Climate Change, Land Cover Change, Wildlife Diversity and Vulnerability in Gashaka Gumti National Park, Nigeria

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Abstract

The focus of this study was to establish whether Gashaka Gumti National Park is experiencing climate change and land cover change and how this may be influencing wildlife diversity and vulnerability. Temperature data was obtained from Nigeria Meteorological Agency, data on land cover change was adapted from Kwesaba, Daniel, Delphine and Benjamin(2023) while diversity and vulnerability status of the park was obtained from the International Union for Conservation of Nature (IUCN, 2008). Analysis of time series was used to present the trend of mean annual temperature and mean annual maximum temperature between 2013 and 2023. Tables were used to present the land cover change while bar graph was used to present the distribution and hence, diversity of species by vegetation type. This was done in order to ascertain the vegetation belt that was biologically more diverse in wildlife abundance. A Table was used to present the vulnerability status of species by vegetation type. Trend line obtained revealed increasing trend for both mean annual temperature and mean annual maximum temperature. For land cover change, between 1991 and 2021, forest cover witnessed 5.61% increase while Savanna (grassland) on the other hand witnessed a decrease of 8.83%. Built-up/bare surface increased by 3.76% between 1991 and 2021 while water body decreased by 0.55% within the same period. It was also ascertained that majority (42.7%) of wildlife species were found in the savannah vegetation belt while only 1.8% were found in the Montane grassland. It was also observed that vulnerability of wildlife species in the park was highest in the savannah (grassland) vegetation. However, more studies will and should be carried *out to increase our knowledge on the link between climate change, land cover change and species diversity and vulnerability in GGNP.*

Key words: Climate Change, Land Cover Change, Wildlife, Diversity, Vulnerability, Vegetation type, GGNP

Introduction

Global warming refer to the observed century-scale rise in the average temperature of the Earth's climate system while climate change is observed century-scale rise in the average temperature of the Earth's climate system and its related effects (IPCC AR4 SYR, 2007; IPCC AR4 WG1, 2 and 3, 2007). The Earth’s climate is vastly different now from what it was 100 million years ago when dinosaurs roamed the planet and tropical plants thrived closer to the poles. However, the Earth’s climate will surely continue to change. Climatic changes in the distant past were driven by natural causes, such as variations in the Earth’s orbit or carbon dioxide (CO_2) content of the atmosphere (Schneider and Root, 2002). Over the past 100 years, the global average temperature has increased by approximately 0.6^0C and is projected to continue to rise at a rapid rate. (Houghton et al., 2001).

Climate change may be a major threat to biodiversity in the next 100 years. Although there has been important work on mechanisms of decline in some species, it generally remains unclear which changes in climate actually cause extinctions of species, and how many species will likely be lost (Roman-Palacios and Wiens 2020). Accurately predicting biodiversity loss from climate change may require a more detailed understanding of what aspects of climate change cause extinctions.

Climate change has become a widespread problem in recent years. It is one of the most important global environmental challenges affecting all the natural ecosystems of the world. Various parameters such as increased CO_2 levels, faster glacier melts, and rainfall variability and severe drought have been associated with climate change. Biodiversity is influenced by climate change in different ways including shifts in ranges, changes in relative abundance within species ranges, and subtler changes in activity timing and microhabitat use (Kour et. al., 2024).

It is widely accepted that global warming presents an extremely pervasive suite of threats to the planet's biodiversity, especially given its potential to affect "undeveloped" areas far from human habitation (Malcolm et al. 2006). The direct and indirect effects of climate change on ecological systems are already causing major poleward and elevational shifts in the geographic range distributions of plants and animals (Parmesan and Yohe 2003). This redistribution of species, communities, and habitats across the landscape may make it difficult for National Parks and other protected areas to meet their mandate of protecting current biodiversity. Climate change is a critical factor affecting biodiversity.

Thus, climate change is a critical factor affecting biodiversity. However, the quantitative relation-ship between temperature change and extinction is unclear. Here, we analyze magnitudes and rates of temperature change and extinction rates of marine fossils through the past 450 million years (Myr). The results show that both the rate and magnitude of temperature change are significantly positively correlated with the extinction rate of marine animals (Song et al., 2021).

Land cover originally referred to the kind and state of vegetation, such as forest and grass cover, but it has broadened in subsequent usage to include other aspects of the natural environment such as soil type, biodiversity as well as surface and groundwater (Turner, 2002). Land cover change has been described as the most hit by anthropogenic disturbance in the environment (Umar, 2019). In essence, both land use and land cover changes are products of prevailing interacting natural and anthropogenic processes by human activities. Land use and land cover change and land degradation are driven by the same set of proximate and underlying factors central to environmental processes (Tiwari & Saxena, 2011).

The growing concern for natural resource management in recent times has been necessitated by increasing demographic pressures and their associated man-made activities, which have resulted in serious environmental stress and ecological instability. Over the last 300 years, the effects of land use and land cover change have grown from significant to dangerous proportions (Briassoulis, 1999). Humans, not natural agents, are expected to cause these changes and to be responsible for their magnitude and severity. Of course, because of the high propensity of population growth and subsequent resource over-exploitation, these changes have been found to be more profound in developing countries (Umar, 2019).

The consequences of these environmental issues are severe, both in the short and long term. Food security, human and wildlife vulnerability, health and safety are all at risk in the short term, while the earth's viability is jeopardized in the long term (Sagan et al., 1999). Concerns about land cover change emerged on the global environmental change research agenda several decades ago, with the realization that land surface processes influence climate (Wolters et al., 2000).

Land use and land cover dynamics must be studied in order to investigate the various ecological and developmental consequences of land use change over time. This makes land use and land cover mapping, as well as change detection relevant inputs into decision-making for implementing appropriate policy res- ponses. Change detection, as defined by Singh (1999), is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Land use and landcover change detection allows for the identification of major change processes and, by extension, the characterization of land use dynamics.

Gashaka Gumti National Park (GGNP) is Nigeria's largest national park (Gloomme news, 2021). This area is important not only as a major watershed but also as a haven for a rich and exotic assemblage of wildlife. The National Park is located in a mountainous region of North-east Nigeria adjacent to the international border with Cameroon, and immediately to the North of the Mambilla plateau. Gashaka-Gumti National Park was created by Federal Decree in 1991 by the merging of Gashaka Game Reserve with Gumti Game Reserve.

The park provides wide range of services as its visitors are able to enjoy lush forests, wide sweeping grasslands, cool highland plateaus, rugged moody mountains, abundant wildlife, and fascinating ethnic cultures, all combined within a single protected area. There are few other places in the world that contain such spectacular scenery and such diverse wildlife (Gloomme News, 2021). The hidden corner of West Africa that is Gashaka-Gumti National Park is surely one of the continent's best kept secrets.

Covering an area of wilderness greater than 6,600km^2, the park is one of Nigeria's and Africa's conservation and protected area that is increasingly being recognized as "a biodiversity hotspot" (Sommer and Rose, 2011). It is the sheer variety of different habitats within Gashaka-Gumti National Park that makes the area so uniquely rich in wildlife. Gloomme News (2021) observed that, the park is actually an intricate mosaic of montane grasslands, savannah woodlands, swamps, lakes, mighty rivers, dark lowland rainforests, and luxuriant, montane rainforests strewn with ferns and orchids. Each habitat supports its own distinctive community of plants and animals.

Most studies carried out in the park link species extinction in the park to mainly poaching activities (Tagowa and Buba, 2012; Mohammed et al., 2013; Kanati, et al., 2020). A document from the park (GGNP, 2021) on wildlife status according to the International Union for the Conservation of Nature (IUCN) reported that Elephant, Lion and Giant Eland, rare species of wildlife have gone into extinction from the park and many others are classified as endangered.

Panetta, Stanton and Harte, (2018), in their study conducted on five plots of Rocky Mountains of Colorado reported that climate warming can cause local extinction. Also, Roman-Palacios and

Wiens (2020), in their study find that the absolute increases in hottest temperatures during the year are most strongly associated with local extinction. They however observed that the survival of most species may be hinged on their ability to tolerate warmer conditions by shifting their climatic niches. Thus, numerous studies have now documented shifts in species geographic ranges that are potentially related to climate change (Root et al., 2003; Parmesan and Yohe, 2003; Moritz et al., 2008; Lenior and Svenning, 2014).

In spite of the aforementioned points, to the best of our knowledge, studies carried out in GGNP were only able to establish poaching as the main driver of wildlife extinction. Therefore, this study seeks to establish with the available data, evidence of temperature rise which is one of the indicators of climate change and the disappearance of wildlife species on one hand and the existence of land cover change in GGNP, Nigeria. To achieve this, the following questions were addressed:

1. What is the mean annual temperature trend in GGNP from 2010 to 2018?
2. What is the extent of Land Cover Change in GGNP between 1991 and 2021?
3. Which vegetation belt is biologically more diverse in wildlife abundance within GGNP?
4. What is the vulnerability level of wildlife in the different vegetation belts within GGNP?

Study Area

Nigeria's Gashaka Gumti National Park (GGNP) lies in southern Taraba State in Nigeria directly bordering Cameroon. It is located between Latitudes 07^{o} 56' – 07^{o} 59' N and Longitudes 11^{o} 48' – 11^{o} 54' E). The Gumti section of the park is in Adamawa State while the Gashaka section is in Taraba State (Akinsoji et al., 2016). Created in 1991, the park covers 6,731km^2, which makes it the largest of Nigeria's 7 national parks (Dunn, 1999; Adanu et. al. 2011). The park's northern sector is named after the village of Gumti and stretches far into neighboring Adamawa state.

The Gumti sector is a flat biome of grassland with small trees, and was until recently home to iconic savannah fauna such as elephant (*Loxodonta africana*), spotted hyena (*Crocuta crocuta*), wild dog (*Lycaonpictus*), lion (*Panthera leo*), roan antelope (*Hippotragus equinus*) and giant eland (*Taurotragus derbianus*). The southern Gashaka sector is named after the small village of Gashaka, once politically important during the 19th century Islamization of this part of sub-Saharan Africa. The mountainous Gashaka sector includes lowland (< 825 m), sub-montane and montane (>1650m) strata, rising to 2,419m at Gangirwal, the "Mountain of Death", Nigeria's highest peak on the Chappal Waddi escarpment (Gumnior and Sommer, 2012). The major occupations of individuals in communities within GGNP are farming, livestock husbandry, vocational jobs, civil service with few hunters and fishermen. There are four main vegetation zones

1. **Lowland Forest**; This occur mainly as gallery forest which are often found as blocks along many of the park's rivers valley, gradually merging into montane forest at higher altitudes. Gallery forests are important reservoirs for biodiversity, providing both forest and forest edge habitat.
2. **Montane Rainforest**; Lowland forest is gradually replaced by montane forest with altitude. The park's montane forests contain species more typical of semi deciduous forests that indicates the forest relative dryness. Much of this forest occur as small gallery forest that is very fragile and is susceptible to disturbance, especially by burning of the surrounding grassland
3. **Montane Grassland**; This occur at altitudes of about 1.300m above sea level. This habitat has been created over time by frequent burning of the plateau areas.
4. **Woodland Savannah**; Savanna woodland dominates most of the area of Gashaka Gumti. Two main types occur, namely southern Guinea savanna woodland that occurs in the southern part and the northern guinea savanna found in the drier northern sector of the park.

Methodology

Analysis of time series was used to present the original trend and trend lines of temperature in GGNP between 1993 and 2023. This trend in the time series was identified using a linear trend line equation calculated as follow:

$y = mx + b$

Where:

m and b are constants

x- independent variable (Time)

y- dependent variable (Temperature)

Figure 1: Location of Gashaka Gumti National Park, Nigeria

Source: Gashaka Primate Project (GPP) /Maren Gumnior; from Sommer and Ross (2011).

Bar graph was used to present the distribution of species by vegetation type. This was done in order to present the vegetation belt that is biologically more diverse in wildlife abundance than the other vegetation belts within GGNP. A Table (Table 3) was used to present the vulnerability status of species by their vegetation type as advanced by the International Union for Conservation of Nature (IUCN). Finally, to corroborate on the findings of this present study, secondary data on the land use land cover classification of the study area was adapted from the findings of Kwesaba, Daniel, Delphine and Benjamin (2023) as presented on Tables 2 and 3.

Results and Discussion

Trend in Mean Annual Temperature in GGNP between 1993 and 2023

Figure 2 below presents the original trends and trend line representing the mean annual temperature of GGNP between 1993 and 2023.

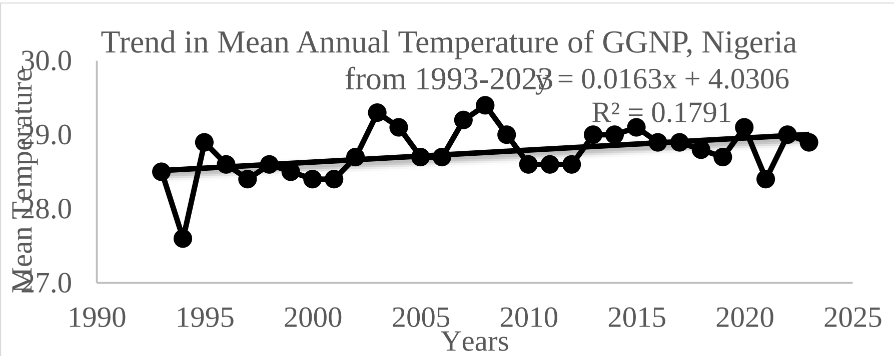

Figure 2: Trend in mean annual Temperature of GGNP between 2013 and 2023

Source: Nigeria Meteorological Agency, 2024

From Figure 2 presented above, the mean annual temperature for the study area is 28.8^{0}C. The years that experienced the highest and lowest mean annual temperatures were 1994 with 27.6^{0}C and 2008 with 29.4^{0}C. The trend line revealed a general increase in mean annual temperature in GGNP signifying that climate change is occurring in the study area.

Trend in Mean Annual Maximum Temperature in GGNP between 1993 and 2023

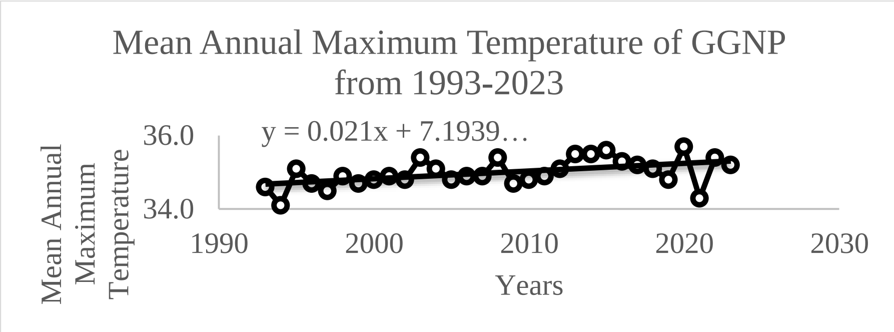

Figure 3: Trend in Mean Annual Maximum Temperature of GGNP between 2013 and 2023
Source: Nigeria Meteorological Agency, 2024

From Figure 3 presented above, the mean annual maximum temperature for the study area is 35.0^0C. The years that experienced the highest and lowest mean annual maximum temperatures were 1994 with 34.1^0C and 2020 with 35.7^0C. The trend line revealed a general increase in mean annual maximum temperature in GGNP. Thus, both the mean annual temperature and mean annual maximum temperature of the study indicate the occurrence of climate change in the study area.

The main consequences of climate change as predicted by most of the existing climate models are an increase in global temperatures, complex precipitation patterns and sea level rise. Thus, the trend of temperature in GGNP is in agreement with IPCC (2007). The Intergovernmental Panel on Climate Change (IPCC) which includes more than 1,300 scientists from the United States and other countries forecasts a temperature rise of 0.76 to 3.0^0C over the next century (IPCC, 2013).

Root, Price, Hall, Schneider, Rosenzweig and Pounds (2003) conducted a study on “fingerprints of global warming on wild animals and plants” from 143 studies using meta analyses. Their analyses revealed a consistent temperature-related shift in species ranging from molluscs to mammals and from grasses to trees. They found that more than 80% of species that show changes are shifting in the direction expected on the basis of known physiological constraints of species. The study also revealed that a significant impact of global warming is already discernible in animal and plant populations. Therefore, they concluded that the synergism of rapid temperature rise and other stresses, in particular habitat destruction, could easily destroy the connectedness among species and lead to a reformulation of species communities, reflecting differential changes in species, and to numerous extirpations and possibly extinctions.

The impacts of temperature may also be more indirect, but still related to physiological tolerances. In spiny lizards for example, local extinctions seem to occur because higher temperatures restrict surface activity during the spring breeding season to a daily time window that is overly short. In aquatic organisms, increased water temperatures may lead to increased metabolic demand for oxygen while reducing the oxygen content of the water (Portner and Knust 2007). Deutsch et al. (2008) and Somero, (2010) found out that factors causing extinction are temperatures that exceeds the physiological tolerance of species. Kearney, Shine and Porter (2009) also observed that increase in temperature may decrease both activity time and increase energy maintenance cost in organisms, leading organisms to die from starvation rather than from overheating.

Similarly**,** Panetta, Stanton and Harte (2018) conducted a study on the Rocky Mountains of Colorado with the major theme “climate change drives local extinction: evidence from observation and experimentation”. They coupled 25 years of situ climate manipulation with experimental seed introductions to identify the causal, mechanistic links between climate change and the local extinction of widespread mountain plant (*androsace septentrionallis*). Their findings revealed that climate warming causes precipitous declines in population size by reducing fecundity and survival across multiple life stages.

Roman-Palacios and Wiens (2020) in “recent responses to climate change” reveal the drivers of species extinction and survival" seek to identify the specific changes in climate that are associated with the widespread local extinctions that have already occurred. They used information from surveys of 538 plant and animal species to predict the extent of future biodiversity loss and to identify which processes may forestall extinction. They found that 44% of these species have already had local extinctions at one or more sites. They also found that locations with local extinctions had larger and faster changes in hottest yearly temperatures (maximum annual temperatures) than those without larger and faster changes in maximum annual temperatures. Sites with local extinctions also had significantly smaller changes in mean annual temperatures.

Currently, at least 20-40% of assessed species (amounting to a minimum of 12,000-24,000 species) are possibly at increased risk of extinction if mean global temperature increases between 1.5-2.5ºC (IPCC, 2007). This means that increases in temperatures have the ability to increase the effects of climate change in an area. Thus, increasing temperature has an effect (direct or indirect) on the survival of wildlife of which GGNP is no exception.

Land use land cover classification of GGNP between 1991 and 2021

The result in Table 1 shows the rate of change in land cover for a period of 30years (1991-2021).

Table 3: Species Vulnerability by Vegetation Type

LULC Class	(Square Km)	Percentage (%)
	1991	
Forest cover	3269.76	48.58
Grassland/Shrub	3269.04	48.57
Built up Area/Bare surface	137.82	2.05
Water body/wetland	54.36	0.81
Total	**6731.00**	**100.0**
	2001	

Forest cover	3212.63	47.73
Grassland/Shrub	3312.90	49.22
Built up Area/Bare surface	197.62	2.94
Water body/wetland	7.85	0.12
Total	**6731.00**	**100.0**
	2011	
Forest cover	3444.60	51.18
Grassland/Shrub	3158.40	46.92
Built up Area/Bare surface	94.35	1.40
Water body/wetland	33.66	0.50
Total	**6731.00**	**100.00**
Forest cover	**2021**	
Grassland/Shrub	3647.61	54.19
Built up Area/Bare	2674.96	39.74
surface	390.93	5.81
Water body/wetland		
Total	17.50	0.26
	6731.00	100.00

Source: Author's Analysis, 2022

From the Table 1 above, forest cover witnessed 5.61% increase from 1991 to 2021. Grassland/shrub on the other hand, witnessed a decrease of 8.83% between 1991 and 2021. Built-up/bare surface increased by 3.76% between 1991 and 2021 while Water body decreased by 0.55% within the same period.

Between 1991 and 2021, forest cover gained a total of 377.83 km^2 (5.61%); the gain in forest cover could be as a result of regeneration of the cleared forest or development of some shrub areas into forest. It could also be as a result of stability in the forest cover due to effective management and control by the Park managers. With this positive result, it shows the Park is achieving its mandate in this regard. Grassland/Shrubs on the other hand, lost about 594.08 km^2, (8.83%) to either forest or Built-up/Bare surface. The loss in Grassland/Shrub could be attributed to regeneration and development of shrubs into forest as earlier observed. This development reduces Grass land/Shrub to the advantage of Forest land. The loss to forest land may be regarded as a positive development as against the one lost to Built-up/bare surface which gained 253.11 km^2 (3.76%). The gain in built-up/bare surface could be as a result of settlement expansion or economic activities of the enclaves. Water body/wetland also suffered loss be- tween 1991 and 2021. The reason for this is as a result of settlement expansion and other anthropogenic activities of the enclave dwellers (Kwesaba, Daniel, Delphine and Benjamin, 2023).

This finding is in agreement with Umar, Yaduma, Dishan and daeze (2019) who in their study in GGNP, found out that in 1991, Guinea and derived Savanna covered 4848.86km^2 of the GGNP. By 2011, it had reduced by 327.24 km^2 and now covered 4521.62 km^2. Montane and gallery forest that together covered 1882.19 km^2 in 1991 increased by 327.19 and now covered 2209.38 km^2 by 2011.

Species Abundance and Vulnerability Due to Habitat Loss

Habitat destruction occurs when a natural habitat, such as a savannah, forest or wetland, is altered so dramatically that it no longer supports the species it originally sustained. Plant and animal populations are destroyed or displaced, leading to a loss of biodiversity (Pimm and Raven, 2000). In fact, in GGNP, between 1991 and 2021, forest cover witnessed a 5.61% increase, grassland/shrub on the other hand, witnessed a decrease of 8.83. Built-up/bare surface increased by 3.76% while water body decreased by 0.55% within the same period.

Table 2: Change in Land Cover in GGNP between 1991 and 2021.

YEAR 1991			**YEAR 2021**		
LULC Class	**Area (km^2)**	**(%)** inc/dec	**LULC Class**	**Area (km^2)**	**(%)** inc/dec
Forest Cover	3269.78	48.58	Forest Cover	3647.61	54.19
Grassland/Shrub	3269.04	48.57	Grassland/Shrub	2674.96	39.74
Built-up/Bare surface	137.82	2.05	Built-up/Bare surface	390.93	5.81

Water body	54.36	0.81	Water body	17.50	0.26
Total	**6731.00**	**100.00**	Total	**6731.00**	**100.00**

Source: Author's compilation (2022)

The results on Table 2 above shows the rate of change in land cover for a period of 30 years (1991-2021). Forest cover witnessed a 5.61% increase from 3269.78km^2 to 3647.61 km^2 between 1991 and 2021. Grassland/shrub on the other hand, witnessed a decrease of 8.83% from 3269.04km^2 to 2674km^2 between 1991 and 2021. Built-up/bare surface increased by 3.76% from 137.82km^2 to 390.93km^2 between 1991 and 2021 while Water body decreased by 0.55% from 54.36km^2 to 17.50 km^2 within the same period.

Deutsch et al. (2008) and Somero, (2010) reported in their finding that factors causing extinction are temperatures that exceeds the physiological tolerance of species. Kearney, Shine and Porter (2009) also observed that increase in temperature may both decrease activity time and increase energy maintenance cost in organisms, leading organisms to die from starvation rather than from overheating.

Furthermore, biodiversity is declining at an unprecedented rate (Ceballos et al., 2015) due to long-term human-induced land-use causing habitat loss and deterioration (IPBES, 2019, Semenchuk et al., 2022) and increasingly also because of impacts of climate change (Arneth et al., 2020, Román-Palacios and Wiens, 2020). Jointly, the impacts of habitat decline and climate change may become a leading 'driver duo' for biodiversity loss (IPBES, 2019, Northrup et al., 2019). Climate change necessitates populations to adjust in place or shift in space (Thurman et al., 2020) but habitat loss and deterioration reduces the potential for such responses (Oliver et al., 2017). Assessing the relative importance of land-use and climate change is important, although noticeably challenging because their effects are often intermingled (Nunez and Alkemade, 2021). Specifically for threatened species, increasing our understanding of the roles of these two drivers would help allocating conservation measures more effectively, as conservation efforts may be diluted if climate change makes original habitats unsuitable (Bellis et al., 2020).

Species abundance by vegetation type due to habitat loss Figure 4 below present the distribution of species by vegetation type. This will present the vegetation belt that is biologically more diverse in wildlife abundance than the other vegetation belts within GGNP.

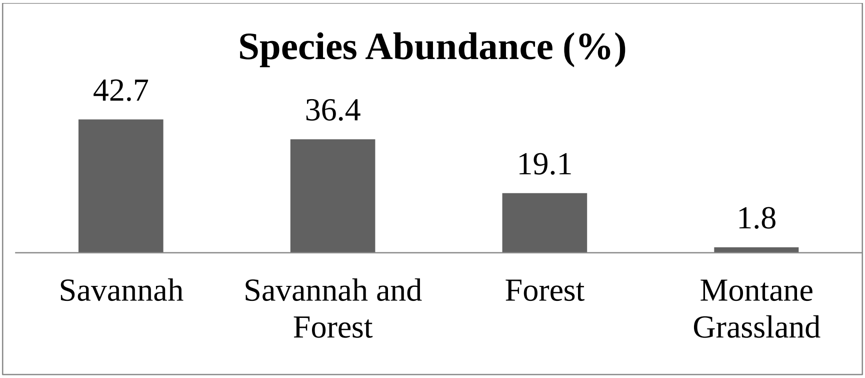

Figure 4: Species Abundance by Vegetation Type
Source: GGNP (2022)

In Figure 4 above, the distribution of species abundance by vegetation type was presented. It shows that majority (42.7%) of wildlife species are found in the savannah vegetation belt while only 1.8% is found in the Montane grassland. What this suggests is that the savannah vegetation belt is biologically more diverse in wildlife abundance than any other vegetation belt in GGNP. The forest vegetation also harbors a large amount of wildlife. Thus, it plays a complimentary role to the savannah vegetation. This is supported by the findings of this research which shows that the percentage of wildlife that shuttles between Savannah and Forest is only second to Savannah (only) that recorded 42.7% of species abundance by vegetation type. However, the rate of change in land cover for a period of 30years (1991-2021) in GGNP shows that habitat loss is being experienced as the Savanna vegetation belt and grassland are actually reducing in size which will certainly threaten species abundance/diversity. Water bodies which provide water are also decreasing. Built up areas and bare surfaces are also increasing which will definitely threaten biodiversity.

Thus, the finding of this study is in agreement with Pimm and Raven (2000) who reported that habitat destruction is considered the most important driver of species extinction worldwide. Therefore, by extension, habitat destruction to a large extent determines specie abundance and vulnerability. The finding of the present study is also supported by Myers et al. (2000) who stated that some regions of the Earth are far more affected by habitat destruction than others. Among the most imperiled are the so-called "biodiversity hotspots", which contain high species diversity, many locally endemic species (those whose entire geographic range is confined to a small area), and which have lost at least 70% of their native vegetation. Many hotspots are in the tropics. The Atlantic forests of Brazil and rainforests of West Africa, both of which have been severely reduced and degraded, are examples of biodiversity hotspots.

The finding of the present study also emphasized the position of Laurance et al. (2002) and Sekercioglu et al. (2002) who found out that few habitats are destroyed entirely. Very often, habitats are reduced in extent and simultaneously fragmented, leaving small pieces of original habitat persisting like islands in a sea of degraded land. In addition to habitat loss, habitat fragmentation is a grave threat to species survival.

The finding of the present study is also supported by Klink and Machado (2005) and Millennium Ecosystem Assessment (MEA, 2005) who in their study, reported that grasslands have not fared as badly as some other biomes even though certain regions have suffered very heavily. In South America for instance, more than half of the biologically-rich Savannas, which formerly spanned over 2 million km^2, have been converted into soy fields and cattle pastures in recent decades, and rates of loss remain very high (Klink and Machado 2005). In addition to that, only less than 3% of the tall grass Prairies of North America has survived with the remainder having been converted to farmland. In southern Africa, large expanses of dryland are being progressively desertified from overgrazing by livestock (MEA 2005).

The finding of the present study is supported by Millennium Ecosystem Assessment (MEA, 2005) who stated that the global area of forests has been reduced by roughly half over the past three centuries. Twenty-five nations have lost virtually all of their forest cover and another 29, more than nine-tenths of their forest (MEA 2005). Tropical forests are disappearing at up to 130 000km^2 a year (roughly 50 football fields a minute). Other ecosystems are less imperiled, and a few are even recovering somewhat following past centuries of overexploitation.

Finally, the findings of this present study on species abundance by vegetation type due to habitat loss cannot be unconnected to and therefore, in agreement with the finding of Kwesaba, Daniel, Delphine and Benjamin (2023) which showed that habitat loss is being experienced in GGNP as forest cover here witnessed a 5.61% increase from 3269.78km^2 to 3647.61 km^2 between 1991 and 2021. Grassland/shrub on the other hand, witnessed a decrease of 8.83% from 3269.04km^2 to 2674km^2 between 1991 and 2021. Built-up/bare surface increased by 3.76% from 137.82km^2 to 390.93km^2 between 1991 and 2021 while water body decreased by 0.55% from 54.36km^2 to 17.50 km^2 within the same period.

Vulnerability of Species by Vegetation Type due to habitat loss

Vulnerability of species by their vegetation type was presented in Table 1 with different vulnerability status as advanced by the IUCN.

Table 3: Species Vulnerability by Vegetation Type

Vulnerability	**Vegetation type**	**Frequency**	**Percentage (%)**
	Savannah	03	100
	Forest	-	-
Extinct (Disappeared)	Both (Savannah and Forest)	-	-
	Montane grassland	-	-
	Total	**03**	**100**
	Savannah	06	60
	Forest	03	30
Endangered	Both (Savannah and Forest)	01	10
		-	-
	Montane grassland	10	100
	Total		
	Savannah	17	54.83
Rare	Forest	05	16.13
	Both (Savannah and Forest)	08	25.81
	Mountain grassland	01	3.23
	Total	**31**	**100**
	Savannah	22	32.8
Common/ Abundant	Forest	13	19.4
	Both (Savannah and Forest)	31	46.3

	Mountain grassland	01	1.5
	Total	**67**	**100**

Source: Author's Analysis, 2022

From Table 3 above, hundred (100) percent of all the wildlife species that has gone into extinction or that has disappeared from the park were all in the savannah vegetation belt. Table 1 also revealed species that are currently classified as endangered species. Sixty (60) percent of endangered species are found in the savannah vegetation belt while ten (10) percent of the endangered species representing those species that shuttle between the savannah and forest vegetation. Analysis on rare wildlife in the park showed that about 54.8% of rare species live in the savannah while only 3.2% of rare species are found in the Montane grassland. Majority (46.3%) of abundant or commonly found species in the park are those that shuttle between the Savannah and Forest vegetation. Only 1.5% of the species have as their habitat the Montane grassland.

What these findings indicate is that vulnerability level of wildlife species is high in the savannah vegetation belt than any other vegetation belt in the park. These findings is in tandem with that of Klink and Machado (2005) who observed that conversion of savannah fields in South America into Soy farms has increased the rate of wildlife loss in the savannah region. Jetz et al. (2007) found that species go extinct when they no longer have any suitable habitat. What this suggests is that, there may be reduction in the land area of the savannah vegetation in the park that is leading to increased vulnerability of wildlife species in the park.

In fact, the rate of change in land cover for a period of 30 years (1991-2021) in GGNP shows that habitat loss is being experienced as the Savanna vegetation belt and grassland are actually reducing in size which will certainly threaten species abundance/diversity. Water bodies which provide water are also decreasing. Built up areas and bare surfaces are also increasing which will definitely threaten biodiversity (Kwesaba, Daniel, Delphine and Benjamin, 2023).

Conclusion

The study was able to address questions raised by the researchers. Major findings in the study suggest that temperature showed an increasing trend in GGNP between 1993 and 2023 while land cover undoubtedly changed. These may not be unconnected with the loss of habitat on the part of wildlife species that were commonly found in GGNP in the past. Findings of the present study prompted the researchers to conclude that reduction in species abundance and increase in species vulnerability in GGNP cannot be unconnected with climate change and land cover change. These are the likely causes of the level of vulnerability observed in GGNP according to the IUCN (2016) vulnerability status rating.

Although, there is relatively limited evidence of current extinctions caused by climate change, studies suggest that climate change could surpass habitat destruction as the greatest global threat to biodiversity over the next several decades (Leadley *et al.* 2010).

Recommendation

Thus, more studies will and should be carried out to establish a link between climate change and species diversity and vulnerability in GGNP. This will be made possible by continuous and prompt collection and storage of data by the relevant authorities concerned. In addition to land-use and climate change, topographic heterogeneity deserve attention as it may buffer the effects of climate change by providing a wider range of patches of suitable microclimate for species to persist (Suggitt et al., 2018).

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