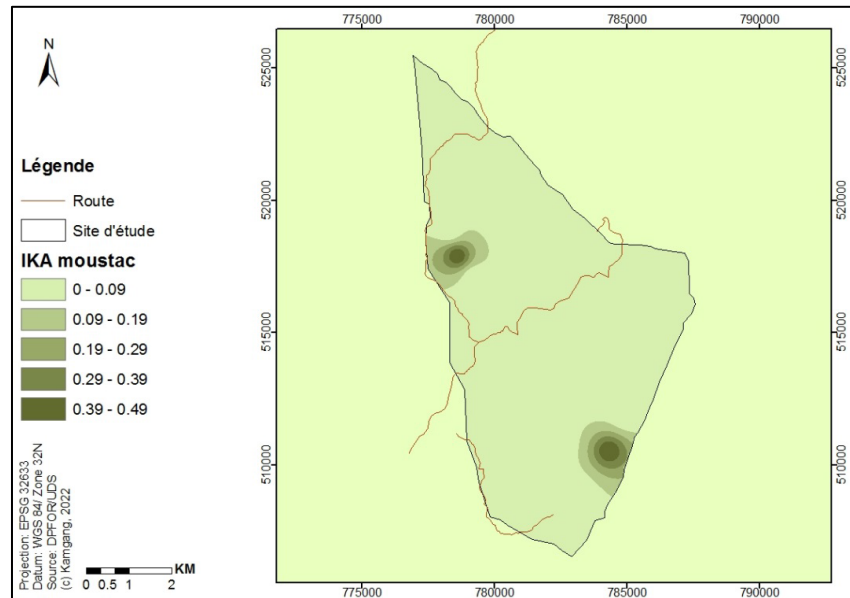


Figure 11. Spatial distribution maps of indices of moustached monkey (*Cercopithecus cephus*) in the study area.

Spatial distribution of pangolin indices

Given the pangolin distribution map, the pockets of high concentration are located in the South ($0 \leq \text{KAI} < 0.49$) and in the Center ($0 \leq \text{KAI} < 0.49$) of the study area (Figure 12).

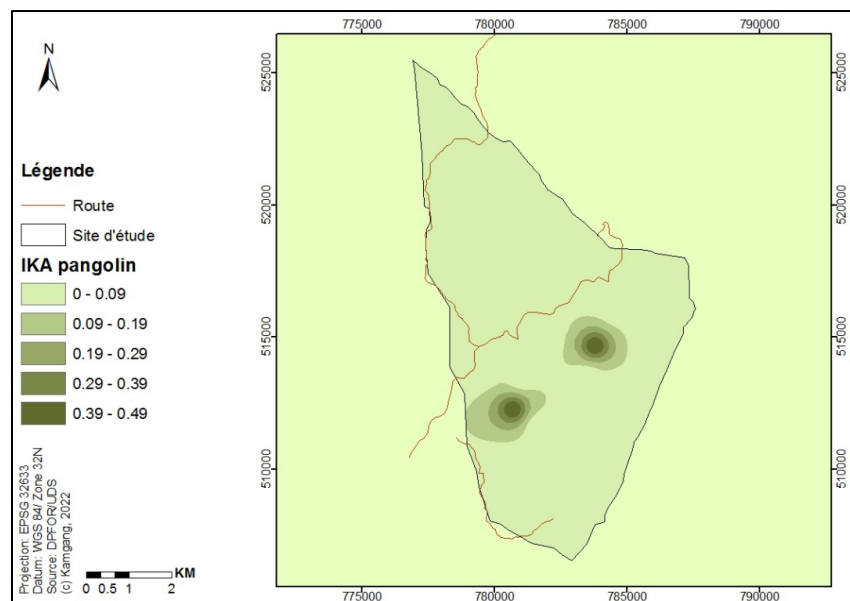


Figure 12. Spatial distribution maps of indices of pangolin (*Manis* sp.) in the study area.

Spatial distribution of civet indices

The spatial distribution obtained from the interpolation of the encounter rates of the civet (**Figure 13**) indicates areas of high concentration located in the northern part of the study area ($0.29 \leq \text{KAI} < 0.49$). In this area, pockets of average to low abundance are also observed ($0 \leq \text{KAI} < 0.29$).

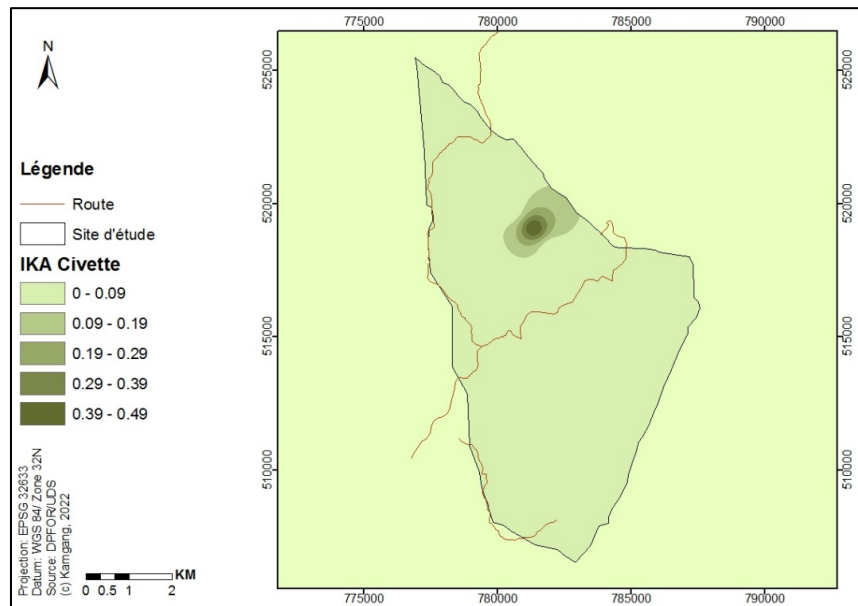


Figure 13. Spatial distribution maps of indices of civet (*Civettictis civetta*) in the study area.

3.2.2. Kilometric Abundance Index (KAI) of Human Activities

In total, 21 indices of human activities were recorded for a total KAI of 0.31 ind./km in the study area. **Figure 14** shows that human houses (0.15 ind./km) and traps (0.07 ind./km) are the most represented of the human indices, followed by roads (0.04 ind./km) and sockets weapons (0.03 ind./km).

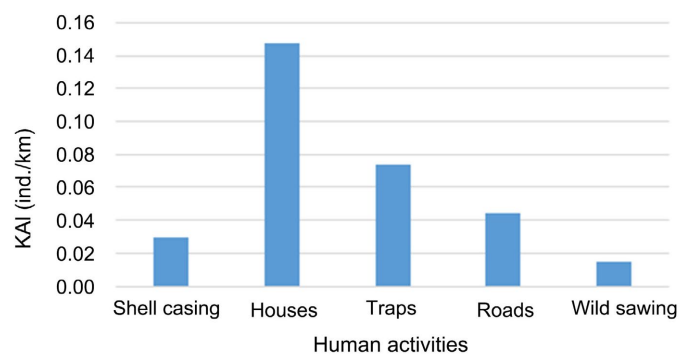


Figure 14. Abundance of human activities in the study area.

Spatial distribution of human activities in the study area

The distribution of indices of human activities in the study area proves that anthropogenic pressure is present almost everywhere. However, three important strata emerge from this distribution (**Figure 15**): a stratum with strong to very

strong human activities ($1.19 \leq \text{KAI} < 2.49$), located in the central zone. These areas are impacted by hunting activities; wild sawing, tracks, and housing; an area with moderately significant human activities ($0.99 \leq \text{KAI} < 1.99$), located in the south; an area with low human activities ($0.00 \leq \text{KAI} < 0.99$), located in the northern part.

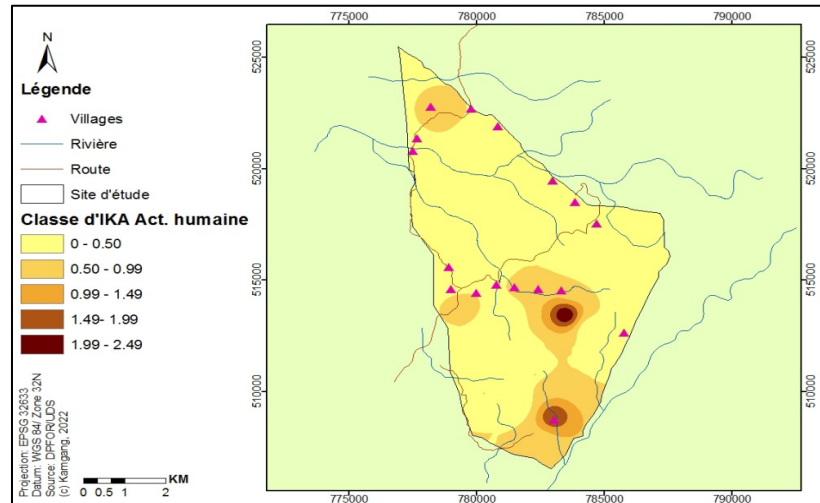


Figure 15. Spatial distribution of human activities in the study area.

Spatial distribution of human houses in the study area

The distribution of human houses in the northeast of the municipality of Mbangassina is presented in **Figure 16**. This figure shows that the human presence is highly concentrated in the South, Center, and Northeast parts ($0.39 \leq \text{KAI} < 0.99$). However, areas of low to medium concentration are observed in the southwestern part of the area ($0.00 \leq \text{KAI} < 0.39$).

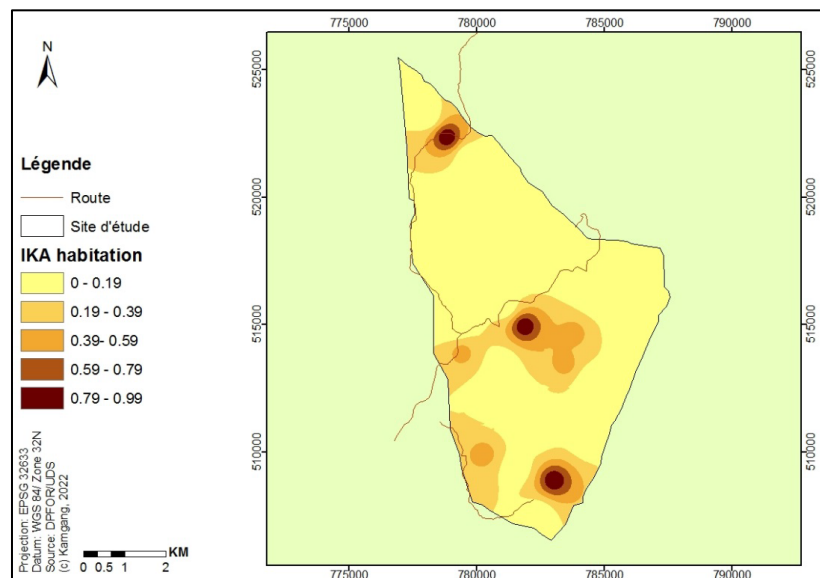


Figure 16. Spatial distribution of human houses indices in the study area.

Spatial distribution of traps in the study area

Figure 17 shows the distribution of traps in the study area. This distribution shows a high concentration of traps in the southern ($0.59 \leq \text{KAI} < 0.99$). However, areas of medium and low concentrations ($0.00 \leq \text{KAI} < 0.59$) are observed in the southern part of the area.

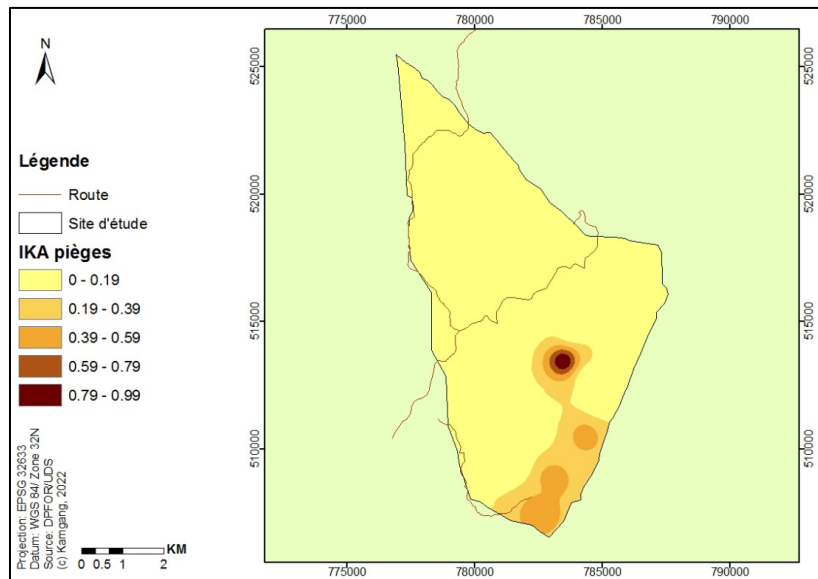


Figure 17. Spatial distribution of traps indices in the study area.

Spatial distribution of shell casings in the study area

The shell casings are among the signs of human activity recorded in the area. Their spatial distribution is illustrated in **Figure 18**. The shell casings are highly concentrated in the southern sectors of the study area ($0.29 \leq \text{KAI} < 0.49$). However, the areas of medium and low concentration are found in these same sectors ($0 \leq \text{KAI} < 0.29$).

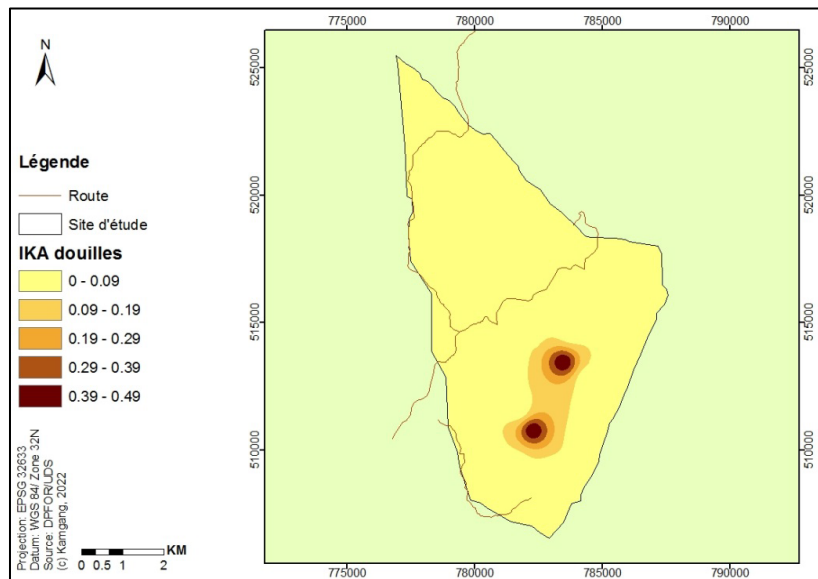


Figure 18. Spatial distribution of shell casings indices in the study area.

Spatial distribution of wild sawing indices in the study area

The spatial distribution obtained from the interpolation of the encounter rates of all wild sawing indices (**Figure 19**) indicates areas of high concentration located in the southern part of the study area ($0.19 \leq \text{KAI} < 0.49$). Pockets of average abundance are found in this same part ($0.00 \leq \text{KAI} < 0.19$). Moreover, the activity is poorly represented in the other part of the study area.

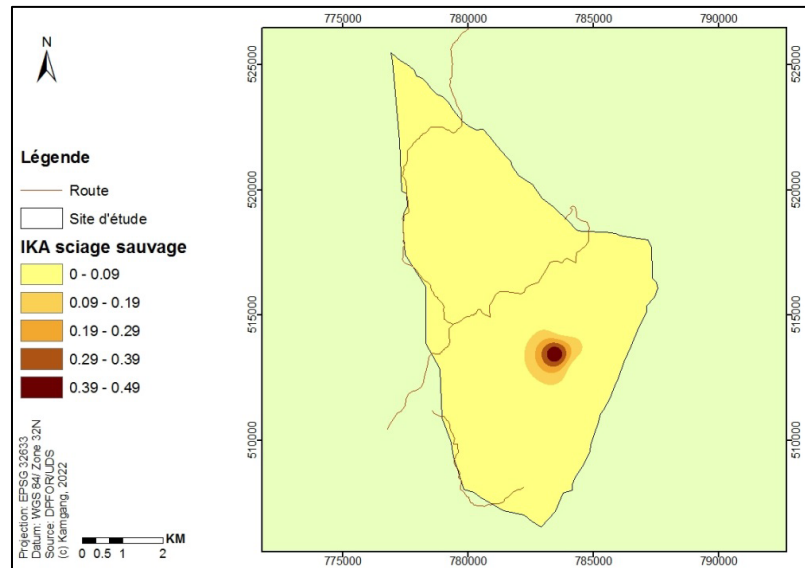


Figure 19. Spatial distribution of wild sawing indices in the study area.

Spatial distribution of tracks and roads in the study area

The distribution of tracks and roads in the northeast area of the Commune of Mbangassina does not differ from the global model of the distribution of anthropogenic activities. Indeed, the pockets of high concentration are located in the northwest, West, and South parts of the study area ($0 \leq \text{KAI} < 0.49$) (**Figure 20**).

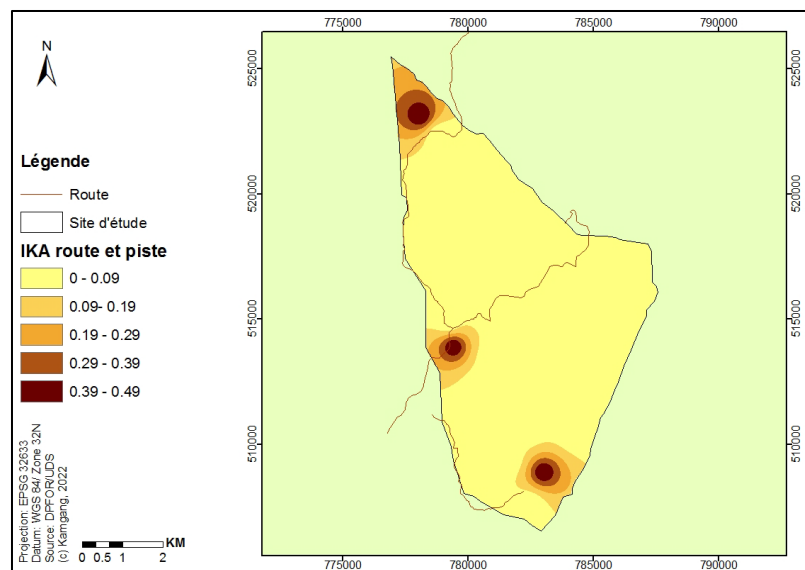


Figure 20. Spatial distribution tracks and roads in the study area.

3.3. Relationship between Human Activities and Indices of the Presence of Mammals

The correlation between human activities and the presence of mammal indices is negative ($r = -0.139$). The relationship (Figure 21) reflects the negative influence of human activities on the presence of mammals in the study area. At the current stage, the fauna still succeeds in finding a necessary and not sufficient ecological niche to satisfy its needs in an environment so disturbed by the human presence. This confirms the presence of different species of mammals in refuges distributed near rivers and roads in the North-East area of the Mbangassina municipality.

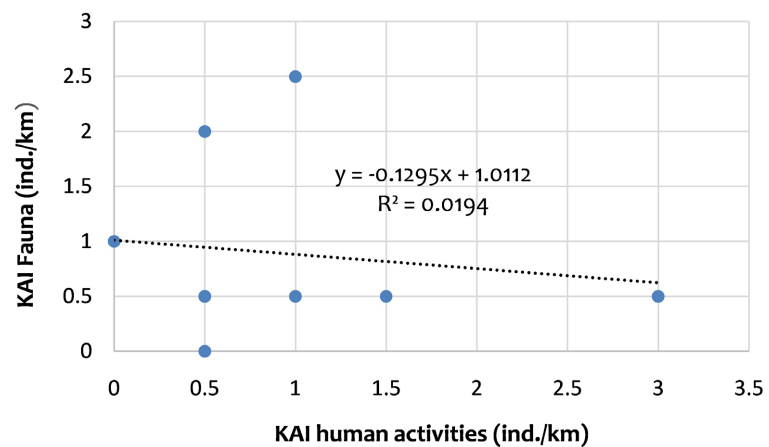


Figure 21. Correlation between the KAI of fauna and the human activities in the study area.

4. Discussion

The survey of large and medium-sized mammals in the northeastern part the Mbangassina Council Forest revealed the presence of nine species large and medium size mammals namely the black-backed duiker (*Cephalophus dorsalis*), the yellow-backed duiker (*Cephalophus silvicultor*), putty-nosed monkey (*Cercopithecus nictitans*) pangolin (*Manis* sp.), moustached monkey (*Cercopithecus cephus*), sitatunga (*Tragelphus spekii*), civet (*Civettictis civetta*), blue duiker (*Philantomba monticola*) and red-flanked duiker (*Cephalophus rufilatus*). The total value of the KAI of 0.51 indices/km in this area is low compared to 7313 indices/km observed in the Dja Faunal Reserve [24]. This low KAI value in our study area demonstrates that, in contrast to unprotected areas, protected areas such as the Dja Reserve are excellent locations for animal conservation and protection. Purpose of animal conservation in protected areas is to provide a long-term paradigm for managing fauna [22]. Despite the fact that anthropogenic activities are widely distributed. The high diversity index (0.99) in the Mbangassina council forest demonstrates the ecological relevance of the municipality's northeastern part for the protection of large and medium-sized mammals. The comparably high diversity can also be attributed to the numerous peasant agricultural practices observed in the area, which is mostly cultivated for cocoa and oil palm. Cocoa plantations in the tropics are a collection of many tree species whose diversity and

structure in the Mbangassina area benefit the local wildlife. This further illustrates how the environment continues to sustain these species despite human pressure.

The agricultural system in the area, notably agroforestry, also supports the protection of large and medium-sized mammals in the northeastern part of Mbangassina municipality, which is well-known for cocoa production in Cameroon. Cocoa agroforests with considerable shade coverage have been shown to assist local wildlife by producing complex and diverse shade canopies [25] that offer many feeding and shelter possibilities for wildlife [26]. The FAO [27] estimates that 70% of the world's cacao supply is produced in West Africa, particularly in four nations Ghana, Côte d'Ivoire, Nigeria, and Cameroon. These nations together account for about 5 - 6 million hectares of land used for cocoa growing. In the world's cocoa production rankings, Cameroon is ranked fifth [27] [28]. As a result, effective cocoa agroforest management is critical to the long-term viability of the local fauna.

The findings indicate that human activities provide a significant threat to large and medium-sized mammals in the Mbangassina council forest, as seen by the negative correlation ($r = -0.139$) found between wildlife KAI and human activity within the research area. Indeed, human activity threatens several species in Congo Basin forests [29]-[31].

In our study area, human growth and the resulting unsustainable use of natural resources pose the biggest threat to wildlife. Three of the species that were recorded in the area are classed as near-threatened (NT), and five species are rated as least concern (LC) based on the IUCN Red List of Threatened Species. The presence of mammals classified as near-threatened in this region is evidence of the importance of the ecosystem and the need to preserve the various ecological niches.

5. Conclusion

The inventory of mammals carried out in the Northeast part of the municipality of Mbangassina confirmed the presence of nine species divided into five (05) Orders and four (04) Families. The high value of the observed diversity index reflects the ecological importance of this ecological entity for the Municipality of Mbangassina. Indeed, the number of species recorded in the study area demonstrates the continued favorable environmental conditions that still prevail in the ecosystem despite the high level of anthropogenic activity. The findings provide baseline data that can be utilized for short-, medium-, and long-term monitoring, as well as future assessments to determine trends in the coevolution of animals and human activities in the research area. Given the negative impact of human activities on the presence of wildlife in the area, the authorities must intensify their protection effort to reduce illegal activities in these areas.

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Data Availability Statement

The authors confirm that the data supporting the findings of this study are within the paper.

Authors' Contributions

Project design: **Martin Tchamba Ngankam, Serge Alexis Kamgang**; fieldwork, data analysis, and writing: **Ervis Manfothang Dongmo, Serge Alexis Kamgang, Guy Herman Zanguim Tchoutezou, Steve Tassiamba Nanfack**.

Supervision: **Martin Tchamba Ngankam, Serge Alexis Kamgang**.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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