

# Ecological Interactions and Habitat Influences on Biodiversity Patterns in A Forest–Savanna Ecotone of Northern Taraba State, Nigeria.

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**Abstract:** *This study examined ecological interactions and habitat influences on biodiversity patterns within the forest–savanna ecotone of Northern Taraba State, Nigeria, with particular focus on Karim-Lamido and Lau Local Government Areas. The research aimed to assess how habitat characteristics and anthropogenic disturbances shape the distribution and diversity of flora and fauna across contrasting land-use types. A stratified ecological sampling technique was employed to collect vegetation and wildlife data across three habitat categories: forest edge, lowland, and farmland ecosystems. A total of 60 quadrats were systematically laid across six sampling sites representing different ecological zones. Vegetation data were collected through field-based assessments, while wildlife presence was documented using direct observation and indigenous ecological knowledge. Species richness, abundance, and evenness were analyzed using the Shannon–Wiener Diversity Index to evaluate biodiversity distribution patterns. Results indicated that forest edge habitats recorded the highest species richness (14 species) and total individuals (59), followed by lowland (10 species, 49 individuals) and farmland (8 species, 50 individuals). Species evenness values ranged from 0.98 to 0.99 across all habitats, indicating relatively balanced species composition. Wildlife observations revealed spatial variation in species distribution, with Jen Kaigama exhibiting the highest species richness (9 species), while Bwe Baba recorded the highest number of individuals (34). The findings suggest that transitional habitats support higher biodiversity due to increased ecological heterogeneity, whereas farmland ecosystems exhibit reduced species diversity resulting from land-use intensification. Anthropogenic factors such as deforestation, agricultural encroachment, and bush burning were identified as major drivers of biodiversity loss in the study area. The study highlights the critical role of habitat structure and ecological interactions in maintaining biodiversity and recommends the integration of sustainable land-use practices and community-based conservation strategies to mitigate biodiversity decline in tropical savanna ecosystems.*

**Keyword:** Biodiversity, Habitat heterogeneity, Ecological interactions, Forest–savanna ecotone, Land-use change

## 1. Introduction

Biodiversity represents the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part (Prakash, 2021). It encompasses diversity within species, between species, and of ecosystems, and serves as a fundamental component of ecosystem functioning and environmental sustainability (Oguh *et al.*, 2021). In tropical ecosystems, particularly within savanna landscapes, biodiversity plays a critical role in maintaining ecological balance through nutrient cycling, climate regulation, soil fertility enhancement, and provision of ecosystem services essential for human survival (Dlamini, 2020). However, in recent decades, global biodiversity has been increasingly threatened by anthropogenic pressures such as deforestation, agricultural expansion, urbanization, and unsustainable resource exploitation (IPBES, 2019). These pressures have resulted in habitat fragmentation and ecosystem degradation, thereby influencing species distribution and abundance patterns across various ecological zones.

In sub-Saharan Africa, land-use change remains one of the primary drivers of biodiversity loss due to the growing demand for agricultural land and settlement expansion (Mohammed, 2020). Forest–savanna ecotones, which represent transitional zones between forest and grassland ecosystems, are particularly vulnerable to environmental disturbances because of their structural heterogeneity and sensitivity to anthropogenic modification (Peacock, 2022). These ecotonal environments often support higher species richness due to the coexistence of species adapted to both forested and open habitats, making them biodiversity hotspots of ecological significance (Cartwright, 2019). However, the increasing rate of land conversion in these transitional zones poses significant threats to ecological stability and long-term biodiversity conservation.

In Nigeria, tropical savanna ecosystems constitute a major component of the country's natural vegetation and provide habitats for diverse plant and animal species. Nevertheless, rapid population growth and expanding agricultural activities have intensified human pressure on these ecosystems, resulting in loss of native vegetation and disruption of ecological interactions among species (Hald-Mortensen, 2023). In Northern Nigeria, including Taraba State, unsustainable land-use practices such as bush burning, overgrazing,

and indiscriminate logging have contributed to declining biodiversity levels and altered habitat structures (Danladi et al., 2025). These activities not only reduce species richness but also compromise ecosystem resilience and productivity.

Karim-Lamido and Lau Local Government Areas of Northern Taraba State are characterized by forest–savanna transitional vegetation that supports a wide range of flora and fauna. Despite the ecological importance of these habitats, empirical data on biodiversity composition and habitat-specific distribution patterns in the region remain limited. Understanding the influence of habitat characteristics and ecological interactions on biodiversity patterns is essential for developing effective conservation strategies and promoting sustainable land management practices.

This study therefore investigates the ecological interactions and habitat influences on biodiversity patterns across forest edge, lowland, and farmland ecosystems in Karim-Lamido and Lau Local Government Areas of Taraba State, Nigeria. By examining species richness, abundance, and distribution across contrasting land-use types, the study provides empirical evidence on the role of habitat heterogeneity in shaping biodiversity dynamics within a forest–savanna ecotone.

## 2. Literature Review

Biodiversity remains a central concept in ecological science, representing the variety of life forms within a given ecosystem and the complex interactions that sustain ecological balance and productivity. According to the Ahmed (2024), biodiversity contributes significantly to ecosystem resilience by supporting ecological processes such as nutrient cycling, pollination, and habitat stability. In tropical savanna ecosystems, plant and animal diversity plays a crucial role in regulating environmental conditions and maintaining ecosystem functionality (Seymour & Joseph, 2019). However, biodiversity in many developing countries has been increasingly threatened by both natural and anthropogenic disturbances, particularly in ecologically sensitive zones such as forest–savanna transitional environments.

Forest–savanna ecotones are characterized by the coexistence of forest and grassland species, resulting in higher biological diversity due to increased habitat heterogeneity (Song & Wang, 2022). These transitional zones often serve as ecological corridors that facilitate species migration and gene flow across landscapes. Studies have shown that ecotonal habitats tend to support greater species richness compared to core forest or open savanna habitats because of their structural complexity and availability of diverse ecological niches (Cardoso *et al.*, 2021). Nevertheless, the ecological stability of such environments is increasingly undermined by human-induced land-use changes such as deforestation, agricultural expansion, and grazing activities.

Land-use change is widely recognized as one of the most significant drivers of biodiversity loss worldwide. Meher *et al* (2025) observed that conversion of natural habitats into agricultural land reduces vegetation cover and disrupts ecological interactions among species, leading to declines in species richness and abundance. In sub-Saharan Africa, rapid population growth and increasing demand for food production have intensified pressure on forest and savanna ecosystems, resulting in habitat fragmentation and loss of native flora and fauna (Mohammed, 2020). These changes often alter species composition and reduce ecosystem resilience, making habitats more susceptible to environmental degradation.

Agricultural intensification has also been identified as a key factor contributing to biodiversity decline in tropical regions. Studies have demonstrated that farmland ecosystems typically exhibit lower species richness compared to undisturbed habitats due to monoculture practices and removal of native vegetation (Belete & Yadete, 2023). Similarly, bush burning and overgrazing have been shown to degrade soil quality and reduce plant diversity, thereby affecting wildlife populations that depend on vegetation for food and shelter (Curry-Lindahl, 2019). The simplification of habitat structures associated with intensive land use often leads to ecological homogenization, which further accelerates biodiversity loss.

In Nigeria, tropical savanna ecosystems are particularly vulnerable to anthropogenic disturbances resulting from agricultural expansion and fuelwood extraction (Ekpo & Mba, 2020). Research conducted in various parts of Northern Nigeria has revealed that unsustainable land-use practices such as logging and bush burning significantly reduce species diversity and alter habitat composition (Izah & Aigberua, 2023). These disturbances not only affect vegetation structure but also disrupt ecological interactions among species, ultimately impacting wildlife distribution and abundance.

Recent ecological studies have emphasized the importance of habitat heterogeneity in maintaining biodiversity within tropical landscapes. Habitat complexity influences species distribution by providing diverse ecological niches that support different functional groups (Andrew *et al.*, 2024). Transitional habitats such as forest edges often exhibit higher species diversity due to the overlap of species adapted to both forested and open environments (Hending *et al.*, 2023). Conversely, farmland ecosystems typically support fewer species due to habitat simplification and increased human disturbance.

Despite growing awareness of biodiversity loss in Nigeria, empirical studies examining habitat-specific biodiversity patterns within forest–savanna ecotones remain limited. Understanding how ecological interactions and land-use practices influence biodiversity distribution is essential for designing effective conservation strategies and promoting sustainable ecosystem management. This study

therefore contributes to the existing body of knowledge by providing empirical evidence on habitat-dependent biodiversity dynamics in Karim-Lamido and Lau Local Government Areas of Northern Taraba State.

### 3. Materials and Methods

#### Study Area

This study was conducted in Karim-Lamido and Lau Local Government Areas (LGAs) of Taraba State, located within the Northern Senatorial District of North-Eastern Nigeria. Karim-Lamido LGA lies between latitudes 8°33'N and 10°21'N and longitudes 10°21'E and 11°24'E, covering an estimated landmass of 6,450.72 km<sup>2</sup>. Lau LGA lies between latitude 8°56'N to 9°20'N and longitude 11°15'E to 11°40'E, with an estimated area of 3,525 km<sup>2</sup>. The study area is characterized by Sudan savanna vegetation interspersed with forest–savanna transitional zones, which provide diverse ecological habitats for flora and fauna.

Climatic conditions in the region are tropical, with distinct wet and dry seasons. The wet season typically extends from May to October, with an average annual rainfall of approximately 1,000–1,200 mm, while the dry season occurs between November and April. The dominant vegetation includes woody species such as *Vitex doniana*, *Borassus aethiopum*, and *Acacia spp.*, alongside herbaceous grasses such as *Andropogon gayanus*. Soil types in Karim-Lamido are predominantly sandy and prone to erosion, whereas Lau LGA contains more loamy and clayey soils that support relatively dense vegetation cover.

#### Research Design and Sampling Technique

A stratified ecological sampling design was employed to ensure representation across different habitat types within the study area. Three major habitat categories were identified in each LGA based on vegetation structure and land-use characteristics:

- Forest Edge
- Lowland
- Farmland

Within each habitat type, two transects measuring 100 meters in length were established to traverse the habitat gradient. Along each transect, five quadrats were systematically placed at 20-meter intervals to facilitate vegetation and wildlife observations. This resulted in a total of 10 quadrats per habitat type and 30 quadrats per LGA, amounting to 60 quadrats across the two LGAs.

Quadrat sizes of 20 m × 20 m were used for assessing woody vegetation, including trees and shrubs, while ground-level observations were conducted to document herbaceous species and signs of wildlife presence.

#### Data Collection Procedures

Vegetation data were collected through field-based surveys conducted within the established quadrats. Species identification was carried out using standard botanical guides and local ecological knowledge. For each quadrat, plant species present were recorded along with the number of individual organisms observed.

Wildlife data were obtained through direct field observation and community-based reporting. Evidence of wildlife presence, including sightings and auditory detections, was recorded alongside species identification and abundance estimates. Local knowledge from community members was also incorporated to complement field observations, particularly for species that are nocturnal or difficult to detect during daytime surveys.

#### Biodiversity Assessment

Species richness and abundance were calculated for each habitat type. Biodiversity was quantified using the Shannon–Wiener Diversity Index ( $H'$ ), expressed as:

$$H' = - \sum (P_i \ln P_i)$$

where  $P_i$  represents the proportion of individuals belonging to the  $i$ th species and  $S$  denotes the total number of species recorded. Species evenness ( $E$ ) was calculated to determine the uniformity of species distribution using the formula:

$$E = \frac{H'}{\ln S}$$

These indices were used to evaluate biodiversity patterns across the different habitat types in the study area.

Descriptive statistical methods were employed to summarize species richness, abundance, and evenness across habitat types. Comparative analysis was conducted to evaluate biodiversity variation among forest edge, lowland, and farmland ecosystems. The results were interpreted to determine the influence of habitat characteristics and anthropogenic activities on biodiversity distribution patterns within the study area.

## 4. Results

### Vegetation Biodiversity across Habitat Types

The analysis of vegetation data revealed variations in species richness and abundance across the three identified habitat types: forest edge, lowland, and farmland ecosystems. Forest edge habitats recorded the highest species richness (14 species) and total number of individuals (59), followed by lowland habitats with 10 species and 49 individuals. Farmland ecosystems exhibited the lowest species richness (8 species), although the total number of individuals recorded (50) was comparable to that of lowland habitats. Species evenness values across all habitat types ranged from 0.98 to 0.99, indicating relatively uniform species distribution within the sampled environments.

**Table 4.1: Vegetation Biodiversity by Habitat Type**

Vegetation Type	Species Richness	Total Individuals	Evenness (Shannon Evenness)
<b>Forest Edge</b>	14	59	0.98
<b>Lowland</b>	10	49	0.98
<b>Farmland</b>	8	50	0.99

The data presented in Table 4.1 indicate notable variation in vegetation biodiversity across the three identified habitat types within the study area. Forest edge ecosystems recorded the highest species richness (14 species) and total number of individuals (59), suggesting that these transitional environments provide favorable ecological conditions that support a wider variety of plant species. The elevated biodiversity observed in forest edge habitats may be attributed to the structural complexity and ecological heterogeneity associated with ecotonal zones, which facilitate the coexistence of both forest-dependent and savanna-adapted species.

Lowland habitats exhibited moderate levels of species richness (10 species) and total individuals (49), reflecting the influence of soil moisture availability and vegetation density on plant distribution. Although lowland ecosystems typically provide fertile conditions for plant growth, periodic disturbances such as seasonal flooding and human encroachment may limit species establishment and reduce overall biodiversity.

Farmland ecosystems recorded the lowest species richness (8 species), despite maintaining a relatively comparable number of individuals (50) to that of lowland habitats. This pattern suggests that farmland environments may be dominated by a limited number of resilient or cultivated species capable of surviving under disturbed conditions. The slightly higher evenness value (0.99) observed in farmland habitats indicates a more uniform distribution of individuals among fewer species, which is often associated with ecological simplification resulting from agricultural activities. Overall, the results demonstrate that habitat characteristics significantly influence vegetation diversity within the forest–savanna ecotone.

### 4.2 Wildlife Distribution across Study Locations

Wildlife observations varied across the sampled locations within Karim-Lamido and Lau LGAs. Jen Kaigama recorded the highest species richness (9 species), while Bwe Baba exhibited the highest number of individual wildlife sightings (34). Other locations such as Jen Ardido, Saredau, Sayonti, and Kunini showed moderate species richness and abundance levels.

**Table 4.2: Wildlife Observation by Location**

Location	Species Richness	Total Individuals
<b>Jen Kaigama</b>	9	21
<b>Bwe Baba</b>	8	34
<b>Jen Ardido</b>	8	14
<b>Saredau</b>	7	24
<b>Sayonti</b>	7	23
<b>Kunini</b>	7	33

The findings presented in Table 4.2 reveal spatial variation in wildlife species richness and abundance across the sampled locations within Karim-Lamido and Lau LGAs. Jen Kaigama recorded the highest species richness (9 species), indicating relatively favorable habitat conditions for wildlife persistence. This may be linked to the presence of adequate vegetation cover and reduced levels of anthropogenic disturbance in the area.

In contrast, Bwe Baba exhibited the highest number of individual wildlife sightings (34), despite having slightly lower species richness (8 species). This suggests that certain species may occur in larger populations within this location, possibly due to the availability of food resources and suitable shelter conditions. Kunini also recorded a relatively high number of individuals (33), further highlighting the importance of habitat quality in supporting wildlife abundance.

Other locations such as Saredau (7 species, 24 individuals), Sayonti (7 species, 23 individuals), and Jen Ardido (8 species, 14 individuals) demonstrated moderate biodiversity levels, which may reflect varying degrees of habitat disturbance resulting from agricultural expansion, bush burning, and grazing activities. The observed spatial differences in wildlife distribution therefore underscore the influence of habitat structure and human activities on faunal diversity within the study area.

The data indicate that areas with relatively intact vegetation tend to support greater wildlife abundance and diversity compared to highly disturbed environments, emphasizing the need for sustainable land management practices to preserve biodiversity within the region.

### 4.3 Comparative Biodiversity Analysis

Comparative analysis of biodiversity indices across habitat types indicated that forest edge ecosystems supported higher species diversity compared to lowland and farmland habitats. The evenness values observed across all habitat types suggest relatively stable ecological conditions, although variations in species richness highlight the influence of habitat structure on biodiversity distribution.

**Table 4.3: Comparative Analysis of Vegetation Biodiversity by Habitat Type**

Habitat Type	Species Richness	Total Individuals	Evenness
Forest Edge	14	59	0.98
Lowland	10	49	0.98
Farmland	8	50	0.99

The comparative analysis presented in Table 4.3 highlights the influence of habitat characteristics on vegetation biodiversity across forest edge, lowland, and farmland ecosystems within the study area. Forest edge habitats exhibited the highest species richness (14 species) and total number of individuals (59), indicating a relatively higher level of biodiversity compared to other habitat types. This observation suggests that transitional ecosystems provide suitable ecological conditions that support diverse plant communities due to increased habitat heterogeneity and availability of ecological niches.

Lowland habitats recorded moderate species richness (10 species) and total individuals (49), reflecting the role of soil fertility and moisture retention in supporting vegetation growth. However, the slightly lower biodiversity observed in these areas may be attributed to periodic environmental disturbances such as seasonal flooding and anthropogenic activities including farming and grazing. These disturbances may affect species establishment and reduce overall vegetation diversity.

Farmland ecosystems demonstrated the lowest species richness (8 species), despite maintaining a relatively comparable number of individuals (50). This pattern suggests that farmland habitats may be dominated by a limited number of species capable of tolerating disturbed environmental conditions associated with agricultural practices. The high evenness value (0.99) recorded in farmland indicates a relatively uniform distribution of individuals among fewer species, which may result from habitat simplification and replacement of native vegetation with cultivated or disturbance-tolerant plant species.

The findings indicate that habitat structure plays a significant role in shaping vegetation biodiversity patterns within the forest-savanna ecotone. The reduction in species richness observed in farmland ecosystems underscores the impact of anthropogenic land-use practices on vegetation diversity and highlights the importance of sustainable land management strategies for biodiversity conservation in the study area.

## 5. Discussion

The findings of this study revealed significant variations in biodiversity patterns across the three identified habitat types forest edge, lowland, and farmland ecosystems within Karim-Lamido and Lau Local Government Areas of Northern Taraba State. The higher species richness observed in forest edge habitats supports the widely held ecological assertion that transitional environments, such as forest-savanna ecotones, tend to harbor greater biological diversity due to the convergence of species from adjacent ecological systems (Van Graan, 2025). These ecotonal zones often provide heterogeneous microhabitats that enhance ecological interactions among plant and animal species, thereby increasing species coexistence and overall biodiversity (Liataud *et al.*, 2020).

In contrast, the relatively lower species richness recorded in farmland ecosystems may be attributed to anthropogenic disturbances such as agricultural expansion, vegetation clearing, and monoculture practices. Previous studies have demonstrated that intensive agricultural activities often lead to habitat simplification and loss of native vegetation, resulting in reduced biodiversity and altered ecosystem functionality (Kline & Joshi, 2020). The comparable number of individuals recorded in farmland habitats, despite lower species richness, suggests dominance by a few resilient or cultivated species that thrive under disturbed environmental conditions. This pattern is consistent with findings by Foley *et al.* (2005), who reported that land-use changes associated with agriculture significantly influence species composition and ecosystem stability.

Lowland habitats exhibited moderate levels of species richness and abundance, which may be related to soil fertility and moisture retention characteristics that support vegetation growth. However, periodic disturbances such as flooding and human encroachment may limit the establishment of certain plant species, thereby affecting biodiversity distribution within these environments (Birhanu *et al.*, 2021). The relatively high evenness values observed across all habitat types indicate balanced species distribution, suggesting that no single species dominates the sampled ecosystems.

Wildlife distribution patterns across the study locations further highlight the influence of habitat structure on faunal diversity. Locations such as Jen Kaigama and Bwe Baba recorded relatively higher species richness and individual counts, indicating favorable habitat conditions for wildlife persistence. These findings align with the observations of Ahmad and Gopi (2025), who emphasized that habitat heterogeneity plays a critical role in supporting diverse wildlife populations by providing adequate food resources and shelter.

Conversely, locations subjected to increased human activities exhibited lower wildlife abundance, underscoring the negative impact of anthropogenic disturbances on faunal distribution. Activities such as bush burning, overgrazing, and deforestation have been shown to disrupt ecological interactions and reduce habitat suitability for wildlife species (Minja, 2025). The spatial variation in species distribution observed in this study therefore reflects the combined effects of ecological conditions and human-induced habitat modification.

The findings of this study underscore the importance of maintaining habitat heterogeneity within forest–savanna ecosystems to support biodiversity conservation. The observed decline in species richness within farmland habitats highlights the need for sustainable land-use practices that minimize ecological degradation and promote ecosystem resilience. These results provide empirical evidence on the role of habitat characteristics in shaping biodiversity patterns and emphasize the urgency of implementing conservation strategies aimed at mitigating biodiversity loss in tropical savanna landscapes.

## 6.1 Conclusion

This study assessed the influence of habitat characteristics and ecological interactions on biodiversity patterns within the forest–savanna ecotone of Northern Taraba State, Nigeria, focusing on Karim-Lamido and Lau Local Government Areas. The findings revealed that habitat type plays a significant role in determining species richness and distribution across the study area. Forest edge ecosystems recorded the highest levels of vegetation diversity, suggesting that transitional habitats support more complex ecological interactions due to increased structural heterogeneity. In contrast, farmland ecosystems exhibited comparatively lower species richness, indicating the influence of anthropogenic disturbances such as agricultural expansion, deforestation, and bush burning on biodiversity decline.

Wildlife observations further demonstrated spatial variation in species abundance across sampled locations, with areas characterized by relatively intact vegetation supporting greater faunal diversity. The high species evenness values observed across habitat types indicate relatively stable ecological conditions; however, the reduction in species richness within disturbed habitats highlights the growing impact of land-use change on ecosystem sustainability. These findings underscore the critical importance of maintaining habitat diversity and minimizing human-induced environmental degradation in order to preserve biodiversity within tropical savanna ecosystems.

## 6.2 Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. **Promotion of Sustainable Land-Use Practices:** Adoption of agroforestry and conservation agriculture practices should be encouraged to reduce habitat degradation and enhance biodiversity within farmland ecosystems.
2. **Strengthening Environmental Policy Enforcement:** Government agencies and local authorities should enforce land-use regulations aimed at preventing deforestation, bush burning, and indiscriminate logging within ecologically sensitive zones.
3. **Community-Based Biodiversity Conservation:** Local communities should be actively involved in conservation initiatives through awareness campaigns and participatory resource management strategies.
4. **Integration of Biodiversity Monitoring into Development Planning:** Biodiversity assessment and monitoring should be incorporated into local development frameworks to ensure sustainable ecosystem management and long-term environmental resilience.

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