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RESEARCH ARTICLE

Seasonal Variations in Waterbird Diversity and Threats to the Barotse Floodplain

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Abstract

This study explored waterbird diversity and associated threats in the Barotse Floodplain, Zambia, a critical wetland in the Zambezi River Basin. Field surveys conducted along a 202 km transect during the cold-dry and hot-dry seasons revealed higher waterbird diversity in the hot-dry season, as indicated by the Shannon-Wiener Index. Chi-square analysis demonstrated significant variations in species distribution across habitat types and seasons. Human settlements and fishing were identified as the primary threats to waterbird populations, emphasising the need for targeted conservation interventions. Grasslands and inland wetlands were the most utilised habitats, underscoring their essential role in supporting waterbird communities. Additionally, the comparable reliance of migratory and non-migratory species on the floodplain suggests its importance for both groups. These findings highlight the ecological significance of the Barotse Floodplain and provide a foundation for developing conservation strategies to protect its avian biodiversity.

KEYWORDS: *Waterbird diversity, Barotse Floodplain, Habitat threats, Migratory Species*

1.0 Introduction

A wetland is defined as an area that is often flooded with water and characterised by saturated soils, with water sometimes covering the ground (Bourgeau-chavez, 2001). Wetlands are identified by the soil, flora, and fauna found within and around them. A floodplain, on the other hand, is a low-lying area adjacent to wetlands and is prone to flooding during periods of high rainfall (Bourgeau-chavez, 2001). Floodplains, by nature, are situated alongside water bodies and are subjected to seasonal inundation (Hansen, 1991). Since floodplains are dynamic, continuous assessments and monitoring are necessary to understand the factors that affect them or are influenced by them. Wetlands consist of loose soil particles, which are prone to erosion during flooding and high-water flows (Mitsch and Gosselink, 2015). These areas may also accumulate new layers of mud, silt, and sand, causing them to shift and change in size (Forsythe, 1991). The rate of degradation in floodplains is closely linked to declines in

biodiversity, leading to habitat modifications that affect water flow, flood control, and species distribution, among other factors (Tockner and Stanford).

As such, wetlands are critical ecosystems for biodiversity, particularly for waterbird species that depend on them for feeding, breeding, and refuge. The Barotse Floodplain, also known as Lyondo, is a prominent part of the Zambezi River Basin in Zambia and one of the largest wetlands in Africa (Roxburgh, 2009). Designated a Ramsar site in 2007 (Ramsar, 2002) and recognised as a Key Biodiversity Area (KBA) by BirdLife International (Roxburgh, 2007; Eken et al., 2004), holds immense conservation and economic value. The highly seasonal wetland system, which includes the Zambezi and surrounding floodplains, supports a diverse range of species, especially waterbirds that rely on it for breeding, feeding, and roosting (Likando et al., 2009). The Barotse Floodplain hosts approximately 339 bird species, some of which are of global conservation concern (Roxburgh, 2009). However, human activities and environmental changes increasingly threaten the floodplain (Roxburgh, 2007). This study assessed the diversity and distribution of waterbird species in the Barotse Floodplain, Zambia, and identified the factors influencing their populations, with a particular focus on the threats posed by human activities and environmental changes.

2.0 Materials and Methods

2.1 Description of Study Site

This study was conducted in the Barotse Floodplain, located in Zambia's Western Province (Figure 1). Spanning approximately 5,500 km², the floodplain is one of Africa's largest and most ecologically significant wetlands (Roxburgh, 2007). It experiences a highly seasonal hydrological cycle, characterised by extensive flooding during the rainy season and distinct dry periods. Geographically, the floodplain extends from Lukulu in the north to Senanga in the south, with the Zambezi River flowing through its centre (Roxburgh, 2007). The Zambezi is a fast-flowing river that slows as it meanders through the floodplain but gains speed in the bordering valleys (Zimba et al., 2018).

The floodplain hosts a diverse range of habitats, including permanent and seasonal wetlands, grasslands, riverine forests, and agricultural lands (Timberlake, 2000). Peak inundation occurs in January and February during the height of the rainy season, after which floodwaters recede between May and July, allowing vegetation to regenerate (Fanshawe, 2010). These dynamic ecosystems support a rich biodiversity, making the floodplain a crucial habitat for both resident and migratory waterbird species.

The Barotse Floodplain experiences significant temperature variations, with a mean maximum of 30°C and a mean minimum of 9°C (Zimba et al., 2018). The region, particularly within Western Province, is shaped by seasonal precipitation, flood-driven hydrological patterns (both longitudinal and transversal), and complex micro-topography (Estrada-Carmona et al., 2020).

Situated within the Zambezi Valley, the Barotse Floodplain has a wet tropical climate characterised by distinct wet and dry seasons. Annual rainfall ranges from 800 mm to 1,200 mm, contributing to moderate to high precipitation levels in the region (Sampa et al., 2019). Due to its proximity to the Zambezi River, the floodplain maintains relatively high humidity, as the water bodies contribute to moisture retention in the air (Zimba et al., 2018).

The wet season, spanning from November to April, is marked by frequent rainfall and rising water levels across the floodplain. The dry season extends from May to October, bringing reduced rainfall and receding floodwaters (Fanshawe, 2010). These seasonal shifts play a crucial role in shaping the region's ecological dynamics.

The Barotse Floodplain is one of Zambia's largest wetland systems, supporting a population of approximately 250,000 people (Kwashimbisa and Puskur, 2004). Seasonal variations within the floodplain influence various aspects of life, including nutrition, food and economic security, labour supply and demand, social events, and livelihood activities across the wet and dry seasons. Livelihoods in the region primarily revolve around fishing, herding, and farming (Rajaratnam et al., 2015). However, if not properly managed, these human activities can lead to fish stock depletion, disruptions in food webs, and habitat fragmentation or degradation. During droughts or the dry season, the floodplain becomes a critical resource for farmers and pastoralists, providing arable land for cultivation and grazing areas for livestock (Banda et al., 2023). Additionally, it offers both direct and indirect benefits, including opportunities for crop diversification, the maintenance of rural livelihoods, and enhanced food security (Parra et al., 20121).

2.2 Data collection techniques

2.2.1 Desk Review

A comprehensive literature review was conducted to address data gaps on the factors influencing avian abundance and distribution in the Barotse Floodplain. Relevant information was gathered from key conservation organisations, including the Department of National Parks and Wildlife (DNPW), BirdWatch Zambia, and the National Museums of Natural History. The review encompassed a wide range of sources, including textbooks, authoritative websites, and bird guides. Insights from literature were instrumental in designing the study methodology, helping to identify appropriate methods, tools, and techniques used in previous studies, along with their limitations and challenges. This ensured the study was well-structured, allowing for potential issues to be anticipated and addressed in advance.

Additionally, the desk review enhanced the quality and accuracy of the study by providing a systematic and rigorous approach to gathering and analyzing existing information. This helped minimize bias while improving the reliability and validity of the findings. Following the field surveys, supplementary data was obtained from the IUCN Red List of Threatened Species (https://www.iucnredlist.org/). For each bird species encountered in the field, information was collected on habitat type, feeding guild, migratory patterns, threat status, family classification, and population trends. This data complemented field observations on species name, abundance, location, seasonality, and habitat preference

2.2.1 Field Surveys

Field data was collected during two survey periods: the cold and dry season (June 2021) and the hot and dry season (November 2021). Conducting surveys across these two seasons allowed for a comprehensive understanding of the ecosystem's dynamics and accounted for seasonal variations in species distribution and habitat characteristics. Data collection was done daily between 7 AM and 6 PM, when waterbirds are most active, using both vehicles and an engine-powered boat.

2.3 Survey Methods

Three primary data collection methods were employed: point counts (point transects), line transects, and opportunistic surveys.

2.3.1 Point Counts

Observers recorded and identified bird species based on visual and auditory cues. At each survey point, data was collected on:

- Species observed or heard
- Number of individuals per species
- Habitat type and dominant vegetation
- Human activities and potential threats to the habitat

Bird identification was based on physical traits, behaviour, and habitat preferences, supplemented by knowledge of bird calls and songs. Visual cues such as size, coloration, and distinctive markings were carefully noted. Unique vocaliations were verified using the mobile apps for Birds of Zambia and the Birds of Africa -South of the Sahara (2nd Edition).

This method was particularly effective for detecting secretive bird species in dense vegetation and provided an accurate measure of species abundance (Ralph et al.,1995; Bibby et al., 2012).

Threats to bird habitats, including settlements, fishing, fires, farming, and other human activities, were recorded as either present or absent. Their frequency was assessed based on encounter rates. Data collected within a single cluster transect was considered as a single point (Burnham et al., 2008).

2.3.2 Line Transects

Four main transects were surveyed along river canals and adjacent floodplains. These transects were pre-selected based on existing access routes through canals from Mongu, the main entry point into the floodplain. The total distance covered was 202 km, with the following routes:

- Mongu–Senanga: 95 km
- Mongu–Ngombala: 45 km
- Mongu–Kalabo: 30 km
- Mongu–Lukulu: 32 km

The Mongu–Kalabo transect was conducted by vehicle along the Mongu–Kalabo causeway, while the remaining three were surveyed by boat. Within each transect, species richness, abundance, and habitat threats were recorded within a 2 km radius (Bibby et al., 2012).

2.3.3 Opportunistic Sampling

Additional bird species were recorded opportunistically while travelling between sampling points, including sightings outside standard survey times and locations. Birds were identified by appearance or call, and all opportunistic observations within the project area were documented (Burnham et al., 2008).

2.4 Data Management and Analysis

The Shannon-Weiner Index (H') was used to analyze bird diversity data collected across the two seasons (Magurran, 2003). This widely used ecological measure accounts for both species' richness (the number of species present) and evenness (the relative abundance of each species), providing a comprehensive assessment of avian diversity in the Barotse Floodplain.

By applying this index, we quantified seasonal variations in bird communities, offering insights into changes in species distribution and abundance.

The Shannon-Weiner index is derived from information theory and measures uncertainty (Barnes et al., 1998). The level of uncertainty in predicting the species of a random sample is directly related to the diversity within a community. In a community with low diversity, where one species dominates, the uncertainty is minimal, as a random sample is likely to be the dominant species. Conversely, in a highly diverse community, the uncertainty increases, as predicting the species becomes more difficult. The index is simply calculated as follows:

$$H' = \frac{N ln\, N - \sum(n_i ln\, n_i)}{N}$$

Where **N** represents the total number of species, and $\mathbf{n_i}$ is the number of individuals in species **i**. This index is particularly sensitive to species richness, meaning it is biased towards measuring the number of species present in a sample. As a result, the Shannon-Weiner index often emphasizes species diversity more than the evenness of their distribution.

To assess potential threats, a frequency analysis was conducted to determine the occurrence and proportion of each identified threat, allowing for an evaluation of their relative prevalence.

For statistical analysis, IBM SPSS Version 23 software was used to perform a chi-square goodness-of-fit test. This test assessed whether the observed frequencies of categorical data aligned with expected frequencies based on a theoretical distribution or hypothesis. By applying this statistical framework, we evaluated how well the observed data conformed to expected patterns, providing deeper insight into the distribution of categorical variables within the dataset.

3.0 RESULTS

3.1 Bird Species Diversity in Barotse Flood Plain

A total of 35,955 individual birds were recorded across 63 species during the survey, highlighting the richness and abundance of avian life in the Barotse Floodplain. Among the observed species, a few stood out due to their high population counts. The African Openbill (*Anastomus lamelligerus*) was the most numerous, with 9,412 individuals, followed closely by the Long-tailed Cormorant (*Microcarbo africanus*, 9,037 individuals) and the Collared Pratincole (*Glareola pratincola*, 7,068 individuals). Other frequently encountered species included the White-faced Whistling Duck (*Dendrocygna viduata*, 4,019 individuals), African Skimmer (*Rynchops flavirostris*, 1,526 individuals), and Blacksmith Lapwing (*Vanellus armatus*, 1,456 individuals). Figure 2 illustrates the abundance of these species within the study area. A comprehensive list of all bird species expected to be found in the Barotse Floodplain is available in Supplementary Material (S1), with species observed during the survey highlighted in green.

A significant difference was observed between the expected and actual number of species across the four surveyed locations, X^2 (3, N = 35,955) = 31,634.4, p = 0.0001. Among the sites, Senanga recorded the highest number of individual birds (Table 1). Assuming an equal distribution of birds across all transects, the expected number of birds per location was uniform. However, Senanga showed the largest deviation from this expectation, with a

difference of 13,963.25 birds (22,952 observed vs. 8,988.75 expected), making it the most significant contributor to the chi-square value (Table 1).

Table 1: Observed and expected bird species at the four different locations in Barotse floodplains

		Test		Contribution
Category	Observed	Proportion	Expected	to Chi-Sq
Ngombala/Mongu	7408	0.25	8988.75	278.0
Kalabo	537	0.25	8988.75	7946.8
Senanga	22952	0.25	8988.75	21690.7
Lukulu	5058	0.25	8988.75	1718.9

3.2 Seasonal Variation in Species Diversity in Barotse Floodplain

The study revealed significant seasonal variations in waterbird diversity within the Barotse Floodplain, with a higher Shannon-Weiner diversity index recorded during the hot-dry season (1.78) compared to the cold-dry season (1.36) (Table 2).

Table 2: Seasonal Variation in Species Diversity in Barotse Floodplain

	Cold and Dry	**Hot and Dry**	**Overall**
Species Abundance	**20215**	**15740**	**35955**
Species Richness	**44**	**50**	**64**
Shannon-Weiner Index (H')	**1.36**	**1.78**	**2.04**

3.3 Species abundance and habitat association

A total of 23 habitat types were associated with waterbirds in the Barotse Floodplain (Figure 3). However, the bird assemblages across these habitats did not exhibit significant variation, as indicated by the statistical result: $F(22, 205) = 0.65$, $p = 0.8$. This suggests that while waterbirds were found across a diverse range of habitats, the overall distribution of species within these habitats did not differ in a statistically significant way.

3.4 Bird Migration in the Barotse Floodplain

The chi-square test results indicate that there was no significant difference in the distribution of full migrants and non-migrants among the observed bird species (X^2 (1, N = 228) = 1.42105, p = 0.233). This suggests that the proportion of migratory and non-migratory species recorded in the Barotse Floodplain aligns with what would be expected under a uniform distribution (Table 3).

The analysis revealed that 54% of the waterbirds observed in the region were full migrants, while 46% were non-migrants (Figure 4). This near-even distribution implies that the floodplain provides suitable habitat conditions for resident and migratory species throughout the year.

Table 3: Contribution to Chi-Sq per migration category of waterbirds in Barotse Floodplain

Test	**Contribution**

Migration	Observed	Proportion Expected	to Chi-Sq
Full migrant	**123**	**0.5**	**114**	**0.710526**
Not a migrant	**105**	**0.5**	**114**	**0.710526**

3.5 Threats to Birds in the Barotse Floodplain

The frequency analysis of threats to waterbird distribution and abundance in the Barotse Floodplain revealed that human settlements and fishing posed the most significant impacts, followed by farming and fire (Table 4). These activities contribute to habitat degradation, resource competition, and potential disturbances that can negatively affect waterbird populations

Table 4: Identified threats to the Barotse floodplain

Threat	Description	No. of encounters *
Human settlements	While most settlements within the floodplain are temporal; only functioning during open fishing season, their density, human population and other activities have resulted in the conversion of suitable habitat as well as disturbance, especially for shy bird species.  *Settlements on the banks of the main tributaries of the Floodplain.*	39

Fishing	The fishing nets used by fishermen act as traps for birds. This is in addition to the fishing activities that scare away birds.  *Drag net composed of a rope and a mosquito net used within the floodplain*	30
Farming (crop and pastoral)	Land conversion to farmland is a common phenomenon within the landscape thereby compromising suitable habitat.	18
Fire	Mostly started by fishermen and farmers with the intent to clear canals off predators and crop fields for agriculture practices.  *Fire in the Barotse Floodplain*	11
Invasive species	The increasing presence of the giant sensitive tree (*Mimosa pigra*), and the Kariba weed (*Salvinia molesta*) that are outcompeting the native species and thereby threatening the long-term health of the ecosystem.  *Mimosa pigra within the Floodplain*	7

Traps	Local people use snares which kill the birds by strangulation if birds are trapped by the neck or feet which leads to stress, anxiety, panic then death. These are mostly mesh strings connected to sticks and strategically placed to trap birds and are mostly invisible.	3
Poison	The local people use monocrotophos (an organophosphate insecticide) to kill birds by adding the chemical to scarce water drinking points that remain during the dry season. The poison kills the birds when they drink from the poisoned waterholes.	1

***Encounter numbers represent absolute counts**

4.0 DISCUSSION

The dominance of some species observed in the Barotse floodplain may be attributed to their adaptability to the floodplain's dynamic wetland conditions and the availability of key resources such as food and nesting habitats. For instance, the African Openbill, a specialist mollusc feeder, thrives in wetland environments with abundant snail populations, while the Reed Cormorant benefits from the numerous water channels that provide ideal fishing opportunities. Similarly, the Collared Pratincole, an aerial insectivore, takes advantage of the exposed sandbanks and mudflats for nesting and foraging, which are more prominent in certain seasons. These findings are fully supported by Dodman and Diagana (2007), who emphasizes how species distribution and dominance in wetlands are influenced by habitat conditions, food availability, and seasonal changes. It, however, also acknowledges that external pressures might alter these dynamics over time.

Further, a statistically significant difference was detected between the expected and observed number of bird species across the four surveyed locations. This result indicates that the distribution of birds was not uniform across the sites, suggesting site-specific factors influencing bird abundance. Among the surveyed locations, Senanga recorded the highest number of individual birds, exceeding the expected count by a substantial margin.
If bird distribution were even across all transects, each site would have recorded a similar number of individuals. However, Senanga displayed a major deviation, with 22,952 observed birds compared to an expected 8,988.75, leading to a difference of 13,963.25 birds. This made Senanga the largest contributor to the chi-square value, suggesting that it harbored significantly higher bird populations relative to the other sites.

The disproportionate bird abundance in Senanga could be attributed to a range of ecological factors, such as the availability of food resources, the presence of suitable nesting and roosting sites, or favourable hydrological conditions. Seasonal flooding patterns, vegetation structure, and human activities might also play a role in influencing bird distribution. These findings align with Boere et al. (2006), who highlight how seasonal flooding and habitat conditions drive waterbird abundance and distribution in African wetlands. Green and Elmberg (2014) further suggests that while ecological factors drive bird abundance, human-induced changes (e.g., agriculture, pollution) can override natural patterns. These findings highlight the importance of site-specific ecological assessments to understand the underlying drivers of species concentration and habitat preference within the Barotse Floodplain.

The seasonal variation in species diversity in the Barotse Floodplain suggests that more species were present and more evenly distributed during the hot-dry season, while the cold-dry season

exhibited lower species richness and a higher dominance of certain species. The observed differences could be attributed to seasonal changes in habitat availability, food resources, and migratory patterns, as many waterbird species may move in response to fluctuating water levels and ecological conditions within the floodplain. Under natural conditions, a floodplain river is a dynamic ecosystem, experiencing seasonal fluctuations in water levels that create the ideal habitat for diverse assemblages of resident and migrating birds (Kingsford and Porter, 2009). While environmental factors play a crucial role, some studies suggest that their influence may not be consistent across all time periods. Although environmental factors are important, their impact on species diversity can vary, suggesting a more complex interaction of factors (Sutherland et al., 2004).

This pattern in the research results suggested that seasonal factors such as resource availability and favourable conditions during the hot-dry season play a critical role in supporting greater species diversity. Overall, the combined Shannon-Wiener diversity index of 2.04 for the study period underscores the ecological richness of this wetland system.

Some habitats, including "Wetlands (inland)", "Grassland", and "Grassland, Wetlands (inland)", had much higher observed frequencies of birds than would have been expected under a random distribution. These habitats appear to be particularly favourable for waterbirds, potentially offering better resources such as food, water, and suitable nesting sites. In contrast, habitats such as "Forest, Grassland", "Forest, Shrubland", and "Savanna, Shrubland" showed lower-than-expected observed frequencies, indicating that these environments might be less attractive or accessible to the bird species surveyed.

These findings suggest that certain habitat types within the Barotse Floodplain are more critical to waterbird populations, potentially due to specific ecological factors such as vegetation structure, water availability, or proximity to feeding areas. However, the lack of significant differences across the full range of habitats indicates that habitat flexibility might also be a characteristic of the birds in the region, allowing them to utilize a broader spectrum of environmental conditions. Our observations regarding habitat specificity and flexibility among waterbird populations in the Barotse Floodplain is supported Gao et al. (2021) who highlights how specific habitat features, such as vegetation structure and water availability, significantly influence waterbird diversity in floodplain ecosystems.

Migratory birds likely utilize the area as a seasonal refuge, benefiting from the dynamic wetland ecosystem, while non-migratory species may rely on local food resources and stable breeding grounds within the floodplain. Although the distribution difference was not statistically significant, the presence of a substantial proportion of migratory species underscores the ecological importance of the Barotse Floodplain as a critical stopover and breeding site for waterbirds. Conservation efforts should therefore consider the seasonal habitat requirements of both groups to ensure the long-term sustainability of waterbird populations in the region. Similarly, Almeida et al. (2016) demonstrate that environmental factors, including vegetation and hydrology, play a crucial role in structuring waterbird communities in floodplains. This suggest that waterbirds exhibit flexibility in habitat use, utilizing a range of environmental conditions, which align with our observations of habitat flexibility in the Barotse Floodplain.

Human settlements lead to habitat fragmentation, increased human-wildlife conflicts, and land-use changes that reduce the availability of suitable breeding and foraging sites for birds.

Fishing, particularly in areas of high waterbird density, can result in food resource depletion and accidental disturbances, especially in species reliant on aquatic prey. Our assertion that human settlements lead to habitat fragmentation, increased human-wildlife conflicts, and land-use changes affecting bird populations, as well as the impact of fishing on waterbird species reliant on aquatic prey, is well-supported by ecological studies. For instance, Luniak (2004) explains how urban development leads to habitat fragmentation, resulting in wildlife adapting to urban environments, often causing increased human-wildlife conflicts. Additionally, the decline in wild bird populations in the UK, has been attributed to habitat loss, among other factors (The Guardian, 2024).

Furthermore, farming practices, especially those involving wetland conversion and agrochemical use, may further degrade important bird habitats, while frequent fires, whether caused by agricultural land clearing or natural occurrences, can disrupt nesting grounds and alter vegetation structure. Our assertion that farming practices, particularly wetland conversion and agrochemical use, degrade bird habitats, and that frequent fires disrupt nesting grounds and alter vegetation structure, is supported by Thomas (2008) who states that pesticides can eliminate some essential food sources animals, causing the animals to relocate, change their diet, or starve. Residues can travel up the food chain. For example, birds can be harmed when they eat insects and worms that have consumed pesticides. The findings highlight the need for conservation strategies that balance sustainable human activities with the preservation of critical bird habitats to maintain the ecological integrity of the floodplain.

Conclusion

This study provides valuable insights into the species diversity, abundance, and habitat associations of waterbirds in the Barotse Floodplain. The findings highlight the critical role of ecological factors such as habitat structure, water availability, and seasonal flooding patterns in shaping bird distributions. The dominance of certain species, such as the African Openbill and Reed Cormorant, reflects their adaptability to the dynamic wetland conditions, while seasonal variations in species richness suggest that fluctuations in water levels and food resources influence bird diversity.

The results also underscore the uneven distribution of waterbird populations across surveyed locations, with Senanga exhibiting significantly higher bird abundance. This disparity suggests that site-specific factors, including hydrological conditions and resource availability, play a key role in determining bird concentrations. Furthermore, while certain habitat types, particularly wetlands and grasslands, emerged as crucial to waterbird populations, the observed habitat flexibility among species indicates their ability to exploit a broader range of environmental conditions within the floodplain.

The study also reinforces the ecological importance of the Barotse Floodplain as a key habitat for both resident and migratory waterbirds. Migratory species utilise the floodplain as a seasonal refuge, benefiting from its rich wetland resources, while non-migratory species rely on stable breeding and foraging grounds. These findings emphasise the need for conservation efforts that consider both seasonal and long-term habitat requirements to ensure the sustainability of waterbird populations. However, increasing anthropogenic pressures, such as habitat fragmentation due to human settlements, agricultural expansion, and fishing activities, pose significant threats to bird populations. Wetland conversion, agrochemical use, and frequent fires further contribute to habitat degradation, highlighting the urgent need for conservation strategies that balance human activities with habitat protection.

Overall, this study contributes to a deeper understanding of waterbird ecology in the Barotse Floodplain and provides a scientific basis for targeted conservation interventions. The results not only contribute to the understanding of species distribution within the floodplain but also serve as a crucial baseline for monitoring population trends and assessing potential conservation concerns in the region.

The study makes the following recommendations:

- Strengthen Habitat Protection and Management: Implement stricter regulations to prevent habitat destruction from human activities, establish protected areas in high-biodiversity zones, and ensure preservation of critical habitats.
- Mitigate Human-Wildlife Conflicts: Promote sustainable fishing practices, educate local communities on the ecological importance of waterbirds, and involve them in conservation efforts to reduce the use of snares and poisons.
- Control Invasive Species: Develop management plans to control invasive species like *Mimosa pigra* and Kariba weed, and encourage the restoration of native vegetation to support native bird species.
- Enhance Monitoring and Research: Establish long-term monitoring programs to track changes in bird diversity and distribution and conduct further research on the ecological roles of different bird species within the floodplain.
- Promote Community Involvement and Education: Engage local communities in conservation activities through awareness campaigns, education programs, and support community-based initiatives that offer alternative livelihoods to reduce dependency on harmful activities.

Declaration of generative AI and AI-assisted technologies

During the preparation of this work, we used ChatGPT in order to improve readability and language. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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APPENDICES: TABLES

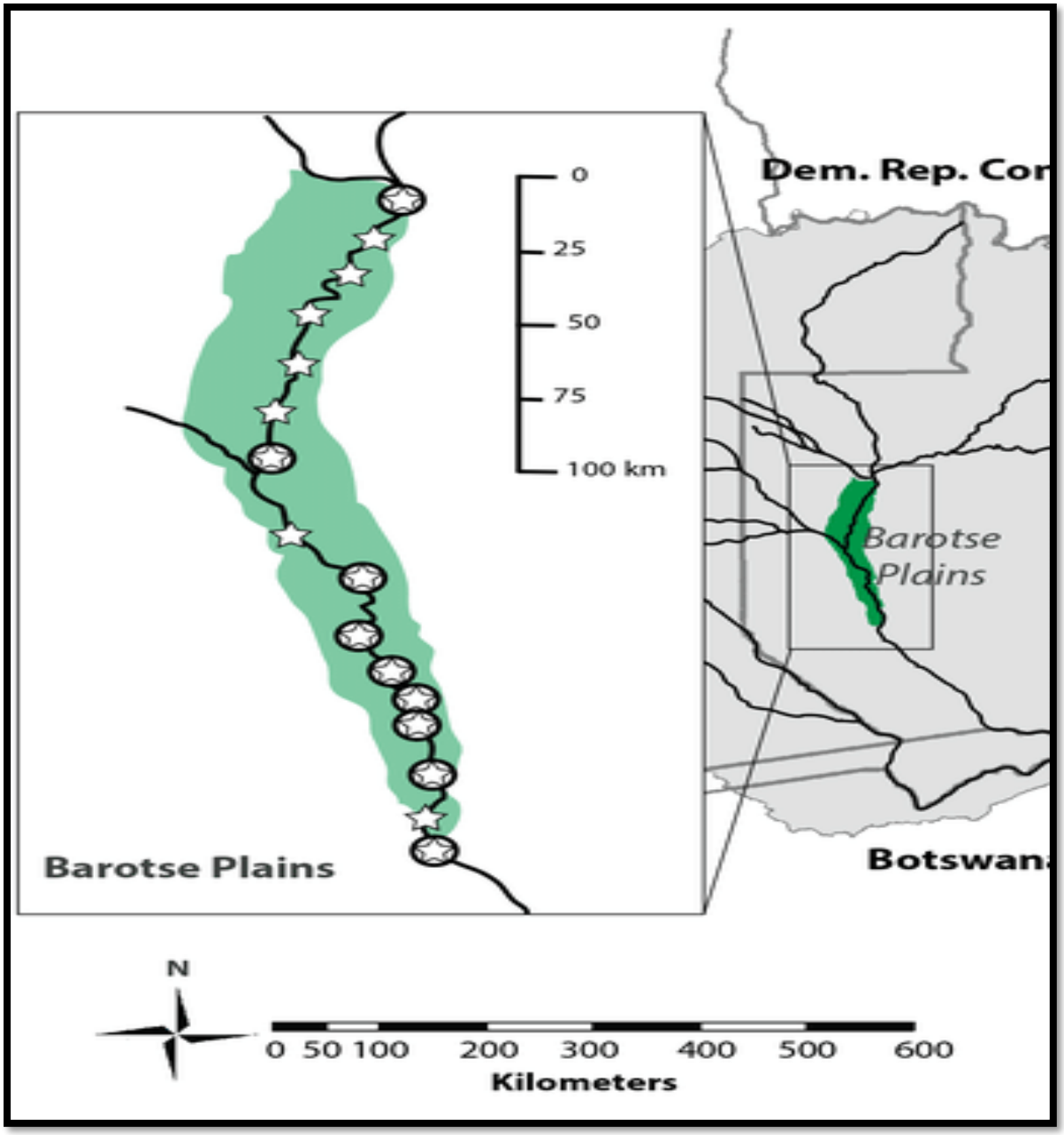

Figure 1: Map of the study Area **(Source: Zuijdgeest et al., 2016)**

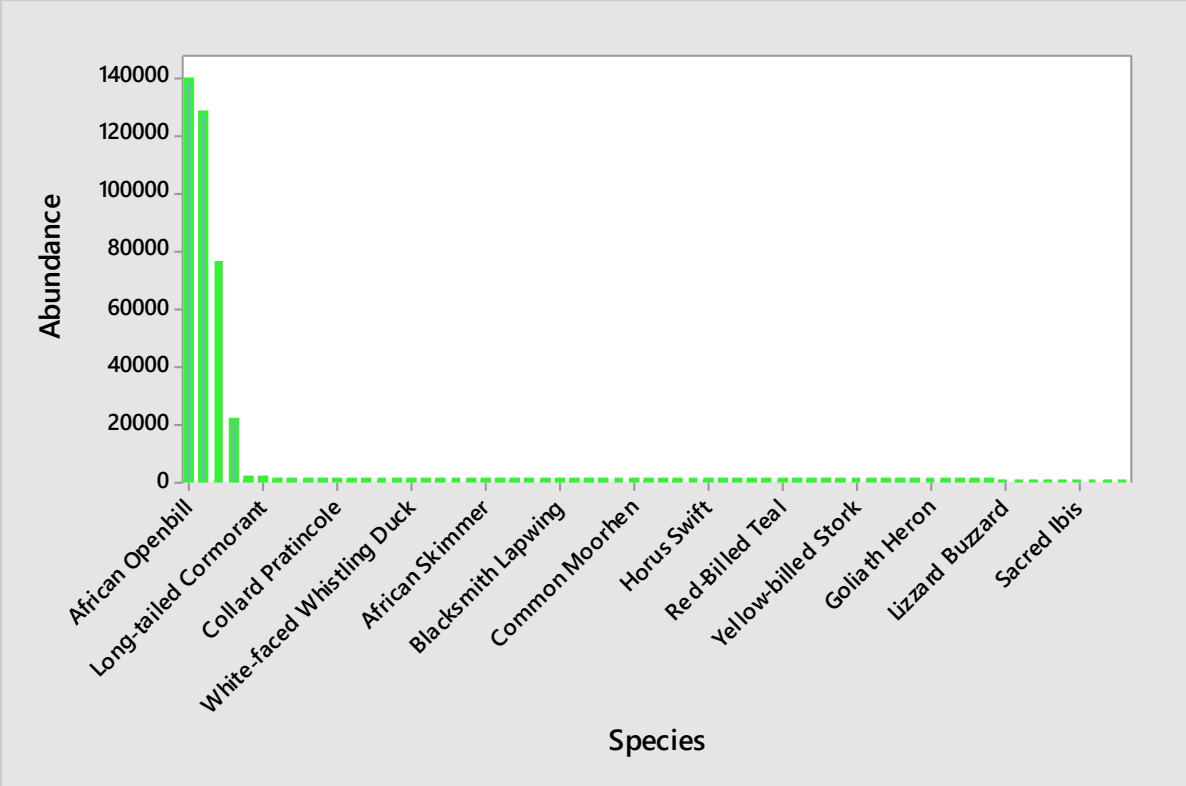

Figure 2: Species Abundance of the most common waterbirds observed during the survey in the Barotse Floodplain

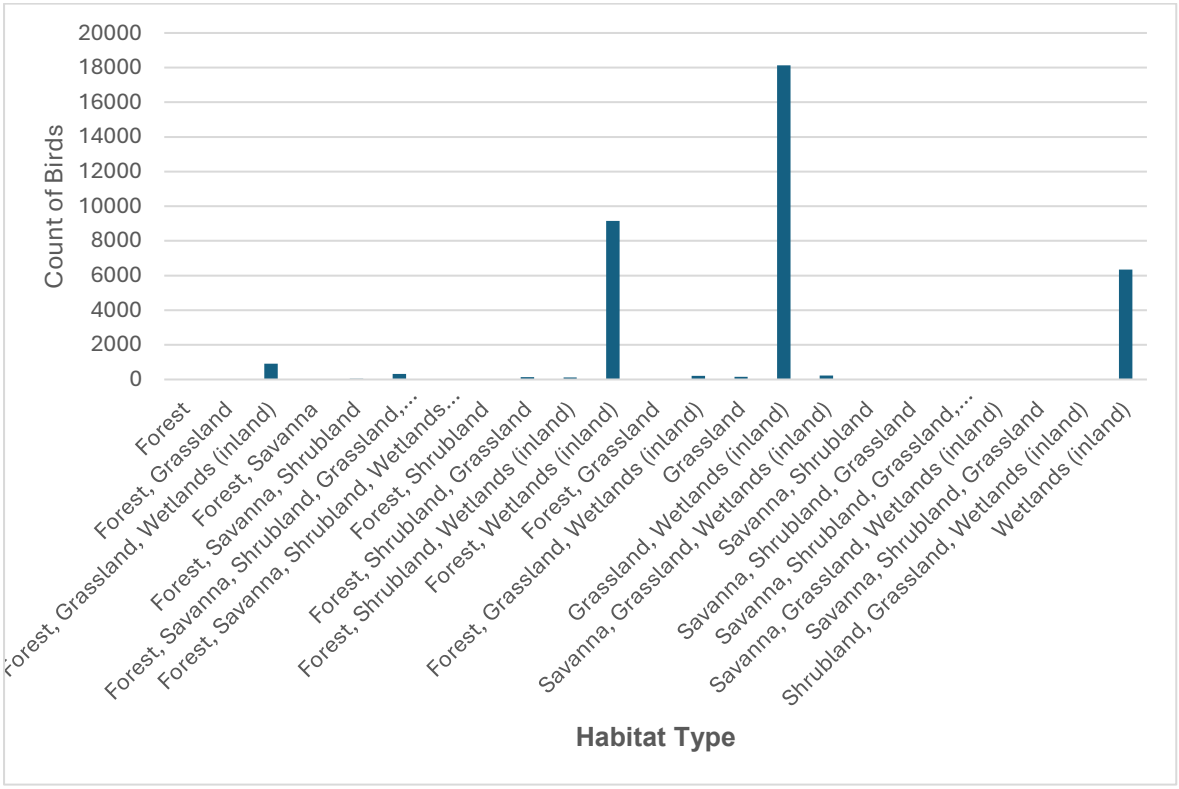

Figure 3:Waterbird abundance per habitat type in Barotse Floodplain

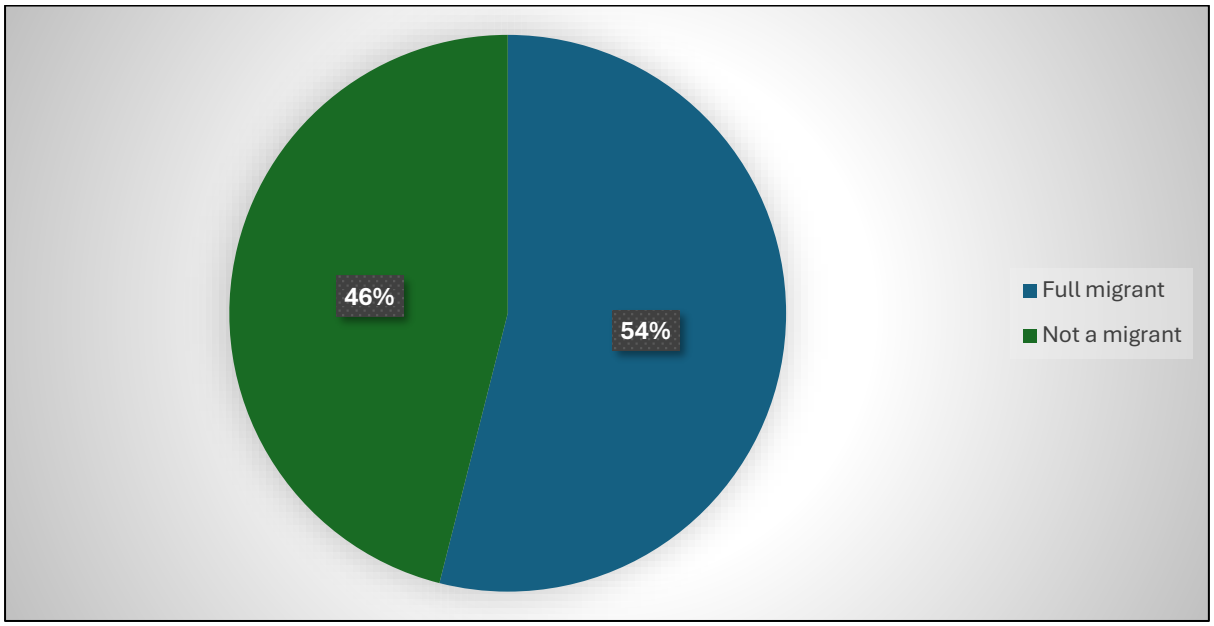

Figure 4: Migration status of bird species likely to be found in Barotse Floodplain