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# DETERMINATION OF THE RELATIONSHIP BETWEEN BIODIVERSITY AND ECOSYSTEM STABILITY IN GASHSKA GUMTI NATIONAL PARK, NIGERIA

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**ABSTRACT**

*This study was carried out to establish the relationship between biodiversity and ecosystem stability in Gashaka Gumti National Park between 1991 and 2021. To ascertain the flora richness and abundance in the study area for the period under study, LandSat data of years 1991, 2001, 2011 and 2021 were obtained from the United States Geological Survey online resource. In a similar vein, fauna richness and abundance data were obtained from the archival records for the same interval of years. They were obtained from the Park's Head Office in Baruwa, Taraba State, Nigeria. Pearson Product Correlation Analysis was used to determine the relationship between the variables. The result shows a negative relationship between the two determining variables in ecosystem stability.*

**Keywords:** Relationship, Biodiversity, Ecosystem stability and Flora and Fauna

## INTRODUCTION

Ecosystem, according to New England Complex System Institute (2011), is a community of organisms and their physical environment. The notion of an ecosystem recognizes the many ways that an organism interacts with and depends on various parts of its environment. The ecosystem idea generalizes the "food chain" and "food web" concepts, allowing for more relationships than just consumption. For example, plants provide not just food for animals but also shelter, shade, moisture, etc.

An ecosystem consists of the biological community that occurs in some locale, and the physical and chemical factors that make up its non-living or abiotic environment (Whiteman, 2017). Examples of ecosystem, according to Whiteman (2017) include: pond, forest, estuary and grassland. The boundaries are not fixed in any way, although sometimes they seem obvious, as with the shoreline of a small pond. Usually the boundaries of an ecosystem are chosen for practical reasons having to do with the goals of the particular study

Diversity within functional groups maintains the rate of ecosystem processes despite environmental fluctuations. Many experimental studies demonstrated that the higher the number of species within an ecosystem, the higher is the likelihood that many ecological functions occur, and this stabilizes the ecosystem. In addition to this, if the ecological functions of different species overlap (a process known as redundancy), even if a species is removed, the ecological function may persist because of the functional compensation of other species with similar functions; also, functional diversity enables an ecosystem to persist. The loss of redundancy, or further species removal due to disturbance, decreases the ecosystem ability to withstand disturbance, thus eroding its resilience. Since most ecological function resides in certain critical functional groups and functional important species, such as keystone species and ecosystem engineers, their presence or absence may determine the aptitude to reinforce ecosystem resilience. Keystone species are defined as strongly interacting species that have a large impact on their ecosystems relative to their abundance, while ecosystem engineers are species that, with their growth, are able to change the feature of the habitat where they live, such as hard corals. The ecological resilience is thus

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generated by diverse, but overlapping functions within a scale and by apparently redundant species that operate at different spatial scales. The species diversity and the species redundancy may hence be empirical measures of ecological resilience (Mitchell, 2014). However, these measures respond slowly to change as they require species to go locally extinct. Alternatively, the relative abundance (or evenness) of species can provide constructive information on ecosystem resilience that responds rapidly to some affectors, such as overfishing, hurricanes, elevated seawater temperature, etc.

Species play essential roles in ecosystems, so local and global species losses could threaten the stability of the ecosystem services on which humans depend (McCann, 2000). For example, plant species harness the energy of the sun to fix carbon through photosynthesis, and this essential biological process provides the base of the food chain for myriad animal consumers. At the ecosystem level, the total growth of all plant species is termed primary production, communities composed of different numbers and combinations of plant species can have very different rates of primary production. This fundamental metric of ecosystem function has relevance for global food supply and for rates of climate change because primary production reflects the rate at which carbon dioxide (a greenhouse gas) is removed from the atmosphere. (Kothari, 2018).

According to Kothari (2018), species diversity has two (2) primary components: species richness (the number of species in a local community) and species composition (the identity of the species present in a community). It is variation in species composition that provides the mechanistic basis to explain the relationship between species richness and ecosystem functioning. Species differ from one another in their resource use, environmental tolerances, and interactions with other species, such that species composition has a major influence on ecosystem stability.

A positive relationship between diversity and ecosystem stability has been mostly demonstrated in man-made and regularly mowed grassland ecosystems (Craven *et al.*, 2018) and therefore its applicability to natural plant communities has been questioned. Whether the processes in experimental or semi-natural grasslands can be extrapolated to predict the consequences of biodiversity change in natural habitats such as diverse temperate and tropical forests subjected to many, often conflicting forces including stochastic disturbances and complex biotic interactions, remain unclear (Paquette and Messier, 2011).

Plant communities can be more stable in time because of various mechanisms directly or indirectly related to species interactions and abilities of subordinate species to either avoid or tolerate competitive pressure from dominant species, especially in productive ecosystems where intense, asymmetric competition for light prevails (del Rio *et al*., 2017). Subordinate species can avoid competitive exclusion to support ecosystem functioning and stability through spatio-temporal niche heterogeneity resulting in species niche segregation. Coexisting subordinates and dominants can have spatially segregated regeneration niches or modified resource acquisition timing due to different phenologies (Dolezal *et al.*, 2019), both leading to spatio-temporal asynchrony in biomass peaks, which in turn bring about higher community stability and diversity.

Avoiding competitive exclusion through niche segregation is one possible mechanism enhancing stability in more diverse communities (Wang *et al*., 2017). Another plausible mechanism is related to species abilities to tolerate different levels of competition. Because most coexisting species in natural communities are perennial

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plants, their competitive exclusion is often a slow process, and eventually can be delayed or even completely avoided (Leps, 2014). Dominant species can suppress subordinate species but their competitive effects are usually not constant over time (Dolezal *et al.*, 2019) but decrease with plant senescence and environmental stress imposed by weather fluctuation and variable disturbance impacts across years. Subordinates then profit from reduced competition with increased growth and biomass production (Yuan *et al*., 2019). These interactions among coexisting species can be translated into negative correlation of biomass production, where a decrease in production of one species is compensated for by an increase of another species.
The effects of species richness and species asynchrony on ecosystem stability can be both related to differential growth and survival strategies of interacting species, and tradeoffs between their competitive strength and resistance to adverse environmental conditions (Grime and Pierce, 2012). Dominant species with traits corresponding to conservative resource use strategy (e.g. slow growth, high longevity, smaller fecundities) often fluctuate less (Majekova *et al*., 2014), while short-lived species with high potential growth rate exhibit high temporal variability. However, tall dominants are often less resistant to disturbances or climate extremes and lose disproportionally more biomass than short-statured subordinates whose faster regrowth (i.e. higher resilience) may compensate for lost biomass and ensure long-term stability in total community productivity (Yuan *et al*., 2019).
A national park is described as an area of land reserved for conservation purposes. Often it is a reserve of natural, semi-natural, or developed land that a sovereign state owns. Although individual nations designate their own national parks differently, there is a common idea which is the conservation of wild nature for posterity and as a symbol of national pride (Irish and Paul, 2011). The International Union for Conservation of Nature (IUCN) and World Commission on Protected Areas (WCPA) has defined "National Park" as category II type of protected areas. Category II here refers to a protected area with large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities. National Parks are the shelters for wild animals and plants that would otherwise be driven into extinction by the activities of humans. They are important tools for the conservation of biological diversity and are cornerstones of sustainable development strategies. They also provide protection to numerous endangered and defenseless species, protect dwindling habitats, and avail protected breeding sanctuaries in which threatened species can recover. With everyone's care and positive attitude, these essential ecosystems can be protected for the benefit of the future generations (Wright, 2018).

The national parks form the cornerstone of biodiversity conservation in Nigeria, containing vital habitat that provides safe havens in which animals and plants can survive and thrive. Together with other protected areas, they provide a ‘backbone’ of core conservation areas that can be linked by conservation efforts across different tenures, supporting a diverse, healthy and resilient environment. Gashaka Gumti National Park, since its establishment has provided protection for so many threatened species. In addition, the park provides life-sustaining services vital for the wellbeing of our environment and society, such as protection of urban water catchments and climate amelioration.

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# MATERIALS AND METHODS

## Description of the Study Area

Gashaka-Gumti National Park, the largest Park in Nigeria, covers 6,731 sq km of wilderness (Akinsoji *et al.* 2016). The Park's name was derived from two (2) of the region's oldest and most historic settlements: Gashaka village in Taraba State, and Gumti village in Adamawa State. Gashaka-Gumti National Park was created by the Federal Government of Nigeria Decree number 36 of 1991 by merging of Gashaka Game Reserve with Gumti Game Reserve. The park, like any other park in Nigeria, was established as a protected area for the purpose of nature conservation, recreation, ecotourism, scientific and medical research and to promote art, craft and cultural value of the indigenous people surrounding the park. The Northern, Gumti sector of the Park is relatively flat and covered with woodlands and grasslands, whilst the Southern, Gashaka sector is more mountainous and contains vast expanses of rainforest as well as areas of woodlands and montane grassland. This rugged terrain is characterised by steep, thickly forested slopes, deep plunging valleys, precipitous escarpments and swiftly flowing rivers. Altitude ranges from 450 metres above sea level in the wild savannah plains of the Northern sector, to the peaks and pinnacles of Gangirwal in the Southern park sector, which at a staggering 2,400 metres above sea level, represents Nigeria's highest mountain (Akinsoji *et al*., 2016).

## Location

Gashska Gumti National Park is located between latitude $7^o$ 56’ to $7^o$ 59’N and longitude $11^o$ 48' to $11^o$ 54’E. The total area of the park covers about 6,731 $km^2$. The park is located in Adamawa and Taraba States (Fig. 1). The Gumti section of the park is in Adamawa State while the Gashaka section is in Taraba State (Akinsoji *et al*., 2016).

## Relief and Drainage

The Northern, Gumti sector of the Park is relatively flat, whilst the Southern, Gashaka sector is more mountainous. This rugged terrain is characterised by steep, thickly forested slopes, deep plunging valleys, precipitous escarpments and swiftly flowing rivers. Altitude ranges from 450 metres above sea level in the plains of the Northern sector, to the peaks and pinnacles of Gangirwal (Chappal Waddi) in the Southern Park sector, which at a staggering 2,400 metres above sea level, represents Nigeria's highest mountain (Dunn, 2001; Mubi, 2010).

There is a good drainage system in Gashaka-Gumti National Park as seen in Akinsoji *et al*. (2016) and Oruonye *et al*. (2017). The park is transversed by rivers such as Mayo Kam, Mayo Yim, Mayo Kpa, Mayo Gamgam, Mayo Beriji and Mayo Burtali which serve as a home to some aquatic animals and a good source of water to the surrounding settlements.

## Geology and Soil

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Gashaka Gumti is composed of sedimentary rock. The sedimentary rocks in the region are known to be mineralized with lead (pb) and zinc zn). The pre-Cambrian Basin also is considered the "oldest, crystalline, solid foundation in the country" and contains the igneous and metamorphic rock. The sedimentary rock is found in the basins that separate the basement complex landmass. The sedimentary rock, which is the main rock type in the area, leads to erosion and weathering of landforms within the park. The mountainous region of Gashaka Gumti National Park provides an optimal landform for the local watershed.
The Gumti section has very fertile soil which supports the various agricultural activities of the enclave settlements within and around the park. Humic ferrisol and lithosols are mostly found in the higher altitudes, and ferruginous tropical soils at the lower elevations, with alluvial soils in river valleys (Akinsoji *et al*. 2016).

## Climate

The climate of Gashska-Gumti National Park is marked by rainy and dry seasons. The park has temperature range of 18$^{o}$C (64$^{o}$F) to 36$^{o}$C (96$^{o}$F) and an annual rainfall of about 1,500mm with a single rainfall maxima in September (Akinsoji *et al,* 2016). The dry season experienced in the study area begins in November and lasts till March. It is characterized by northeasterly or the harmattan wind from Sahara Desert.

With the Northward movement of the Inter-Tropical Convergence Zone (ITCZ) over West Africa, heavy showers coming from convective clouds are experienced. Early onset of rain is experienced along the coastal area in January-February, April-May in Central state and June-July in Northern parts of the country (Akinsoji *et al.* 2016). The average temperature of GGNP is 29 degrees centigrade while the humidity level of the area is at an average of 38 percent (Mubi, 2010).

**Figure 1.1: Map Nigeria Showing the Gashaka Gumti National Park**

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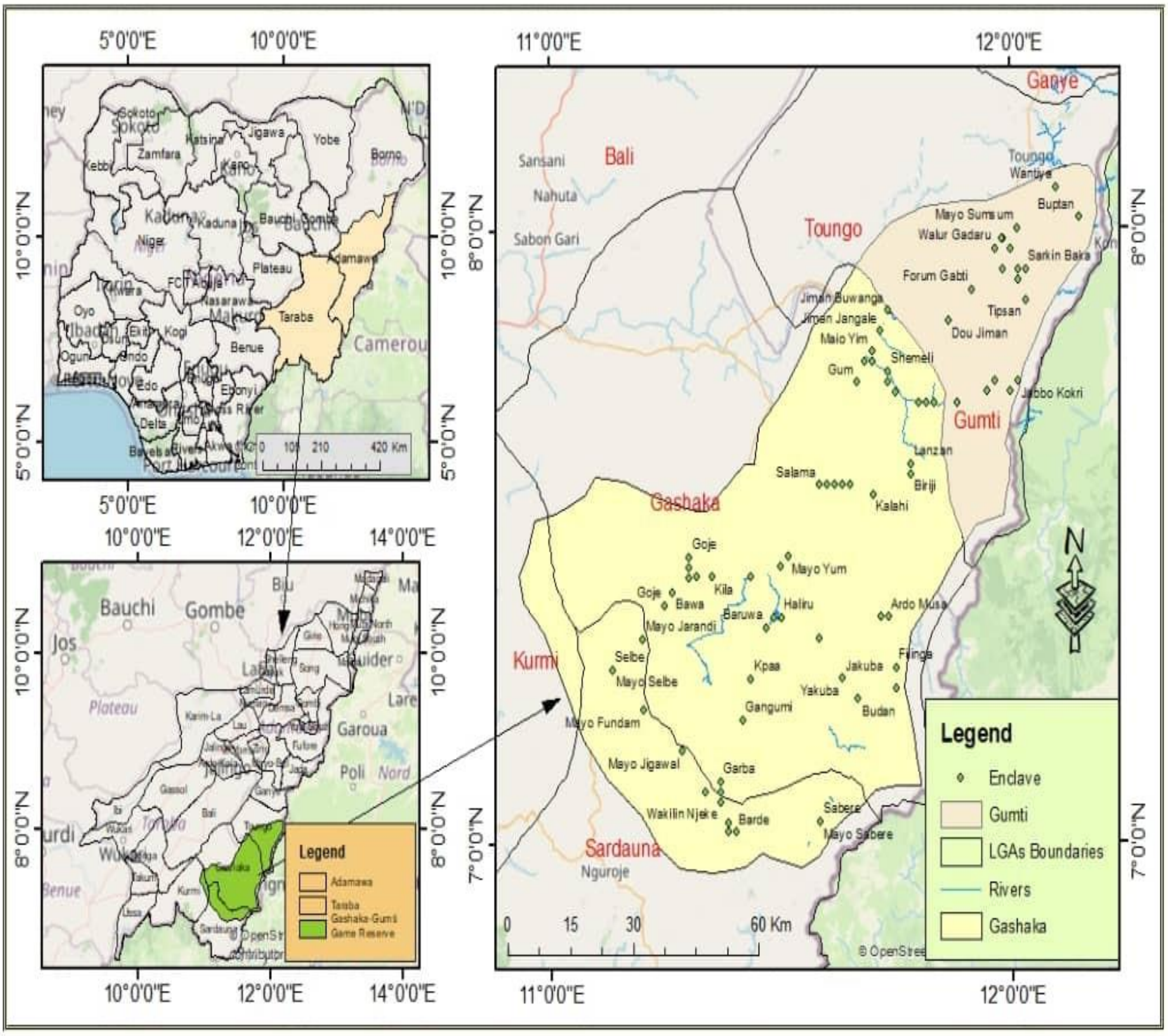


**Source: (Joshua, 2021)**

## Instrument for data collection

Landsat images of Gashaka Gumti National Park for years 1991, 2001, 2011 and 2021 were used to obtain spatial and temporal information on the study area. Remote sensing data is preferred because it is the most reliable and widely used method of acquiring spatial information on a given location. It is also the most effective instrument for environmental change detection and monitoring (Jensen, 1996; Islam *et. al.*, 2010). To acquire the data on the major fauna (mammals) found in the park, archival records of the Park were used.

## Data Needs/Source

This research work requires only secondary data to achieve the expected objectives. Temporal and spatial data are required to achieve the first aspect of the objective of

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this study.. These were acquired through Landsat images of 1991, 2001, 2011 and 2021. They were all obtained from the United States Geological Survey online resources. The images were subjected to the different satellite image processing methods before usage. The archival records of animal richness in the Park were required to achieve the second aspects of the objective of this study. . The archival data were obtained from the Park's Head Office at Baruwa, Gashaka Local Government Area, Taraba State. The records were subjected to Shannon Wiener Diversity Index analysis to determine the fauna richness and abundance within a given interval of years under study.

**Methods of Data Analysis**

**i. Satellite Image Preprocessing**

Comparative study using different Landsat data can be challenging due to the instrumental errors related to ache sensor, noise from several sources, and uncertainty in scale and geometric conditions. Preprocessing of satellite imagery before conducting image classification and change detection therefore becomes very necessary to minimize those errors and to build a more thorough association between the obtained data and biophysical features on the ground (Coppin, Jonckheere, Nackaerts, Muys and Lambin, 2004)**.** The raw Data collected were preprocessed in ERDAS imagine for band combination and sub-setting of the image on the basis of Area of Interest (AOI).

**ii. Image Classification**

Image classification was done in order to assign different spectral signatures from the LANDSAT datasets to different land use land cover. This was done on the basis of reflectance characteristics of the different land use land cover types. Different colour composites were used to improve visualization of different objects on the imagery. Infrared colour composite NIR (4), SWIR (5) and Red (3) was applied in the identification of varied levels of vegetation growth and in separating different shades of vegetation.

Other color composites such as Short Wave Infra-red (7), far Infra-red (3) and Red (3) combination which are sensitive to variations in moisture content were applied in identifying the built-up areas and bare soils. This was supplemented by a number of field visits and use of goggle earth software that made it possible to establish the main land use land cover types.

For each of the predetermined land use land cover type, training samples were selected by delineating polygons around representative sites. Spectral signatures for the respective land use land cover types derived from the satellite imagery were recorded by using the pixels enclosed by these polygons. A satisfactory spectral signature is the one ensuring that there is 'minimal confusion' among the land covers to be mapped (Gao and Liu, 2010).

Maximum Likelihood classifier algorithm with decision rule was used for supervised classification by taking 300 training sites for four major land use land cover classes in the study area. The Maximum Likelihood Classification is the most widely used per-pixel method by taking into account spectral information of land cover classes (Qian, Zhou and Hou, 2007).

**iii. Accuracy Assessment**

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This study adopted the Error Matrix approach (ERRMAT in ArcGIS) to assess the accuracy of the classification. The error matrix assesses accuracy using four parameters which include overall accuracy, user's accuracy, producer's accuracy and the Kappa Index of Agreement (KIA).

**a. Individual Class Accuracy**

Individual Class Accuracy is calculated by dividing the number of correctly classified pixels in each category by either the total number of pixels in the corresponding column; Producer's accuracy, or row; User's accuracy.

Individual class accuracy can be expressed as

$\hat{c} = \frac{p}{c}$ …. Equation [1] *for Producer's accuracy*

$\hat{c} = \frac{p}{r}$ …. Equation [2] *for User's accuracy*

Where

ꝑ = number of correctly classified pixels

c= total number of pixels in the corresponding column

r= total number of pixels in the corresponding row

**b. Overall Accuracy**

Overall accuracy is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels

Overall accuracy can be expressed as:

$\bar{A} = \frac{\sum p}{N}$ ….. Equation 1

Where

ꝑ = number of correctly classified pixels

Ŋ = Total number of points



**c. Kappa Coefficient Estimation**

Cohen's kappa statistic measures interrater reliability (sometimes called interobserver agreement). Interrater reliability, or precision, happens when your data raters (or collectors) give the same score to the same data item. The Kappa statistic varies from 0 to 1 as in table 1 below:

**Table 1: Kappa Statistics**

| **Interpretation of Kappa Statistic** | |
|---|---|
| **Kappa** | **Agreement** |
| <0.20 | Poor classification |
| 0.21-0.40 | Fair classification |
| 0.41-0.60 | Moderate classification |
| 0.61-0.80 | Good classification |
| 0.81-100 | Very Good classification |

(Alawamy *et al.*, 2020).

Theoretically, Kappa can be express as

$\check{K} = \frac{\text{Observed accuracy} - \text{Chance agreement}}{1 - \text{Chance agreement}}$ …. Equation 1

- Observed accuracy determine by sum of diagonals (points correctly mapped) in the error matrix
- Chance agreement determine by sum of product of row and column totals of each class

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Kappa coefficient can therefore be statistically expressed as

$$\check{K} = \frac{Ŋ \sum ƥ - ρ}{Ŋ^2 - ρ} \quad \ldots\ \text{Equation 2}$$

Where

Ŋ = Total number of points

ƥ = Sum of correctly classified pixels

ρ = Sum of product row and column totals of each class

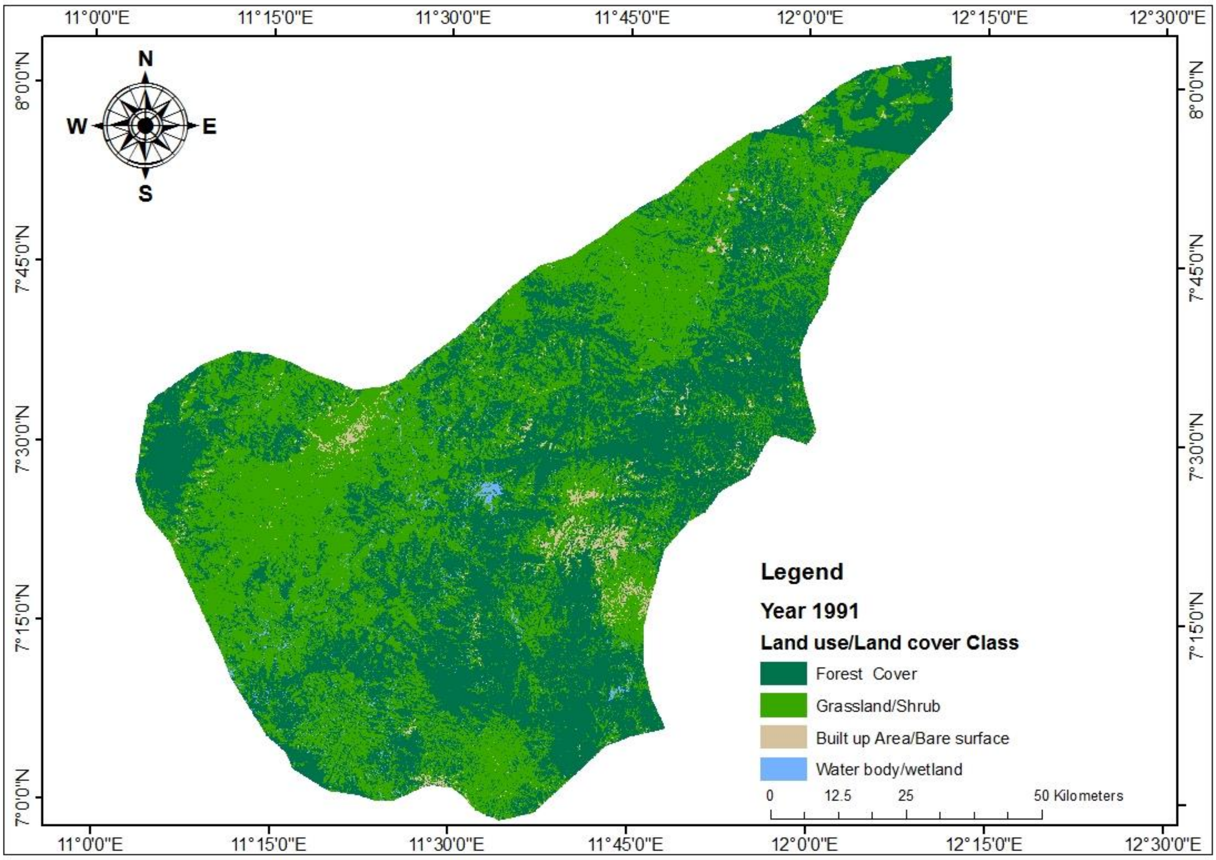
## RESULT AND DISCUSSION

### Results.

### i. Flora Richness and Abundance in GGNP

Figure 1 and table 2 show the land use land cover classification of GGNP in 1991. Out of the 6,731 square kilometer ($Km^2$) land area of the Park, the forest cover took 3, 269.78 $Km^2$ with 48.58%, followed by Grassland/Shrub 3,269.04 $Km^2$, representing 48.57%, then Built-up/bare surface covered 137.82 $KM^2$ representing 2.05%, while water body/wetland on the other hand, had 54.36 $KM^2$ with 0.81%.

**Figure 1. Land Use Land Cover Classification of GGNP-1991**




**Source: Source: United States Geological Survey (1991)**

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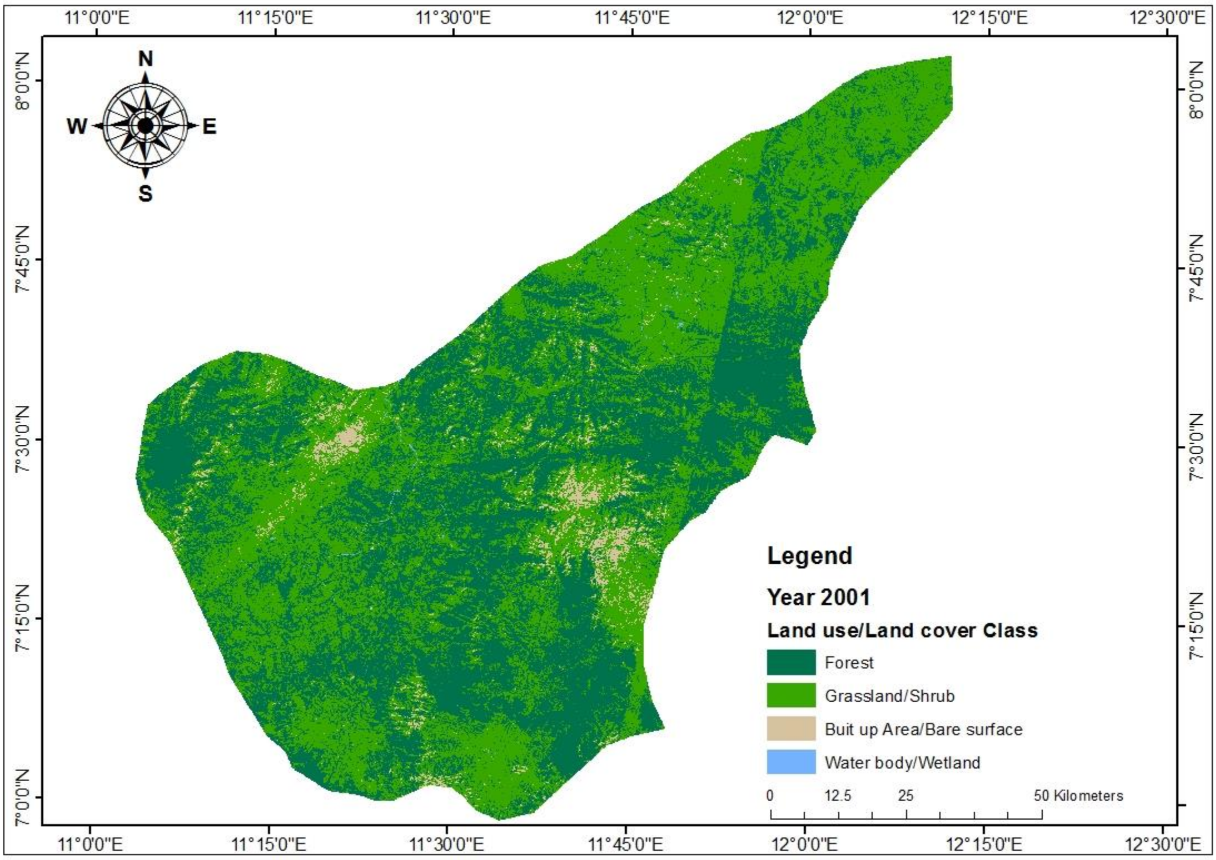
**Table 2: Land use Land Cover Classification-1991**

| | **YEAR 1991** | |
|---|---|---|
| LULC_Class | Area (Square Km) | Percentage |
| Forest Cover | 3,269.78 | 48.58 |
| Grassland/Shrub | 3,269.04 | 48.57 |
| Built up Area/Bare surface | 137.82 | 2.05 |
| Water body/wetland | 54.36 | 0.81 |
| **Total** | **6,731.00** | **100** |

**Source: United States Geological Survey (1991)**

In 2001, forest land covered 3,212.63 $Km^2$ representing 47.73%, Grassland/Shrub covered 3,312.90 $Km^2$ with 49.22%. On the other hand, Built up area/Bare surface had 197.62 representing 2.94%, while Water body/Wetland covered 7.85 $Km^2$ of land with 0.12%. ( figure 2 and table 3)

**Figure 2: Land Use Land Cover Classification of GGNP-2001**




**Source: United States Geological Survey (2001)**

**Table 3: Land Use Land Cover Classification-2001**

| | **YEAR 2001** | |
|---|---|---|
| **LULC_Class** | Area (Square Km) | Percentage |
| Forest | 3212.63 | 47.73 |
| Grassland/Shrub | 3312.90 | 49.22 |
| Built up Area/Bare surface | 197.62 | 2.94 |

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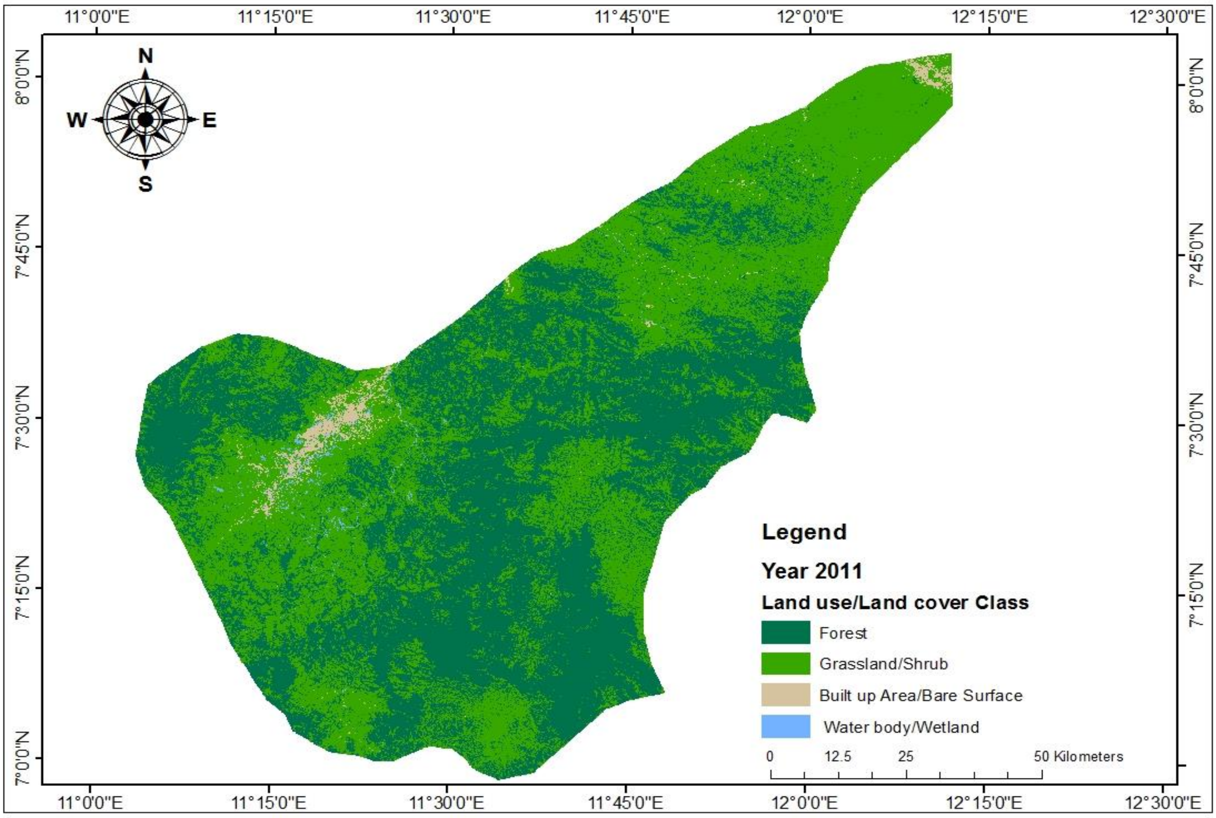
| | | |
|---|---|---|
| Water body/wet land | 7.85 | 0.12 |
| **Total** | **6731.00** | **100** |

**Source: United States Geological Survey (2001)**

In year 2011, Forest land covered 3.444.60 Km$^2$ representing 51.18%. Grassland/Shrub on the other hand, covered 3,158.40 Km$^2$ of land with 46.92%. Built up Area/Bare Surface and Water body/Wetland covered 94.35 Km$^2$ and 33.66 Km$^2$ representing 1.40% and 0.50% respectively. (figure 3, table 4).

**Figure 3: Land Use Land Cover Classification of GGNP-2011**




**Source: United States Geological Survey (2011)**

**Table 4: Land Use Land Cover Classification-2011**

| | **YEAR 2011** | |
|---|---|---|
| **LULC_Class** | Area (Square Km) | Percentage |
| Forest | 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 |

**Source: United States Geological Survey (2011)**

Figure 4 and table 5 show that in 2021, forest land covered 3,647.61 Km$^2$ representing 54.19%. Grassland/hrub land had 2,674.96 Km$^2$ with 39.74%. Built up Area/Bare surface covered 390.93 Km$^2$ with 5.81%. Water body/Bare Surface recorded 17.50 Km$^2$ representing 0.26%.

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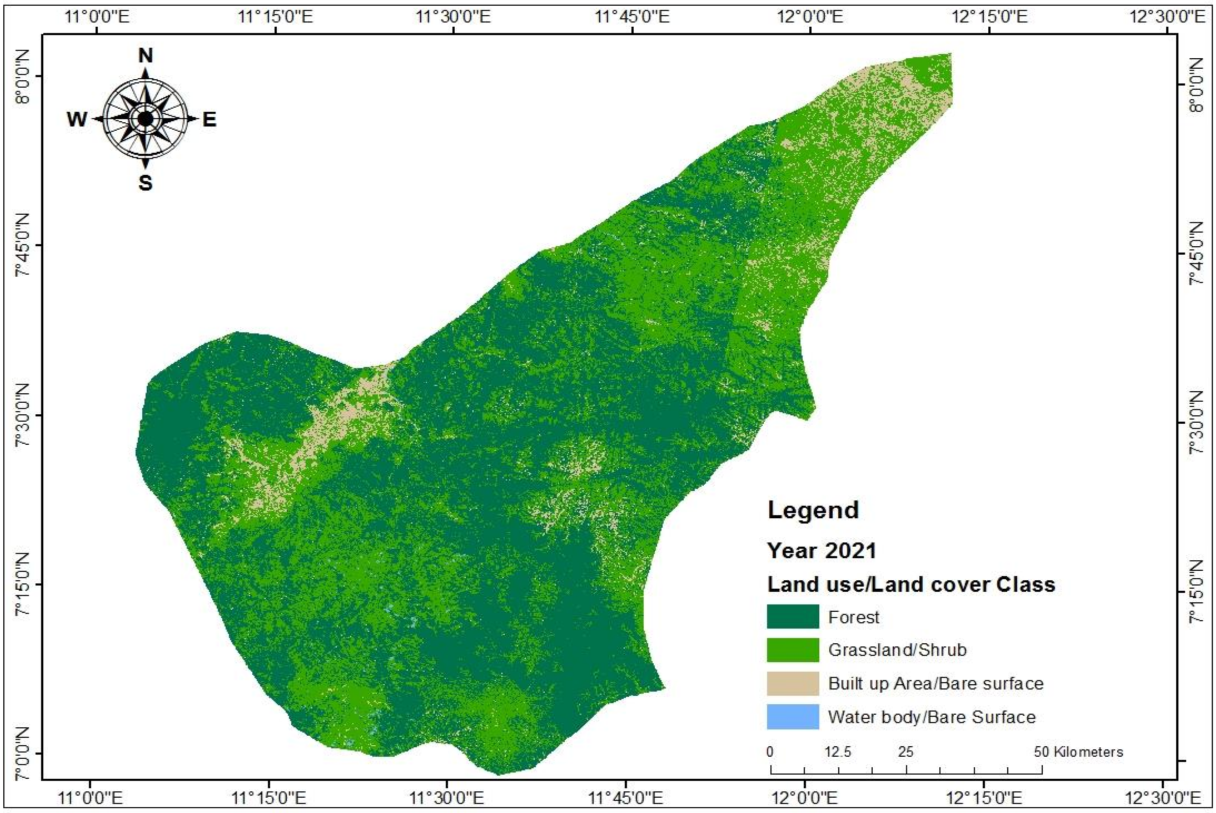
**Figure 4 : Land Use Land Cover Classification of GGNP-2021**




**Source: United States Geological Survey (2021)**

**Table 5: Land Use Land Cover Classification-2021**

| | **YEAR 2021** | |
|---|---|---|
| **LULC_Class** | Area (Square Km) | Percentage |
| Forest | 3647.61 | 54.19 |
| Grassland/Shrub | 2674.96 | 39.74 |
| Built up Area/Bare surface | 390.93 | 5.81 |
| Water body/wetland | 17.50 | 0.26 |
| **Total** | **6731.00** | **100** |

**Source: United States Geological Survey (2021)**

### ii. Fauna Richness and Abundance in GGNP

Table 6 shows animal fauna richness and abundance per 10 years interval. Primates were the majority and increased from 1991 (244), 2001 (368), 2911 (481) to 2021 (556), followed by Kob from 1991 (56), 2001 (101), 2011 (113) to 2021 (216), then

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Buffalo from 1991 (43) , 2001 (62), 2011 (114) to 2021 (174) while the least were Hippopotamus from 1991 (22), 2001 (42), 2011 (40) to 2021 (36) and Giant Pangolin from 1991 (12), 2001 (19), 2011 (34) to 2021 (41).

**Table 6: Animal Population from 1991-2021 at 10 Years Interval**

| | Buffalo | Bush Buck | Duiker | Harte beest | Water Buck | Hippopo tamus | Primates | Roan Antelope | Klip Springer | Leopard | Kop | Giant Pang olin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | 43 | 6 | 10 | 41 | 29 | 22 | 244 | 24 | 11 | 16 | 56 | 12 |
| 2001 | 62 | 27 | 46 | 96 | 56 | 42 | 368 | 39 | 32 | 61 | 101 | 19 |
| 2011 | 114 | 44 | 71 | 111 | 94 | 40 | 481 | 53 | 52 | 82 | 113 | 34 |
| 2021 | 174 | 86 | 108 | 102 | 124 | 36 | 556 | 86 | 64 | 122 | 216 | 41 |

**Source: researcher's fieldwork (2022)**



**Relationship Between Biodiversity and Stability in GGNP**

A Pearson product correlation analysis was conducted between animals population and vegetation cover within the park. The result was found to have a high negative relationship but statistically not significant $r\ (2) = -.731$, $p > 0.05$ (Table 7).

**Table 7: Correlation Analysis Matrix**

| Variables | | Animal Population | Vegetation Cover |
|---|---|---|---|
| Animal Population | Pearson Correlation | 1 | -.731 |
| | Sig. (2-tailed) | | .269 |
| | N | 4 | 4 |
| Vegetation Cover | Pearson Correlation | -.731 | 1 |
| | Sig. (2-tailed) | .269 | |
| | N | 4 | 4 |

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

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## Discussion

To determine whether a relationship exist between biodiversity and ecosystem stability,vegetation a Pearson product correlation analysis was conducted. The results shows that animals population and vegetation cover within the park was found to have a high negative correlation but statistically not significant $r\ (2) = -.731$, $p > 0.05$ (see table 7). This shows that, an increase or decrease in vegetation cover does not lead to corresponding increase or decrease in animal population and vice vassal. The highly negative correlation however may not be statistically significant as this might be as a result of small sample size. Thus, this finding cannot be generalized to the whole population.

## Conclusion

**The finding of this research shows that increase or decrease in one component of the ecosystem does not result to a corresponding increase or decrease in the other. Based on this, the study concludes that there is negative relationship between biodiversity and ecosystem stability in Gashaka Gumti National Park,**