Impacts of Infrastructure Development on African Cape Buffalo Behavior: A Case Study of Lake Nakuru National Park, Nakuru County, Kenya

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Abstract
Infrastructure development is a necessary activity; however, if the developers do not consider the environment during the design, planning and construction stages, ecosystem losses are bound to happen. African Cape buffalo behavior alteration is the main challenge caused by the existence of infrastructure in Lake Nakuru National Park. The primary purpose of this study was to assess the effects of infrastructural development on African buffalo behavior in Lake Nakuru National Park. Primary data collection was done using; Key Informant Interviews (KIIs), structured questionnaires and field observation. Secondary data was collected by reviewing government documents, published documents and related documents. Quantitative data was managed using Statistical Package for social science (SPSS). The study sought to recommend strategies to remedy the behavioural changes of the African Cape buffalo triggered by infrastructure existence in Lake Nakuru National Park.

Key words: Infrastructural development, Africa Cape Buffalo behavior

1. Introduction

Infrastructure is a term used for the underlying physical systems of a society. It is inclusive of transportation, communication, sewage, water, water points, electric fence, viewing points and electricity structures. Infrastructural development, therefore, is the construction and improving the foundational services in a given society (Torres, Jaeger, & Alonso, 2016). Infrastructure is an essential development in any sector. Physical development provides the underpinnings of modern society. Human population growth and development heavily depend on infrastructural development, making it nearly impossible to neglect it.

Recreation and tourism in protected areas are important economic activities which necessitate the availability of infrastructural development In Lake Nakuru National park. Despite the enormous potential of the protected area to generate income through proper infrastructural development at tour destinations, there are several negative impacts on the wild game (Sindiga, 2018). For example, construction of roads in a protected area fragments the habitat for the African Cape buffalo and other wildlife species. Additionally, in adverse cases, it may lead to both fauna and flora loss altering with the density balance of the ecosystem. Infrastructure alters

with the African Cape buffalo home ranges therefore, altering their behavior. Home range and resource abundance and distribution are directly proportional (Wilson, Gilbert-Norton, Gese, 2012). Therefore, any changes on African Cape buffalo home range will result in tremendous behavioral changes.

1.1 Objectives

The objective of the study was to assess the impacts of infrastructural development on African Cape buffalo behavior in Lake Nakuru National Park.

1.2 Problem Statement

Altering of the African Cape buffalo behavior in Lake Nakuru National Park have been occurring over years. Infrastructure existence in park causes stress and pressure African Cape buffalo as it reduces their home ranges and confines them in a small geographical area. This leads to the behavioral changes amongst the African Cape buffalo.

2   Literature Review

Infrastructure plays a significant part in the development associated with the human population. However, it has devastating effects on the environment, especially in areas where endangered or threatened species are in existence (Lee, 2014). For instance, a road through a rain forest fragments the wildlife habitats. Additionally, the migration patterns of the fauna are altered as their routes get interfered. Freshwater streams within the vicinity get diverted disrupting the aquatic ecosystem, which is already struggling through dry seasons (Torres *et al.,* 2016). Infrastructure opens up regions long kept pristine by their inaccessibility. The development cultivates illegal activities, for instance, logging and poaching. Such activities detour the ecological systems as their population is interrupted.

The accident is a common phenomenon in modern society; they are therefore prone to happen even in the protected areas. Accidents cause oil spills, which cause marine pollution, and as a result, many aquatic organisms are lost in the process (Alcock, & Rubenstein, 2019). Spills of oil also alter the chemical composition of the soil killing microorganism, which plays a significant role in the trophic level interactions. The means of transporting, for instance, cars and trains may kill the organism on their path. Additionally, they cause noise and introduce unwanted substance to the air causing pollution to previously undisturbed areas. All these activities affect wildlife either by altering their behavior or decreasing their population.

Chemical pollutants, artificial lighting, microclimatic and hydrological changes, traffic noise movement, and vibration are among the sources of disturbance in an ecosystem (Lee, 2014). In many situations, such interference is marginal on wildlife since many of them can habituate quickly if the infrastructure only exists for a short period. This does not imply that the short term infrastructural development should not be considered in the environmental impact assessment (EIA) stage (Miller, 2017). On the contrary, if the infrastructural development existence is long term, the effects it has on wildlife is significant and at times can be alarming as
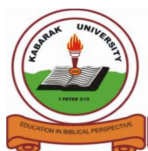
the wild game population drops or increased number of endangered species and those facing extinction.

Habitat disturbance occurs as a result of infrastructural development in protected areas. Infrastructure tends large spaces ranging from a few meters to kilometers (Gichuhi, 2016). Despite the facts that infrastructural developments only occupy small landmass compared to the available land, it influences the land use and habitat function, which directly affects the behavior of the wild game. It has been estimated that infrastructure in the United States of America (USA) directly affects unruly game behavior 19 times larger than the 1% land surface that is physically occupied (Lee, 2014). This implies that their wild game is affected in a great extent by the presence of infrastructural development in the protected areas. As a result, they can adopt new behavior or characteristics to survive in the new environment.

The academic review provides a comprehensive view of how infrastructural development affect the wild game and their natural environment (Gichuhi, 2016). However, there is a lack of concrete evidence of how infrastructural development affects African buffalo. Attempts have been made to quantify the effects of infrastructural development with few results. Derived models such as the vulnerability model are not based on a meta-analysis, therefore, not giving concreate results of conclusion (Lee, 2014). This, therefore, necessitates the research. The study aims at assessing the effects of infrastructural development on the African buffalo in Lake Nakuru national park.

3   Methodology

The study employed descriptive survey design. Inferential data analysis was done using SPSS version 24. For ethical purposes, the study employed distance observation without collaring and darting, therefore, reducing stress on the African Cape buffalo target population in Lake Nakuru National Park.

4   Results

The study sought to identify impact of infrastructural development on African buffalo behavior

Table 1: In your opinion, does infrastructural development have impacts on African buffalo behavior?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	116	95.1	95.1	95.1
	no	6	4.9	4.9	100.0
	Total	122	100.0	100.0	

On whether infrastructural development has impacts on African buffalo behavior, the results on table 1 indicate that majority of the respondents 116 (95.1%) indicated that infrastructural development had impacts on African buffalo behavior while 6(4.9%) of the respondents held the opinion that infrastructural development does not have any impact on African buffalo behavior.

Further, on the impact of infrastructural development on African buffalo behaviour, key informants held the views that; Infrastructure development exposes the African Cape buffalo to new ecosystem settings therefore limiting their movement and migration, feeding, breeding, territory marking and defence. This is because a new ecosystem with different characteristics is created which alters with resource availability. For survival, the African Cape buffalo needs food, shelter and reproduction to continue existing. The infrastructural development present in the park affects these three key elements necessary for the African Cape buffalo. At the point where all the three elements are at their maximum, favourable conditions are availed to the African Cape buffalo marking the highest productivity. This point is known as the optimum.

The study sought to establish effect of infrastructural development on African buffalo behavior

Table 2: Which among the following African buffalo behavior is affected most by infrastructural development?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	breeding	20	16.4	16.4	16.4
	feeding	51	41.8	41.8	58.2
	migration	27	22.1	22.1	80.3
	territory marking	14	11.5	11.5	91.8
	defense	10	8.2	8.2	100.0
	Total	122	100.0	100.0	

On which African buffalo behavior was affected most by infrastructural development, the results on table 2 indicate that most respondents 51(41.8%) held the opinion that feeding was most affected, 27(22.1%) of the respondents indicated that migration was most affected, 20(16.4%) of the respondents held the opinion that breeding was most affected, 14(11.5%) of the respondents indicated that territory marking was most affected while 10(8.2%)of the respondents held the opinion that defense as ban a African buffalo behavior was affected most by infrastructural development

In addition on the effects of infrastructural development on the following African buffalo behaviour, key informants asserted that;

i. On Feeding- Reduces grazing fields. The sewage line that crosses the park to the main sewage often contaminates available browse when they burst. This reduces the available browse for the African Cape buffalo. Additionally, the sewage system is not efficient in purifying the waste; however, the by-products of the purifying process are released to the park. This contaminates the lake which is the main source of water to the African Cape buffalo. This effluent infests the buffalos with worms which interfere with their health. New invasive species such as *Achyranthes aspera, Solanun incanum, Parthenium hysterophorus* and *Urtica Massaica* get introduced in the park, which becomes food to the African Cape buffalo.

ii. On Migration -Limits the movement of the African Cape buffalo to the nearing ecosystem. The electric fence erected around the park confides the Buffalos in the park. Limiting their feeding grounds and territories. Confiding the African cape buffalos in the park makes them compete with other browsers and grazers in the park for the food available.

iii. On Breeding- Infrastructural development interferes with the African Cape Buffalo breeding. The utilization of the infrastructural development such as roads disrupts the breeding activities of the African Cape buffalo. This is due to the noises produced as these infrastructures are used.

iv. On Territory marking- African Cape buffalo territory marking activities are affected by infrastructural development in park. The African Cape buffalo territories overlaps with other wild animals in the park therefore causing conflicts amongst the wild animals. Occasionally, the African Cape buffalo territories spills over to the ranger bases, which at times causes human wildlife conflicts. Human wildlife conflict within the park arises when one of the buffalo gets separated from the herds making them wild due to being frightened.

v. On Defense-African Cape buffalo moves in herds since they are social animals. The herds forms their defence unit and builds their confidence. However, at times infrastructural development such as houses may create barriers which may cause separation of the herds. Upon separation individual buffalos become easy target for carnivores such as lions and cheetah. Additionally, separated individual buffalo tend to be very violent as a security counter measure causing human-wildlife conflict with the rangers living at the ranger base.

Descriptive results for infrastructural development

Measurable indicators N=122	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
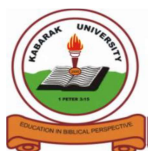
						Mean	SD
Infrastructural development has significant effects on African buffalo breeding	1 (0.8%)	8 (6.6%)	26 (21.3%)	70 (57.4%)	17 (13.9%)	3.77	0.801
Infrastructural development has significant effects on African buffalo migration	2 (1.6%)	4 (3.3%)	30 (24.6%)	61 (50%	25 (20.5%)	3.84	0.843
Infrastructural development has significant effects on African buffalo territory marking	4 (3.3%)	8 (6.6%)	49 (40.2%)	43 (35.2%	18 (14.8%)	3.52	0.938
Infrastructural development has significant effects on African buffalo feeding	3 (2.5%)	7 (5.7%)	8 (6.6%)	47 (38.5%	57 (46.7%)	4.21	0.973
Infrastructural development has significant effects on African buffalo defense	5 (4.1%)	29 (23.8%)	48 (39.3%)	21 (17.2%	19 (15.6%)	3.16	0.086

On infrastructural development the results on table 3, indicate that majority of the respondents 87 (71.3%) were in agreement that infrastructural development has significant effects on African buffalo breeding (mean=3.77, SD=0.801). There was agreement among most respondents 86(70.5%) that infrastructural development has significant effects on African buffalo migration (mean=3.84, SD=0.843). According to a fair majority of the respondents 61 (50%) infrastructural development has significant effects on African buffalo territory marking (mean = 3.52, SD=0.938) while 43(35.2%) of the respondents showed neutrality in opinion on this statement. A larger majority of the respondents 104 (85.2%) were kin agreement that infrastructural development has significant effects on African buffalo feeding (mean=4.21, SD=0.973). In

addition, 48 (39.3%) of the respondents held neutral opinion that infrastructural development has significant effects on African buffalo defense (mean=3.16, SD= 1.086), 40 (32.8%) were in agreement while 34 (27.9%) of the respondents were in disagreement with this statement. All the responses had standard deviation values less than 1 which implies that there was no disparity in opinions among the respondents on infrastructural development statements.

Inferential Statistics

This section presents the results of inferential statistics that was namely; Pearson correlation coefficient and regression analysis

Correlation Analysis

Correlation coefficient analysis was used to measure the non-causal relationship (correlation) between the independent variable and the dependent variable. . The Results are between -1 and 1. A result of -1 means that there is a perfect negative correlation between the two values, while a result of 1 means that there is a perfect positive correlation between the two variables. Result of 0 means that there is no correlation between the two variables Gujarat, (2004).Table 4 presents the results.

Table 4: Correlations

		infrastructure development	behavior
infrastructure development	Pearson Correlation	1	.529
	Sig. (2-tailed)		.000
	N	122	122
Behavior	Pearson Correlation	.529	1
	Sig. (2-tailed)	.000	
	N	122	122

The results on table 4 also show that there exists a statistically significant positive correlation between infrastructure development existence within Lake Nakuru national park and African Cape buffalo's behavior in Lake Nakuru national park ($r = 0.529$, $p < 0.05$). This means that when infrastructure development is within Lake Nakuru national park enhanced, African Cape buffalo's behavior in Lake Nakuru national park improves

Regression analysis

Regression analysis was carried out to examine causal relationship between infrastructure development existence within Lake Nakuru national park and African Cape buffalo's behavior in Lake Nakuru national park

Table 5 presents the model summary for the regression between the predictor variable and the dependent variable. The overall R^2 = 0.317 indicates that 31.7 percent of the variation in the dependent variable is explained by the independent variable that is included in the model, with 68.3 % variation in the dependent variable being explained by other factors not included in the model denoted by **(ε)** in the model.

Table 5: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.429[a]	.317	.218	.59329	.317	16.235	1	120	.000	1.901

a. Predictors: (Constant), infrastructure development

b. Dependent Variable: behavior

As shown on Table 5, the F-statistics of the regression result is $F_{(1, 120)}$ = 16.235which is statistically significant. This indicates that the model applied can thus significantly predict the change of the dependent variable as result of the independent variable include in the model. Thus, the coefficients of the model are not equal to zero, suggesting that the model fits the data significantly.

Recommendations and Areas for Further Studies

The sewage needs to be relocated to another area. The policies should be flexible enough to regulate the population of the African Cape buffalo since they are in excess through the following the following channels;

Selling- the excess African Cape buffalo should be sold to licenced game dealers for consumption or preservation.

Harvesting- the policies should be flexible enough to allow harvesting the African cape buffalos in cases where they are in excess. They can be harvested and be used in; feeding the rangers therefore cutting the cost of feeding the park employees and they can also be harvested to provide food for carnivores in orphanages and museums.

Opening up the park towards Soysambu conservancy- this will enable the African Cape buffalo to migrate to the neighbouring ecosystem in search of food and water during dry seasons.

The study employed a case study approach. It is recommended that this study be carried on a broader scale. Single case study findings cannot be generalized in compared to multiple case study. The study also recommends further research to test and validate the research findings using a quantitative approach.

Conclusion

It was concluded that infrastructural development exists within Lake Nakuru national park. There is an electric fence enclosing the park, therefore, it confides the wild animals within the park. The sewage is part of the park, but the land was leased to the county government by the Kenya wildlife service. There are also sewage lines passing through the park from the neighbouring community to the sewage. After purification the by-products are released to the park. Rangers are provided for a base within the park to enable them carry out their supervision activities in the park easy. There are electric lines passing through the park to the hotels, campsites and ranger base. There are a number of motorable major roads and router roads feeding the park. To facilitate water availability during dry seasons, water troughs around the park have been built in strategic places.

It was concluded that infrastructure development within Lake Nakuru National park have a significant negative impact on African Cape buffalo's behavior in Lake Nakuru national park. It can be deduced further that, infrastructure development has significant effects on African buffalo breeding, migration, territory marking some of the respondents showed neutrality in opinion on this statement,feeding and to some extent African buffalo defense.

It was concluded that the current wildlife policy helps in conserving and protecting African buffaloes. The current environmental policy helps in conserving and protecting the African buffaloes. It was not clear whether the current forest policy helps in conserving and protecting the African buffaloes as result of more neutrality in opinion among the respondents. Further, the current Kenya wildlife conservation Act helps in conserving and protecting African buffaloes.

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