



EXPEDITION OVERVIEW

ZAMBEZI RIVER

SIOMA TO
LIVINGSTONE



THE WILDERNESS PROJECT

ABOUT THE WILDERNESS PROJECT

By 2035, in partnership with local communities, governments, researchers and NGOs, The Wilderness Project aims to explore, study and better protect 1.2 million square kilometers of irreplaceable African wilderness. Central to this effort is establishing detailed hydrological and ecological baselines of the largely undocumented sources and watersheds of Africa's greatest river basins — the Zambezi, Congo, Nile, Chad and Niger.

ACKNOWLEDGEMENTS

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**Ministry of
Fisheries and
Livestock**



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INTRODUCTION

356
km

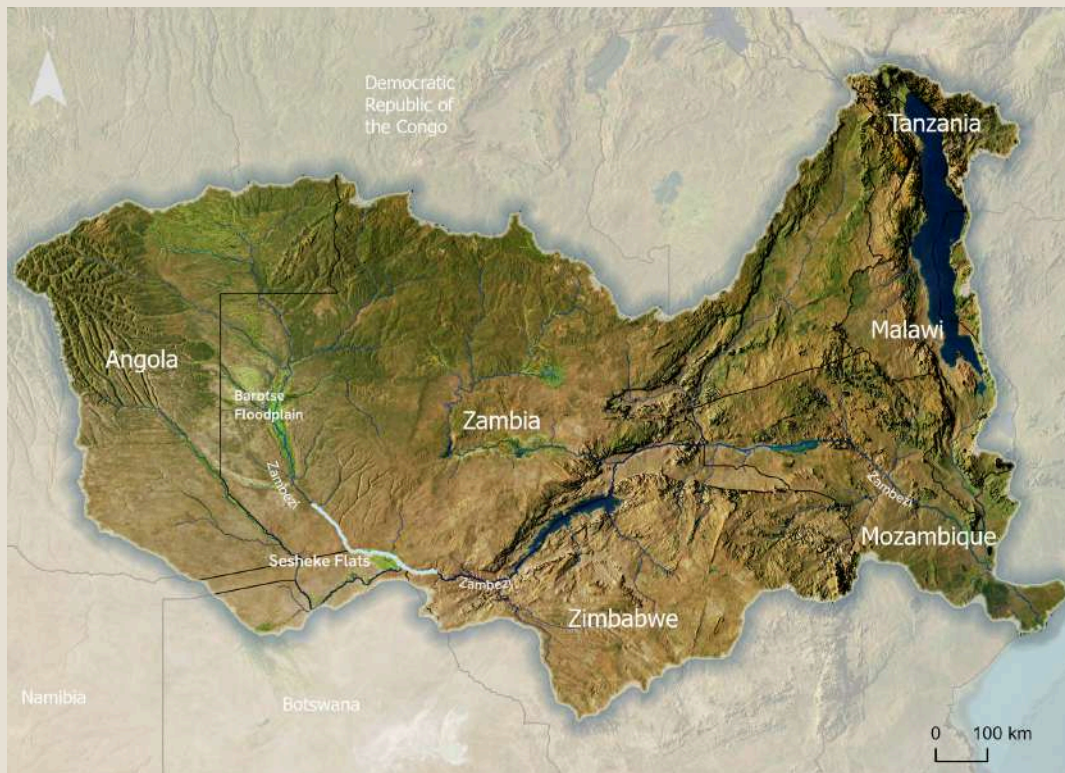
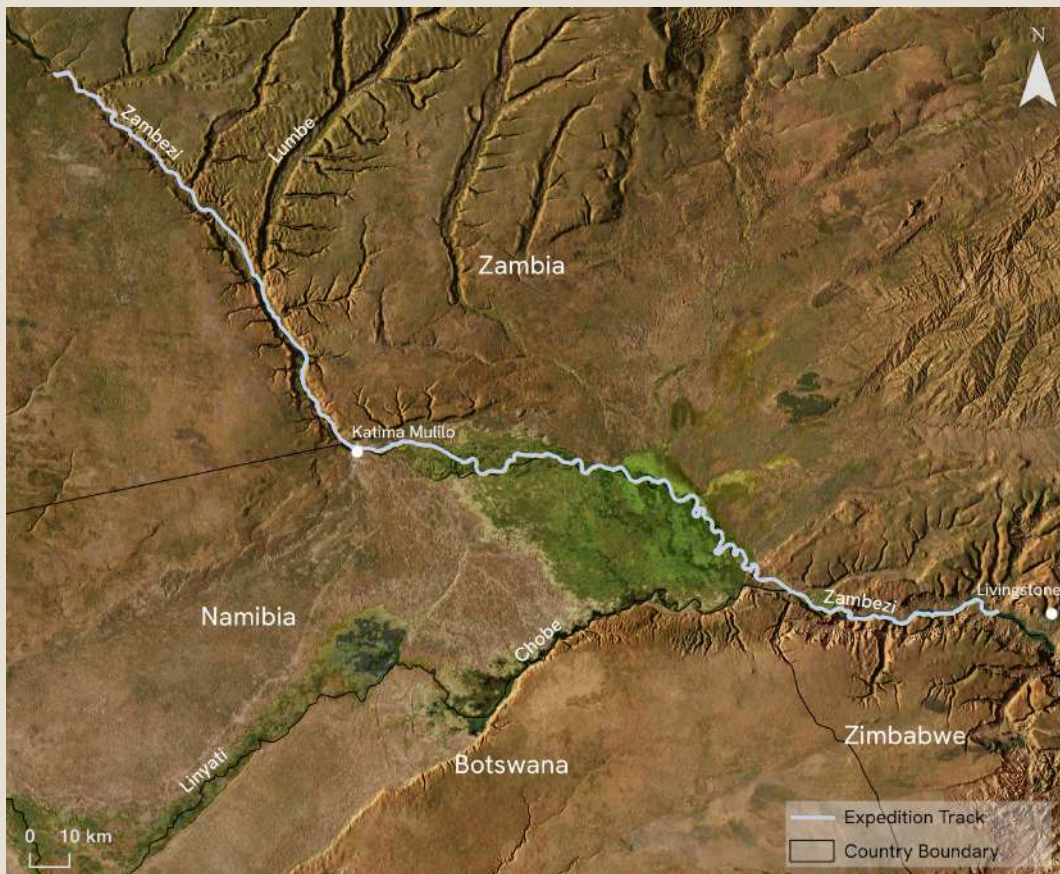
The total distance
travelled from Sioma
to Livingstone



The Zambezi Basin is the largest in southern Africa, spanning 1.3 million km² and eight countries. The Zambezi River flows for 3,421 km from its headwaters in Angola and Zambia to the Indian Ocean, supporting one of the most important freshwater systems on the continent¹. The upper Zambezi functions as a critical water tower, regulating flows that sustain downstream floodplains, wetlands, and riverine ecosystems. These systems underpin regional livelihoods and economies by supporting fisheries, flood-recession agriculture, grazing, hydropower generation, and freshwater supply for millions of people across the basin.

Six sub-basins feed the upper Zambezi River: the Upper Zambezi, Lunga, Kabompo, Luanginga, Barotse and Cuando/Chobe. The flow of these sub-basins is consolidated by the Barotse Floodplains — the second-largest wetland in Zambia². Below the Barotse, another wetland of immense importance, the Sesheke Flats, further cleans and regulates the flow of the Zambezi River. Combined, these wetlands support one of the largest fisheries in Zambia, providing a direct source of income and food security to over 180 villages³.

To better understand the biodiversity, water quality and flow of the Upper Zambezi River, the Wilderness Project (TWP) conducted a research survey between Sioma (immediately downstream of the Barotse Floodplain) and Victoria Falls. The survey was conducted over the 1st - 12th August 2023, forming part of a wider effort to study the Zambezi from its source to its end. The 356 km survey was conducted entirely in purpose-built canoes, covering vital river sections including including Ngonye Falls, Sesheke Flats, Katima Mulilo, and the Zambezi National Park.



The expedition followed the Zambezi River from just below the Barotse Floodplain to Livingstone, crossing the Sesheke Flats. This stretch of the river lies within the greater Zambezi Basin, a vast transboundary system spanning eight countries in southern Africa.

METHODS

Along the transect, researchers collected data related to biodiversity, fisheries, river flow, water quality, and human development. In addition, the team mapped the river using a 360-degree camera and a series of drone photographs, collecting footage that serves as a virtual library for future generations. Combined, this information offers a snapshot of the ecological health of the upper Zambezi River, providing a vital resource for the water-use planning, research and conservation of this vital system.

CONTINUOUS MONITORING

During the transect, teams collected continuous survey data and 360° imagery. Each team included an observer and a recorder. Observers scanned the river and both banks — up to 100 m from the edge — identifying features such as land use, infrastructure, biodiversity, and signs of disturbance. Recorders logged observations in real time using the Survey123 (ESRI) app on a smartphone, ensuring spatially referenced data across diverse indicators.



FIXED SURVEY SITES

Fixed survey sites were established at regular intervals to capture detailed information on water quality, biodiversity, and land use. These sites offer a strong foundation for long-term monitoring by communities, river authorities, and NGOs involved in river stewardship.



- *Every 10km:* using drone imagery and water analysis, researchers revealed patterns not visible through observation alone.
- *Every 50-75km:* eDNA sampling, macroinvertebrate surveys, and further testing provide a foundation of river health and biodiversity.

OPPORTUNISTIC SITES

To complement continuous observations, researchers conducted targeted sampling at selected sites along the transect. Leveraging local river conditions and insights from visual surveys, they deployed overnight bat recorders, set traps for freshwater fish and crustaceans, collected water samples, and measured river discharge. This approach enabled more detailed assessments of the river's hydrochemistry, hydrology, and biodiversity.



RESEARCH SITES

40 research sites

35

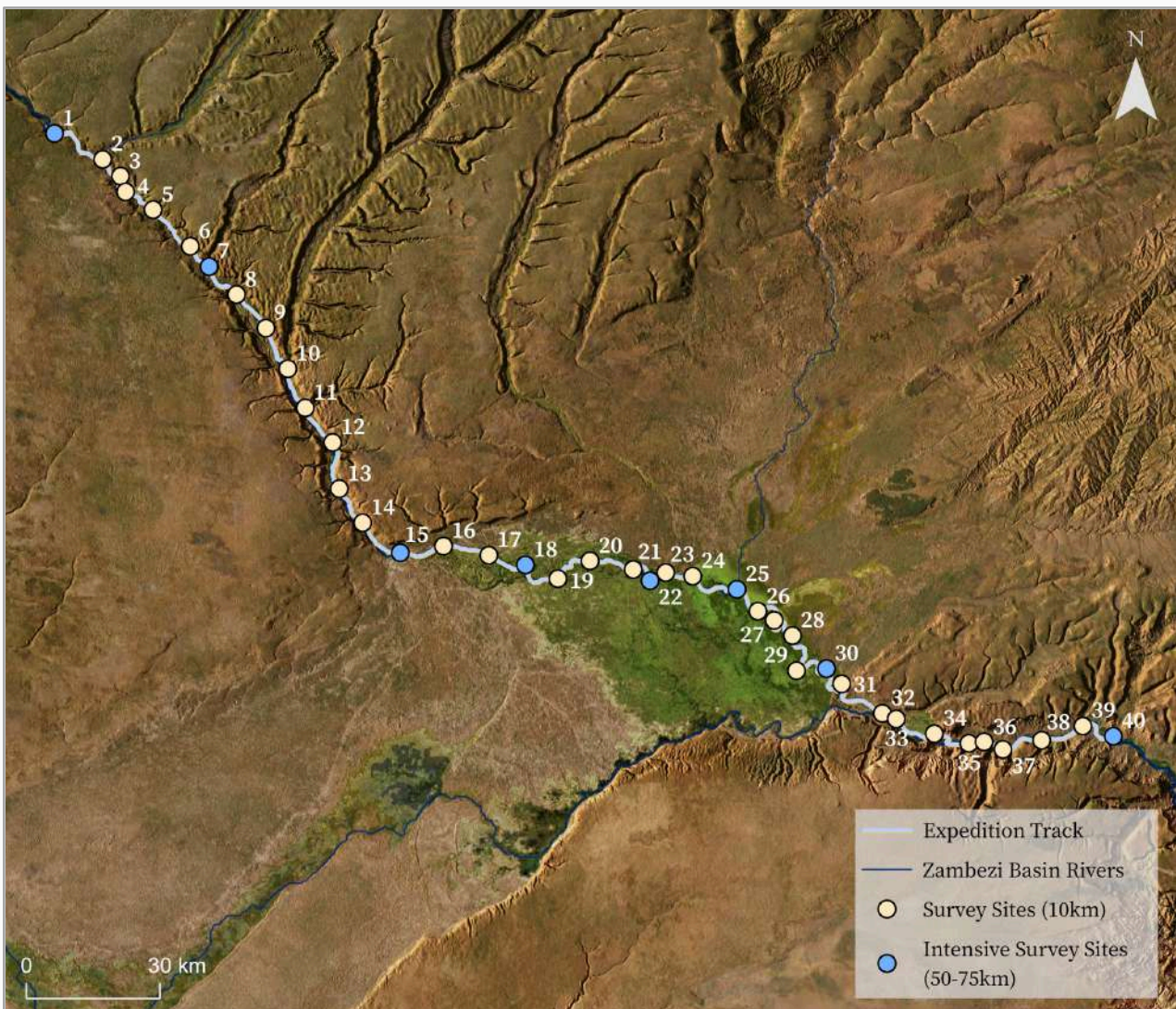
water quality
measurements

6,765

birds identified

769

fishes identified



| Locations of 10 km and 50-75 km research sites along the transect.

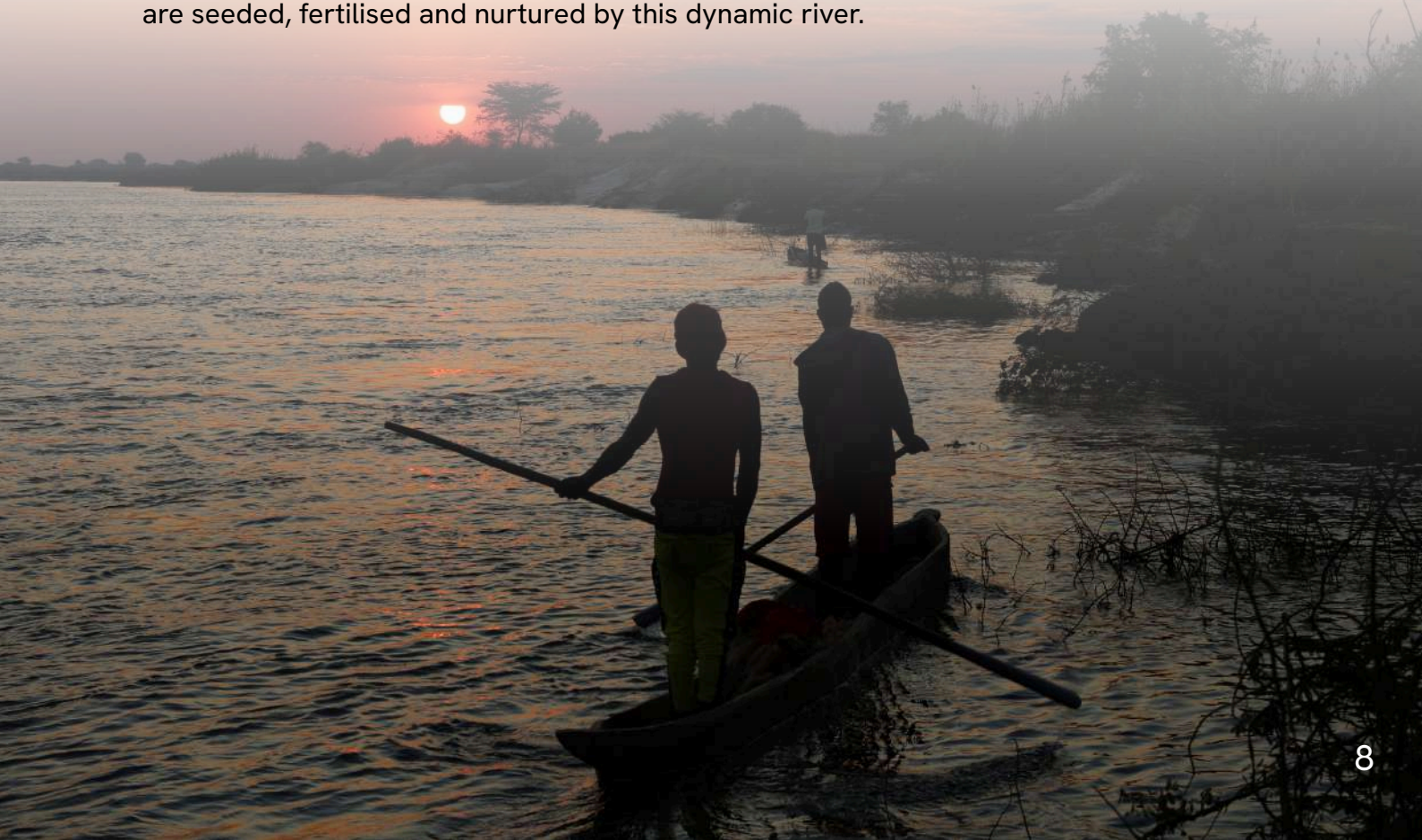
SESHEKE FLATS

The Sesheke Flats — also known as the Eastern Caprivi, Southern Barotse Floodplain, or Chobe-Zambezi Floodplain — spans approximately 100 km along the Zambezi River between Sesheke and Mambova. The floodplain extends up to 35 km into Namibia and 8 km into Zambia, encompassing 3,700 km² at the heart of the Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA). The Sesheke Flats forms an important hydrological link between the Zambezi, Cuando, Linyanti, and Chobe Rivers⁴.

The floodplain is predominantly inhabited by the Lozi cultures, belonging to the Subia and Mafwe tribes, and underpins a subsistence-based economy centred on agriculture, livestock grazing, and fishing. Staple crops include millet, maize, and sorghum, which are cultivated along floodplain margins. In addition, the floodplain is burned annually to facilitate regrowth of palatable grasses for livestock⁵.

The Sesheke Flats plays a key role in maintaining ecological connectivity across the broader KAZA landscape. The floodplains provide critical habitat for a wide array of wetland-associated birds, including threatened species such as the wattled crane and vulnerable slaty egret. The wetland also sustains diverse fish communities, with regionally significant species like the broadhead catfish and striped killifish. Although large mammal numbers have declined in recent decades, species such as red lechwe and sitatunga are still present, mostly in protected areas.

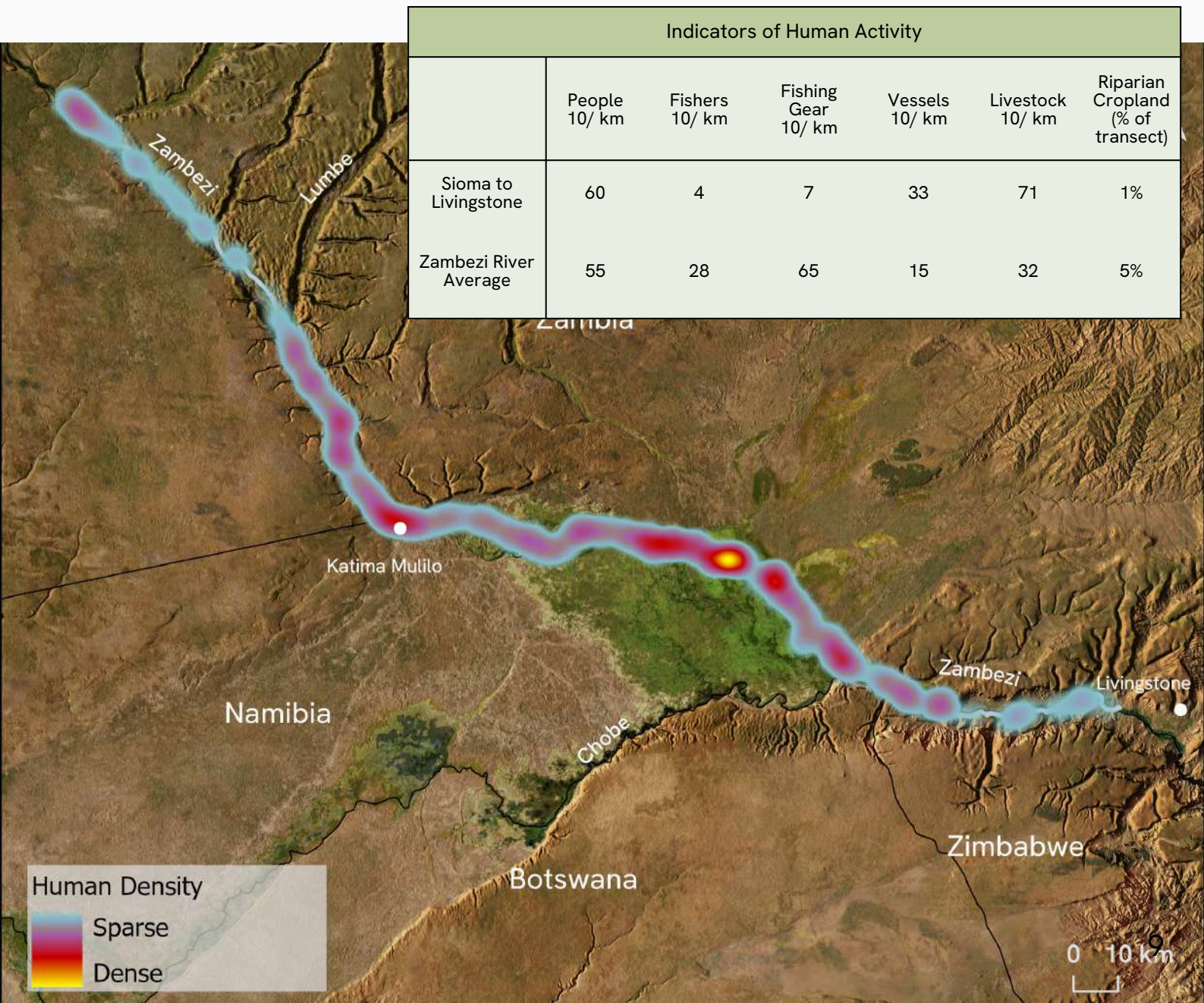
As with other wetlands in Zambia, productivity and biodiversity within the Sesheke Flats is driven by the seasonality of the Zambezi River. Changes in temperature, flooding extent, nutrient availability and sediment loads trigger biological responses that drive fish reproduction and wildlife migration. Communities within the wetland have adapted over centuries to take advantage of seasonal fisheries and productive grazing lands that are seeded, fertilised and nurtured by this dynamic river.



HUMAN ACTIVITY

The Zambezi River supports a mosaic of rural and urban communities. The livelihoods of these communities are directly tied to the health of the river, which provides water, food and transport — thereby facilitating the local economy. It is important to understand the ways that people interact with the river to ensure that policy and research are geared towards positive outcomes for both local livelihoods and biodiversity.

A total of 2,161 people were recorded along the transect, averaging 60 people/10 km. This is similar to other sections of the Zambezi River, where the human population density in riparian zones ranges between 22-106 people/10 km. The highest population density was detected near the towns of Sioma and Katima Mulilo, and within seasonal villages in the Sesheke Flats. Importantly, this transect ended just upstream of Livingstone, which has a population of at least 170,000 people.



The Sesheke Flats supports one of the largest fisheries in the Upper Zambezi Basin — second only to the Barotse. Roughly one-third of Sesheke Flats residents rely on fishing for both income and food security³. The fishery is dominated by three key cichlid species (*Oreochromis andersonii*, *O. macrochir*, and *Coptodon rendalli*), most of which are sold in Livingstone or exported to markets in Namibia.

Between 2010 and 2017, the region experienced a dramatic 58% decline in annual fish yield. This is largely blamed on the proliferation of illegal monofilament gill nets^{5,6}. Today, an estimated 98% of fishing households use gill nets, typically two per household, most of which are made from monofilament^{5,6}. Once discarded, monofilament nets often persist as ‘ghost nets,’ drifting through the water and continuing to entangle fish and other aquatic life.

The concentration of fishing activity recorded along the transect. The Sesheke Flats stands out as the most important fishery along this stretch of the Zambezi River.





| *When discarded, monofilament gill nets continue to trap fish and other wildlife.*

MUKORO AND MUKULA



Wooden dugout canoes are commonly used for fishing and transportation along the Zambezi River. These are known as *mukoro* or *mukolo* in the local Lozi dialect and account for up to 90% of the vessels in-use between Sioma and Livingstone. Dugout canoes are typically carved from large hardwood trees, including African rosewood (*mukula*, or *Pterocarpus tinctorius*).

Hardwood trees are increasingly rare in Zambia because of industrial-scale, illegal deforestation. The trade in African rosewood from Zambia to China is estimated at 110,000m³ per annum, with a market value of over US\$100 million⁷. African rosewood is typically transported to China via Namibia — the main export being Katima Mulilo and the greater Sesheke area⁸.

Most African rosewood is illegally harvested by foresters who receive an average profit of just US\$4.1 per tree⁹. While there may be immediate monetary gains, this practice can result in social-ecological disconnection that reduces the resilience of forest communities to climate change impacts. In addition, unsustainable removal of large hardwood trees depreciates the natural integrity of the landscape, thereby limiting opportunities for alternative, sustainable revenue streams.





Mosupa Molaiemang, a TWP river guide from Botswana, sits on a large African rosewood trunk at a mukoro workshop adjacent the Zambezi River, upstream of Katima Mulilo.

BIODIVERSITY

The Zambezi River connects landscapes within the Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA) — the largest transfrontier conservation area of its kind¹⁰. The KAZA TFCA is shaped by a mosaic of habitats including farmlands, dry woodlands, floodplain grasslands, permanent wetlands and riparian forests. This habitat complexity supports a rich and regionally distinct biodiversity, including key populations of iconic large mammals such as African elephant and African wild dog, as well as an array of wetland and forest bird species.

The KAZA TFCA aims to promote the resilience of wildlife populations in southern Africa by linking protected areas across national borders, thereby encouraging ecological connectivity. Most studies within the landscape focus on connectivity between terrestrial corridors, however the focus of riparian corridors within the KAZA TFCA has been comparatively limited. Ongoing research should examine the role of rivers and wetlands as avenues for genetic dispersal within the KAZA TFCA.

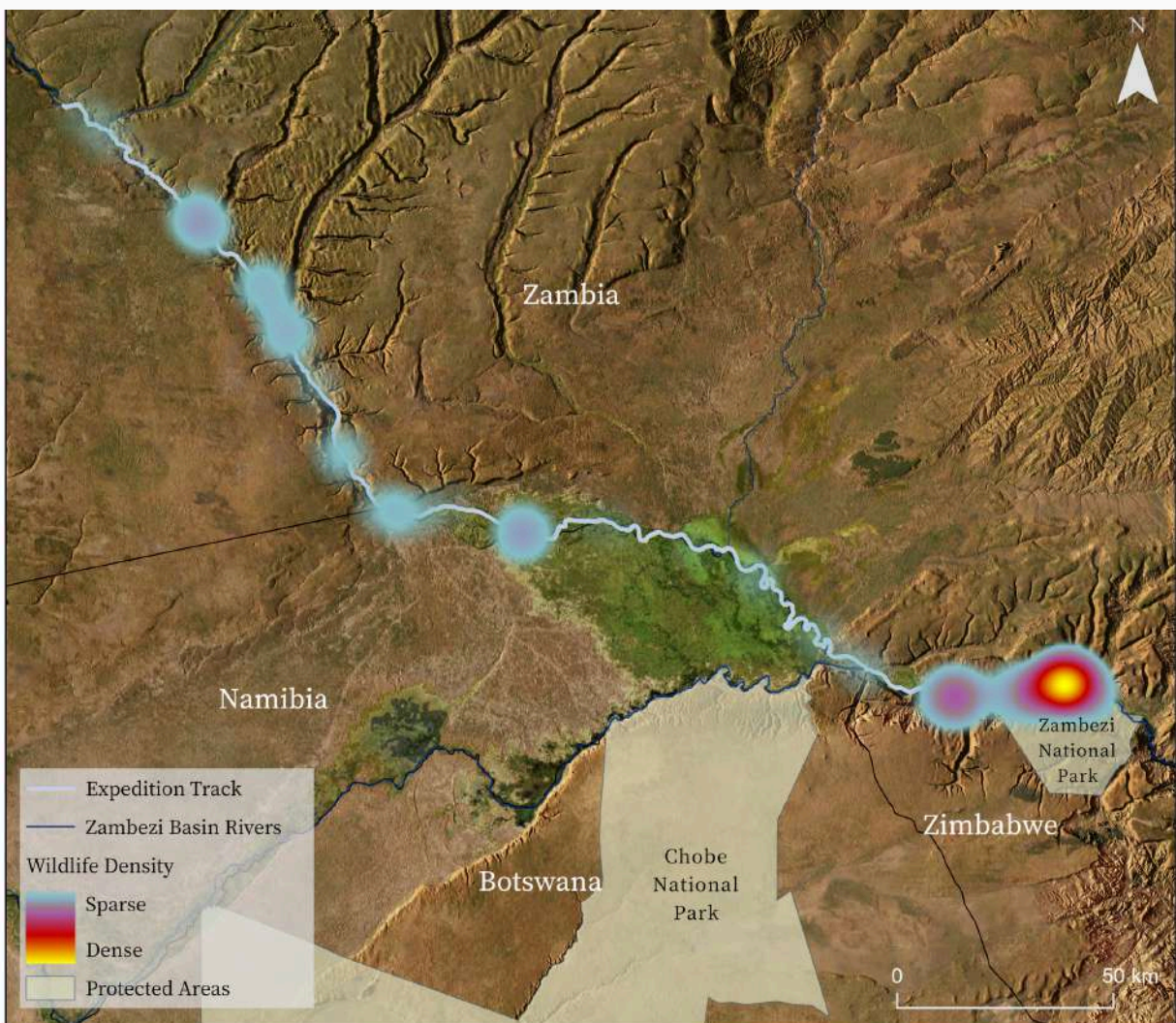
The KAZA TFCA is home to some of the greatest populations of large mammals anywhere on Earth — a testament to conservation efforts across national and geographical boundaries. Ongoing monitoring is important to understand wildlife movements within the landscape. In addition, monitoring outside of existing parks will encourage the identification of previously overlooked conservation areas. These can be earmarked for ongoing conservation efforts.



LARGE WILDLIFE

The biodiversity of the Zambezi River is well-studied compared to other rivers in the region. However, biodiversity studies are often isolated to specific areas or zones along the river. There are comparatively few studies examining patterns of biodiversity along the river extent. To improve understanding of biodiversity distribution along the Zambezi River, the 2023 TWP survey counted all large animals along the river.

There were 453 large animals along this transect, with an average density of 12 animals/10 km. Sightings were unevenly distributed, with the majority concentrated in the Zambezi National Park and the adjacent Kasane Forest Reserve. These observations highlight the important role of protected areas in supporting wildlife populations within the KAZA TFCA, particularly downstream of the Chobe National Park. Although wildlife densities were low within the Sesheke Flats at the time of the survey, the Simalaha Wildlife Corridor is known to serve as an important connection between the Chobe and Kafue National Parks.



The distribution of wildlife along the transect. Note the high concentration in Zimbabwe's Zambezi National Park and the adjacent Kasane Forest Reserve. Species like giraffe, elephant, and zebra were observed only within these protected zones.

WETLAND BIRDS

The Sesheke flats is classified as both an Important Bird Area (IBA) and a Key Biodiversity Area (KBA)¹¹, supporting more than 400 bird species — one of the highest levels of bird diversity in the region^{12,13}. The mixture of seasonal floodplains and permanently inundated vegetation provides important habitat for resident wetland birds, and seasonal foraging grounds for migratory birds, raptors, and waders.

Our survey recorded 6,765 birds from 68 species along the Zambezi River between Sioma and Livingstone — an average of 19 birds/km, higher than the river-wide average of 16 birds/km. The Sesheke Flats wetlands were a hotspot of abundance, hosting nearly 75% of all birds recorded along the transect. Species like the near-threatened African skimmer were almost entirely restricted to these wetlands.

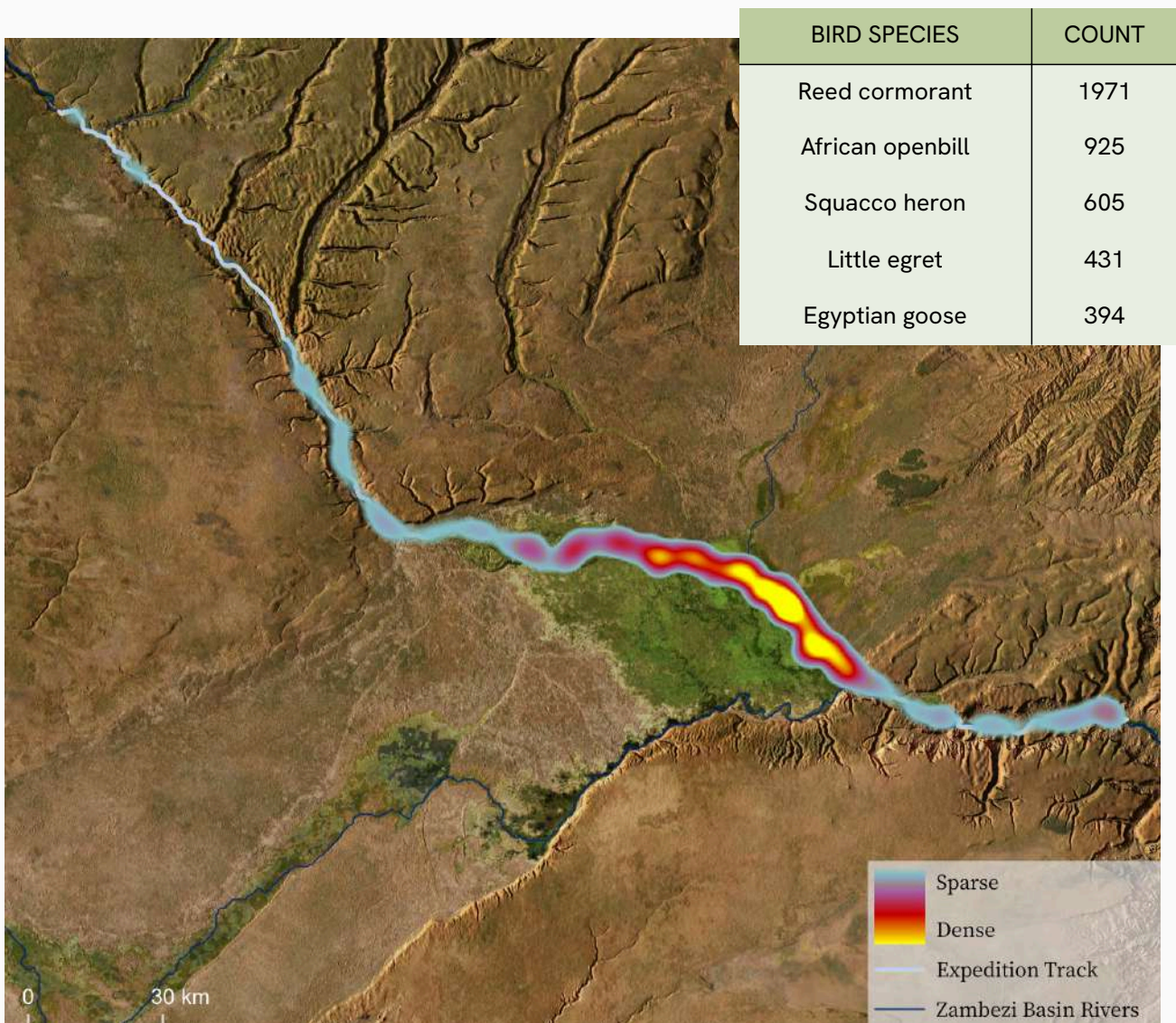


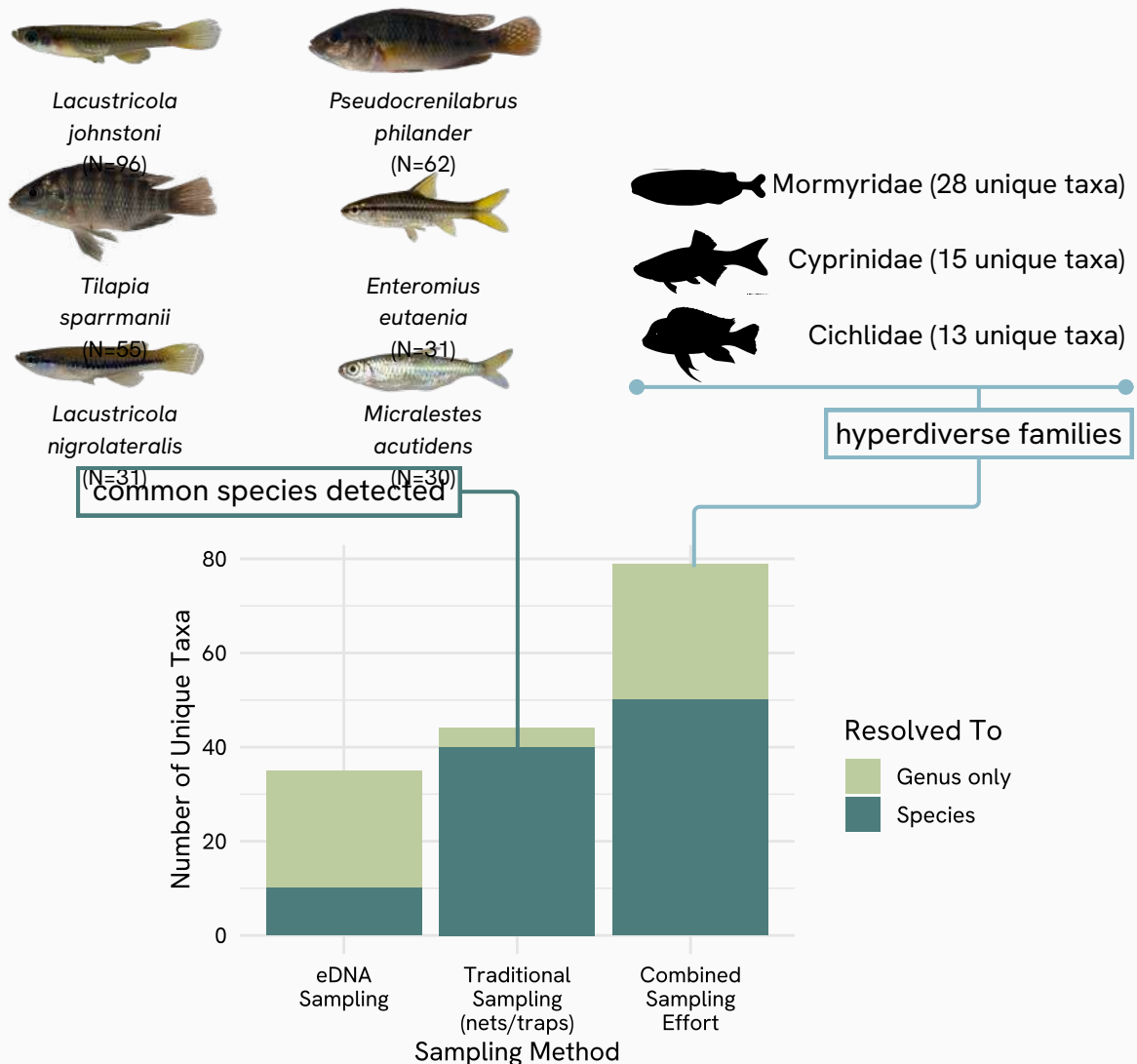
Figure: The distribution of wetland-associated birds from Sioma to Livingstone, highlighting the high concentration of birds observed along the Sesheke Flats. Table: The ten most abundant bird species observed along the Zambezi River between Sioma and Livingstone.

FISH SAMPLING

The complementary use of environmental DNA (eDNA) and traditional sampling methods is vital for understanding fish diversity, monitoring ecosystem health, and guiding sustainable fisheries management. It helps detect changes in fish populations, identify the presence of diseases like Epizootic Ulcerative Syndrome (EUS), and assess the impacts of environmental pressures such as overfishing and habitat loss.

At least 77 fish taxa were detected between Sioma and Livingstone. Most of the diversity belonged to the Mormyridae (N=28 unique taxa), Cyprinidae (N=15), and Cichlidae (N=13) families. Only three species were detected by both eDNA and traditional sampling methods (*Coptodon rendalli*, *Micralestes acutidens*, and *Tilapia sparrmanii*). While fish diversity was high, many fish had lesions, believed to be EUS, which may pose a threat to fisheries¹⁴.

Importantly, 40 taxa were omitted from this eDNA richness estimate, as they could not be assigned to a genus. This is due to an incomplete genetic reference library for the fishes of the Zambezi Basin and highlights the urgent need for a regional freshwater fish barcoding initiative.



RIVER FLOW

The seasonal flow of the Zambezi River is regulated by the Barotse Floodplain, which absorbs peak discharge from the upper catchment and gradually releases water downstream. As a result, flooding in the Sesheke Flats begins mid-cycle relative to the Barotse, typically starting in December and peaking in March-April, with waters receding by September. During high Zambezi floods, backflow can extend into the Chobe River and reach Lake Liambezi, contributing to its seasonal recharge¹⁵.

The hydrology of the Chobe River is strongly influenced by the Zambezi River, which pushes floodwaters into the Chobe during high discharge in late March-April. A secondary flood pulse from the Cuando River arrives via the Linyanti Channel and Lake Liambezi around June-July, maintaining flow through the dry season. Once Zambezi flood levels recede, the Chobe resumes downstream flow into the Zambezi.

To sample the flow of the river at the time of the transect, river discharge was measured at three sites: Ngonye Falls, the Lumbe River tributary, and the upper reach of the Sesheke Flats. Measurements at these sites provide a baseline snapshot of flow magnitude and distribution during the sampling period and offer critical context for interpreting hydrological connectivity, floodplain functioning, and downstream ecological processes.

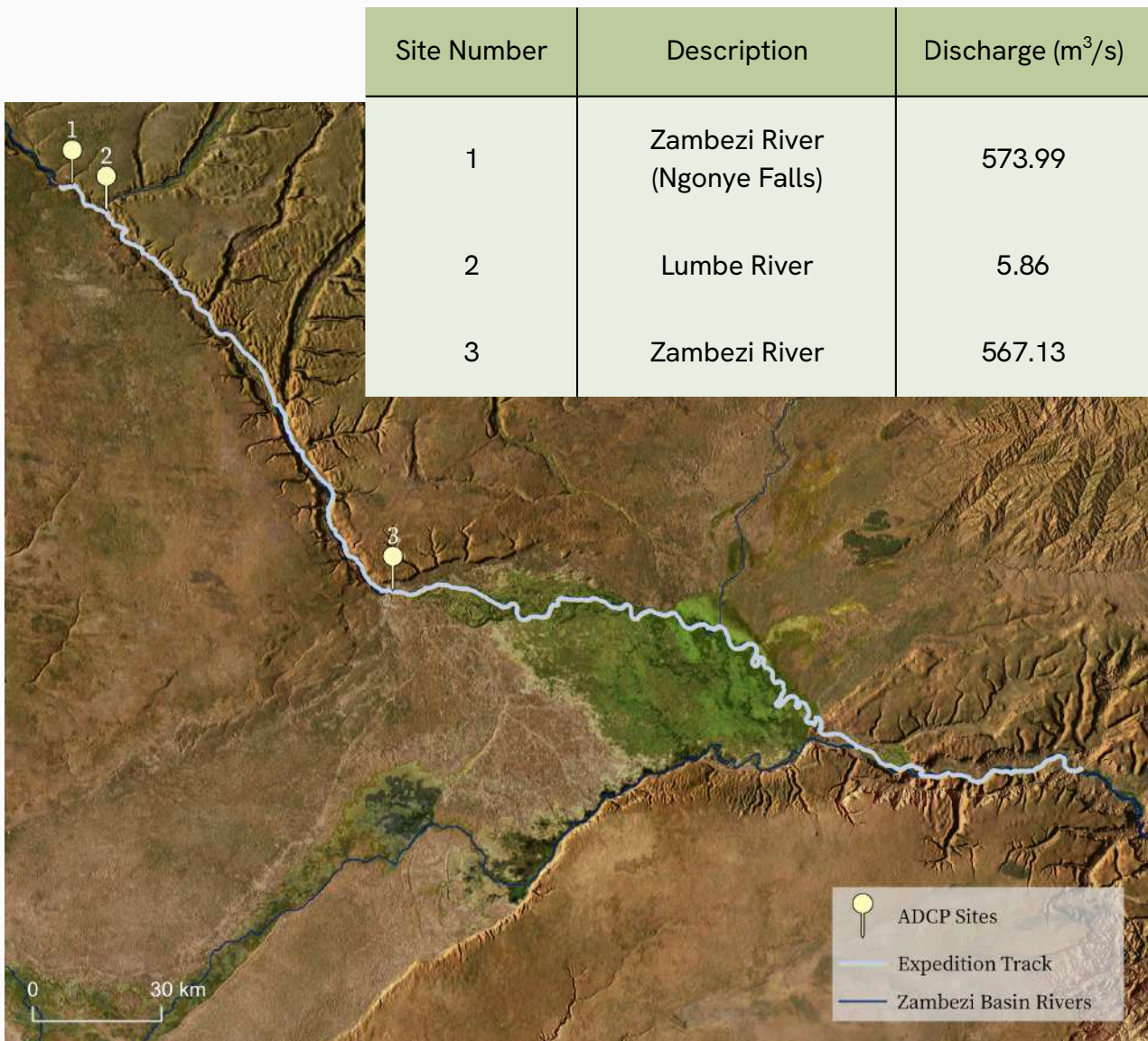
Ngonye Falls on the upper Zambezi River. The falls support life below the surface by oxygenating the water and shaping habitat structure.



At Ngonye Falls, discharge was approximately $570 \text{ m}^3/\text{s}$ — about one-quarter of the discharge ($\sim 2,300 \text{ m}^3/\text{s}$) measured by TWP in the wet season in May 2023. Historical data from the Zambezi River Authority shows that peak flood levels can exceed $5,000 \text{ m}^3/\text{s}$, while average dry season flows remain around $400 \text{ m}^3/\text{s}$. These fluctuations are regulated by the upstream Barotse Floodplain, without which seasonal flow variation would be extreme.

The proposed hydropower station at Ngonye Falls will alter the natural flow regime of the Zambezi River, changing the timing and frequency of flood events. This is highly likely to alter the floodplain ecology in the downstream Sesheke Flats, including potentially reducing habitat availability.

The Sesheke fishery supplies a significant share of the Livingstone market, with fish from this wetland traded in markets across the country. Fisheries productivity in the Sesheke Flats is driven by the annual recruitment of wetland-dependent species that rely on seasonal flood pulses for spawning and feeding. If not carefully managed, alterations to these flood pulses resulting from construction of the Ngonye Falls Hydroelectric Dam could lead to declines in fisheries productivity.



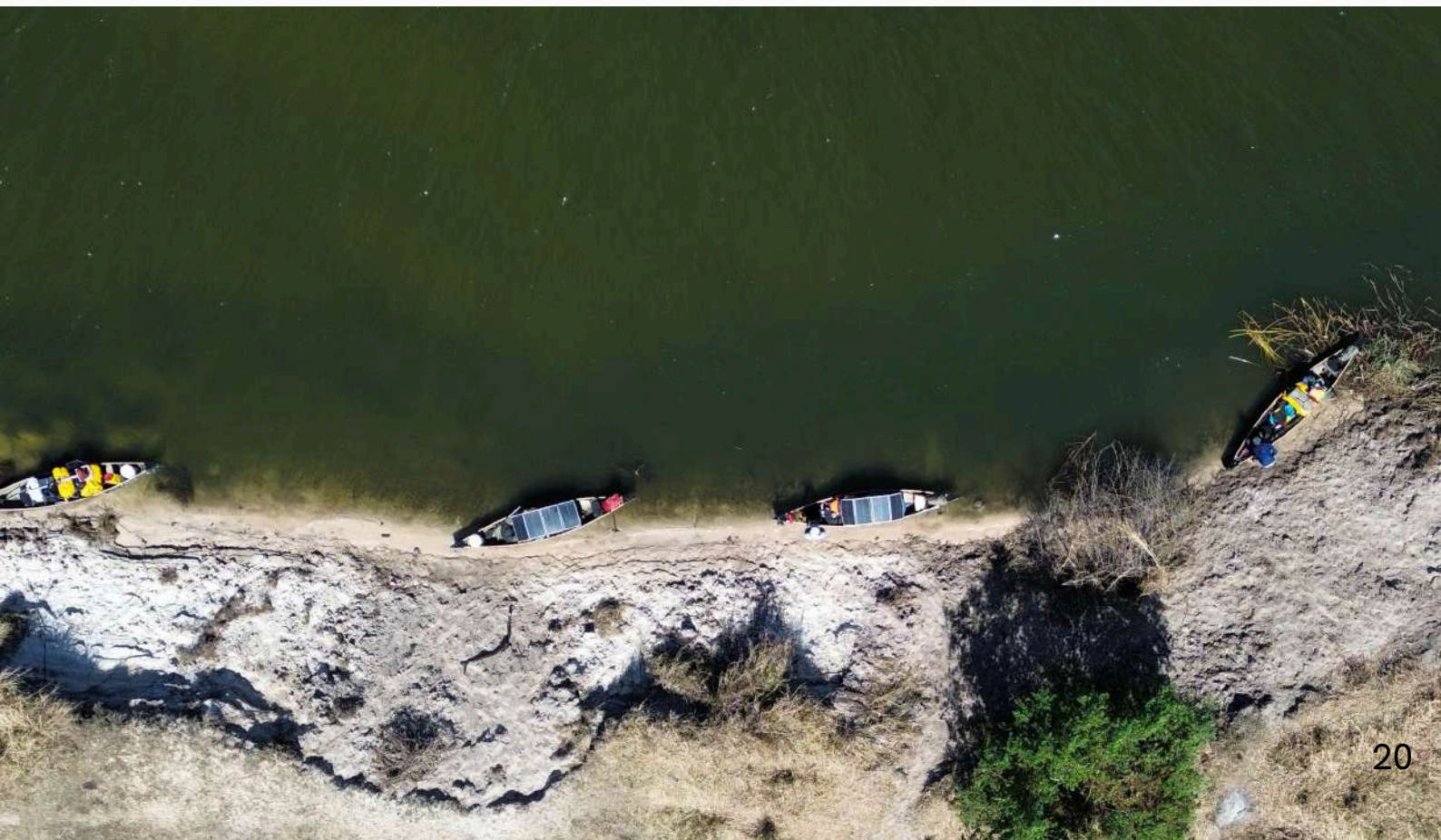
River discharge measurement sites along the Zambezi River from Sioma to Livingstone.

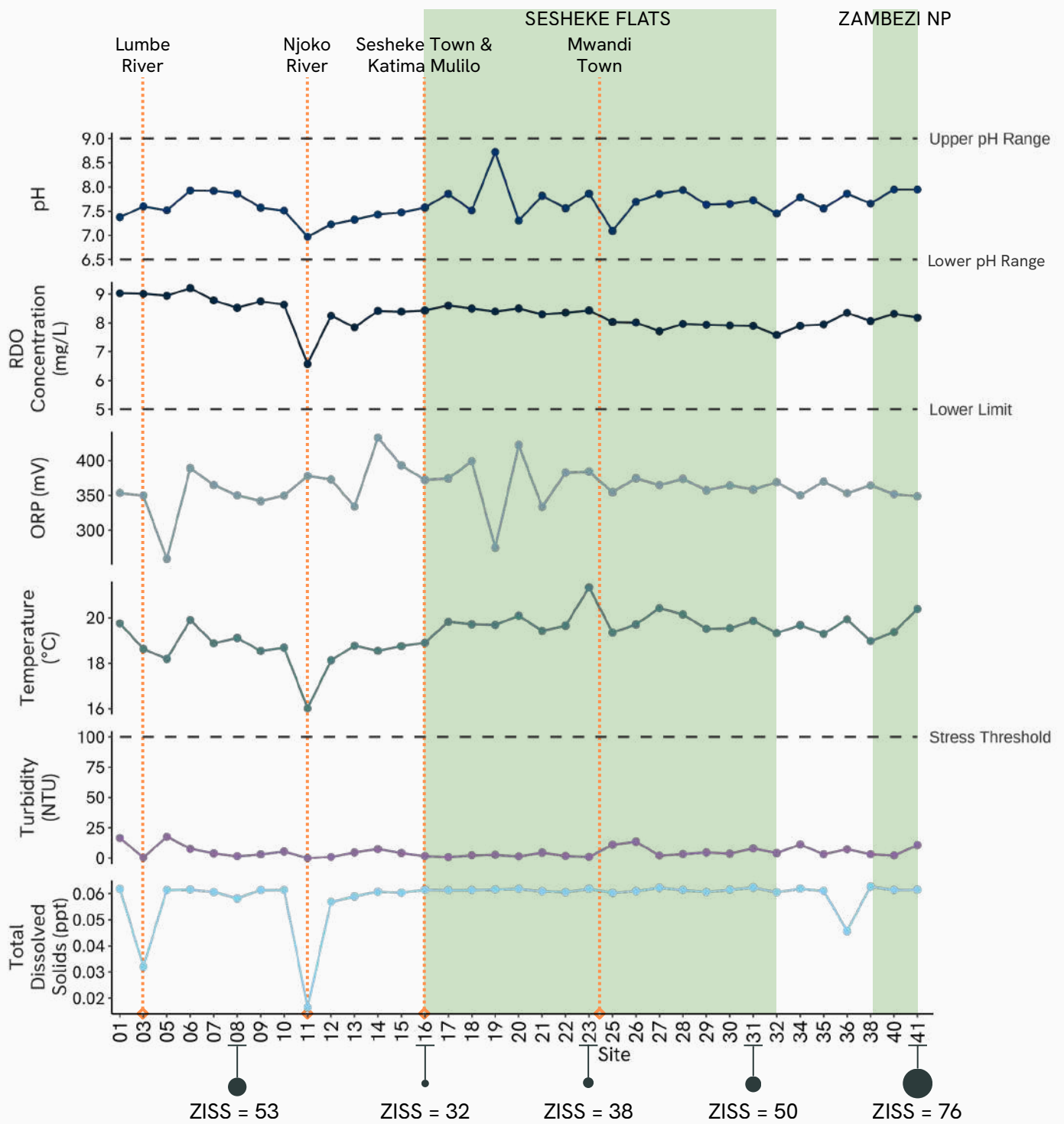
WATER QUALITY

Water quality monitoring along the Zambezi River is essential for assessing ecosystem integrity and guiding conservation efforts. Water quality measurements can detect local drivers — like contribution of contaminants from mining and agriculture, or the settlement of suspended particles in wetlands. Measurements can also shed light on upstream drivers of water quality, including changes caused by impoundment. Water quality has implications for all aquatic biodiversity, human health, and the long-term health of the Zambezi ecosystem.

Water quality along the Zambezi River between Sioma and Livingstone was generally within acceptable limits¹⁶, though spatial variability across sites was observed. Key parameters such as pH, turbidity, dissolved oxygen (DO), and total dissolved solids (TDS) varied in response to tributary inputs, river morphology, and land-use. At site 11, where the Njoko River meets the Zambezi, pH, DO, temperature, and TDS all declined — likely reflecting differences in river flow and structure, as the slower Njoko likely carries less dissolved material with lower oxygenation. While still within limits, this contrast illustrates how tributaries can alter water quality over short distances.

Site 19, within the Sesheke Flats, saw pH rise to 8.7 — about one unit above the transect average — coinciding with a sharp decline in oxidation-reduction potential (ORP). While both values remained within guideline limits, the cause and implications of this shift are unclear. ORP also fluctuated notably across the transect, suggesting underlying geochemical variability that could be further explored through targeted hydrogeochemical analyses.





Macroinvertebrate assessments using the Zambian Invertebrate Scoring System (ZISS) also help contextualise water quality findings — high ZISS scores indicate good water quality as the site supports a range of pollution-sensitive taxa¹⁷. The highest score (76) was recorded at site 41 in the Zambezi National Park, while lower scores occurred at sites 16 and 23, near towns. However, sites 16 and 23 are also within the Sesheke Flats, and these low scores are likely linked to the limited sampling of stones and gravel habitats. Ongoing macroinvertebrate assessments should be conducted over time to provide continuous insights into ecosystem health.

INVASIVE SPECIES

Alien invasive plants (AIPs) pose significant threats to river systems across Africa. They displace native vegetation and alter nutrient cycling, leading to declines in native biodiversity¹⁸. AIPs also affect water quality by increasing evaporation, reducing stream flow, and limiting the river's natural dilution capacity¹⁹. Regular monitoring is essential to detect these species early and to manage their impacts on riverine ecosystems.

Between Sioma and Livingstone, four invasive alien plant species were recorded: *Mimosa pigra*, *Salvinia molesta*, *Eucalyptus globulus*, and *Ricinus communis*. The most widespread of these was the giant sensitive plant (*Mimosa pigra*), which was particularly prevalent in the Sesheke Flats and estimated to cover approximately 1,062 m² along the transect*.

Mimosa pigra is a highly invasive species that threatens wetlands, grasslands and floodplain ecosystems, including those of the Zambezi River and its tributaries^{20,21}. The spread of *M. pigra* across the basin undermines local livelihoods by reducing rangeland productivity and access to fishing areas. Management and removal of *M. pigra* are therefore essential for both ecological conservation and the economic well-being of communities that depend on these ecosystems.



Salvinia molesta, commonly known as giant salvinia, forming dense floating mats on a freshwater surface

*Counts were limited to within 100m of the river's edge along the transect.

RECOMMENDATIONS

BIODIVERSITY MONITORING AT THE HEART OF THE KAZA TFCA

Future research should aim to better understand the role of the Zambezi River as a wildlife corridor within the KAZA TFCA, particularly beyond charismatic megafauna. Wetland birds, bats, fishes, amphibians, insects, and reptiles comprise the vast majority of the region's biodiversity and are fundamental to ecosystem health. Many species within these groups depend on aquatic or riparian corridors for dispersal, yet their genetic connectivity and foraging movements along these systems remain poorly understood. As a result, they are frequently overlooked in landscape-scale conservation planning.

MAINTAINING PRODUCTIVITY OF THE SESHEKE FLATS

The environmental assessment of the Ngonye Falls Hydroelectric Dam should carefully consider the likely impact of the dam on the seasonal productivity of the Sesheke Flats. Local fisher and farmer livelihoods rely directly on the productivity of the wetland, which is driven by the seasonal flood cycle of the Zambezi River. The river deposits fertile sediments, maintains groundwater flow, and encourages the growth of vegetation that provides critical habitat to fisheries. A robust projection of the hydrological changes from the Ngonye Falls Hydroelectric Dam will support informed decision-making that balances power generation with ecological productivity and livelihoods security.

RIVER FLOW

Flow monitoring should be implemented along the Chobe River to capture its seasonal dynamics — including peak floods and dry-season pulses — in order to accurately assess its contribution to the Zambezi River. This should include a flow station at Kasane, to assess river dynamics near the Chobe-Zambezi confluence.

INVASIVE SPECIES MANAGEMENT

A comprehensive invasive species management plan is urgently needed for the Sesheke Flats, with focus given to *Mimosa pigra*. This plan should include: i) mapping the distribution and density of invasive plant species across the landscape; ii) fostering community-led interventions in coordination with government, NGOs, and local stakeholders; iii) applying mechanical removal, targeted monitoring, and biological control where feasible; and iv) supporting local communities towards sustainable long-term management of the wetland.


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