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Effect of temperature and rainfall variability on greater kudu (T*ragelaphus strepsiceros*) population in Lake Bogoria landscape, Kenya

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Abstract

Climate change is one of the major factors threatening biodiversity and ecosystem services. Studies have proved that extremely high or low temperatures may lead to habitat degradation for the large herbivores in the Kenyan Savanna. Greater kudu *(Tragelaphus strepsiceros),* a large herbivore within Lake Bogoria Landscape (LBL) in Baringo County, Kenya is a major tourist attraction thus important revenue contributor for the County. Limited information on the effects of temperature and rainfall variability on greater kudu (GK) population in the landscape forms basis for this study. Long-term (1981 - 2022) temperature and rainfall monthly data was obtained from Kenya Meteorological Department. Transect line survey data collected by Lake Bogoria National Game Reserve since the year 2019 and data collected during the study period in 2022 were used to assess the abundance, distribution and trends of Kudu population for the last four (4) years. It was found that there is long-term and seasonal variation of maximum temperature, minimum temperature and rainfall and that both maximum and minimum temperature variability ($r(1) = -.42$, $p > 0.05$ and $r(1) = .45$, $p > 0.05$ respectively) and rainfall ($r(1) = -.10$, $p > 0.05$) did not significantly affect GK population although 98% of the total variation in GK population was related to rainfall variability. It was concluded that temperature and rainfall extremes have affect GK dispersal in the landscape. Deliberate efforts by conservation agencies to create awareness on effects of climate change, and the necessary governance structures and financial support provided towards adoption of sustainable and affordable production technologies will improve livelihoods of the communities.

Keywords: *Greater kudu (Tragelaphus strepsiceros); Lake Bogoria Landscape; Temperature variability; Rainfall Variability*

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Introduction

The International Union for Conservation of Nature (IUCN) Red list of threatened species predicted that 4,161 species are threatened by climate change. Out of these, 33% are at the risk from climate change-induced habitat shifts and alteration; 29% are due to temperature extremes, whereas 28% are due to drought (IUCN, 2020). According to Sintayehu (2018) Climate change is one of the major threats to biodiversity and ecosystem services in Africa. Climate change directly affects terrestrial ecosystems through seasonal changes in rainfall and temperature and indirectly through other disturbances such as fire and drought (IPCC, 2019). These changes can affect biodiversity in many ways, including altering life cycles, shifting habitat ranges and species distribution, changes in abundance, changes in migration patterns, and changes in the frequency and severity of pest and disease outbreaks (Zanamwe *et al.,* 2018; Sintayehu, 2018; Veldhuis *et al.,* 2019).

Greater kudu (*Tragelaphus strepsiceros)* range extends from Ethiopia, Eritrea, Kenya, Tanzania, and the southern part of the continent, particularly in Angola, Zambia, Botswana, Namibia, Zimbabwe and South Africa. The large herbivore within Lake Bogoria landscape in Baringo County, in Kenya (World Wildlife Fund, 2018) is a major tourist attraction for the County. It has been reported that 92% of all the County's tourists visited Lake Bogoria National Game Reserve (LBNGR) in the year 2017 mainly because of the greater kudu. Owing to the great value and importance attached to the greater kudu, its photo on has been adopted as Baringo County's logo making this herbivore a flagship species (Baringo County, 2018).

Staudinger *et al.,* (2013) noted that improved understanding of intrinsic adaptive capacity – evolutionary potential, phenotypic plasticity, and dispersal capabilities – will help to identify which species will be able to adjust and keep pace with the rate and magnitude of climate change. In a recent study, Aduma *et al.,* (2018) found that high temperatures impacted on wildlife because of other drivers like competition with livestock, predation, and human activities and settlements that block migration or dispersal corridors of wildlife from the high temperature areas to cool and wet areas. They also noted that increasing temperatures are leading to habitat loss among the large herbivores in the Kenyan Savanna.

According to Simpson, 1972, greater kudu populations in South Africa moved to higher ground in winter, where food, cover and water resources were poorer, but night temperatures were warmer and there was less of a daily range thus indicating that temperature was significant in limiting kudu distribution during the cold season. Further, it has been noted that in semi-arid ecosystems, climatic changes in frequency and severity of droughts are likely to exacerbate the effects of drought on forage availability, which can feedback to regulate reproduction and offspring recruitment among ungulates (Zanamwe *et al.,* 2018). In a study to determine rainfall variability and droughts in arid and semi-arid lands (ASALs) of Baringo County, it was observed that the County witnessed threats of drought events, which had a negative effect on livelihoods (Ochieng *et al.,* 2017).

Rainfall variability has consequences on the biophysical environment such as changes in the start and length of the seasons hence unpredictability. These changes have already had an observable impact on biodiversity at the species level, in term of phenology (timing of events), distribution and populations, and ecosystem level in terms of distribution, composition and function (Both *et al.,* 2006).

Studies have demonstrated that populations of large herbivores may increase or decline dynamically with changing temperature and rainfall patterns (Vanacker *et al.,* 2005; Ojwang *et al.,* 2017). Currently, there is paucity on data and information on impacts of temperature and rainfall variability on the distribution of greater kudu in Lake Bogoria landscape to guide conservation decisions. The objective of this study was to assess impacts of temperature and rainfall variability on population of greater kudu in Lake Bogoria landscape in the last four years for enhanced conservation and improved livelihoods.

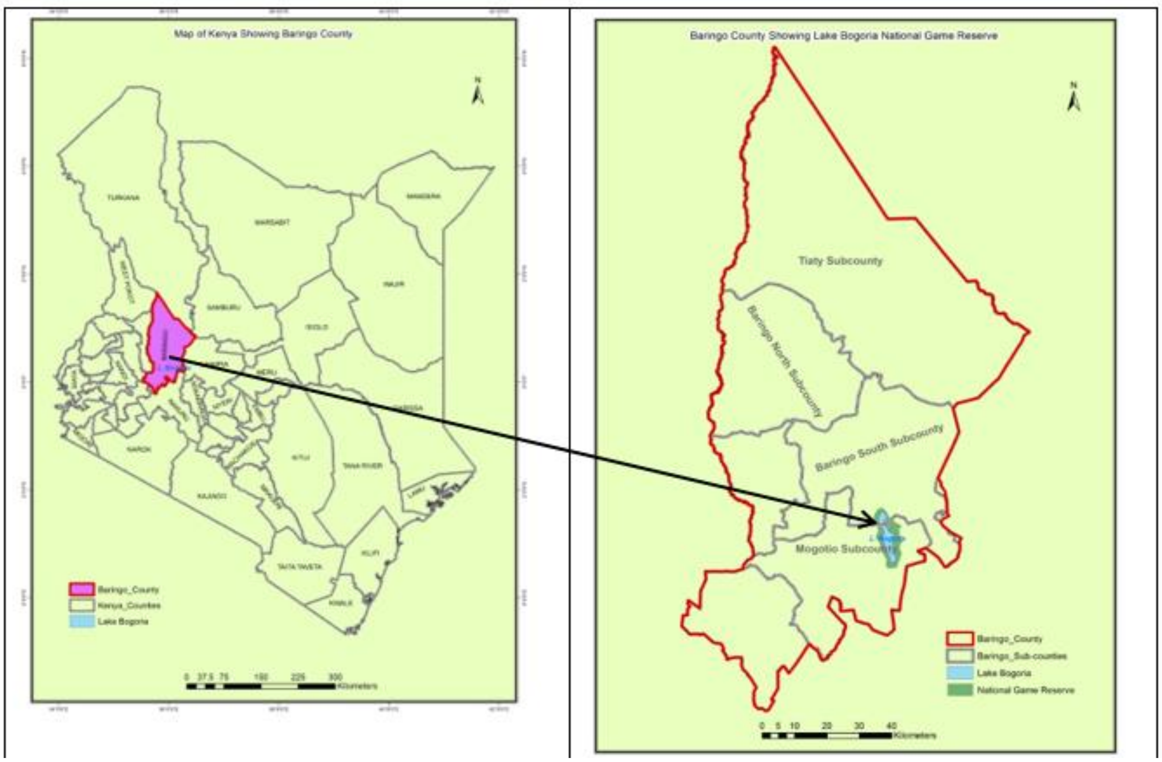
Materials and Methods

Study area

Baringo is one of the 47 counties in Kenya. It is situated in the Rift Valley region. Baringo covers an area of 11,015.3 km² of which 165 km² is covered by surface water from Lake Baringo, Lake Bogoria, and Lake Kamnarok (Baringo County, 2018). The Lake Bogoria National Reserve which is 107 km² comprises of the lake and the terrestrial portion with various vegetation types depending on soil types and terrain. Lake Bogoria National Game Reserve, lies between 36° 4′ and 36° 7′ East and 0° 20′ North and about 10km North of the equator in Baringo County (Figure 1). It has an altitude between 970m a.s.l at the lake to 1650m a.s.l on Siracho escarpment. The climate in the study area is arid to semi-arid regimes except in the moist highlands around Subukia. The climatic conditions are strongly influenced by the ITCZ (Inter Tropical Convergence Zone) and there are two distinct wet and dry seasons. Temperatures around the Lake range from $18^{0}C$ to $39^{0}C$ with a daily mean of $25^{0}C$. Mean annual precipitation varies from 500-1000mm and falls in two seasons April- May and October- November (County Council of Baringo [CCB] *et al.,* 2007). According to Kenya's population and housing census conducted in 2019, the population of Baringo County was 666,763 showing positive trend over the years (Kenya National Bureau of Statistics, 2019). The area is rich in wildlife species characterized by a high diversity at low densities. Animals found in the study area include the greater kudu, impala, vervet monkey, dikdik, warthog, and common jackal, among others. There are several reptiles that include monitor lizard, lizards, tortoise, crocodiles, various species of snakes and over 373 species of birds.

Figure 1

Map of the study area (Constructed by author using ArcGIS 10.8)



Research design

This study sought to establish long-term (1981 - 2022) temperature and rainfall trends and the relationship between Kudu population dispersal and changes in monthly maximum and minimum temperature and rainfall in the eastern side of the landscape (Chebirebei sub-location) and the western side of the landscape (Maji Moto sub-location) in the last four years (2019 – 2022).

Secondary data that had been collected by LBNGR since the year 2019 and data collected during the study period in 2022 were used to assess the abundance, distribution and trends of kudu population for the last four (4) years. The transect lines in the study area had been established in the year 2019 by Friends of Nature Bogoria with the aim of monitoring kudu seasonal population trends over the years. The area covered by the transect line survey is the same every year, making it possible to carry out spatial and temporal comparison of the distribution and population trends of greater kudu.

The distances of the identified Kudus from the already laid out transect lines were recorded and their geographic positions captured using GPS. During the study period, data was collected once in a year during the dry (December to March) season (between 6am and 11am) mainly because of the cost implication of getting a set of such data. For temporal analysis, secondary data from LBNGR for years 2019 and 2020 for similar season (dry) were compared with the primary data. The data for the year 2021 was missing due to travel and activity restrictions associated with Covid-19 pandemic.

Long-term (>40 years) secondary monthly temperature and rainfall public data available at Kenya Meteorological Department was analyzed to assess temperature and rainfall variability as indicators of natural-induced threats on temporal distribution of the greater kudu in Lake Bogoria landscape. Monthly weather data for years between 1981 and 2022 was sorted using Excel to derive both monthly maximum and minimum temperatures range and also precipitation range. Three seasons of a year in the study area include: dry season (December, January and February – DJF); long rainy season (March, April and May – MAM); and the short rainy season (June, July, August, September, October and November-JJASON).

Data collection
Long-term (1981-2022) monthly temperature and rainfall data were sourced from Kenya Meteorological Department for two wards (sub-locations): Chebirebei to the east of Lake Bogoria and Maji Moto to the west.

Secondary greater kudu population data for period 2019-2021 was obtained from LBNGR and primary data collected during the study period (2022) were used to assess the abundance, distribution and trends of Kudu population for the last four (4) years.

Data Analysis
The climate variables analyzed included average seasonal temperature (maximum and minimum temperatures) and precipitation, temperature and precipitation ranges, extreme values (temperature in the hottest and coldest months, precipitation in the wettest and driest months) and combinations (precipitation in the hottest month, temperature in the driest month). Linear regression analysis was used to evaluate temperature and rainfall variability trends.

Pearson's correlation was used to relate temperature and rainfall variability trends with greater kudu population trends over the 4 years (2019, 2020, 2021 and 2022). Mean values of rainfall, maximum temperature and minimum temperature of the two sub-locations were correlated with greater kudu population. After correlation analysis, linear regression analysis was used to predict changes of greater kudu population (dependent/outcome variable) based on the effect of temperature and rainfall variability (independent/predictor variables).

Results

Maximum and minimum temperature range
Although the hot spell according to CCB *et al.,* (2007) begin from January to March and the cold spells in the months of July and August, the findings from the study showed that the maximum temperature range in Chebirebei sub-location was between 25.9^{0}C in July 2018 and 39.2^{0}C in August 2019. However, mean monthly average was in agreement with CCB *et al.,* (2007) where February and March recorded 32.5^{0}C and 32.6^{0}C respectively with July being the coldest month with an average 29.1^{0}C. A similar trend was recorded for Maji Moto sub-location with the lowest maximum temperature of 25.9^{0}C in the months of July 2018 and 2020; and the highest of 38.5^{0}C in in the months of August 2019 and 2020. Mean monthly maximum temperatures in Maji Moto sub-location had the hottest months being February and March both recording 32.9^{0}C and the coldest month was July with 29.2^{0}C.

On the other hand, monthly minimum temperature range in Chebirebei sub-location was between 11.2^{0}C in January 2019 and 22.0^{0}C in February 2010 with long-term mean monthly temperature showing the highest in the months of March/April 19.4^{0}C and the lowest in the month of July 18.1^{0}C. The lowest minimum recorded in Maji Moto sub-location was 9.5^{0}C in September 2018 and the highest was 20.0^{0}C in January 1998 with long-term mean monthly temperature recording the lowest of 16.3^{0}C in the month of July and the highest 17.5^{0}C in the month of April.

From the results above, it was found that the long-term monthly temperature range for maximum temperature is from 25.9^{0}C to 39.2^{0}C and that for minimum temperature is 9.5^0C to 22.0^0C in the study area. It was observed that the ranges of lowest and highest maximum temperature in the recent past have been widening ranging from 9.5^0C to 39.2^0C as compared to between 18^0C and 39^0C reported by CCB *et al.,* (2007).

Long-term Temperature Variability

It was observed that long-term monthly maximum temperature remained the same overtime for both Chebirebei and Maji Moto sub-locations (Figures 2 and 3) with a marginal decrease of 0.2% and 0.5% respectively (R^2 = 0.0015 and R^2 = 0.0046 respectively).

Figure 2

Maximum temperature annual trends from 1981 to 2022 at Chebirebei Sub-location, Baringo County, Kenya

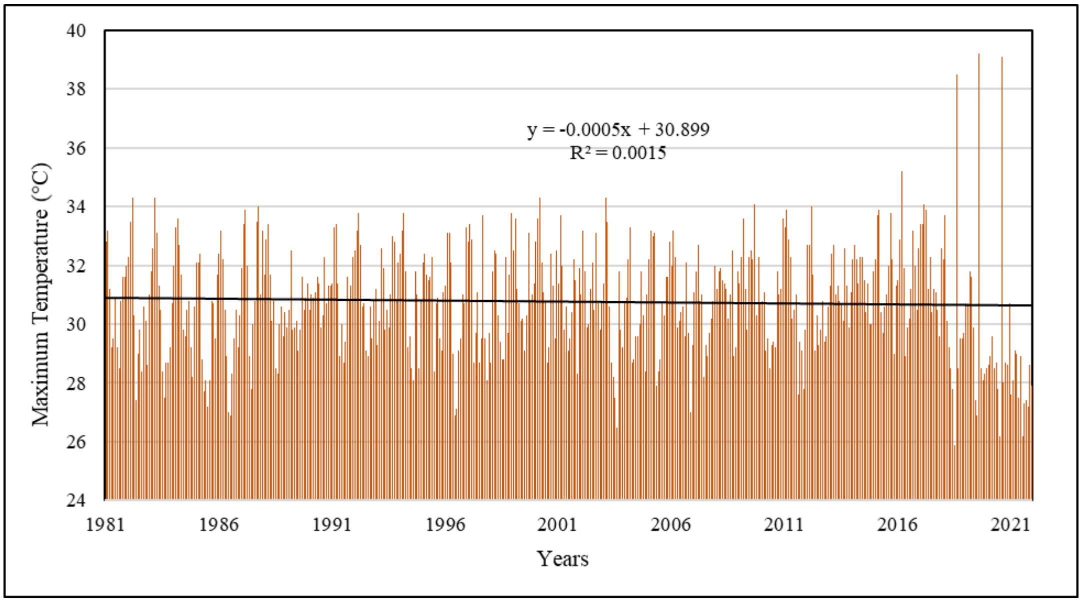
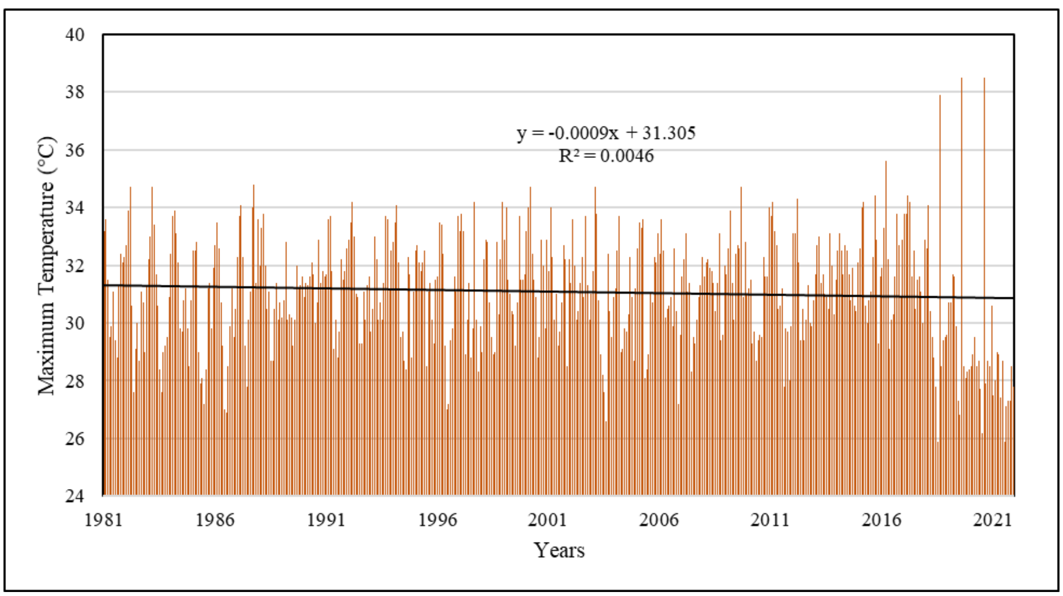


Figure 3

Maximum temperature annual trends from 1981 to 2022 at Maji Moto Sub-location, Baringo County, Kenya



Similarly, long-term monthly minimum temperature showed a decreasing trend in the study area both in Chebirebei and Maji Moto sub-locations (Figures 4 and 5) recording percentage decrease of 7.56% and 5.1% respectively (R^2 = 0.0756 and R^2 = 0.051 respectively).

Figure 4

Maximum temperature annual trends from 1981 to 2022 at Chebirebei Sub-location, Baringo County, Kenya

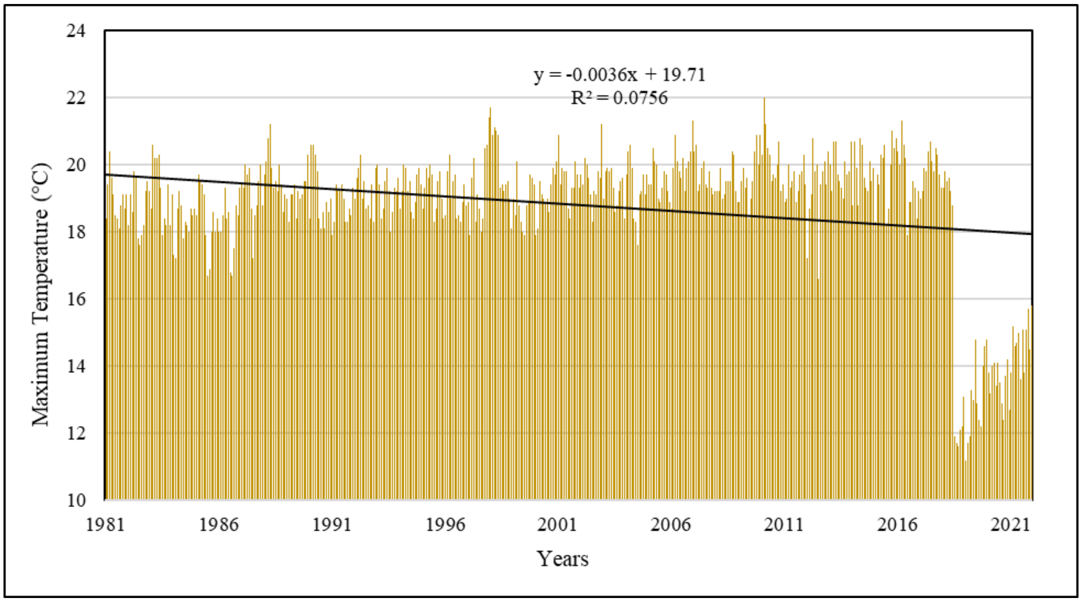
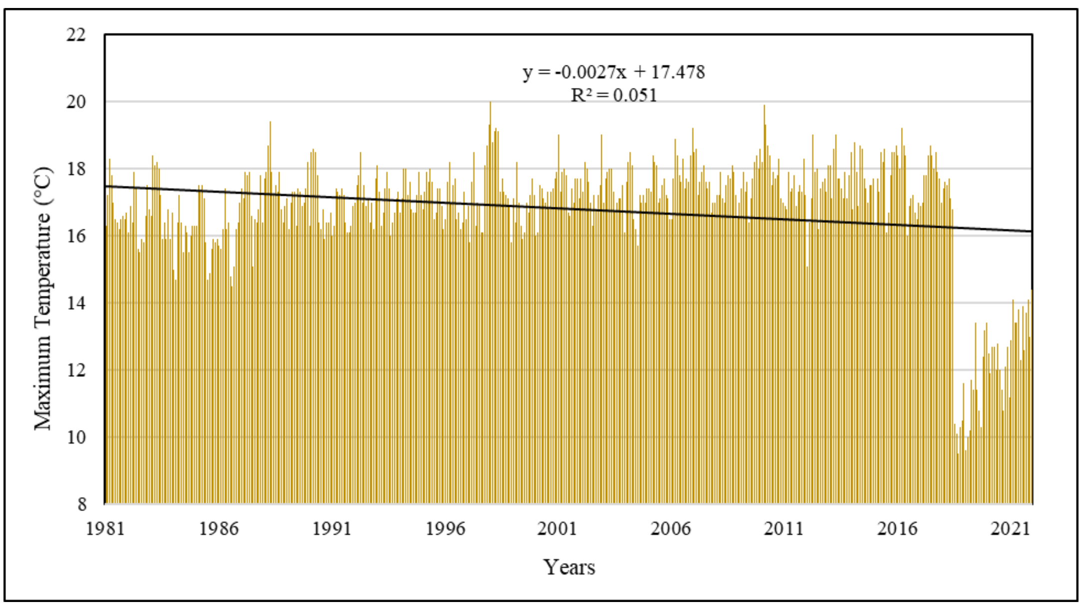


Figure 5

Maximum temperature annual trends from 1981 to 2022 at Chebirebei Sub-location, Baringo County, Kenya



Seasonal Maximum Temperature Variability

Seasonal maximum temperature analysis showed that it has decreased for all the three seasons (DJF, MAM and JJASON) in both Chebirebei and Maji Moto sub-locations with a percentage decrease of 9 and 10.3 respectively (R^2

= 0.0899 and R^2 = 0.103 respectively) for season DJF; percentage decrease of 3.2 and 4.7 respectively (R^2 = 0.0324 and R^2 = 0.0469 respectively) in MAM season; and percentage decrease of 1.7 and 0.2 respectively (R^2 = 0.0177 and R^2 = 0.0026 respectively) in JJASON season.

Seasonal Minimum Temperature Variability

A similar seasonal trend to that of maximum temperature was observed for minimum temperature for the three seasons (DJF, MAM and JJASON) for both Chebirebei and Maji Moto sub-locations with a percentage decrease of 10 and 6.7 respectively (R^2 = 0.1002 and R^2 = 0.0675 respectively) in DJF season; decrease of 11.3% and 8.9% respectively (R^2 = 0.1131 and R^2 = 0.0893 respectively) in MAM season; and percentage decrease of 7.7 and 4.9 respectively (R^2 = 0.0772 and R^2 = 0.0489 respectively) in JJASON season.

It was also noted that although to a large extent, temperature showed a decreasing trend, extreme temperatures (both maximum and minimum) in the recent past were of great concern. For instance, the months of August for years 2018 to 2020 for both Chebirebei and Maji Moto sub-locations recorded maximum temperature between 38.5^{0}C and 39.3^{0}C way beyond the long-term mean of 32.6^{0}C. The lowest minimum temperatures were observed in September 2019 (9.5^{0}C) and also in January 2019 (9.6^{0}C) at Maji Moto sub-location. This was almost two times lower than the long-term minimum temperature of 16.3^{0}C in the study area.

Rainfall monthly and annual range

It was evident that the month of February was the driest in Chebirebei sub-location with no rainfall received for years 1986, 1997, 2000 and 2003. Correspondingly, the month of February for years 1981, 1986, 1997, 2000, 2003 and March 2000 were the driest months in Maji Moto sub-location.

The wettest month for both Chebirebei sub-location (314.6mm) and Maji Moto sub-location (298.3mm) was June 2007. The long-term mean monthly rainfall put February the driest month both for Chebirebei and Maji Moto sub-locations with an average of 20.6mm and 18.8mm respectively. The month of April is the wettest month for both Chebirebei and Maji with an average of 115.2mm and 105.5mm respectively. However, annual rainfall totals varied from 304mm in 1984 to 1608mm in 2020 for Chebirebei sub-location with a long-term annual mean of 792mm. A similar variation was noted for Maji Moto sub-location recording annual rainfall range of 232mm in 1984 to 1514mm the year 2020 in with a with a long-term annual mean of 701mm.

Long-term rainfall variability

It was evident that rainfall (mm) depicted an increasing trend (Figures 6 and 7) between 1981 and 2022 in both Chebirebei (by 2.6%) and Maji Moto (by 3.5%) sub-locations (R^2 = 0.0269 and R^2 = 0.0351 respectively).

Seasonal rainfall variability

The seasonal trends also showed that rainfall has been increasing over time. Firstly, the rainfall trend for DJF season (dry season) in Chebirebei and Maji Moto sub-locations depicted an increase of 9.3% and 13.4% respectively (R^2 = 0.0929 and R^2 = 0.1344 respectively).

Secondly, an upward trend of rainfall for MAM season in Chebirebei and Maji Moto sub-locations with an increase of 4.3% and 4.3% respectively (R^2 = 0.0433 and R^2 = 0.0431 respectively) was also observed. This increase is marginally lower than that of DJF.

Thirdly, an upward rainfall trend for the short rainy season (JJASON) was also indicated for the two sub-locations Chebirebei and Maji Moto. It is worth mentioning that the highest increase was recorded during this season compared to the other two seasons (DJF and MAM) with an increase of 18.4% and 22.8% respectively (R^2 = 0.1838 and R^2 = 0.2284 respectively).

Figure 6

Long-term rainfall annual trends from 1981 to 2022 at Chebirebei Sub-location, Baringo County, Kenya

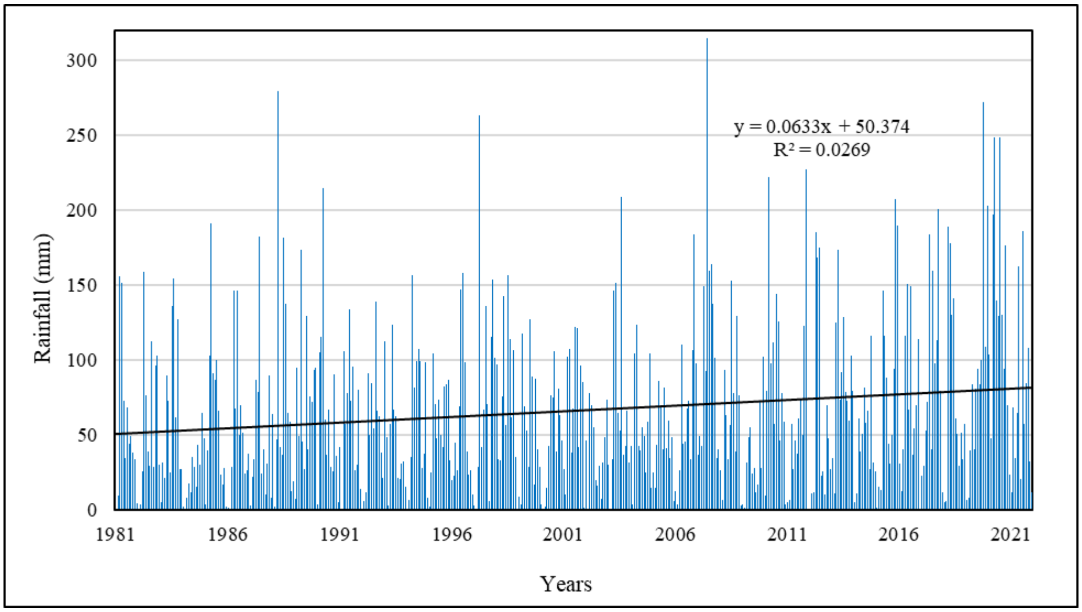
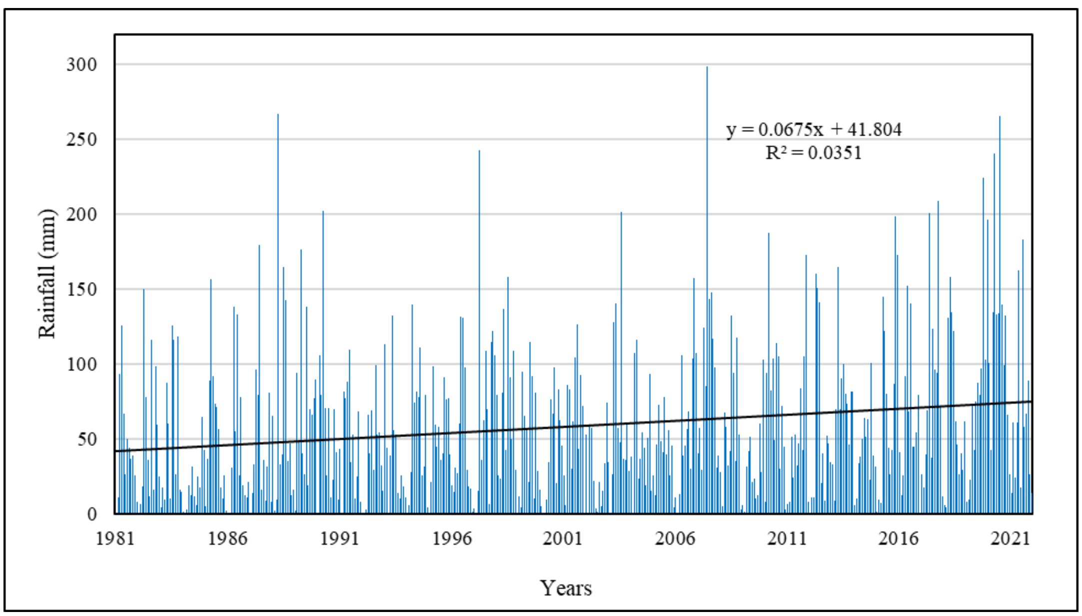


Figure 7

Long-term rainfall annual trends from 1981 to 2022 at Maji Moto Sub-location, Baringo County, Kenya

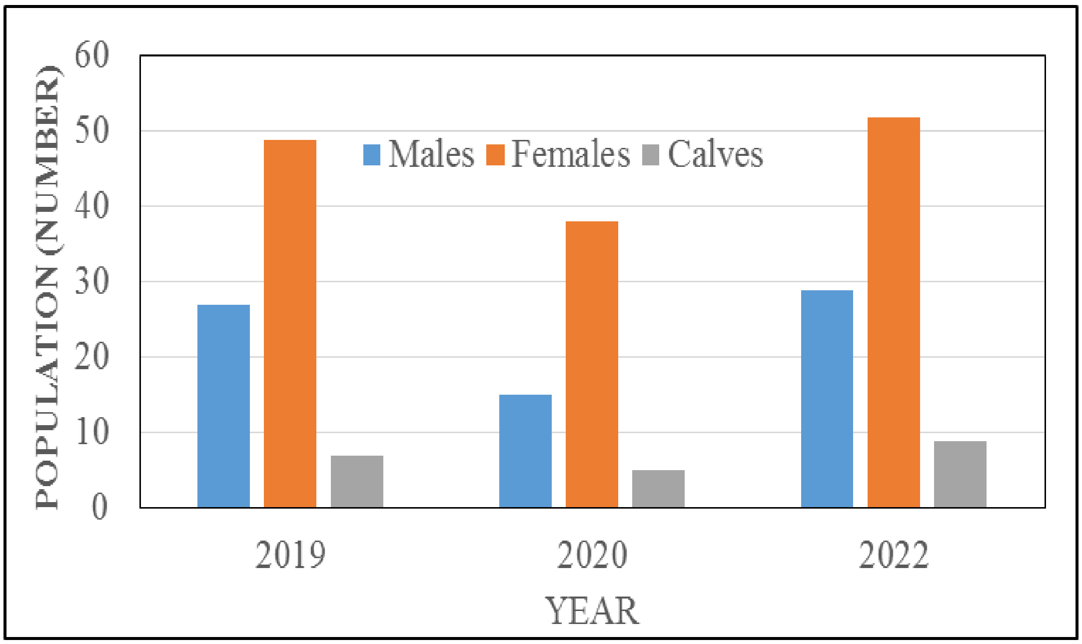


Greater kudu Population

Based on transect counts, the population of greater kudu improved slightly from 2019 to 2022 (Figure 6). The population increase is attributed to improved conservation campaigns and support by the conservation partners through community based conservancies. There was a slight decrease in numbers in 2020 due to above normal rainfall received in the study area. This may have affected the breeding cycle of kudus which usually begins at the end of a rainy season. From this study, the number of greater kudus' females was significantly higher than that of the males, as well as that of the calves (Figure 6). The number of calves was lowest in the year 2020. As indicated in Figure 6, females make the largest percentage of the total population with the year 2020 having the highest percentage at 66%. This was expected since male kudus have been found to be more susceptible to malnutrition and less agile than females due to their larger body sizes predisposing them to being caught easily by predators (Owen-Smith, 2002).

Figure 6

Greater kudu numbers over the period 2019 to 2022 at Lake Bogoria National Reserve, Kenya



Correlation analysis

From Table, 1 it was evident that maximum temperature had an inverse correlation with greater kudu population though not statistically significant $r(1) = -.46$, $p > 0.05$ and only 21% of variation in kudu population was related to maximum temperature. On the other hand, minimum temperature had a positive relationship with greater kudu population but also not statistically significant $r(1) = .45$, $p > 0.05$ although 20% of the variation of kudu population could be associated to minimum temperature variability. It was also evident that rainfall (mm) has a negative effect on greater kudu population in the landscape although marginally significant $r(1) = -.99$, $p > 0.05$.

Linear Regression analysis

From linear regression analysis between maximum temperature (predictor) and greater kudu (outcome), R value of 0.46. This confirms some degree of correlation between maximum temperature and greater kudu although R^2 value of 0.212 indicated that only 21% of the total variation in kudu population is related to maximum temperature variability.

Additionally, linear regression analysis to predict effect of minimum temperature (predictor) on greater kudu population (outcome) was also carried out. R value of 0.445 indicated some degree of simple correlation exists between the variables however, R^2 value of 0.198 showed that only 20% of the total variation in kudu population is related to minimum temperature variability.

Linear regression analysis between rainfall (predictor) and greater kudu (outcome) had R value of 0.99. This confirms a high degree of correlation between rainfall and greater kudu. R^2 value of 0.98 indicated that 98% of the total variation in Kudu population is explained by rainfall variability.

Table 1

Correlation coefficients between Kudu population and weather parameters in LBNR

		Maximum Temperature (⁰C)	*Minimum Temperature (⁰C)*	*Rainfall (mm)*
Greater kudu Population	Pearson Correlation (*r*)	-.461	.445	-.991
	Sig. (2-tailed)	.695	.707	.088
	N	3	3	3

*. Correlation is significant at the $p \leq 0.05$ level (2-tailed).

Discussion

Climate change directly affects terrestrial ecosystems through seasonal changes in rainfall and temperature and indirectly through other disturbances such as fire and drought (IPCC, 2007). Contrary to our expectation, there was a drop of both maximum and minimum temperature in LBNR landscape. The drop in temperatures according to the local community would be ascribed to the introduction of *Prosopis juliflora* - a tree native to South America that was intentionally introduced for its adaptability to desert conditions, fast growth, and source of fuel wood, livestock fodder, human food and bee forage. The tree also provides shade, stabilizes soil through extensive root system hence controls soil erosion and increases soil fertility through litter and fixing of atmospheric nitrogen as it belongs to the legume family. It has progressively become a vibrant species, colonizing many parts of Kenya's arid and semi-arid areas (ASALs) (Choge *et al.,* 2022).

The widening temperature range in the recent paste indicates a likelihood of extreme temperature occurrences as a result of climate change in the study area. The findings illustrate that Kudus thrive in warm temperatures – extremely hot or cold temperatures may not favour their survival. The findings in the study agree with Simpson (1972) who noted that greater kudu in South Africa moved to higher ground in winter despite limited food and water resources there but because night temperatures were warmer there. A study by Bothma *et al.,* (2002) indicated that extreme minimum temperatures in late winter and early spring were fatal to Kudus. Further, Aduma *et al.,* (2018) indicated that extreme maximum temperatures (above 36°C in wet season and 30°C in the dry season) have great impacts on wildlife because it triggers complex ecosystem dynamics that lead to habitat loss among the large herbivores in the Kenyan Savanna and affected the foraging habits of greater kudu (Owen-Smith 2002).

It has been reported that increasing temperatures are leading to habitat loss among the large herbivores in the Kenyan Savanna (Aduma *et al.,* 2018). Moreover, it has been reported that species have shown modification in their morphology, physiology, and behavior due to changes in climatic variables (Muluneh, 2021) -painted turtles grew larger in warmer years and reached sexual maturity faster during warm sets of years (Iverson and Smith, 1993). Similarly, juvenile red deer (*Cervus elaphus*) in Scotland grew faster in warmer springs leading to increases in adult body size (Sheridan and Bickford 2011).

It was also noted that both seasonal and annual trends showed that rainfall has been rising over time in the study area. The results affirm what was expected to occur in the East African region; a 5% - 20% increase in rainfall from December-February and a 5% - 10% decrease in rainfall from June to August by 2050 due to the pattern of Indian Ocean warming – the Indian Ocean Dipole (IOD) which interacts with the El Niño-Southern Oscillation (ENSO) to generate El Ninos (IPCC, 2013).

The results, especially those of rainfall range, indicated that rainfall in the study area is largely erratic from months with no rainfall to months in some years with quite a substantive high rainfall. Such rainfall affects food security particularly in communities and locations that depend on rain-fed agriculture necessitating solutions like bringing extra land into agriculture (Muluneh, 2021) and this may compromise conservation of greater kudu and biodiversity in general. Results in Table 4.1 show that rainfall (mm) had a negative effect on greater kudu population in the landscape though marginally significant) $r(1) = -.99$, $p > 0.05$ and 98% of the total variation in Kudu population related to rainfall variability.

A similar relationship was explained by Owen-Smith (1972) where he observed that although rainfall affects availability of food supply for the Kudus especially the nutrient rich forbs, it also inversely affects Kudus juvenile survival rate. Therefore, where there are plenty of food resources with minimum fluctuations between the years as is the case in the study area, the increase in rainfall may suppress greater kudu population growth. Whereas rainfall influences the growth and availability of feeding resources to the Kudus, Both *et al.,* (2006), indicated that its distribution determines onset of seasons which in turn affect biodiversity at the species level on timing of events like migration, dispersal and breeding habits populations.

According to Owen-Smith (2013), both mature and juvenile Kudus are negatively affected by prolonged drought conditions leading to water and food scarcity and partly because it exposes them more to predators as they move for long distances in search of food and water. For instance, in Kruger National Park of South Africa, 40% of lion kills were during the three months of the dry season (Owen-Smith, 2002). High rainfall improves range conditions by enabling rapid vegetation growth and providing ready access to surface water which may lead to population increases. However, excess water in the form of floods may cause population declines, directly or indirectly, through waterlogging and reduced availability of food (Ojwang *et al.,* 2017). In fact, Vanacker *et al.,* (2005) found that several ecosystems across sub-Saharan Africa are highly sensitive to short-term rainfall variability.

Rainfall affects availability of forage as well as its nutrition which decreases during drought (Owen-Smith, 2002). Greater kudus are adapted to browse on a variety of vegetation, but the reduced nutrition of browse during a drought increases the amount needed (Owen-Smith, 2002; Dorgeloh, 2001). Males in poor condition at the end of the rutting season may not be able to endure the dry season (Skinner and Chimimba, 2005). Furthermore, the dry season is especially dangerous for predation of greater kudu. Therefore, understanding the effects of temperature and variability on wildlife species is vital in conservation biology and wildlife management, especially proactive management and formulation of conservation status decisions (Zanamwe *et al.,* 2018).

Conclusion

Our findings indicate that Kudus thrive well in a warm environment – neither too hot nor too cold environment, and thus we conclude that temperature variability affects the population of greater kudu within Lake Bogoria landscape. Hence the null hypothesis that temperature variability did not affect the population of greater kudu within Lake Bogoria landscape in the last four years was rejected. Further, from this study, an increase of rainfall led to Kudu population decline thus the null hypothesis that rainfall variability did not affect the population of the greater kudu within Lake Bogoria landscape in the last four years was rejected.

It is recommended that deliberate efforts by conservation agencies to create awareness on effects of climate change, and the necessary governance structures and financial support provided towards adoption of sustainable and affordable production technologies will improve livelihoods of the communities. Owing to observed variability in temperature and rainfall, stakeholders involved in Kudu conservation are urged to embrace soil and water conservation measures geared towards enhancement of environmental security in the Lake Bogoria Landscape. Further, for purposes of enhanced conservation, continuous monitoring and awareness campaigns on the greater kudu and its dispersal in the landscape is recommended.

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