Original Research Article

Impact of illegal anthropogenic activities on the spatio-temporal variations in the distribution of the defassa waterbuck population (*Kobus ellipsiprymnus defassa*, Rüppel, 1835) in the Classified Forest and Game Ranch of Nazinga, Burkina Faso

ABSTRACT

The number of defassa waterbuck populations in the Nazinga Classified Forest and Game Ranch is declining. Few studies have been carried out on the distribution of this population. In general, the defassa waterbuck populations as well as other mammals are subject to abusive exploitation linked to anthropogenic activities. This study was to evaluate the influence of anthropogenic activities on the distribution of the defassa waterbuck population in the Nazinga Classified Forest after fourteen years (2006-2019) of collection. For this, the line transect method was used for the census of fauna and indices of the presence of anthropogenic activities. Thus, from these data, the numbers varied from 2434 individuals [95% CI (1074-5512)] in 2006 to 646 individuals [95% CI (292-1430)] in 2019 and the densities of 0.71 [95% CI (0.32) -1.57)] in 2019 to 2.67 [95% CI (1.18-6.04)] in 2006. This population remained a group from 2006 to 2019 in the conservation zone integral in search of tranquility. Indices of poaching, human presence and livestock significantly influence the numbers of this population over time. The results obtained will make it possible to develop the conservation and management plan for hunting resources aimed at preserving the wildlife diversity of the Ranch.

Keyword: Nazinga, defassa waterbuck, distribution, Anthropogenic activities

I. INTRODUCTION

The preservation of biodiversity is a crucial issue in a world where human activities exert increasing pressure on the natural ecosystems [1]. Wildlife face increasingly complex challenges due to anthropogenic activities that alter their natural environment [2]. Defassa waterbucks, a species of antelope endemic to protected savannah areas, are one of these species whose conservation has become a priority [3]. The defassa waterbuck population could be used to assess the health of the ecosystem [4]. According to the IUCN red list, the population of the species is near threatened [5]. Despite the above, few studies have been carried out on the factors influencing the distribution of defassa waterbucks. The Nazinga Classified Forest, like all other protected areas, plays a role as a refuge for wildlife. However, it is not immune to degradation linked to anthropogenic activities which can lead to fragmentation of animal populations.

This study focuses on the impact of anthropogenic activities on the spatio-temporal distribution of the defassa waterbuck population in the Nazinga Classified Forest.

Our results will be able to highlight the interactions between illegal activities and the defassa waterbuck population. This work will allow us to implement sustainable and harmonious management strategies for the species and its environment.

II-METHODOLOGY

2.1. Study site

The study was carried out in the Nazinga Classified Forest and Game Ranch (NCFGR) located south of the capital (Ouagadougou), straddling the south-central and west-central regions. It has an area of 97,436 ha and is located at a distance of approximately 200 km from Ouagadougou. Our site is located in the South Sudanian phytogeographic zone. The vegetation is composed of gallery forests, wooded savannahs, shrubs and trees [6].

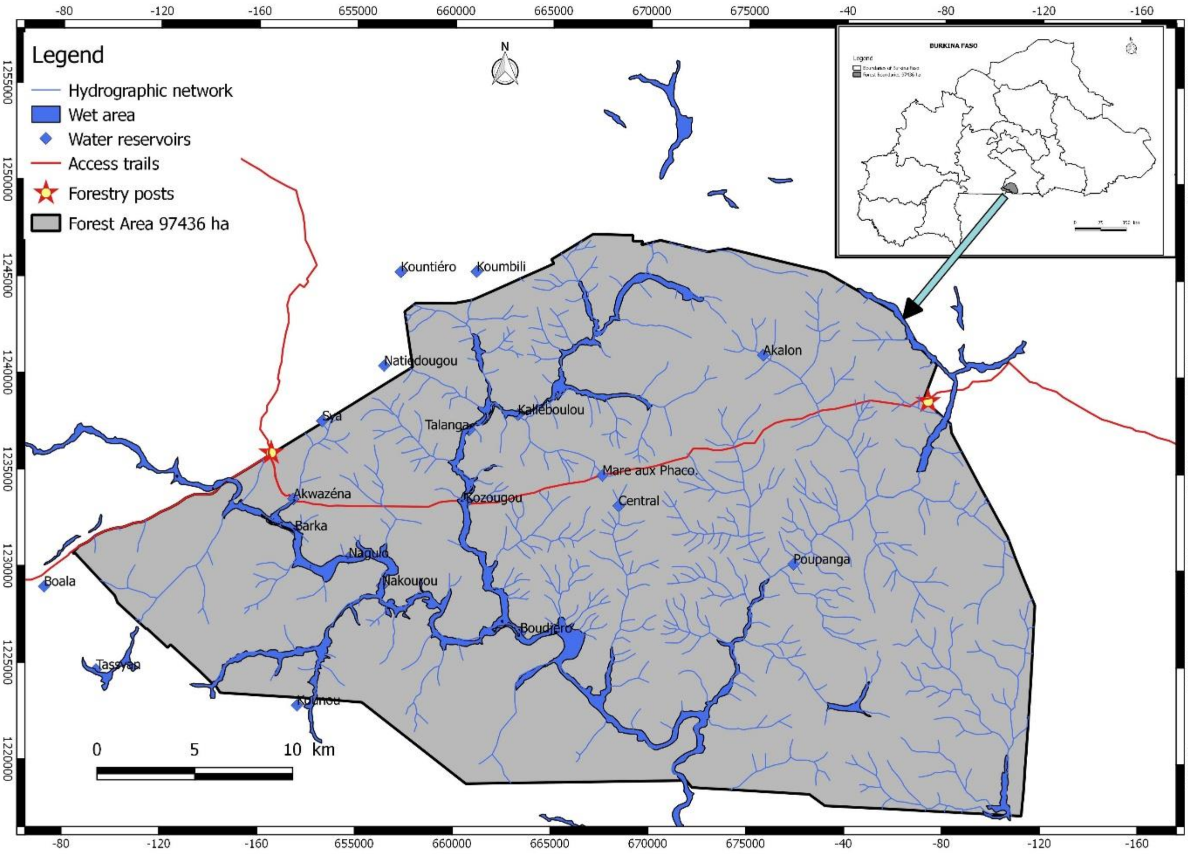

Figure 1: Location map of the Nazinga Classified Forest and Game Ranch, Burkina Faso

2.2. Data gathering

The census of diurnal mammals in the NCFGR has been carried out using the line transect method since 1981. A total of 30 transects equidistant by 1.4 km subdivided into 79 transects and distributed in 7 blocks covering the entire forest were covered in the dry season (Figure 2).

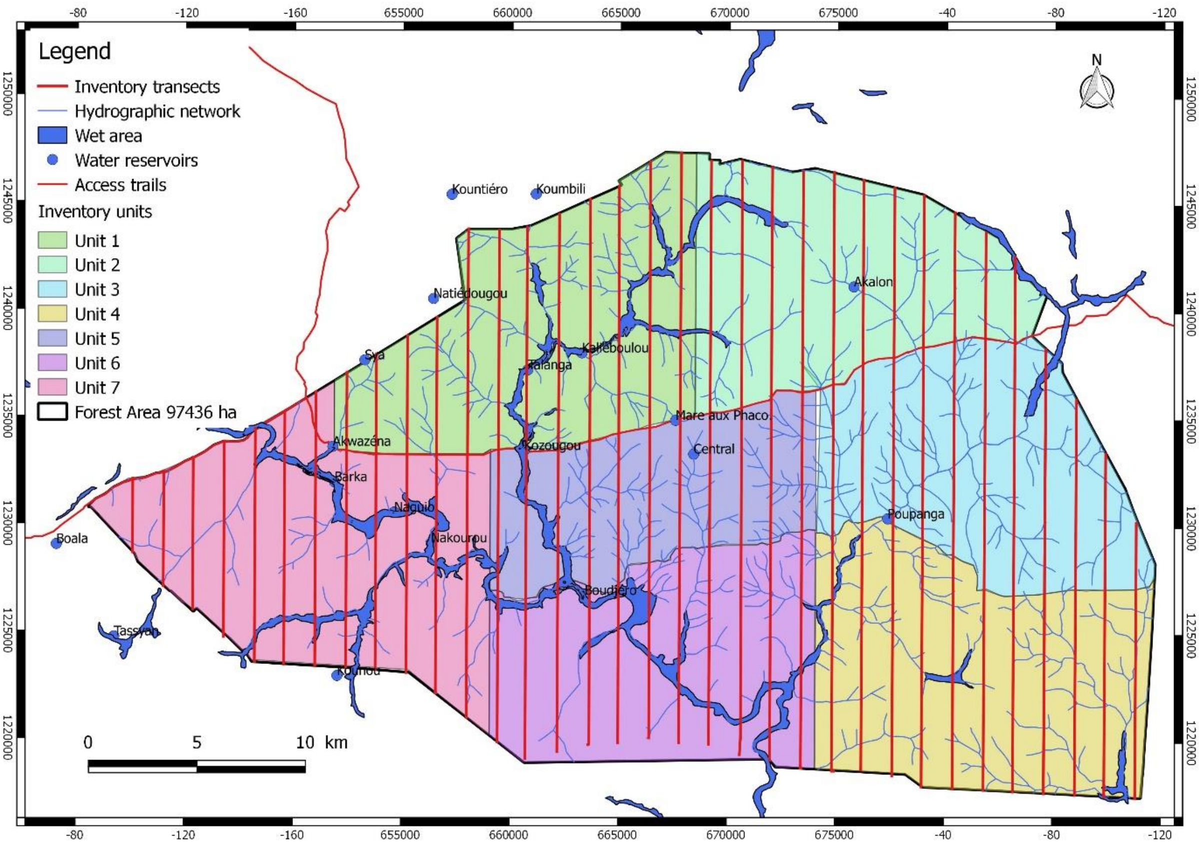

Figure 2: Map of the walking inventory survey plan showing inventory blocks and transects.

We used the databases from 2006 to 2017 and in 2019 we carried out the inventory using the same collection methods. The same transects were covered (691,811 km) during each annual inventory. All transects were oriented from South to North and each entrance and exit of the transects was marked by a metal plate with numbers attached to a tree at eye level. The start of each inventory was preceded by training sessions for the inventory teams. The transects were covered by 12 teams of three people per team and made up of a team leader and two observers (ecoguards coming from villages bordering the park).

The method used was linear transects of variable width [7] [8] [9]. The teams were equipped with binoculars, Garmin 64S GPS to geolocate the different observations, Suunto compasses for measuring observation angles, telemeters to determine the radial distance, maps and cards on which the names of the species observed were noted. , the number of individuals, their sexes and their age, as well as the radial distance, the angle which separates the observation distance and the line of march and illegal anthropic activities (stalking, poaching, tree cutting, Honey extraction, traces of oxen, human presence, carbonization site, presence of domestic animals, field, mutilation) . All inventories began at 6 a.m. which was a time when visibility conditions were met even at a distance.

2.3. Data analysis

We used the DISTANCE SAMPLING software version 7.4 to estimate the densities and numbers of the defassa waterbuck population [10] [11]. The formula for estimating density used by the software is:

$$\widehat{D} = n\hat{f}(0)/2L$$

- $\hat{D}$ is the density estimator;
- *n* is the sample size (number of observations);
- *L* is the total length of the transects;
- $\hat{f}(0)$ is the estimator of the effective half width of the strip; it is the detection probability function estimated by the software through robust mathematical models linked to the probability density function.

We used Morisita's normalized dispersal index (Ip) [12] to determine the mode of dispersal of the animal population and human activities observed during the years considered (2006-2019). Ip varies from – 1 to +1, the dispersion is said to be random if Ip = 0; if Ip < 0 the dispersion is uniform and the dispersion is grouped or aggregative if Ip > 0.

As part of this study, we used the QGIS software, version 3.30.2 to spatialize the different observations made in the field. This software was also used to measure the distances separating the animals observed during different anthropogenic activities. These distances were measured from the points where the defassa waterbuck were located to the points where the factors were located on the map.

We adjusted the values of the number of defassa waterbucks and the distances separating the number of defassa waterbucks to the different anthropogenic activities using the logarithmic transformation. This allowed us to apply parametric tests [13] [14].

To show the relationships between abundance and the variables studied we used scatterplots using the Past 3.23 software package.

The graphs of the defassa waterbuck number as a function of each of the explanatory variables were then analyzed.

We also analyzed the distribution of defassa waterbucks. Then we carried out the statistical analyzes allowing us to orient ourselves on the construction of the explanatory model from the variables.

IBM SPSS Statistics 21.0 statistical software and the Past 3.23 software package were used for correlation analyzes between the number of observed waterbucks and anthropogenic activities as well as the analysis of the log-linear regression model of the Poisson law.

I- RESULTS

3.1. Trend in the size of the defassa waterbuck population and illegal anthropogenic activities

The numbers of the defassa waterbuck population fluctuated from 2434 individuals [95% CI (1074-5512)] in 2006 to 646 individuals [95% CI (292-1430)] in 2019 with a fairly wide confidence interval. Generally speaking, we observed a decline in the size of the defassa waterbuck population from 2006 to 2019 (Figure 3); i.e. a workforce reduction rate of 73.46%. The linear regression analysis shows a collapse in the estimated population numbers and it is not significant ($r = -0.569$; $df = 11$; $p = 0.053$). The evolving trend over the years explains the decline in numbers estimated at 32.4%. As for the densities, they varied between 0.71 [95% CI (0.32-1.57)] in 2019 to 2.67 [95% CI (1.18-6.04)] in 2006.

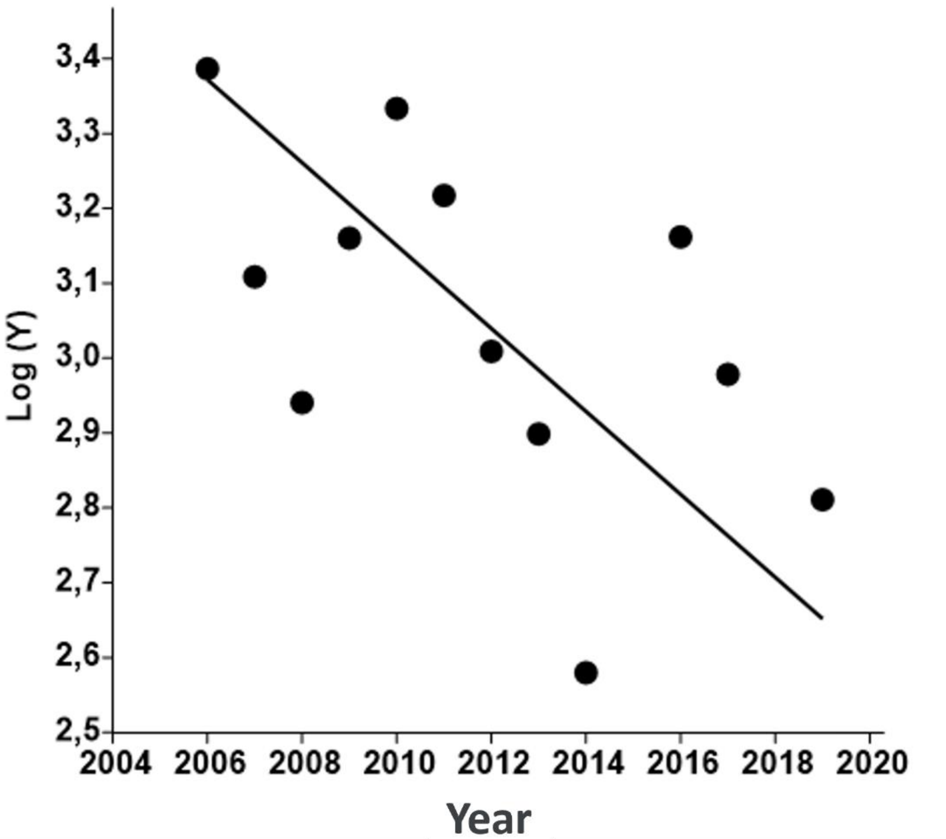

Figure 3: Trend in the waterbuck population from 2006 to 2019; Ln (Y) is the estimated waterbuck population size

Analysis of the log-linear regression model with the Poisson law shows that the evolution of the years significantly affects the estimated numbers. Estimated numbers decrease considerably over the years ($p = 0.000$) according to the following relationship: $\ln (Y) = 149.035 - 0.071 (\text{year})$.

From the analysis of the trend in the number of illegal anthropogenic activities, it appears that over the twelve years considered, a maximum of 146 illegal anthropogenic activities were recorded in 2019 and a minimum of 66 in 2016. There are on average 102 illegal human activities per year, with a standard deviation of 22.59.

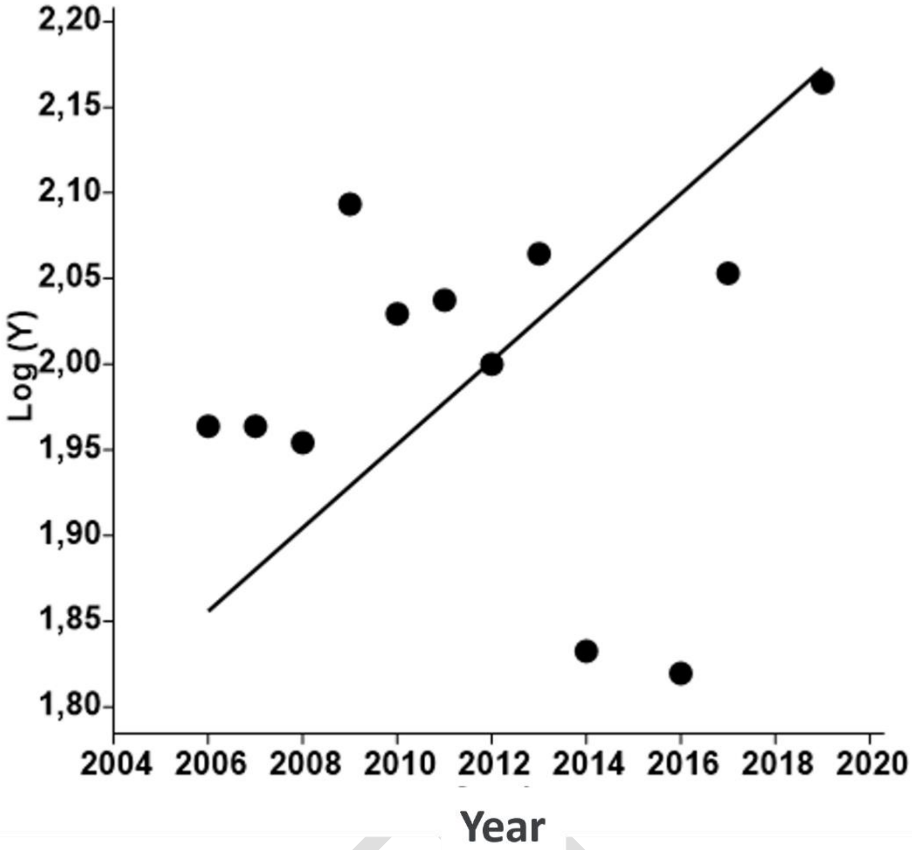

Figure 4: Trend in numbers of indices of illegal anthropogenic activities from 2006 to 2019

This number has increased over the years in general with an increase rate of 58.69%. The linear regression model shows that this increase in the number of illegal anthropogenic activities is not linked to the years and is not significant ($r = 0.14$; $df = 11$; $p = 0.67$). The generalized linear model shows that the number of illegal anthropogenic activities does not increase significantly over time ($p = 0.63$) and it depends on the number of years according to the relationship $\ln (Y) = 0.003 (X) – 4.77$.

3.2.Spatio-temporal distribution of the defassa waterbuck population and illegal anthropogenic activities from 2006 to 2019

Spatial distribution of the defassa waterbuck population in the Nazinga Classified Forest considered was aggregative (Ip > 0). The dispersion indices (Ip) remained almost constant from 2006 (Ip = 0.56) to 2019 (Ip = 0.57). The difference between the values is not significant (r = 0.52; p = 0.087) from one year to the next.

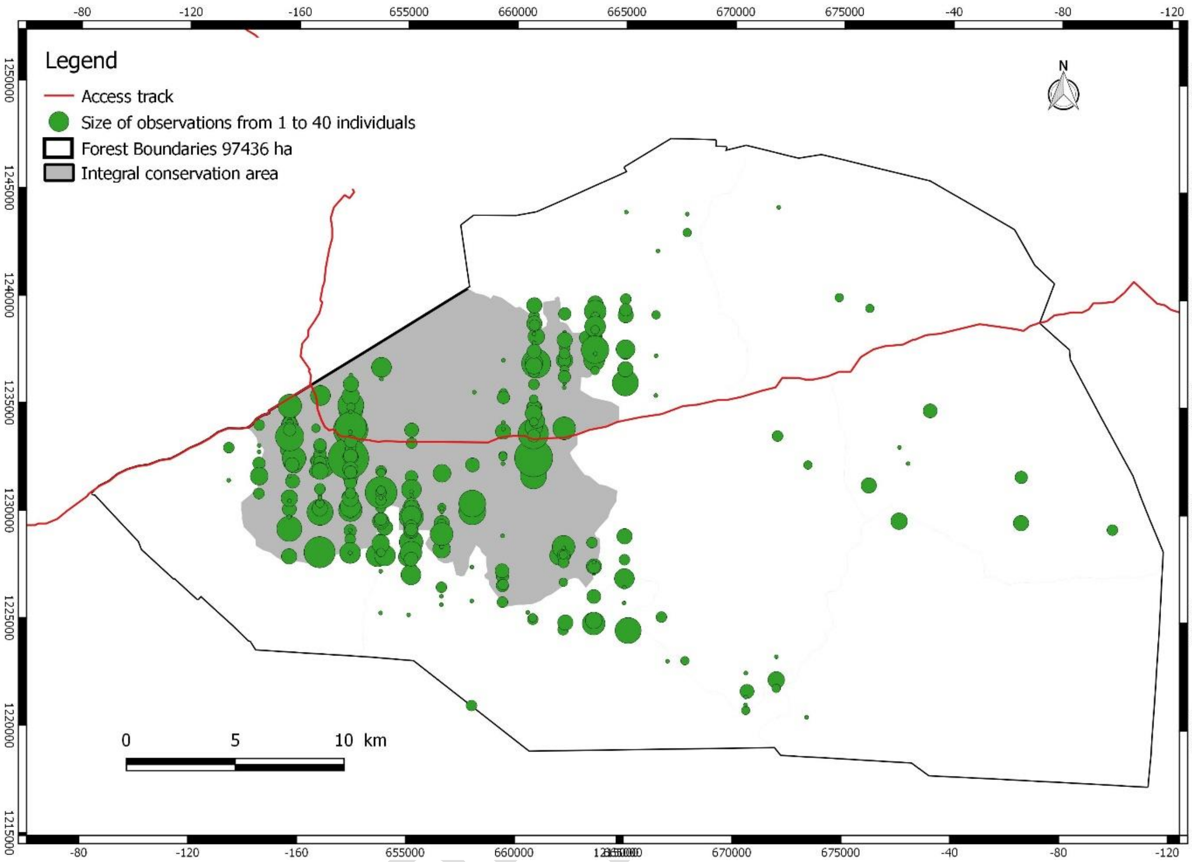

Figure 5: Map of the distribution of the waterbuck population from 2006 to 2019

The common minimum population area of the defassa waterbuck is 93 km² (Figure 5).

The number of illegal anthropogenic activities recorded during the inventories from 2006 to 2029 fluctuated from 66 in 2016 to 146 in 2019. During the same period, the distribution areas of these activities varied from 607 km² in 2014 to 910 km² in 2019. Generally speaking, these activities are observed over the entire surface of the forest. But they are concentrated in the North, East, South and South-East parts.

Analysis of Spearman's correlation between the number of illegal anthropogenic activities and their distribution areas shows a significant correlation (r = 0.58; df = 11; p = 0.047).

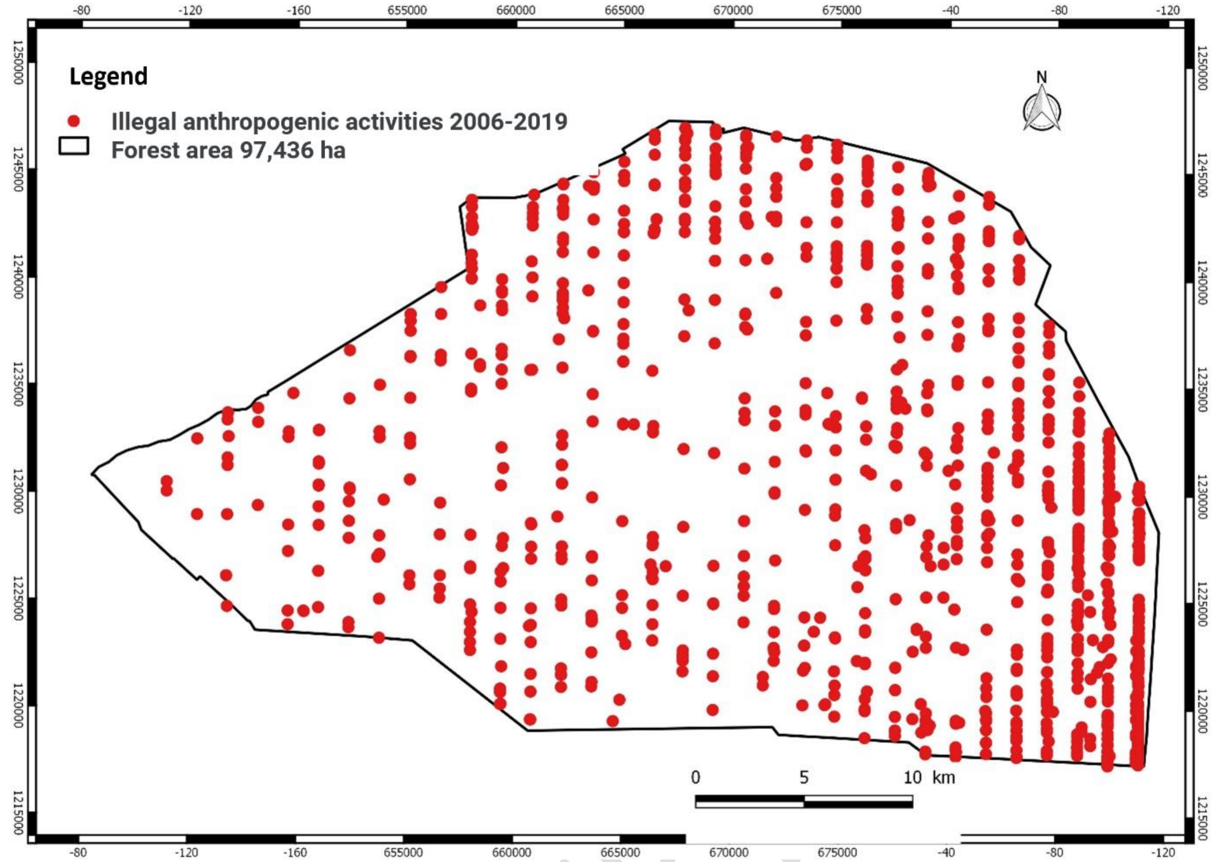

Figure 6: Spatio-temporal distribution of illegal anthropogenic activities from 2006 to 2019

The result of the spatial analysis using the nearest neighbor method of illegal anthropogenic activities explain that these activities also remained group from 2006 to 2019 with an average of R = 0.86 < 1.

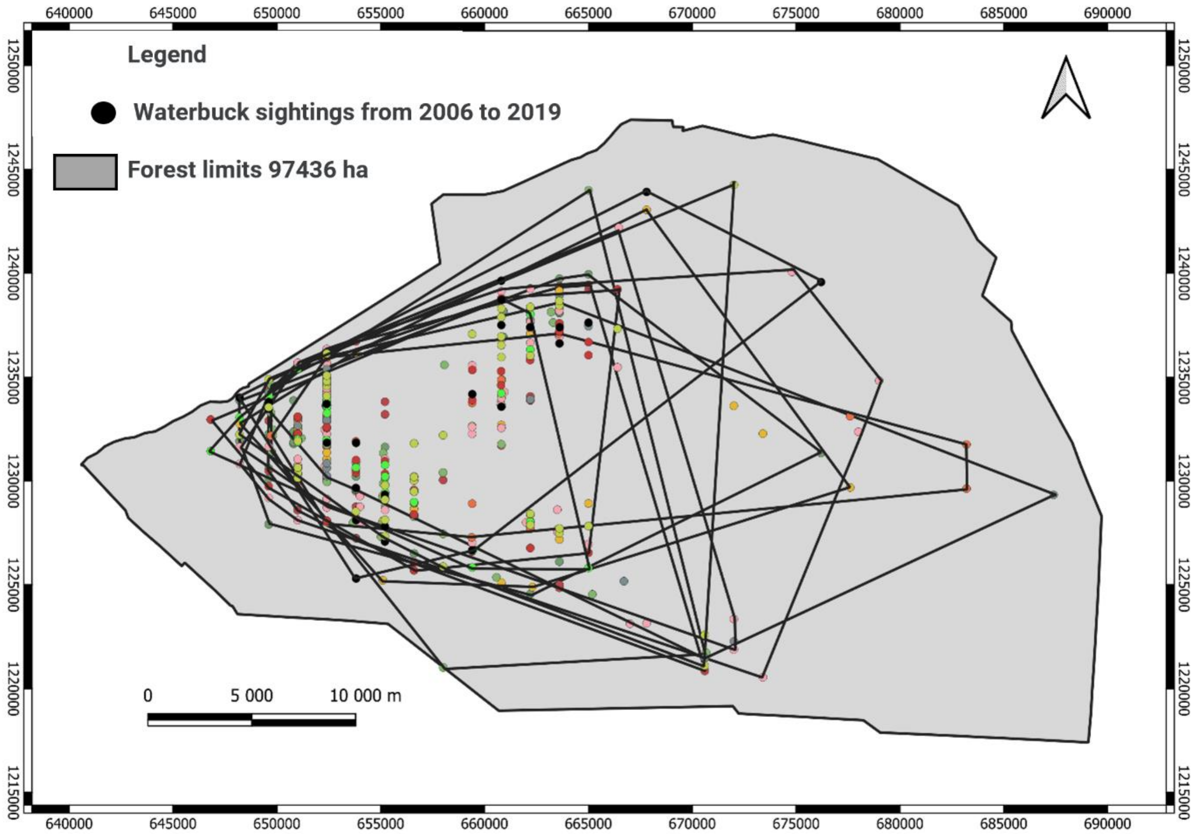

Figure 7: Map of the minimum common area of the waterbuck population from 2006 to 2019

However, during the years considered the population distribution area collapsed continuously (Figure 7) with a reduction rate of 3.88%. But according to the linear regression test, this collapse is not significant ($r = -0.50$; $df = 11$; $p = 0.09$).

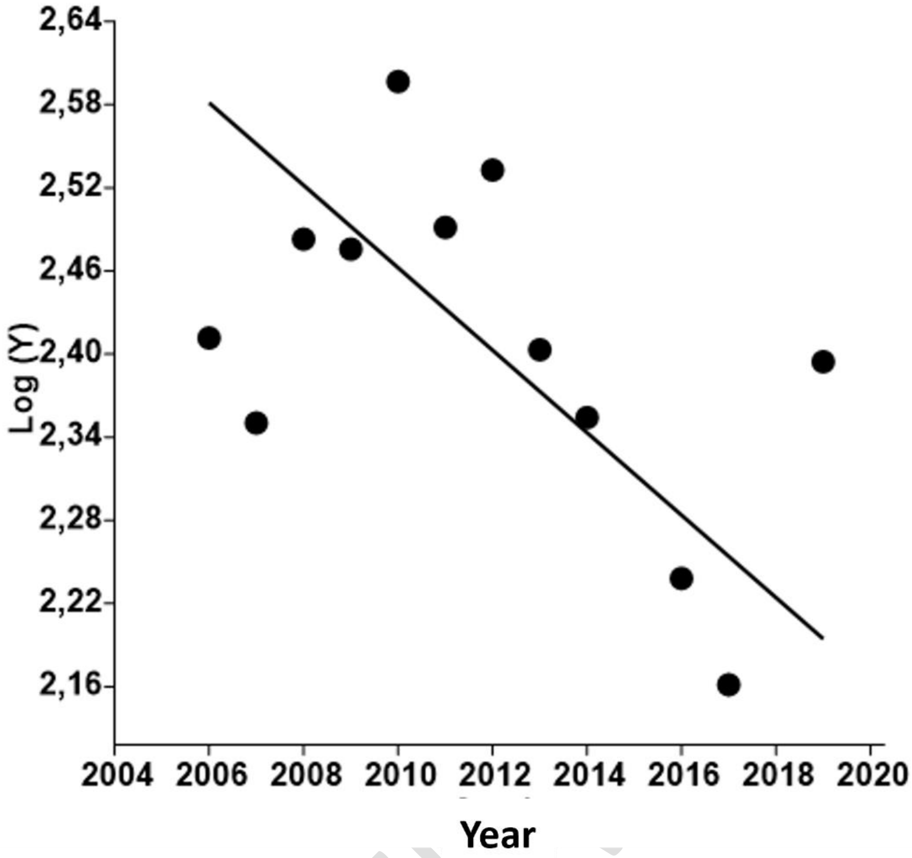

Figure 8: Trend in the distribution area of the defassa waterbuck population from 2006 to 2019

The frequency of the decrease in the area occupied by the defassa waterbuck population via a fish model depends on the number of years (p = 0.000) according to the relationship

Ln(Y) = -0.071(X) + 149.035.

At the same time, the analysis of the trend in the area occupied by the indices of illegal anthropogenic activities evolved (Figure 9). This increase is not significant (r = 0.18; df = 11; p = 0.57).

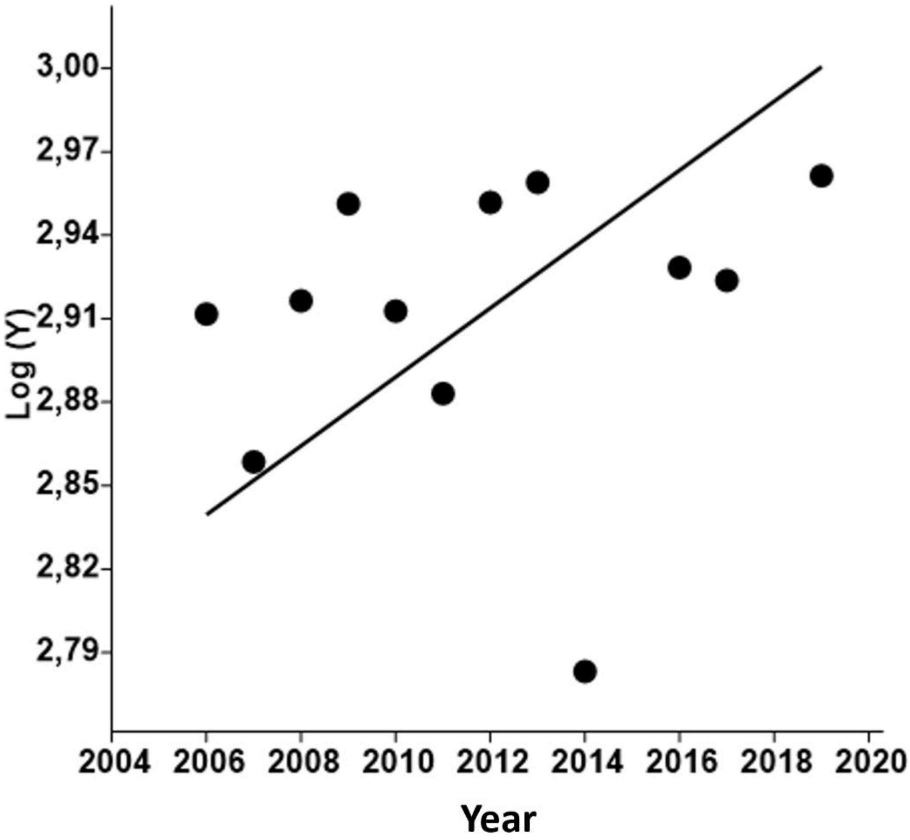

Figure 9: Trend in the distribution area of illegal anthropogenic activities from 2006 to 2019

The analysis of the log-linear regression model shows that the size of the distribution area of illegal anthropogenic activities evolves according to the following equation: ln (Y) = 0.002 (X) – 1.64; with X corresponding to the year and Log (Y) the log transformation of the area of the distribution area of illegal anthropogenic activities.

3.3. Impact of indications of illegal anthropogenic activities on the defassa waterbuck population

The linear regression analysis between the estimated numbers of the defassa waterbuck population and the numbers of the indices of illegal anthropogenic activities generally shows that the more the number of indices increases, the numbers of the population decreases. However, the test indicates that the relationship between the two values is not statistically significant

($r = -0.063$; $p = 0.846$) and the number of indices poorly explains the estimated numbers of the population ($r^2 = 0.004$). The prediction can be done according to the following equation: Y = -1.690 (Number of index) + 1428.267

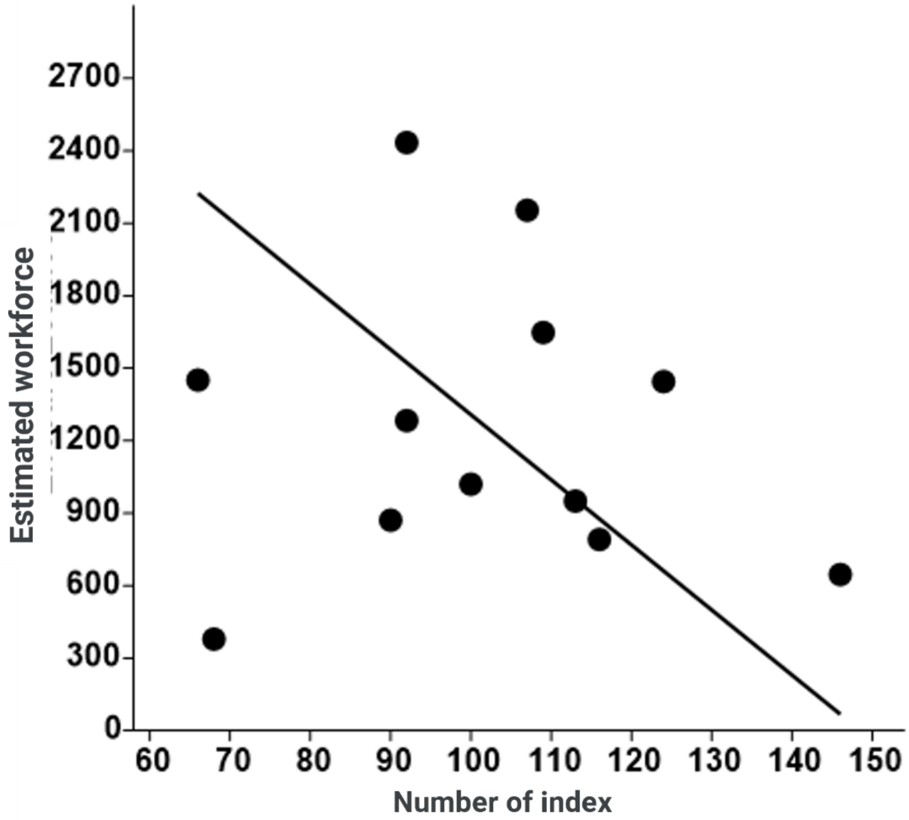

Figure 10: Relationship curve between the number of indications of illegal activities and the size of the defassa waterbuck population from 2006 to 2019

During the period considered (2006 – 2019), we inventoried 1115 indicators of illegal anthropogenic activities, or on average 93 indicators per year. These activities have been grouped into three (03) major activities which are the poaching indices, the human presence indices and the presence of livestock. The most frequent indicators are those of poaching with an average encounter rate of 54.41%, followed by the index of the presence of livestock (29.60%), and finally those of the human presence (13.99%). These indices have an increase rate of – 0.77% for the poaching indices, 2.33% for those of the presence of livestock and 13.81% for those of human presence.

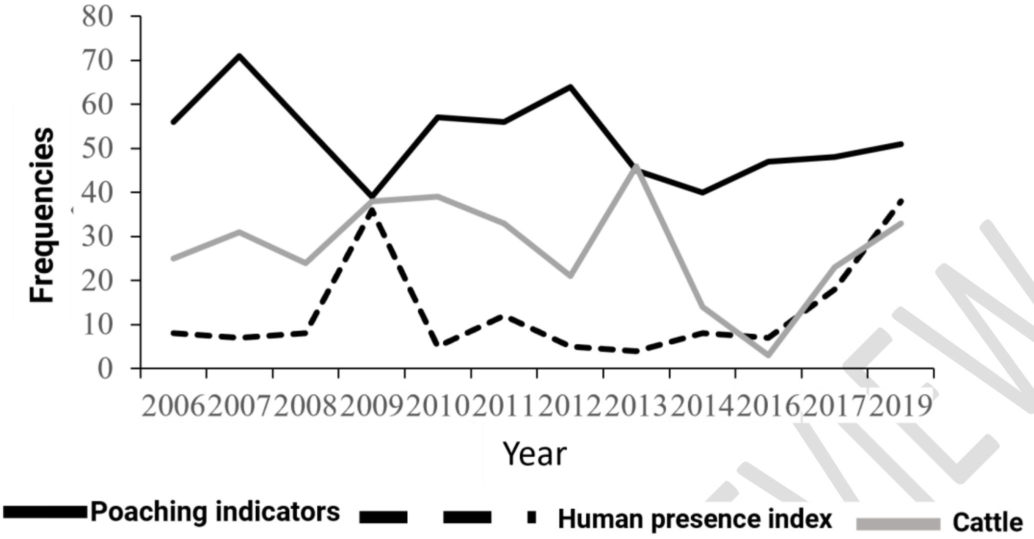

Figure 11: Trend in frequencies of illegal anthropogenic activities from 2006 to 2019

The Generalized Linear Model (GLM) shows a significant relationship between the estimated values of the numbers of the defassa waterbuck population and the different indices (Table 1).

Table 1: Result of the Generalized Linear Model (GLM)

Explanatory variables	Estimate	Standard error	Wald	p
Constant	6,352	0.0587	11723,244	0.000
Poaching indicators	0.013	0.0010	167,842	0.000
Human presence index	-0.005	0.0009	40,488	0.000
Livestock presence index	0.007	0.0008	72,203	0.000

II- DISCUSSION

Trend in the size of the defassa waterbuck population and illegal anthropogenic activities

Our study concerned inventory data of the defassa waterbuck population from 2006 to 2019 in the NCFGR. We used the line transect method to assess population numbers. The trend revealed a continuous decrease during the years considered (2006-2019). However, these inter-annual collapses in the numbers and densities of the defassa waterbuck population are not significant. The causes of the decline in the defassa waterbuck population could be caused by poaching and the intensification of carnivore predation [15] [16]. According to [16] the reduction in the numbers of the herbivore population is due to rainfall regimes.

Other causes such as the variation in the rate of precipitation [17] [18] [16], the variation in the structure of age and sex classes [19] could be at the origin of the negative trend in the number of this population. The conditions in which this work was carried out and the study sites should be taken into account. Lake Nakuru National Park is a closed site that does not allow ungulates to migrate. The estimate of numbers using the DISTANCE SAMPLING method was quite biased by the variation in the number of contacts during the inventory years considered.

Spatio-temporal distribution of the defassa waterbuck population

The defassa waterbuck population is one of the most abundant species in the Nazinga Classified Forest and Game Ranch. Our results indicate a distribution of the species remaining aggregative ($Ip > 0$) during the study period considered (2006 – 2019) around the water points and the forestry station located in the integral conservation zone. This aggregation could be explained by the presence of permanent water points in the integral conservation zone [20], and the dependence behavior of the species on water [21] [22]. This could also be linked to the negative influence of illegal anthropogenic activities [23]. The constant aggregative distribution of this population could be due to the combined effects of poaching and the presence of domestic livestock [24] and sport hunting. The integral conservation zone would be a shelter for these species [25]. During the same period, the areas of distribution of illegal activities oscillated from 62.30% in 2014 to 93.91% in 2019 of the forest area. They continue to increase over time if nothing is done.

Impact of indications of illegal anthropogenic activities on the defassa waterbuck population

During the inventories, the anthropogenic activities recorded and considered illegal were grouped into 3 indices which are: poaching indices, human presence indices and those of the presence of livestock. Among these signs, those of poaching were the most encountered, followed by signs of the presence of livestock and finally those of human presence. The combined analyzes show that these indices each have a significant impact on the size of the defassa waterbuck population over time. This indicates that these activities have an impact [26] on the defassa waterbuck population. The increase in these indices could be linked to the fact that forests are places where local populations can have natural resources [27].

CONCLUSION

The numbers of the defassa waterbuck population were estimated using the Distance Sampling method. Using this same method, we identified signs of illegal anthropogenic activities. Generally speaking, the estimated numbers of the defassa waterbuck population show a regressive trend over time. Dispersal analysis revealed that this population remained clustered in the integral conservation zone over time. The species' distribution areas have decreased over the years to the detriment of those occupied by illegal anthropogenic activities. This distribution is influenced by the number of illegal anthropogenic pressures recorded. Analysis of trends in illegal anthropogenic activities reveals that the poaching rate has decreased slightly unlike other activities. The continued decline in the size of the defassa population is strongly linked to the combined effects of different illegal anthropogenic pressures.

This study highlights the impact of types of anthropogenic pressures on the defassa waterbuck population in the Nazinga forest. It challenges managers on the need to reverse the trend for sustainable management of this species in West Africa.

Data Availability Statement: The authors declare that their data will be provided in case of request by interested readers.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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