Advancing Wildlife Conservation in Nigeria: Integrating Behavioural Ecology and Cutting-Edge Technologies

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Abstract

Nigeria, recognised as one of Africa's biodiversity hotspots, hosts exceptional species diversity including unique primate populations like the Cross River gorilla and Nigeria-Cameroon chimpanzee. However, this rich biological heritage faces escalating threats from habitat fragmentation, poaching, and climate change. This review synthesises innovative approaches in behavioural ecology, movement ecology, and conservation technology that are transforming wildlife research and protection in Nigeria. We examine how non-invasive monitoring techniques, including camera traps, acoustic sensors, and genetic analyses, are providing unprecedented insights into animal behaviour, spatial ecology, and population dynamics without disturbing sensitive species. The integration of community-based conservation models with technological innovations has demonstrated particular success in engaging local populations as active partners in protection efforts. We highlight case studies from Nigerian protected areas such as Afi Mountain Wildlife Sanctuary and Cross River National Park where these approaches have been effectively implemented. Additionally, we explore how landscape genetics and species distribution modelling are guiding conservation planning in the face of rapid environmental change. Despite these advances, significant challenges remain in scaling up these technologies and approaches, including funding limitations, technical capacity building, and infrastructure development. This review identifies future research priorities and strategic directions for strengthening wildlife conservation science in Nigeria, emphasising the need for interdisciplinary collaboration and context-specific methodologies. By critically assessing the current state and potential of these innovative approaches, we provide a comprehensive roadmap for advancing conservation behavioural ecology and species protection in Nigeria and across the West African region.

Keywords

Conservation Technology, Behavioural Ecology, Community-Based Conservation, Non-Invasive Monitoring, Wildlife Management, Cross River Gorilla

1. Introduction

Nigeria, occupying a strategic geographical position in West Africa, encompasses a remarkable diversity of ecosystems ranging from mangrove swamps and rainforests to savannas and montane regions. This ecological heterogeneity supports exceptional species richness and endemism, particularly in the Guinean Forests of West Africa biodiversity hotspot . Notably, Nigeria hosts at least 12 primate species, placing it among the top five African countries for primate diversity. These include critically endangered species such as the Cross River gorilla (Gorilla gorilla diehli), Nigeria-Cameroon chimpanzee (Pan troglodytes ellioti), and several monkey species like the red-eared guenon (Cercopithecus erythrotis) and Sclater's guenon (Cercopithecus sclateri). The country's varied landscapes also provide habitats for diverse avian species, mammals like forest elephants (Loxodonta cyclotis), and countless plant, insect, and microbial species that remain poorly documented.

Despite its ecological significance, Nigeria's biodiversity faces unprecedented threats. Rampant deforestation, driven by agricultural expansion, logging, and infrastructure development, has resulted in one of the highest rates of forest loss globally. Between 2010 and 2015, Africa lost approximately 3.9 million hectares of forest annually, with Nigeria experiencing particularly severe depletion of its forest cover. Additional pressures include unsustainable hunting for bushmeat and the wildlife trade, human-wildlife conflict, pollution, and the emerging impacts of climate change on ecosystem integrity and species survival. The consequences are dire: Côte d'Ivoire, Nigeria's western neighbor, has witnessed a 67% reduction in forest cover since the 1960s and the loss of 90% of its chimpanzee population over the past three decades. Similar trends threaten Nigeria's unique biodiversity, demanding urgent and innovative conservation responses.

Traditional conservation approaches in Nigeria have often relied on protected area establishment and law enforcement. While these methods remain important, they have frequently proven insufficient due to limited resources, inadequate personnel, and minimal community engagement. The emergence of new technologies and interdisciplinary approaches has revolutionised conservation science globally, yet their application in Nigeria has been uneven and poorly documented. This review addresses this gap by synthesising and critically evaluating cutting-edge methodologies in

animal behaviour, ecology, and conservation science that are being applied or show promise for Nigerian ecosystems. We examine how technological advances in monitoring, data analysis, and community engagement are transforming conservation practice, highlighting success stories, persistent challenges, and future opportunities for integrating these approaches into a cohesive framework for biodiversity conservation in Nigeria.

2. Nigeria's Biodiversity: Status, Challenges and Conservation Significance

2.1 Ecosystem Diversity and Species Endemism

Nigeria's ecological gradient spans from the coastal mangrove forests and freshwater swamps in the Niger Delta to the lowland rainforests of the south, then to the savanna woodlands, grasslands, and montane ecosystems in the central and northern regions. This topographic and climatic variability has created numerous niches for species adaptation and diversification. The Afi Mountain Wildlife Sanctuary in southeastern Nigeria exemplifies this ecological richness, harboring one of the country's last remaining tropical rainforests and serving as a critical refuge for endangered species. Similarly, the Cross River region along the Nigeria-Cameroon border represents an area of exceptional endemism, particularly for primates and plants.

The primate communities in Nigeria's forests display remarkable diversity and specialization. Of the 701 primate species recognized globally, Africa contains approximately 43%, with Nigeria ranking among the top five African nations for primate diversity. These non-human primates play crucial ecological roles as seed dispersers, influencing forest regeneration and structure. Their proximity to humans evolutionary makes them particularly valuable for scientific study, while their cultural significance in many Nigerian communities adds another dimension to their conservation importance. Beyond primates, Nigeria provides habitat for other threatened mammals including the African forest elephant (Loxodonta cyclotis), lion (Panthera leo), and numerous antelope species, though many populations are declining and becoming increasingly fragmented.[1]

2.2 Pressures and Conservation Urgency

The conservation challenges facing Nigeria's biodiversity are complex and interconnected. Habitat destruction represents the primary threat, driven by agricultural expansion (both subsistence farming and commercial plantations), logging, urbanization, and infrastructure development. The rate of forest loss in Nigeria is among the highest globally, with profound implications for species survival. For example, Côte d'Ivoire has experienced a 67% reduction in forest cover since the 1960s, and similar trends are evident in Nigeria, particularly in the southwestern regions.

Illegal hunting for bushmeat and the wildlife trade constitutes another major pressure. While traditional hunting practices were often sustainable, the commercialisation of bushmeat hunting has led to overexploitation of many species. Primates are particularly vulnerable due to their low reproductive rates and high visibility in forests. As noted by Koné (2025), "global 62% of non-human primate species are threatened with extinction," with habitat loss and illegal hunting being the primary drivers. Additional threats include human-wildlife conflicts, pollution, climate change impacts, and policy weaknesses in natural resource management.[2]

Table 1. Threatened primate species in nigeria and their conservation status.

Species	Global Status	Primary Threats	Key Conservation Sites
Cross River gorilla (Gorilla gorilla diehli)	Critically Endangered	Habitat fragmentation, hunting	Afi Mountain, Cross River NP
Nigeria-Cameroon chimpanzee (Pan troglodytes ellioti)	Endangered	Habitat loss, hunting	Gashaka Gumti NP, Okwangwo
Red-eared guenon (Cercopithecus erythrotis)	Vulnerable	Habitat loss, hunting	Afi Mountain, Cross River NP
Sclater's guenon (Cercopithecus sclateri)	Vulnerable	Habitat fragmentation, hunting	Lower Niger Basin
Olive baboon (Papio anubis)	Least Concern	Human-wildlife conflict, persecution	Widespread
Patas monkey (Erythrocebus patas)	Near Threatened	Habitat loss, hunting	Northern savannas

Table 1: This table shows the most threatened primate groups in Nigeria and notes:

- Critically Endangered and Endangered species (such as the cross-river gorilla and the Nigerian-Cameroonian chimpanzee) face severe threats primarily due to deforestation and poaching.
- Some species (such as the olive baboon) are currently less at risk but are still affected by human conflicts.
- Specific national parks (such as Cross River NP and Gashaka Gumti NP) are key protected areas.

The urgency for effective conservation is underscored by the rapid decline of many species and the potential for irreversible ecosystem changes. For instance, the Cross River gorilla, with an estimated population of fewer than 300 individuals, represents the most endangered gorilla subspecies worldwide. Their survival depends on immediate and sustained conservation intervention combining habitat protection, anti-poaching measures, and community engagement. Similar efforts are required for numerous other species facing extinction risks. The following sections explore how innovative approaches in behavioural ecology and conservation technology are addressing these challenges in Nigeria.

3. Advanced Approaches in Animal Behavioural Research

3.1 Non-Invasive Monitoring Technologies

The advent of non-invasive monitoring technologies has revolutionised the study of animal behaviour in Nigeria's sensitive ecosystems, enabling researchers to gather robust behavioural data without disturbing wildlife or their habitats. At the Afi Mountain Wildlife Sanctuary, infrared camera traps have been deployed as part of a comprehensive biodiversity monitoring program, providing valuable insights into the distribution and activities of endangered species. These camera systems have captured previously unobserved behaviours of Cross River gorillas and Nigeria-Cameroon chimpanzees, including tool use, social interactions, and ranging patterns. The continuous data collection capability of these systems, operating 24 hours daily regardless of weather conditions, has revealed temporal patterns in wildlife activity and detected rare or nocturnal species that were poorly documented previously.[3]

Acoustic monitoring represents another transformative approach, particularly for studying vocal species like primates and birds. Passive acoustic sensors deployed in Nigerian forests are capturing species-specific vocalizations, enabling researchers to identify presence, distribution, and behavioural context through sound. For example, studies in Cross River National Park have utilized acoustic monitoring to document the vocal repertoire of the Nigeria-Cameroon chimpanzee, identifying dialect variations between communities that may have implications for population connectivity. Advanced algorithms can now automatically detect and classify vocalizations, significantly reducing data processing time compared to manual analysis. When combined with camera trap data, acoustic monitoring provides a multidimensional understanding of animal behaviour and community ecology.

Genetic analyses based on non-invasively collected samples (faeces, hair, saliva) are providing crucial insights into population structure, genetic diversity, and disease prevalence among Nigeria's threatened wildlife. For instance, researchers from the Nigerian Conservation Foundation have utilized faecal DNA to assess the genetic health of Cross River gorilla populations, identifying low levels of genetic diversity that could increase vulnerability to disease and environmental change. Such genetic monitoring enables conservationists to track individual animals, estimate population sizes, and detect zoonotic disease outbreaks without capturing or even observing the animals directly. These methodologies represent significant advances over traditional behavioural observation techniques, which often required proximity that could alter natural behaviours or prove logistically challenging in dense forest environments.[4]

3.2 Cognitive and Behavioural Ecological Studies

Innovative approaches to studying animal cognition and decision-making are revealing how Nigeria's wildlife adapts to increasingly human-modified landscapes. Experimental paradigms using touchscreen systems and puzzle boxes have been adapted for use with captive populations in Nigerian zoos and sanctuaries, providing insights into problem-solving abilities and learning patterns that inform understanding of wild counterparts. For example, studies at the Pandrillus sanctuary in Calabar have examined cognitive abilities of drill monkeys (Mandrillus leucophaeus), demonstrating sophisticated social learning and tool use behaviours that have implications for how this endangered species might adapt to habitat changes.

Movement ecology has been transformed by the deployment of GPS tracking technology on larger wildlife species in Nigeria. Satellite collars fitted on elephants in Yankari Game Reserve have revealed migration corridors and habitat selection patterns critical for conservation planning. Similarly, GPS tags deployed on vultures in northern Nigeria have uncovered extensive movements across the Sahel region, highlighting the need for international cooperation in conservation efforts. These tracking technologies provide continuous, high-resolution data on animal movements, revealing responses to environmental gradients, human disturbances, and climatic variations that were previously undetectable through direct observation alone.[5]

The integration of behavioural endocrinology into conservation research represents another frontier. By measuring steroid hormone metabolites in faecal and urinary samples, researchers can non-invasively monitor physiological stress, reproductive status, and energetics in wild populations. Studies in Gashaka Gumti National Park have used these techniques to assess stress levels in chimpanzee communities facing different degrees of human disturbance, providing insights into the physiological costs of habitat modification. Such physiological metrics complement behavioural observations by revealing sublethal effects of environmental challenges before they manifest as population declines. Together, these advanced behavioural research methods are providing a more comprehensive understanding of how Nigeria's wildlife perceives, interacts with, and adapts to their changing world.

4. Ecological Research and Conservation Planning

4.1 Species Distribution Modelling and Landscape Ecology

Species distribution models (SDMs) have become indispensable tools for conservation planning in Nigeria, enabling researchers to predict species occurrences across vast and often inaccessible areas. These models combine field observation data with environmental variables such as climate, topography, vegetation cover, and human pressure to create predictive maps of habitat suitability. In Nigeria, SDMs have been particularly valuable for identifying potential habitats for rare and endangered species like the Cross River gorilla. For example, modelling efforts by the Cross River State Environment Ministry have helped delineate key corridors connecting fragmented populations of this critically

endangered primate. The Half-Earth Project methodology, which focuses on protecting half the earth's land and sea to conserve 85% or more of species, exemplifies the global effort to use spatial analysis for conservation prioritization.[6]

The application of landscape genetics—which combines population genetics with spatial data—is revealing how habitat fragmentation affects gene flow and population connectivity in Nigeria's threatened species. Research on the Nigeria-Cameroon chimpanzee has employed microsatellite markers and single nucleotide polymorphisms (SNPs) to assess genetic structure across their range in Nigeria. Results indicate that rivers and human settlements constitute significant barriers to gene flow, highlighting the importance of maintaining forested corridors in conservation planning. Similarly, studies on drill monkeys in the Cross River region have revealed unexpected genetic connectivity between supposedly isolated populations, suggesting the existence of clandestine movement corridors through agricultural landscapes. These findings have direct implications for protected area management and the design of ecological networks.

Table 2. Conservation prioritization using species distribution models in nigeria.

Modeling Approach	Application in Nigeria	Key Insights	Limitations
MaxEnt	Predicting suitable habitat for Cross River gorilla	Identified previously unknown potential habitats	Limited by presence-only data
Circuit Theory	Modeling connectivity for chimpanzee populations	Revealed pinch points in movement corridors	Requires high-resolution landscape resistance data
Ensemble Modeling	Projecting range shifts under climate change	Forecasted contraction of montane species habitats	Limited by regional climate projections
Multi-Species Prioritization	Identifying key biodiversity areas	Highlighted regions with high complementary value	Data scarcity for many taxonomic groups

Table 2: This table is show how different modeling techniques are used in conservation planning in Nigeria, ranging from predicting habitats to simulating ecological connectivity and even the impacts of climate change. However, all methods are limited by data availability, model accuracy, or the resolution of environmental data.

4.2 Protected Area Effectiveness and Management

Evaluating the effectiveness of protected areas is crucial for conservation success in Nigeria. Modern approaches combine satellite-based monitoring of habitat change with field surveys of wildlife populations to assess conservation outcomes. The World Database on Protected Areas (WDPA) provides a comprehensive global dataset that enables such evaluations. In Nigeria, analyses using WDPA data have revealed significant variations in management effectiveness between protected areas, with well-funded parks like Cross River National Park generally showing better outcomes than poorly resourced reserves. The integration of species rarity metrics with protected area maps has helped identify gaps in the conservation network, particularly for range-restricted species in the Afi Mountain region.[7]

The concept of ecological integrity is increasingly guiding protected area management in Nigeria. This approach moves beyond simple species presence/absence to assess ecosystem composition, structure, and function. In Okwangwo Division of Cross River National Park, researchers have developed an integrity index incorporating metrics such as primate group composition, tree size distribution, and incidences of human disturbance. This comprehensive assessment enables managers to track ecosystem health and identify emerging threats before they cause irreversible damage. The Nigerian Conservation Foundation has adopted similar approaches in its management of the Afi Mountain Wildlife Sanctuary, where regular monitoring of ecological indicators guides targeted conservation interventions.

Adaptive management frameworks, which incorporate ongoing monitoring and program adjustment, are being implemented in several Nigerian protected areas. For instance, in Gashaka Gumti National Park, monitoring data on elephant distribution and human-elephant conflict incidents inform the deployment of conflict mitigation measures such as bee fences and chili pepper barriers. Similarly, research on the West African red colobus monkey (Piliocolobus badius) in Taraba State has revealed behavioral adaptations to hunting pressure, leading to recommendations for seasonal patrol intensification during peak hunting seasons. [8] This evidence-based approach ensures that limited conservation resources are deployed where and when they are most needed, maximizing impact for threatened species.

5. Community-Based Conservation and Interdisciplinary Approaches

5.1 Integrating Local Knowledge and Community Engagement

The critical role of local communities in successful conservation outcomes is increasingly recognized across Nigeria. Traditional knowledge systems often contain detailed information about species distribution, behavior, and ecological relationships that complement scientific data. In the Tanoé-Ehy swamp forest initiative, community members provided crucial observations about the presence and habits of the critically endangered Miss Waldron's red colobus (Piliocolobus waldronae), which had been thought extinct until local hunters reported encounters. Such participatory monitoring approaches not only improve data collection but also foster local ownership of conservation initiatives. The community protection project in the Tanoé-Ehy swamp forest stands as a testament to this approach, successfully integrating local needs and knowledge into conservation practice.[9]

Structured community conservation programs have been implemented in several Nigerian biodiversity hotspots. At Afi Mountain Wildlife Sanctuary, the deployment of community ranger patrols has created employment opportunities while

enhancing protection efforts. These local rangers possess intimate knowledge of the terrain and wildlife movements, enabling more effective patrol routes and detection of illegal activities. The program has established a direct link between conservation efforts and community welfare, demonstrating that environmental protection can yield tangible local benefits. Similarly, in the Cross River region, community forests managed under traditional governance systems have proven effective in maintaining habitat connectivity between formal protected areas.

Environmental education initiatives represent another key component of community-based conservation in Nigeria. Programs targeting both children and adults aim to cultivate a culture of respect for nature and promote sustainable lifestyles. For instance, the Nigerian Conservation Foundation's school outreach program incorporates wildlife conservation into extracurricular activities, while village-level workshops demonstrate the economic benefits of sustainable resource management. These efforts focus on instilling environmental awareness from an early age and fostering a collective identity connected to conservation. The emphasis on connecting conservation with cultural values has proven particularly effective in regions with strong traditional governance systems.[10]

5.2 Interdisciplinary Frameworks and Technological Integration

The complexity of conservation challenges in Nigeria demands interdisciplinary approaches that integrate biological, social, and economic perspectives. Research initiatives increasingly combine ecological monitoring with surveys of household livelihoods, institutional analyses, and assessments of governance frameworks. For example, the Afi Mountain project incorporates ecological data collection alongside studies of community dependence on forest resources, enabling the development of alternative livelihood strategies that reduce pressure on protected species. This integrated approach recognizes that biodiversity loss is ultimately a socio-ecological issue requiring solutions that address both human and ecological needs.

Novel technological platforms are facilitating more sophisticated community engagement in conservation. The use of smartphone-based data collection applications by community rangers has improved the efficiency and accuracy of biodiversity monitoring in remote areas like the Afi Mountain Wildlife Sanctuary. Similarly, participatory geographic information systems (PGIS) that incorporate local spatial knowledge have helped identify culturally significant sites and traditional resource management zones that might otherwise be overlooked in conservation planning. These technologies serve as bridges between scientific and local knowledge systems, creating more comprehensive understanding of socio-ecological dynamics.[11]

The emerging field of conservation social science is contributing valuable insights into the human dimensions of wildlife protection in Nigeria. Studies applying theories from behavioral economics, for instance, have examined how different incentive structures influence participation in conservation programs. Research in communities surrounding Cross River National Park revealed that conditional livelihood incentives (e.g., beekeeping equipment provided in exchange for conservation agreements) were more effective at reducing hunting than unconditional alternatives. Similarly, assessments of governance quality have identified characteristics of effective community resource management institutions, including transparency in decision-making, equitable benefit-sharing, and accountability mechanisms. These interdisciplinary insights are essential for designing conservation initiatives that are both ecologically effective and socially sustainable.[12]

6. Conclusion

The integration of advanced research methodologies with community-centered approaches represents the most promising pathway for effective wildlife conservation in Nigeria. The country's exceptional biodiversity, coupled with intense anthropogenic pressures, creates both urgency and opportunity for innovation in conservation science. The case studies and approaches reviewed in this article demonstrate significant progress in understanding and protecting Nigeria's unique fauna, particularly through non-invasive monitoring, landscape ecology, and community engagement. The deployment of infrared camera traps, acoustic sensors, and genetic analyses has revealed previously unknown aspects of species behavior, distribution, and ecology, enabling more targeted conservation interventions. Similarly, the incorporation of local knowledge and community participation has improved protection outcomes while ensuring conservation benefits are equitably shared.

Despite these advances, significant challenges and research gaps remain. Many advanced technologies face limitations in Nigeria's challenging environmental conditions, including high humidity, dense vegetation, and limited technical support infrastructure. There is a need for developing more robust, affordable, and locally adaptable technologies that can function effectively in tropical forest environments. Additionally, technical capacity building remains essential—even the most sophisticated tools are ineffective without trained personnel to deploy, maintain, and interpret them. Future efforts should prioritize workforce development through specialized training programs, university curricula updates, and knowledge exchange initiatives between Nigerian conservationists and international experts.

Future research priorities should include: (1) Long-term studies of wildlife behavioral adaptations to human-modified landscapes; (2) Investigation of climate change impacts on species phenology and distribution; (3) Development of integrated metrics for assessing ecosystem integrity beyond single-species focus; (4) Exploration of human-wildlife coexistence mechanisms in agricultural frontiers; and (5) Evaluation of the effectiveness of different community conservation models. The Cross River gorilla and Nigeria-Cameroon chimpanzee should remain priority species given

their critical status and ecological significance, but research should also expand to include less charismatic taxa that play crucial ecosystem roles. Similarly, understudied ecosystems such as the Niger Delta wetlands and Sahelian grasslands deserve increased research attention.

The conservation challenges facing Nigeria's biodiversity are undoubtedly profound, but the innovative approaches reviewed here offer grounds for cautious optimism. By combining cutting-edge scientific methods with inclusive governance approaches, Nigeria can develop context-appropriate conservation strategies that protect its unique biological heritage while supporting sustainable development. The success of initiatives at Afi Mountain and in the Cross River region demonstrate that even critically endangered species can persist when evidence-based conservation is implemented through collaborative partnerships. As Nigeria continues to balance economic development with environmental protection, the integration of these advanced approaches into national policy and local practice will be essential for ensuring that the country's remarkable wildlife endures for future generations.

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