Remote Sensing Analysis of Habitat Change and Seasonal Monkey Distribution in Okomu National Park, Nigeria

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ABSTRACT

Tropical primate habitats are increasingly threatened by fragmentation and degradation, necessitating systematic monitoring to inform conservation strategies. This study examined the seasonal distribution of monkeys in Okomu National Park, Edo State, Nigeria, and assessed the long-term impacts of habitat change on their persistence. Visual and acoustic surveys were conducted across ten systematically sampled blocks during both rainy and dry seasons, while GIS-based analyses of land-cover change from 1984, 2001, and 2017 provided insights into habitat dynamics. Results demonstrated that monkey detections were consistently concentrated in core forest blocks across seasons, indicating stable spatial use irrespective of rainfall variability. Land-cover analysis revealed that high forest (57.46%) and low forest (29.23%) dominate the park, while grassland (3.78%) and degraded areas (3.60%) have expanded slightly over time, signaling localized threats to ecological integrity. Comparative synthesis with regional and global primate studies underscores that forest continuity, rather than short-term climatic variation, is the critical determinant of primate persistence. The findings highlight the urgent need for management strategies that prioritize the protection of intact forest, rehabilitation of degraded zones, and prevention of further habitat loss. By integrating spatial ecology with temporal land-use dynamics, this research provides evidence-based guidance for sustaining primate populations in Okomu National Park and contributes to broader discourse on tropical biodiversity resilience under anthropogenic and climatic pressures. Ultimately, the study reinforces the interconnectedness of forest quality and primate survival, emphasizing conservation interventions that safeguard ecological continuity.

Keywords: *Primate conservation, Okomu National Park, habitat fragmentation, GIS, seasonal distribution, tropical forest ecology, biodiversity resilience, land-use change*

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INTRODUCTION

Tropical rainforest reserves are often perceived as stable habitats for wildlife, yet many of them exist within landscapes undergoing ecological change (John et al., 2024). Even in formally protected areas, internal habitat modifications can occur through gradual forest degradation, historic land-use impacts, and edge effects from surrounding human activities (Kumar et al., 2022). These processes alter forest structure, continuity, and habitat quality in ways that may not be immediately visible but become evident over time (Edwards et al., 2019; Kumar et al., 2022). Consequently, native animals adjust their spatial distribution within protected areas in response to habitat shifts rather than simply natural movement patterns. Primates, in particular, are highly sensitive to forest deterioration because they depend on complex forest structures and predictable food supplies (Robira et al., 2023). Variations in canopy height, tree species composition, and forest integrity influence their movement, group dispersion, and habitat selection (Lowry et al., 2021; Bersacola et al., 2022). Seasonal variability further shapes these dynamics, as wet and dry seasons affect vegetation cover and resource accessibility. During wet periods, primates may exploit a wider range of habitats, whereas in dry seasons they concentrate in areas that retain sufficient cover and resources (McKinney et al., 2017; Robira et al., 2023).

Advances in geospatial technologies have transformed ecological research by enabling multi-scale analysis of wildlife habitat relationships. Remote sensing allows detection and measurement of land-use and forest-cover changes over time, facilitating comparisons between historical and recent habitat conditions (Lechner et al., 2020). When combined with field-based species occurrence records and geographic information systems (GIS), these datasets support spatial analysis and visualization of distribution patterns (Fassnacht et al., 2024). Such integrative approaches help evaluate how wildlife distribution correlates with habitat types, forest alteration, and landscape configuration (Whitlock et al., 2018).

Okomu National Park, located in southern Nigeria, exemplifies these challenges. As a lowland rainforest system, it comprises a heterogeneous mosaic of high forest, secondary forest, grassland, degraded areas, and water bodies (Osabiyi et al., 2022). Despite its protected status, the park has experienced significant land-use changes and forest-cover alterations over recent decades, driven by both historical management practices and external pressures. Yet, animal distribution patterns have rarely been studied in direct relation to spatially explicit measures of habitat change. Without such integration, it remains unclear whether seasonal distribution reflects short-term ecological adjustments, long-term habitat shifts, or both. This research therefore aims to determine the seasonal spatial patterns of monkey species in Okomu National Park with respect to land-use and forest-cover change, using GIS-based and remote sensing techniques.

Remote sensing has become indispensable in monitoring tropical ecosystems, where biodiversity is both rich and vulnerable. Satellite imagery and sensor-based data provide robust frameworks for tracking environmental change, particularly in critical refuges such as Okomu National Park in Edo State, Nigeria. As one of the last remaining fragments of lowland rainforest in the country, Okomu supports diverse primate populations whose seasonal distribution is closely tied to habitat quality and resource availability (Ehiorobo & Ogbeibu, 2026). However, anthropogenic pressures including logging, agricultural encroachment, and infrastructural development continue to threaten the park's ecological integrity (Adeoye, Aluko, & Oke, 2026; Okoduwa, Amaechi, Ogbebor, & Obayagbona, 2026). Remote sensing analyses reveal forest-cover loss, fragmentation, and regrowth, offering temporal perspectives on habitat transformation (Bejide, Emiola, & Olaniran, 2026; Yahaya, Wang, Ogbue, & Yahaya, 2025). Coupling these spatial datasets with ecological surveys of monkey populations enables researchers to assess how seasonal variations in food resources, canopy structure, and human disturbance influence primate distribution (Olaleru, 2020).

Previous studies highlight the role of habitat heterogeneity in shaping primate ecology, with vegetation shifts directly affecting species abundance and movement (Fabolude et al., 2023; Bisong, 2012). In Okomu, seasonal fluctuations marked by wet and dry periods further complicate distributional trends, as monkeys adjust their ranging behavior in response to fruiting cycles and water availability (John et al., 2024). Comparative research across West and Central Africa underscores the broader implications of forest loss and conservation conflicts for biodiversity resilience (Franta et al., 2026; Anthony et al., 2026; Beuchle et al., 2025). Against this backdrop, the present study seeks to analyze habitat change in Okomu National Park using remote sensing techniques and to examine how these changes correlate with the seasonal distribution of monkey species. By integrating spatial analysis with ecological data, the research aims to provide evidence-based insights into conservation strategies that can mitigate habitat loss and ensure the long-term survival of primates in Nigeria's rainforest ecosystems.

METHODOLOGY

Study area

The study was conducted in Okomu National Park, located in Ovia South-West Local Government Area of Edo State, Nigeria (6°15′–6°25′N, 5°9′–5°23′E). Covering about 200 km², it is the smallest of Nigeria's seven national parks, carved from the Okomu Forest Reserve (gazetted in 1935) and upgraded to national park status in 1999 (Figure 1). The park lies 45 km west

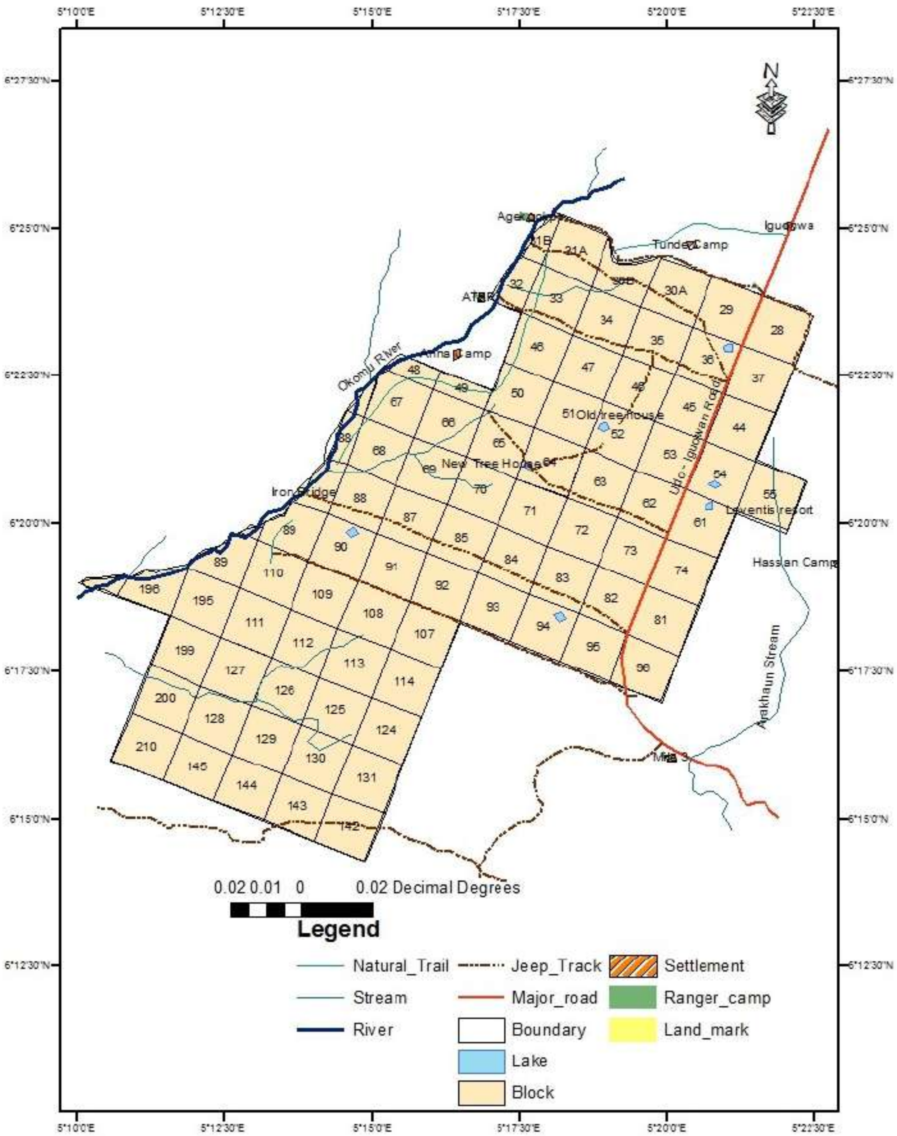

Figure 1: Map of Okomu National Park showing blocks and compartments

of Benin City and derives its name from the Okomu River, a tributary of the Osse River. Rainfall exceeds 2,500 mm annually, with temperatures ranging between 21–25°C. Vegetation is predominantly lowland rainforest with freshwater swamp forests along rivers, dominated by species such as *Khaya ivorensis*, *Milicia excelsa*, and *Terminalia ivorensis*. The park is divided into three ranges: Arakhuan (66.5 km²), Igwuowan (38.3 km²), and Julius Creek (41 km²). Okomu harbours diverse wildlife, including monkeys, birds, reptiles, and amphibians, but faces threats from logging, farming, and poaching.

GIS data sources

The study used spatial data, which were acquired both beyond and through primary and secondary sources. Primary data were GPS points that were taken during fieldwork to sample blocks, primate sighting points and important features of the landscape. The secondary spatial information was 1:50,000 topographic maps, satellite images of Edo State Ministry of Land and Survey and the United States Geological Survey (USGS), United States National Imagery and Mapping Agency (NIMA), and Google Earth satellite imagery.

GIS data model and database design

It adopted a vector-based GIS data model to model spatial features as points (primate locations), lines (rivers) and polygons (habitat units, classes of land-use and park compartments). The design of the attribute tables was to hold both the descriptive and quantitative data and at times specified types of data and field constraints to guarantee consistency and integrity. The logical schema was created to arrange spatial objects and their connections.

Data conversion and processing

Topographic maps were scanned at analogue level and georeferenced before they had the relevant features digitized onscreen. The satellite images were cropped on the study area and unsupervised classification was adapted to come up with land-use and land-cover layers. All the spatial datasets were standardized into a uniform coordinate reference system.

GIS database creation and management

The spatial data were incorporated in a GIS database which was created in ArcGIS 10.0. Classes of features and attribute tables were established and filled in and more fields were added where these were necessary. Domain constraints ensured data integrity and the database security and frequent backups were introduced to ensure that the data was not lost.

Spatial analysis and mapping

The spatial distribution of primate observations these features and habitat types, land-use patterns, river networks, and boundary of compartments within the Okomu National Park were mapped on the GIS database. The combined spatial layers facilitated the basis of biodiversity distribution spatial interpretation and conservation planning.

RESULTS

Season distribution of monkeys in Okomu National Park

Monkey distribution varied slightly between the rainy and dry seasons (Figures 2 and 3, respectively) based on visual and acoustic detections across sampled blocks. During the rainy season, monkey presence was recorded in blocks 36, 47, 49, 55, 61, 68, 71, 81, 90, and 96. In the dry season, detections occurred in the same set of blocks, indicating spatial consistency in core habitat use across seasons. The repeated occurrence of monkeys in these blocks suggests stable habitat suitability and continued use of these areas irrespective of seasonal conditions, with seasonal variation influencing detectability rather than overall spatial distribution.

Habitat change as it affects the monkey species in Okomu National Park

Figures 4 to 9 show the land use patterns of the study area from 1987 to 2017. The land-use classification (Table 1) indicates that high forest is the most extensive cover type in Okomu National Park, occupying 57.46% of the mapped area, while low forest accounts for 29.23%. Water bodies cover 5.96% of the park, reflecting the presence of rivers and wetlands within the landscape. Grassland and degraded areas occupy relatively smaller proportions, representing 3.78% and 3.60% of the area, respectively. The dominance of high and low forest classes shows that forest vegetation remains the prevailing land cover, while the presence of grassland and degraded areas points to localized habitat modification within the park.

DISCUSSION

Seasonal Stability in Habitat Use

The observation that monkeys in Okomu National Park consistently occupy the same habitat blocks across both wet and dry seasons demonstrates the stabilizing effect of intact forest cover. The dominance of high forest (57.46%) and low forest (29.23%) between 1984–2017 (Table 1) provides a structurally rich environment that buffers against seasonal variability. This supports findings that forest-dependent primates exhibit spatial stability when core forest areas remain intact (Bryson-Morrison et al., 2017; Binczik et al., 2019). In Okomu, the relatively small proportions of grassland (3.78%) and degraded areas (3.60%) appear insufficient to disrupt this stability, allowing monkeys to maintain predictable spatial utilization patterns.

Comparative Evidence from Other Primates

Seasonal similarity in habitat use is consistent with multi-scale studies of arboreal monkeys. Samango monkeys (*Cercopithecus albogularis schwarzi*) in South Africa preferentially select large, continuous forest patches with tall-canopy structures, which provide ecological support for persistence (McKinney & Dore, 2018; McKinney, 2025). Coleman et al. (2021) showed that samango monkeys adapt their foraging strategies to seasonal climatic changes, yet their reliance on structurally intact forests remains constant. Similarly, Gelada monkeys (*Theropithecus gelada*) in Ethiopia expanded their home ranges during the dry season due to reduced habitat quality (Desalegn, 2023). In contrast, Okomu monkeys displayed spatial stability across seasons, suggesting that the dominance of high forest cover mitigates the need for extensive seasonal adjustments.

Population Evidence from Okomu

Ojo (2022) reported mean encounter rates of 3.79/km in the dry season and 2.09/km in the wet season for Nigerian white-throated monkeys (*Cercopithecus erythrogaster pococki*), with densities of 2.99 ± 1.86/km² and 2.24 ± 1.04/km², respectively. Despite seasonal differences in encounter rates, the species was found across all ranges of Okomu, with Arakhuan Range harboring the highest population estimates. This reinforces the idea that extensive high forest cover

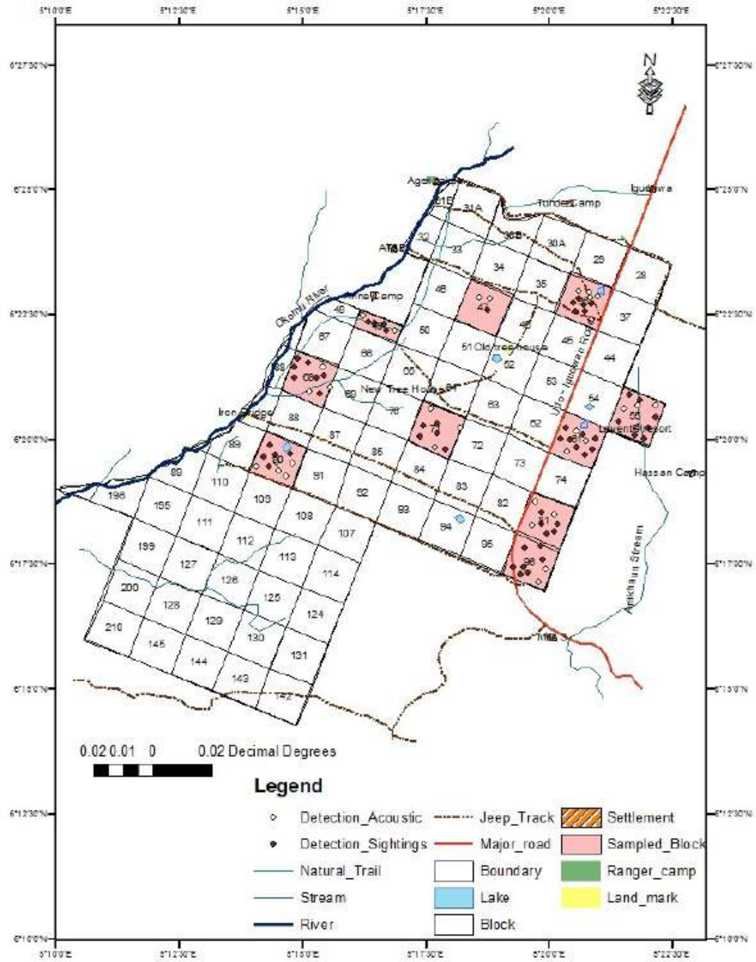

Figure 2: Distribution of Monkeys during rainy season at Okomu National Park

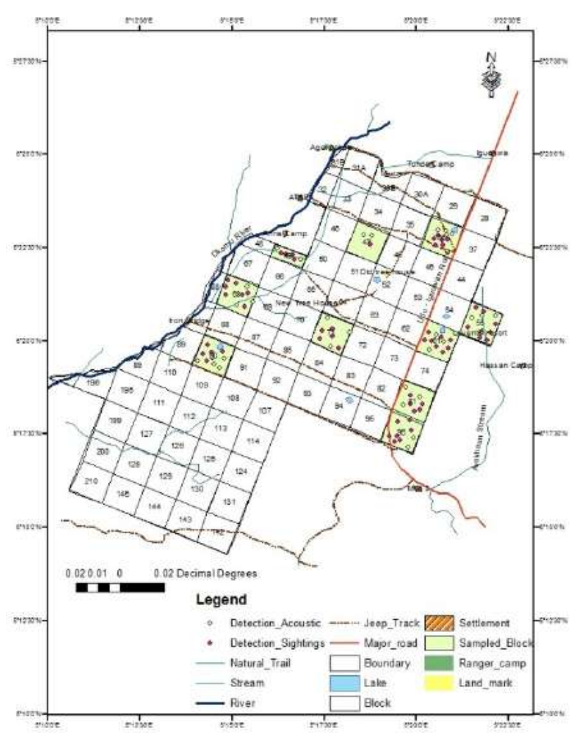

Figure 3: Distribution of Monkeys during dry season at Okomu National Park

Table 1: Summary of habitat change at Okomu National Park between 1984 – 2001 and 2001 – 2017.

Land use type	Pixel count	Area cover	Percentage of area
Water body	17,566	526,980	5.96%
High forest	169,258	5,077,740	57.46%
Low forest	86,106	2,583,180	29.23%
Grassland	11,129	333,870	3.78%
Degraded area	10,597	317,910	3.60%
Total	294,656	8,839,680	100%

Table 2: Comparative Summary of Primate Habitat Use and Seasonal Adaptation.

Study/Species	Location	Habitat Composition/Condition	Seasonal Adaptation	Key Findings
Monkeys in Okomu NP	Nigeria	High forest (57.46%), Low forest (29.23%), Grassland (3.78%), Degraded (3.60%), Water (5.96%)	Stable use of core forest blocks across wet and dry seasons	Forest continuity underpins spatial stability; encounter rates vary but distribution remains consistent (Ojo, 2022).
Samango Monkeys (*C. albogularis schwarzi*)**	South Africa	Montane forests with tall canopy	Flexible foraging; increased leaf intake in colder months	Reliance on intact forest patches; behavioral flexibility supports persistence (McKinney & Dore, 2018; Coleman et al., 2021).
Gelada Monkeys (*T. gelada*)**	Ethiopia	Natural forest, cliff/rocky, farmland mosaics	Expanded home ranges in dry season due to reduced habitat quality	Seasonal range shifts linked to human disturbance and resource scarcity (Desalegn, 2023).
Chimpanzees (*P. troglodytes ellioti*)**	Nigeria-Cameroon	Differentiated forest habitats	Habitat use shaped by forest structure rather than short-term climate	Forest continuity critical; fragmentation reduces suitability (Abwe et al., 2019).
White-Throated Monkey (*C. erythrogaster pococki*)**	Okomu NP, Nigeria	Found across all ranges; highest in Arakhuan Range	Encounter rates higher in dry season	Population stability tied to forest cover dominance (Ojo, 2022).
Capuchins (4 species)	Brazil	Forests under land conversion pressure	Reduced suitable habitat with conversion	Land conversion significantly reduces extent of occurrence; forest specialists most vulnerable (Farias et al., 2024).
Chimpanzees (*P. t. verus*) in agriculture-swamp matrix**	Sierra Leone	Human-modified mosaics	Abundance declines outside continuous forest	Anthropogenic landscapes cannot substitute for primary forest (Garriga et al., 2019).
Amazon Mammals	Brazil	Continuous tropical forest under deforestation and fragmentation	Habitat loss reduces persistence	Forest fragmentation undermines biodiversity resilience (da Rocha, 2021; 2022).
Climate Change Impacts on Primates	Global	Forests under shifting vegetation cycles	Alters resource predictability	Climate change compounds habitat pressures, reducing resilience (He & Li, 2024).

provides consistent refuge, supporting population stability even when seasonal resource availability fluctuates.

Broader African and Global Comparisons

Comparative studies across West and Central Africa highlight similar patterns. Abwe et al. (2019) documented habitat differentiation among Nigeria-Cameroon chimpanzee populations, showing that forest structure and continuity strongly influence ranging and ecological adaptation (Table 2). Hoover et al. (2021) linked habitat pressures to developmental instability in Nigerian olive baboons (*Papio anubis*), underscoring the physiological consequences of habitat degradation. Garriga et al. (2019) further demonstrated that chimpanzee abundance in agricultural-swamp mosaics outside protected areas was strongly influenced by forest availability, with populations declining in landscapes lacking continuous forest. These findings parallel Okomu, where monkeys' reliance on intact forest blocks suggests that habitat fragmentation could destabilize populations. At a global scale, He & Li (2024) emphasized that climate change exacerbates habitat pressures by altering vegetation cycles and resource predictability, further challenging

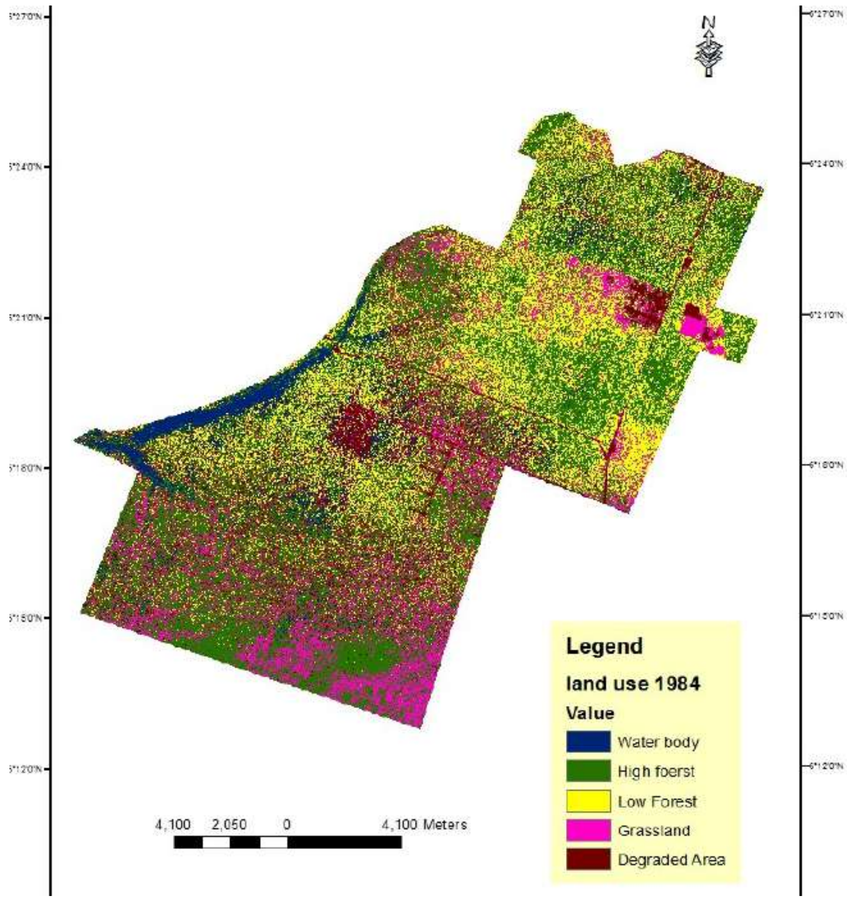

Figure 4: Land use pattern and forest cover in Okomu National Park as of 1984

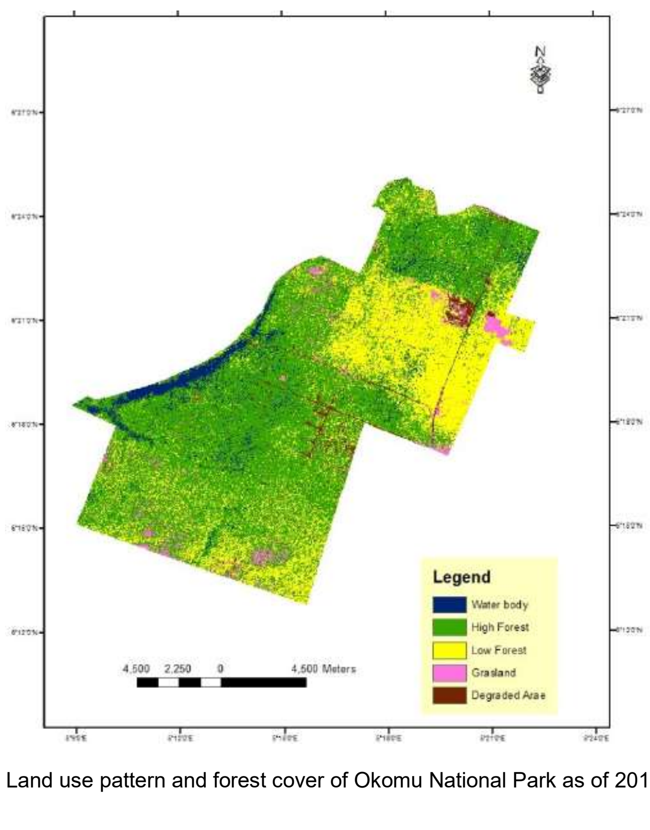

Figure 5: Land use pattern and forest cover of Okomu National Park as of 2017.

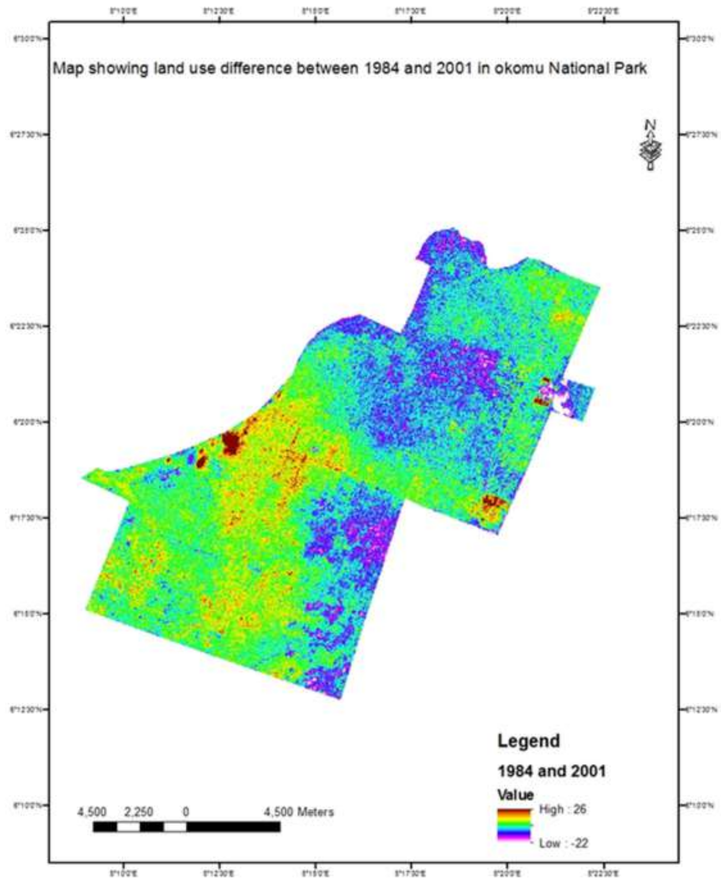

Figure 6: Land use pattern and difference between 1984 and 2001

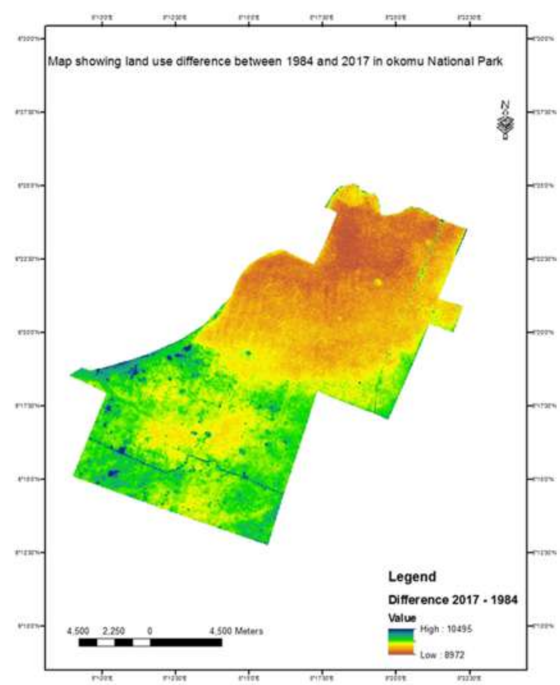

Figure 7: Land use pattern and difference between 1984 and 2017

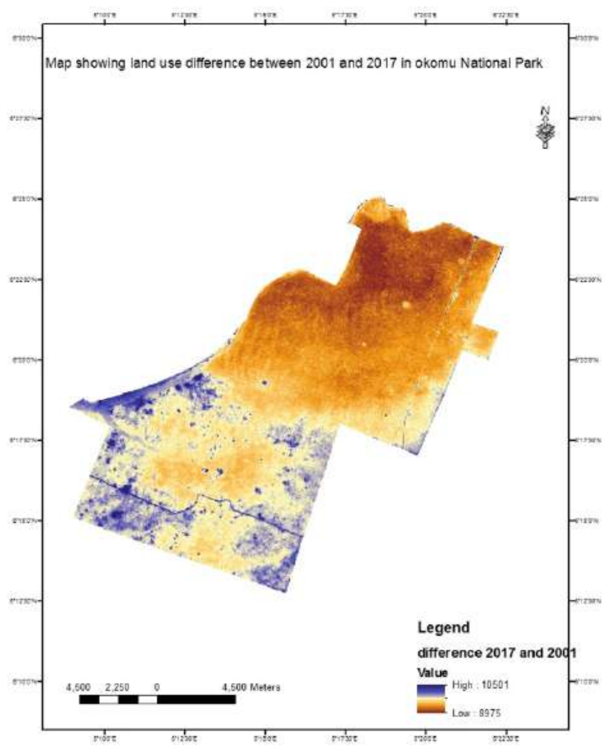

Figure 8: Land use pattern and difference between 2001 and 2017

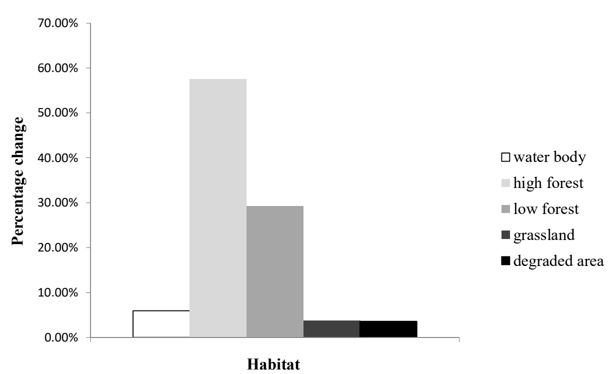

Figure 9: Summary of habitat change at Okomu National Park

primate persistence in fragmented landscapes. Farias et al. (2024) refined occurrence data for capuchin species in Brazil, showing that land conversion significantly reduces suitable habitat, particularly for forest specialists. Similarly, da Rocha (2021; 2022) highlighted that forest loss and fragmentation in the Amazon undermine mammalian persistence by reducing habitat continuity. Estrada et al. (2017) found that primate communities are highly sensitive to forest degradation, with declines in richness and abundance of forest specialists. In Okomu, although degraded areas and grasslands are relatively small, their expansion could pose long-term threats by reducing connectivity and habitat quality, echoing Maisels et al. (2018) who reported fewer chimpanzee nests in areas where dense forests were converted to grasslands.

Conservation Implications

Taken together, the Okomu results demonstrate that the dominance of high forest cover underpins the seasonal stability of monkey distributions. While seasonal variability influences encounter rates and behavior, structurally rich forests act as ecological anchors, enabling primates to maintain stable distributions. Comparative evidence from samango monkeys, Gelada monkeys, chimpanzees, capuchins, and Amazonian mammals underscores the broader principle that forest continuity is indispensable for primate persistence. Conservation strategies must therefore prioritize the protection of core forest habitats in Okomu, as even small shifts toward degraded or grassland areas could erode habitat quality and compromise long-term biodiversity resilience, especially under the added pressures of climate change and land conversion.

Conclusion

This paper shows that the population of monkeys in the Okomu National Park exhibits spatial stability in that even during rainy and dry seasons, the species are detected in the same block, meaning that the areas are used regardless of seasonal fluctuations. The forest (high and low forest) occupies the largest part of the park landscape, occupying 86.69 percent of the area, whereas water bodies, grasslands and degraded land make up the small proportion indicating localized habitat alteration. The fact that monkeys persevere in core forest blocks is important in demonstrating that the continuity and the intact forest structure of a habitat is important in sustaining the primate population. The analysis of habitat change reveals that there was to some extent some spread in degraded areas and grasslands over time and this could predict the future primate habitat pressure. It is suggested that conservation should be more focused on preserving the integrity of the forests and avoiding further degradation of the habitat.

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