THE WILDERNESS PROJECT

EXPEDITION OVERVIEW

LOWER ZAMBEZI

MOZAMBIQUE

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 kilometres of irreplaceable African wilderness. Central to this effort is the establishment of detailed hydrological and ecological baselines of the largely undocumented sources and watersheds of Africa's greatest river basins — the Zambezi, Congo, Nile, and Okavango.

ACKNOWLEDGEMENTS

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CONTENTS

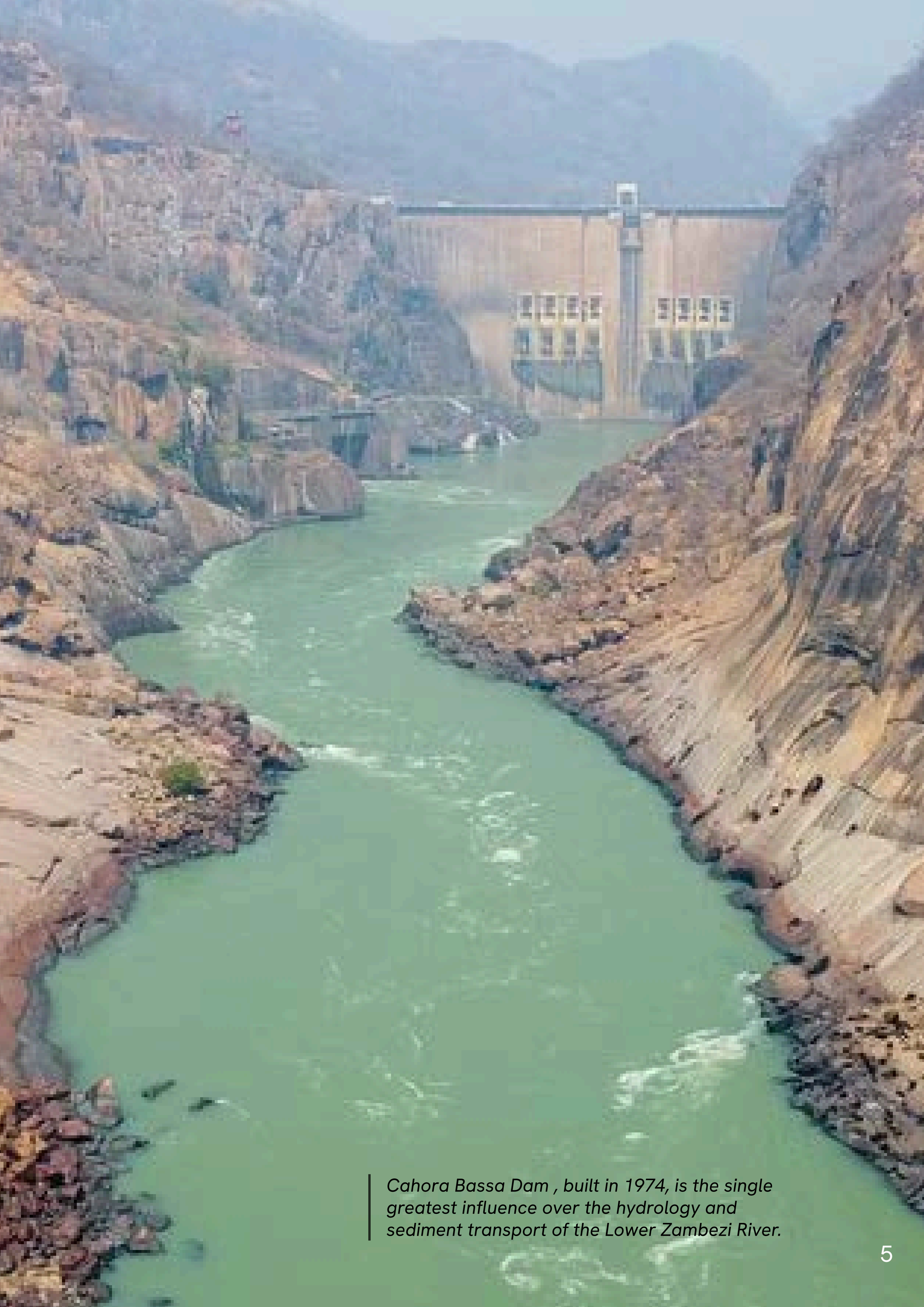
INTRODUCTION

The Zambezi River begins in the highlands of Zambia and Angola, flowing over 2,575 km until it reaches the Indian Ocean in Mozambique. The catchment is immense — 1,320,000 km^2 — spanning eight countries and home to at least 30 million people. Many of these communities rely directly on the Zambezi River for their food and water security, as well as their livelihoods. The river is significant even outside its basin: the Cahora Bassa Hydroelectric Dam generates electricity that powers cities in South Africa.

Below the Mupata Gorge, the Zambezi River widens and gradually slows towards a deltaic triangle that extends roughly 120 km inland and 200 km along the coast. This is the Zambezi Delta — a broad flat alluvial plain with vast mosaics of tropical grassland, palm, thicket, woodland, deep water swamp, and some of the most extensive mangrove communities on the East African coast[1]. Within this area, the 5,000 km^2 Marromeu Complex is designated as both a Ramsar Wetland of International Importance and a conservation area.

The construction of the Cahora Bassa Dam in 1974 profoundly changed the Lower Zambezi River. By disrupting the natural flood cycle, the dam caused a reduction in the peak flood level and reduced sediments in the river by up to 70%[2]. Where heavy wet season flows once deposited fertile sediments along the Lower Zambezi, the river became regulated and subdued, with detrimental impacts on downstream riverine communities[3,4].

The Lower Zambezi River forms a vital but under-protected riparian corridor between the Zimbabwe–Mozambique–Zambia Transfrontier Conservation Area (ZIMOZA TFCA) and the Marromeu Complex. This corridor supports seasonal wildlife migrations, sustains fisheries, and provides critical ecosystem services to local communities. Further research is needed to understand these linkages, towards maintaining ecological connectivity, biodiversity resilience, and the socio-economic stability of the wider Zambezi landscape.



Cahora Bassa Dam , built in 1974, is the single greatest influence over the hydrology and sediment transport of the Lower Zambezi River.

THE EXPEDITION

650km

Traversed by inflatable raft and canoe

10 people

From five African countries

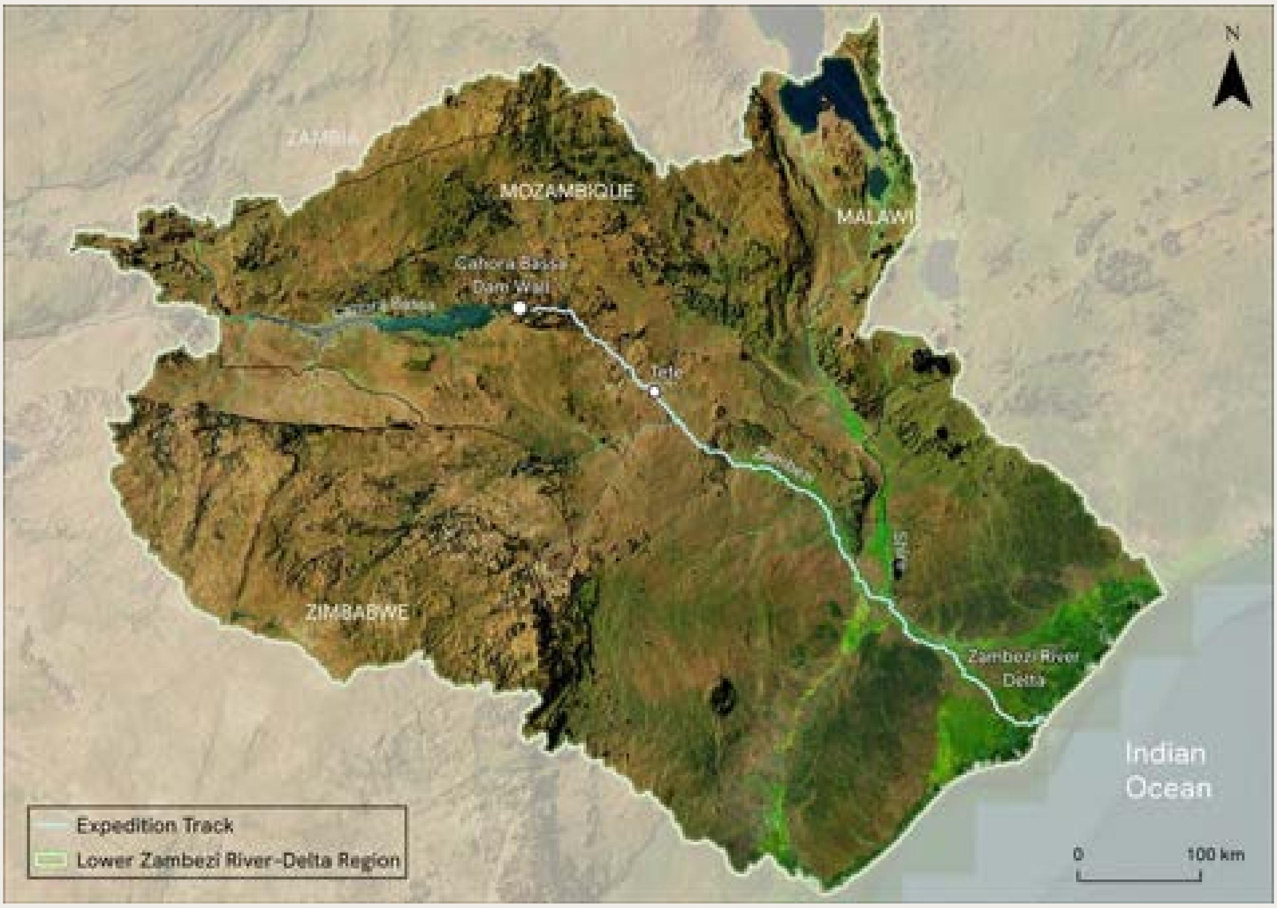
66

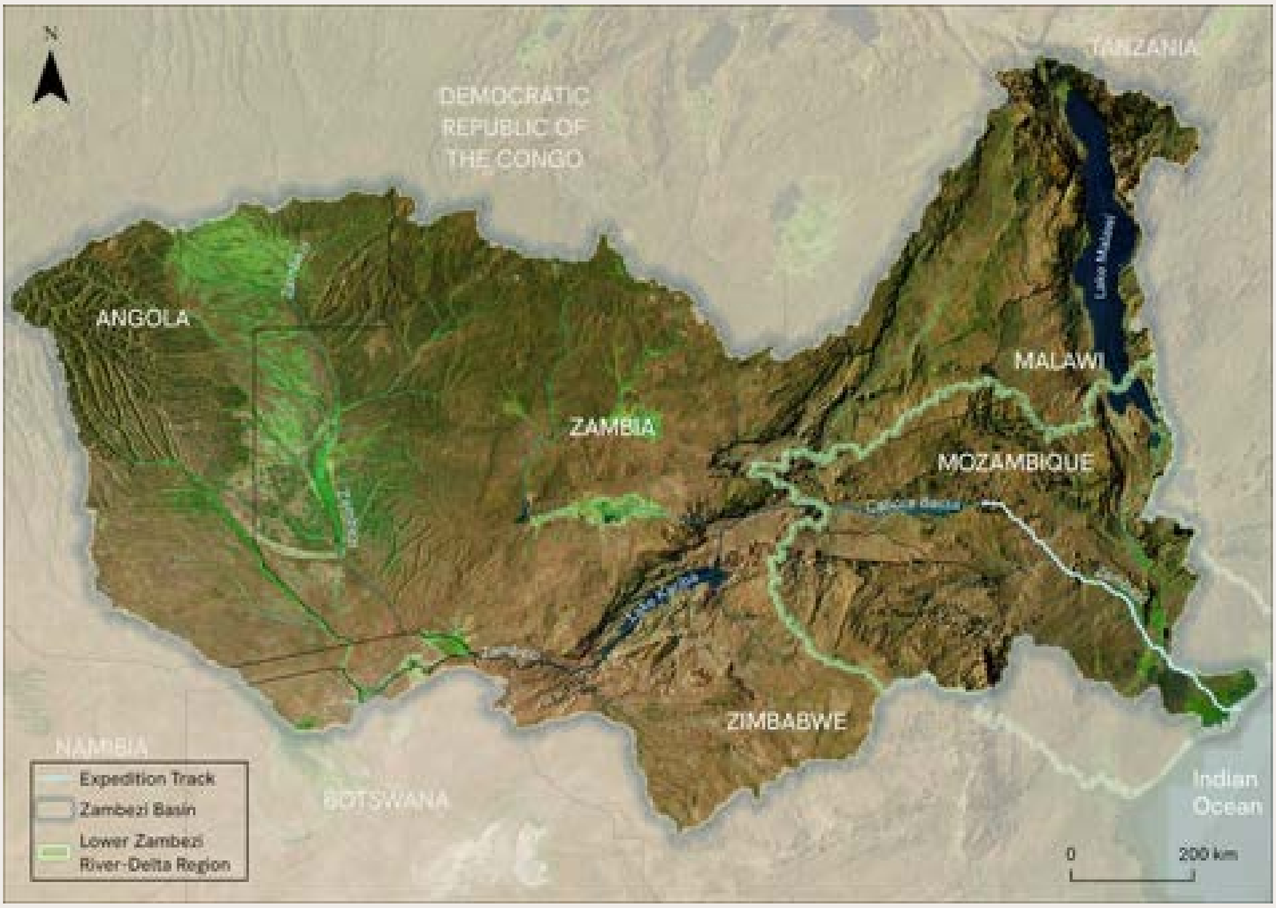
Fixed survey sites established

17 days

15 September – 1 October 2024

Between 2022 and 2024, through a series of self-propelled expeditions, TWP surveyed the entire Zambezi River. Our team traced the river from its sources in Zambia and Angola to the sea in Mozambique. The 2024 Lower Zambezi Expedition marked the end of this two-year journey, completing the most comprehensive baseline assessment of the river to date, and providing a unique picture of its health, interdependencies, and threats across the region.





The Lower Zambezi Expedition covered 650 km from the Cahora Bassa Dam wall to the Indian Ocean, following the river through the heart of Mozambique.

METHODS

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.

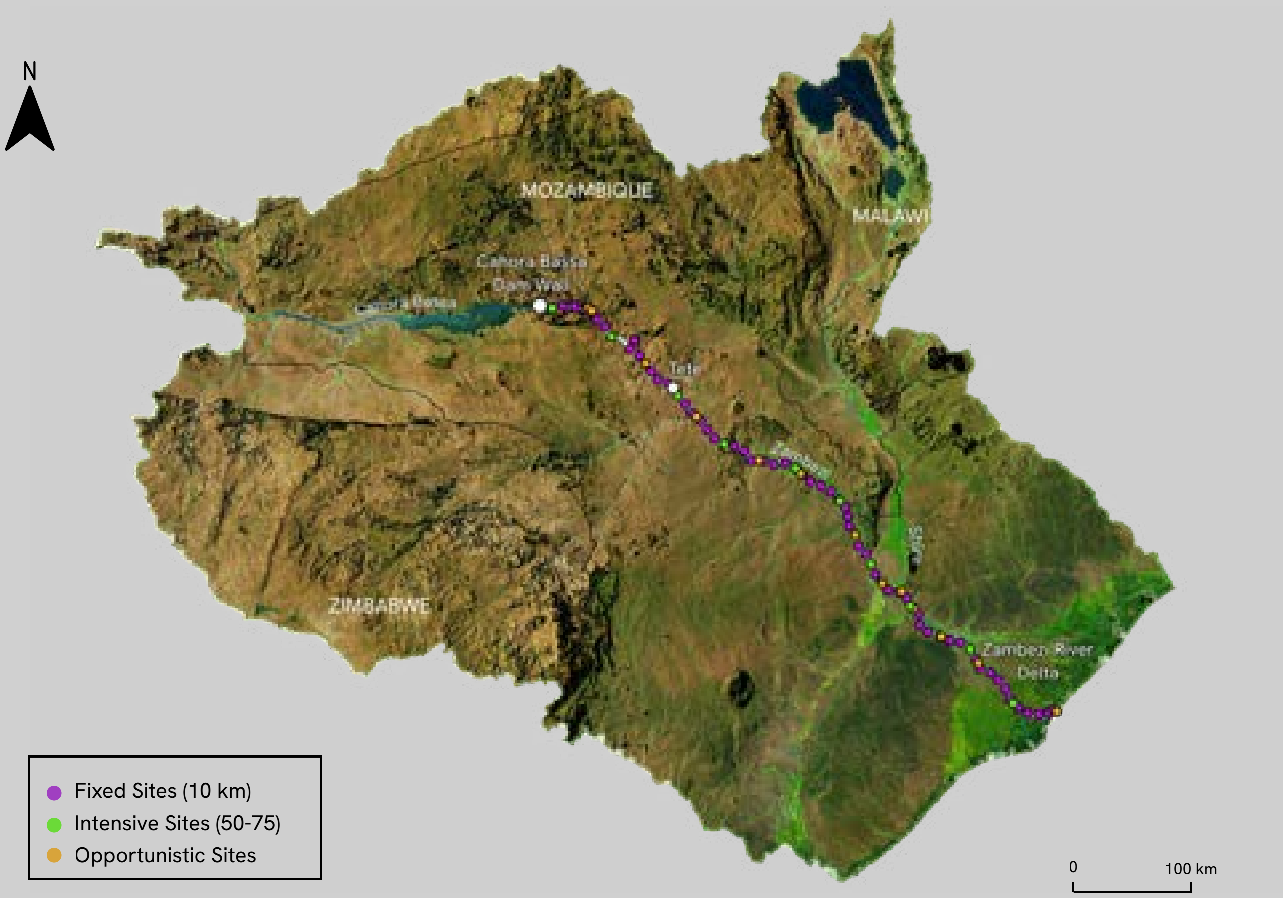
OPPORTUNISTIC SITES

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 and soil samples, and measured river discharge. This approach enabled more detailed assessments of the river’s hydrochemistry, hydrology, and biodiversity.

OVERVIEW OF DATA

81 research sites

67 aerial drone surveys	11 eDNA samples	14 invertebrate assessments
107 GB bat-call recordings	17 fish species	6 flow measurements



The locations of 66 fixed, 10 intensive, and 19 opportunistic research sites.

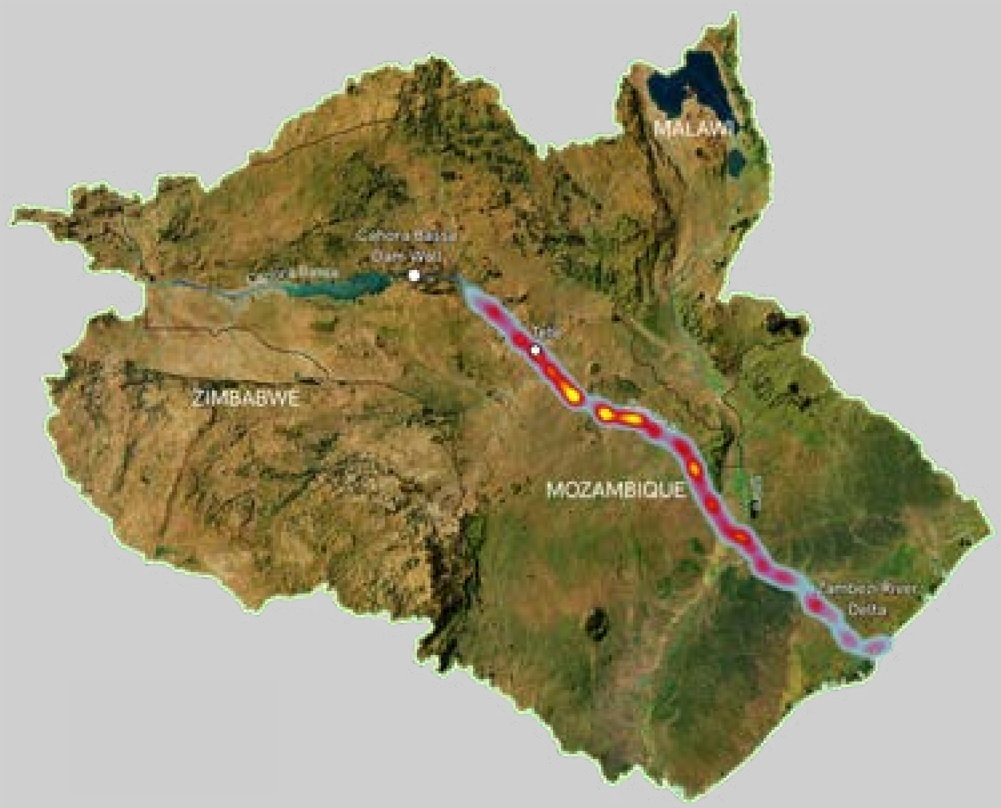
RESULTS

LIVELIHOODS

At least one million Mozambicans are directly dependant on the Lower Zambezi River for their livelihoods, and the basin is home to approximately one quarter of the national population[4]. On average, there are 106 people/10 km along the river — almost double the average population density recorded upstream in Zambia, Zimbabwe and Angola. Many of these people grow crops using water directly from the river, highlighting the vital link between the Lower Zambezi River and the food and water security of the Mozambican people.

The Lower Zambezi Valley has the highest density of continuous riparian cropland recorded anywhere along the Zambezi River. The floodplain contains rich dark *makande* soils, which have been deposited by centuries of seasonal floods. These soils are cultivated by local communities and by seasonal migrants from inland arid areas, and are preferred for their higher fertility and water retention compared to the sandy soils found further inland.

The regulation of flows by upstream dams, particularly Cahora Bassa, has reduced seasonal flooding, allowing people to farm permanently on land that was once underwater for months at a time. This contrasts with the seasonally inundated wetlands of the Upper Zambezi, where farmers still practice flood-recession agriculture. While the flattening of the flood cycle has extended the growing season and made multiple harvests possible, it comes at a cost: soils are no longer replenished by nutrient-rich sediments, leading to a decline in soil fertility and crop productivity.



	Lower Zambezi	Zambezi Average
People/ 10 km	106	65
Vessels/ 10 km	20	37
Livestock/ 10 km	54	52
Cropland (% of transect)	19	5

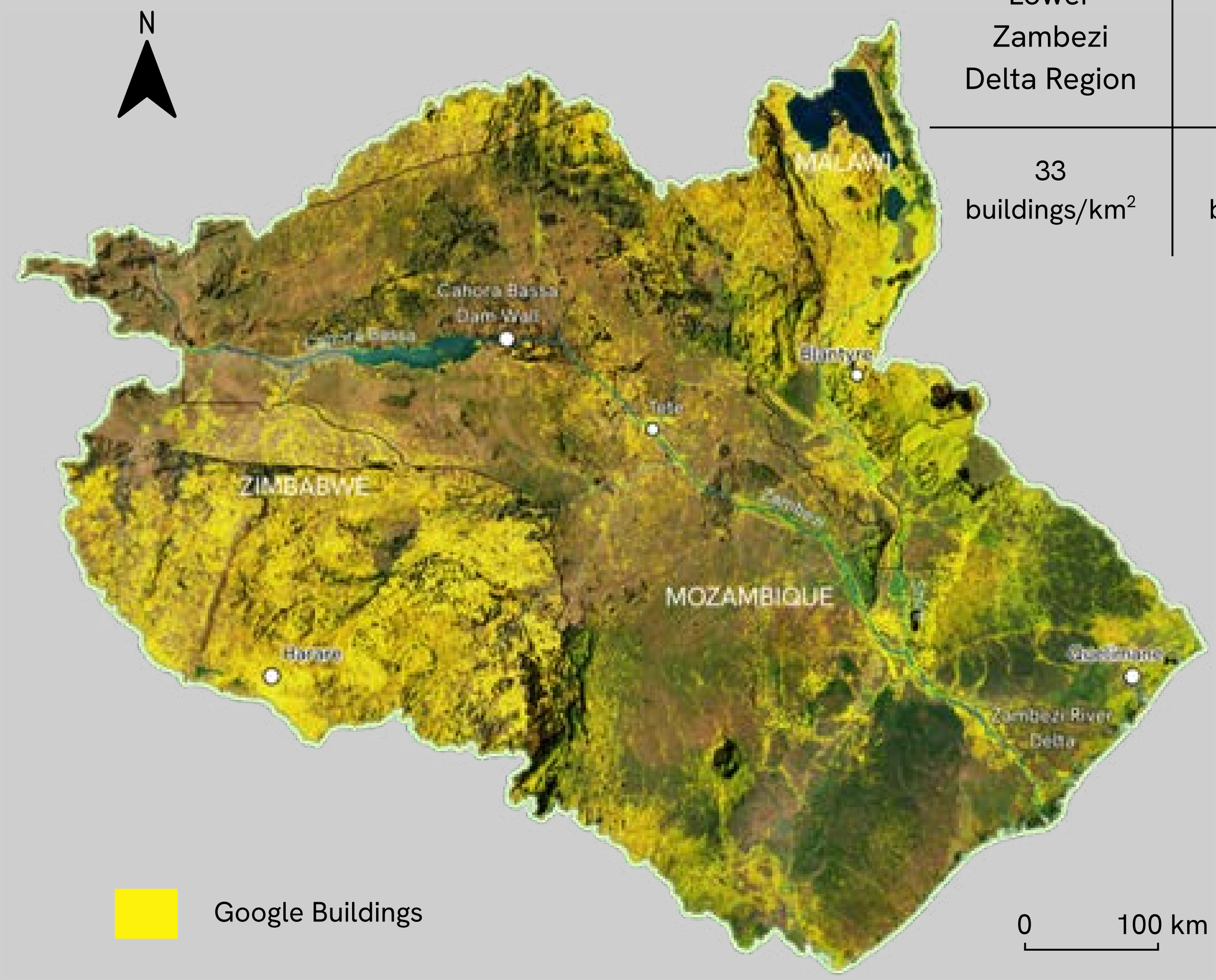
Distribution of people along the transect (left). The summary of observations (right) shows several indicators of human activity, averaged per 10 km along the transect; the observed percentage of cropland along the transect corresponds to approximately 125 km of riverbank with adjacent cropland.

BUILDING ANALYSIS

Google's Open Buildings dataset is a global mapping resource that uses high-resolution satellite imagery to identify and outline individual building footprints[5]. By mapping the location and density of buildings, the data provides a landscape-wide view of human activity. This perspective allows for consistent, basin-scale analyses that help to identify areas of potential environmental impact.

The Lower Zambezi Delta Region, with a building density of 33 buildings/km^2, is notably more developed than the broader Zambezi Basin, which averages 20 buildings/km^2. Within a 4 km buffer of the Lower Zambezi River, the building density is 56 buildings/km^2 — more than four times higher than along the rest of the Zambezi River, from its Zambian source to Cahora Bassa, where the average is only 13 buildings/km^2. This pronounced concentration of development highlights greater land-use pressure and potential ecological vulnerability in the delta, where intensive human activity overlaps with sensitive wetland and floodplain ecosystems.

Lower Zambezi Delta Region	Zambezi Basin
33 buildings/km^2	20 buildings/km^2

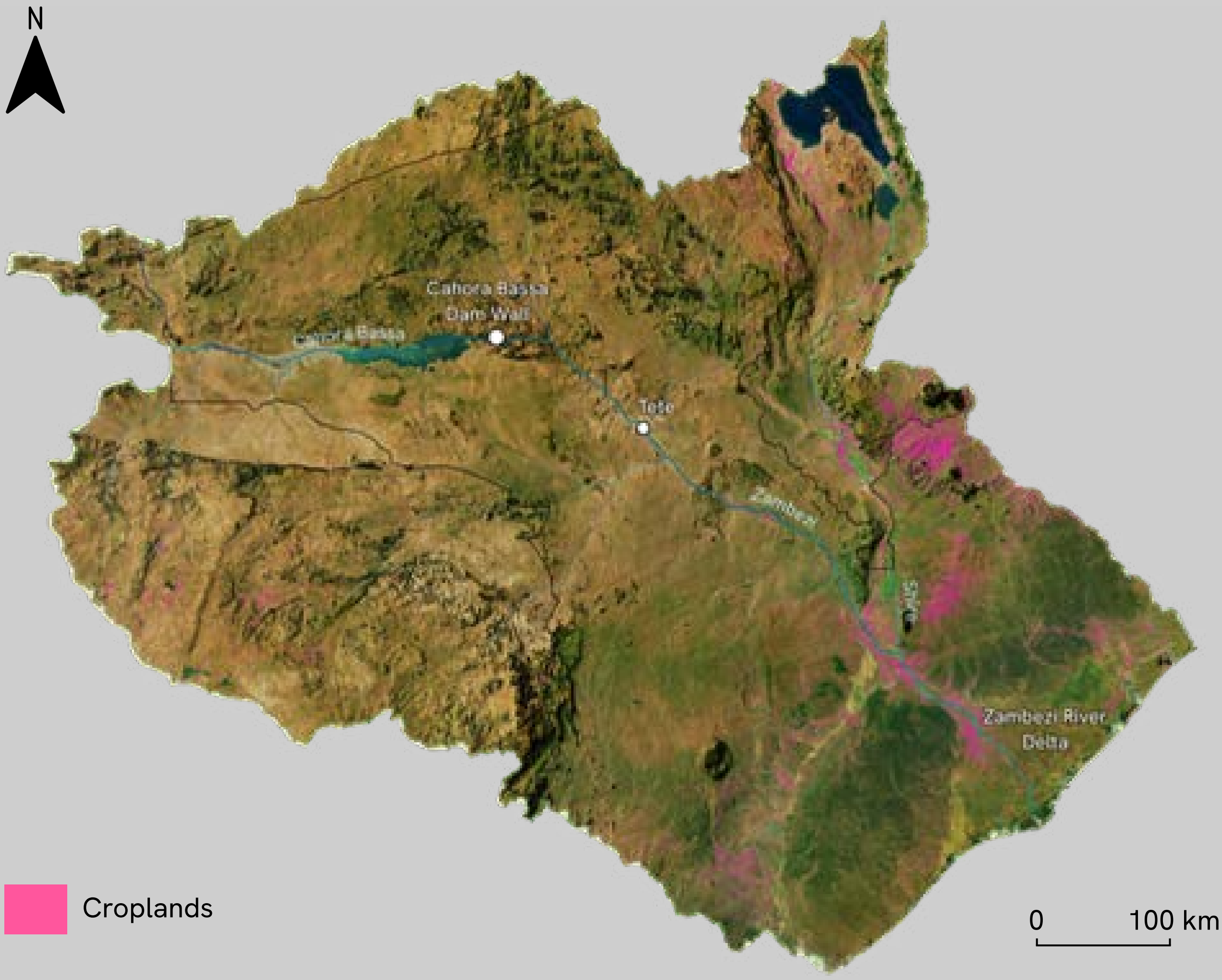


Google building footprint data for the Lower Zambezi Delta Region. Note the high concentration of buildings along the river and coastal areas.

CROPLAND ANALYSIS

WorldCereal is an open-source system — developed under the European Space Agency's initiative — that provides comprehensive, seasonal, and reproducible maps of global crop extents[6] . In this analysis, WorldCereal data was used to calculate the extent of cropland within the Lower Zambezi Delta Region.

Croplands cover approximately 1.7% (5,654 km^2) of the Lower Zambezi Delta Region, indicating that cultivated land occupies only a small portion of the landscape. Most cropland is concentrated along the Zambezi River floodplain, particularly downstream near the delta and around the Shire River, where fertile alluvial soils and abundant water make conditions favourable for agriculture. In contrast, upland and drier areas in the western and central parts of the basin support little cultivation.



Croplands in the Lower Zambezi Delta Region. Most cropland is concentrated along the Zambezi River floodplain.

RESULTS
BIODIVERSITY

Wetland-associated birds

The 2024 TWP survey recorded 7,167 wetland-associated birds along the Lower Zambezi River, representing at least 72 species. The most common were the African openbill (N=1,182), white-faced whistling duck (N=1,055), western cattle egret (N=831), and little bee-eater (N=591). Combined, these species accounted for over 50% of the total birds counted along the transect.

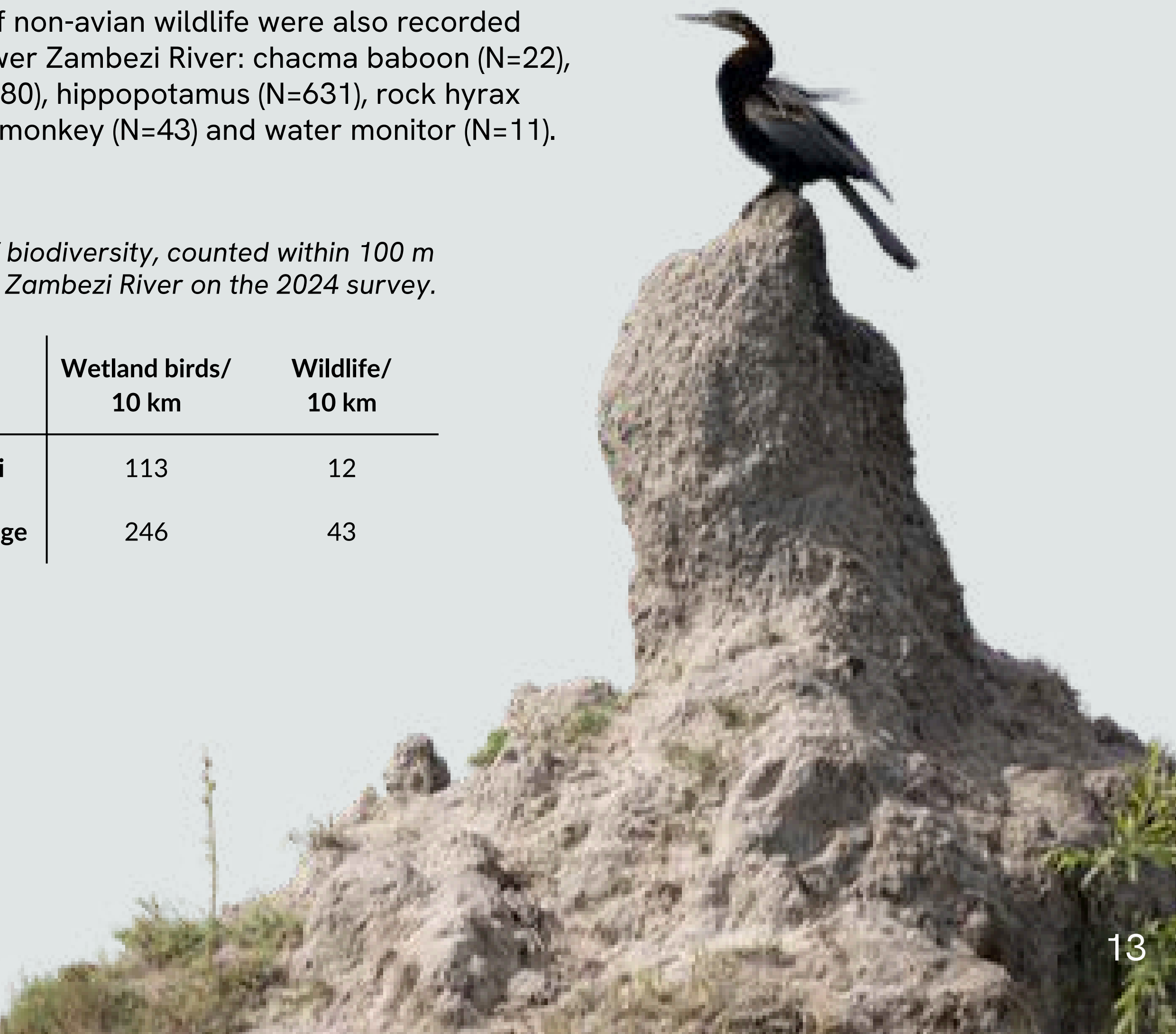
Wetland bird abundance along the transect was lower than the Zambezi River average of 246 birds/10 km. However, the density of wetland birds within the Zambezi Delta was high (220 birds/10 km, compared to 80 birds/10 km outside of the delta), reaffirming its importance as a bird area. Other wetland bird hotspots identified by TWP along the Zambezi River include the Middle Zambezi Valley (Mana Pools and surrounding areas), the Barotse and Sesheke Flats, Lake Kariba, and Cahora Bassa.

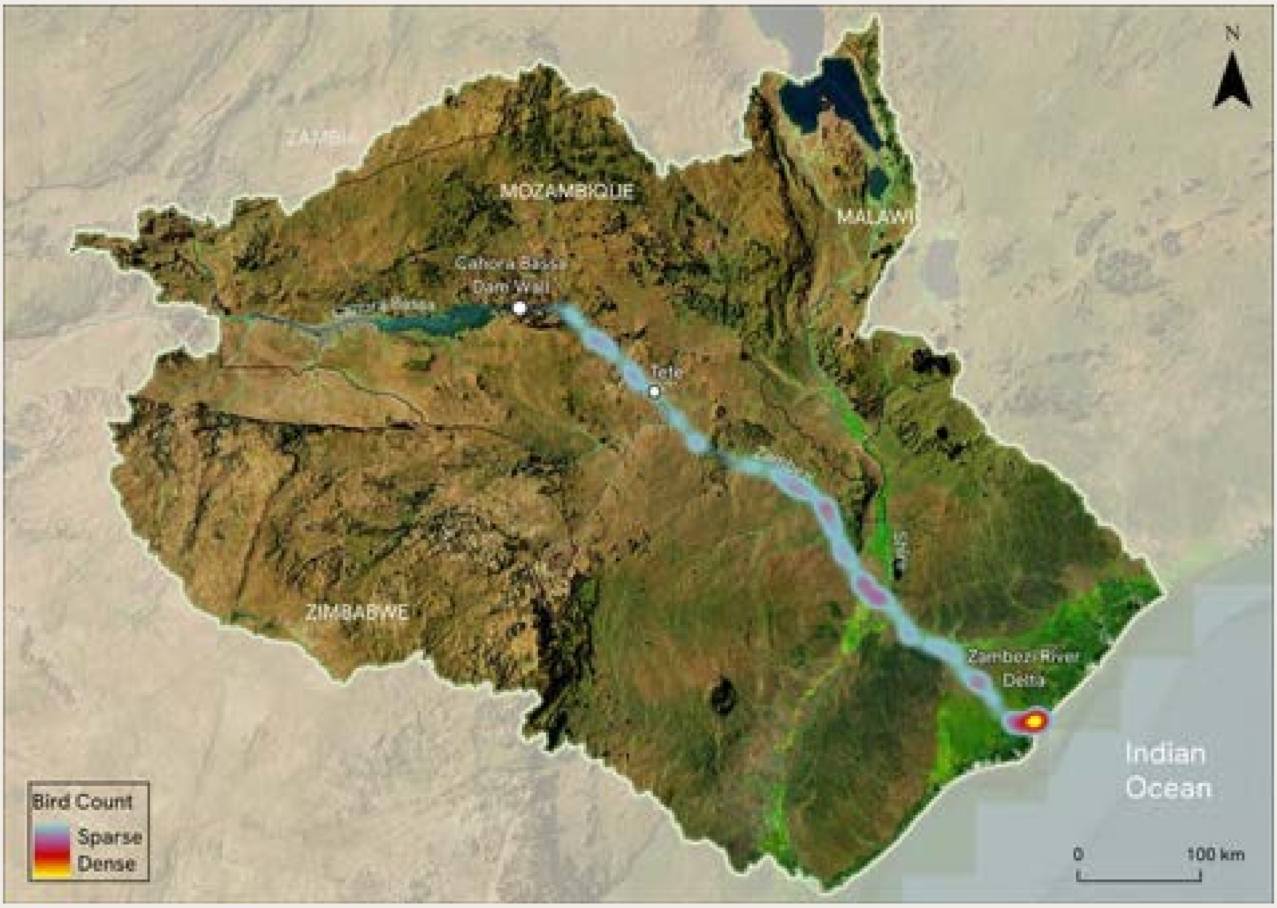
Wildlife

Six species of non-avian wildlife were also recorded along the Lower Zambezi River: chacma baboon (N=22), crocodile (N=80), hippopotamus (N=631), rock hyrax (N=3), vervet monkey (N=43) and water monitor (N=11).

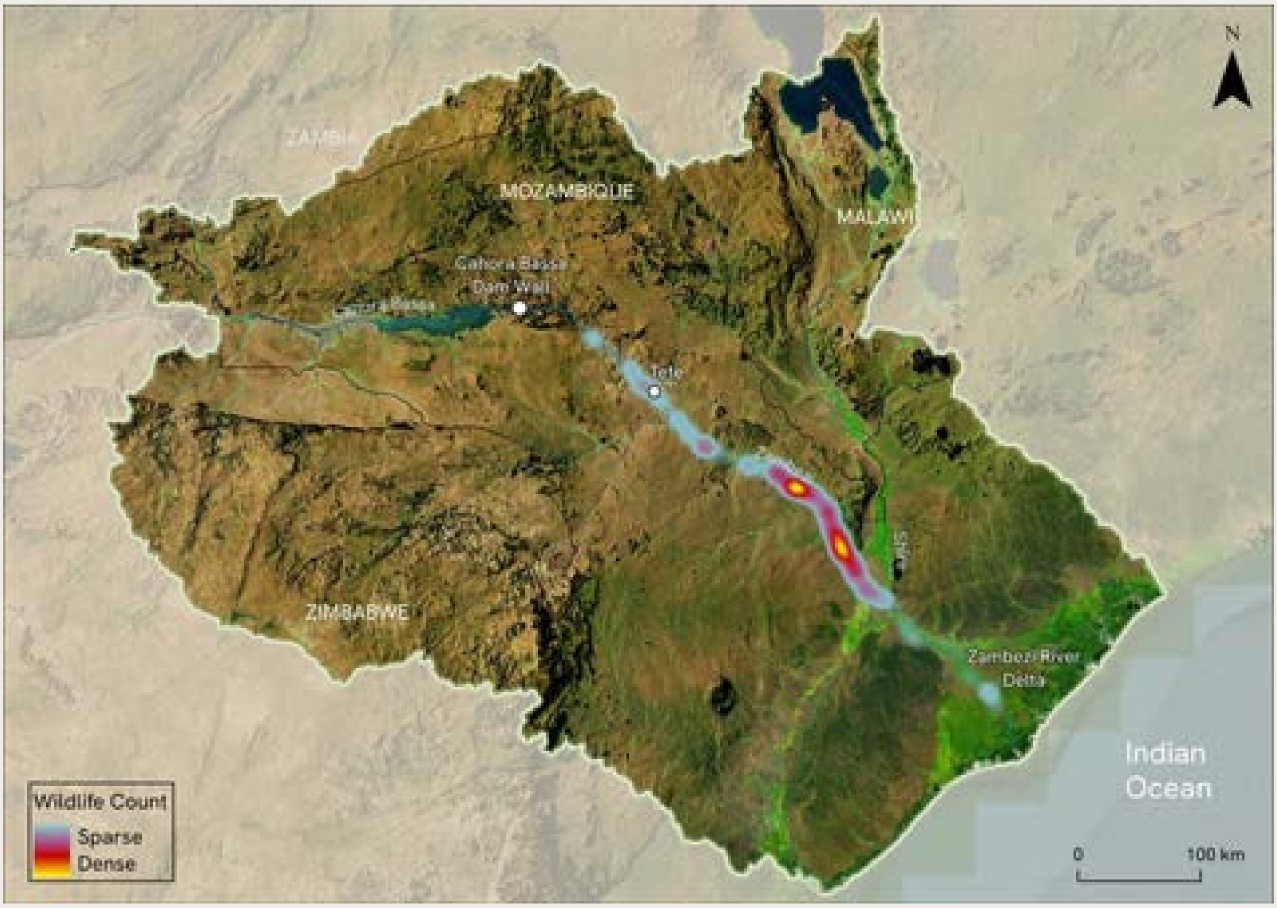
Indicators of biodiversity, counted within 100 m of the Lower Zambezi River on the 2024 survey.

	Wetland birds/ 10 km	Wildlife/ 10 km
Lower Zambezi	113	12
Zambezi Average	246	43





The density of birds from Cahora Bassa Dam to the Indian Ocean.



The density of wildlife from Cahora Bassa Dam to the Indian Ocean.

HIPPOS

In 2016, aerial surveys conducted by the National Administration for Conservation Areas (ANAC) estimated approximately 8,000 hippos in Mozambique[7]. More than half of these were in Cahora Bassa, and a further 1,200 within the Lower Zambezi River. Combined, these habitats accounted for 70% of the country's hippos. Additionally, further surveys of the Zambezi Delta in 2019 estimated the hippo population of the Marromeu Complex to be approximately 200 individuals, with just 37-60 living along the Zambezi River within the delta[8].

The TWP 2024 survey was conducted by boat and restricted to the Zambezi River which limits its comparability to previous aerial surveys. Nevertheless, the survey recorded 631 hippos along the Zambezi River — 50% of the population estimated in 2016. Only 14 of these were counted within the Zambezi Delta. Most hippos were distributed in the floodplain habitat between Tambara and Mutarara, outside of protected areas.

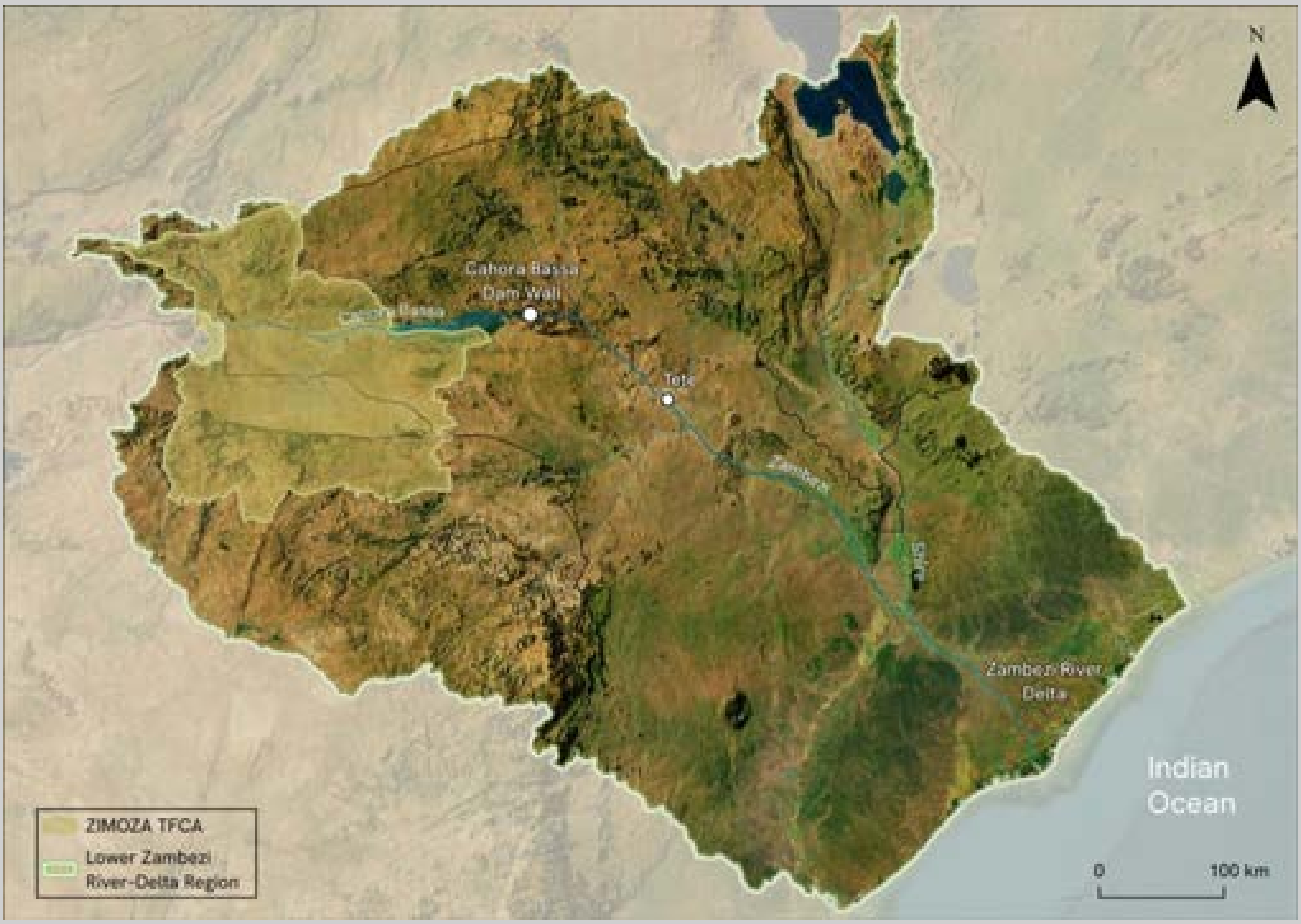
Along other stretches of the Zambezi, hippo distribution is concentrated around national parks and other protected areas. This pattern is largely driven by habitat availability and protection from hunting. In the Lower Zambezi in Mozambique, however, many hippos live adjacent to community-managed lands, making their survival dependent on the protection provided by local communities between Tambara and Mutarara. Further consultation with these communities should help identify mechanisms to better support their conservation efforts.

The density of hippos along the Lower Zambezi River, between Cahora Bassa Dam and the Indian Ocean. Most hippos are found outside of protected areas, where communities are the guardians of these charismatic animals.

ZIMOZA TFCA

The Zimbabwe-Mozambique-Zambia Transfrontier Conservation Area (ZIMOZA TFCA) spans the border region between Mozambique, Zimbabwe, and Zambia. Formally established in July 2024, the TFCA covers over 39,000 km^2 and integrates diverse ecosystems surrounding the lower Zambezi and its tributaries, including portions of Cahora Bassa, Mágoè, and Zumbo districts. The conservation area connects a network of protected regions, community lands, and river systems, forming a critical ecological corridor that strengthens landscape connectivity and supports regional biodiversity resilience[9,10].

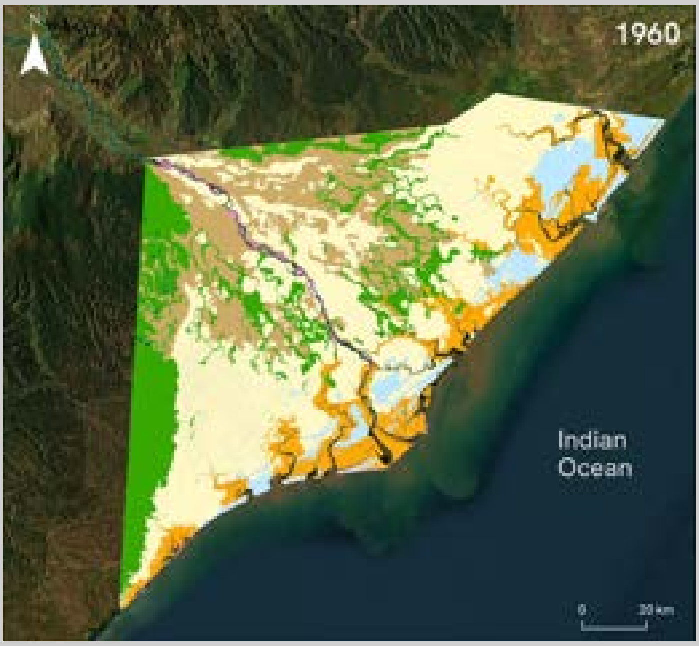
Although outside of the ZIMOZA TFCA, the Lower Zambezi River forms a crucial ecological link to the Marromeu Complex. Continuous riverine habitat supports seasonal wildlife movements, sustain productive fisheries, and provides essential resources for communities who depend on the river. Within this broader transboundary context, the TFCA framework helps promote more coordinated land-use planning and community-focused stewardship, strengthening efforts to maintain connectivity along the corridor. Preserving the Lower Zambezi as an ecological linkage is fundamental to support biodiversity, sustain ecosystem processes, and enhance the resilience of the wider Zambezi landscape.

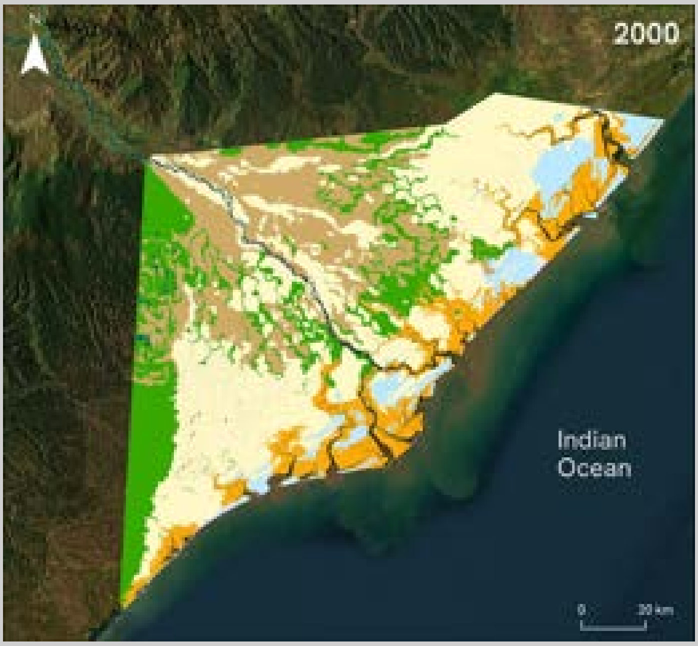


ZAMBEZI DELTA

Land Cover and Land Use Change in the Zambezi Delta by Beilfuss, Dutton, and Moore provides a basin-wide record of ecological change across the lower delta[11]. Using multi-decadal satellite imagery, aerial photography, and field surveys, the study traced shifts in vegetation and surface water from the 1960s to the early 2000s, showing how the Cahora Bassa Dam reshaped the landscape through reduced flooding and sediment supply.

The analysis found widespread encroachment of palm savanna and Acacia thicket, loss of flood-tolerant wetland species, and replacement of freshwater grasslands with saline communities. Former channels have dried, mangrove and thicket habitats have declined, and sandbars and deltaic shores have been reworked. Together, these changes mark a transition from a dynamic, flood-driven wetland system to a more static landscape with reduced ecological diversity and resilience[12].





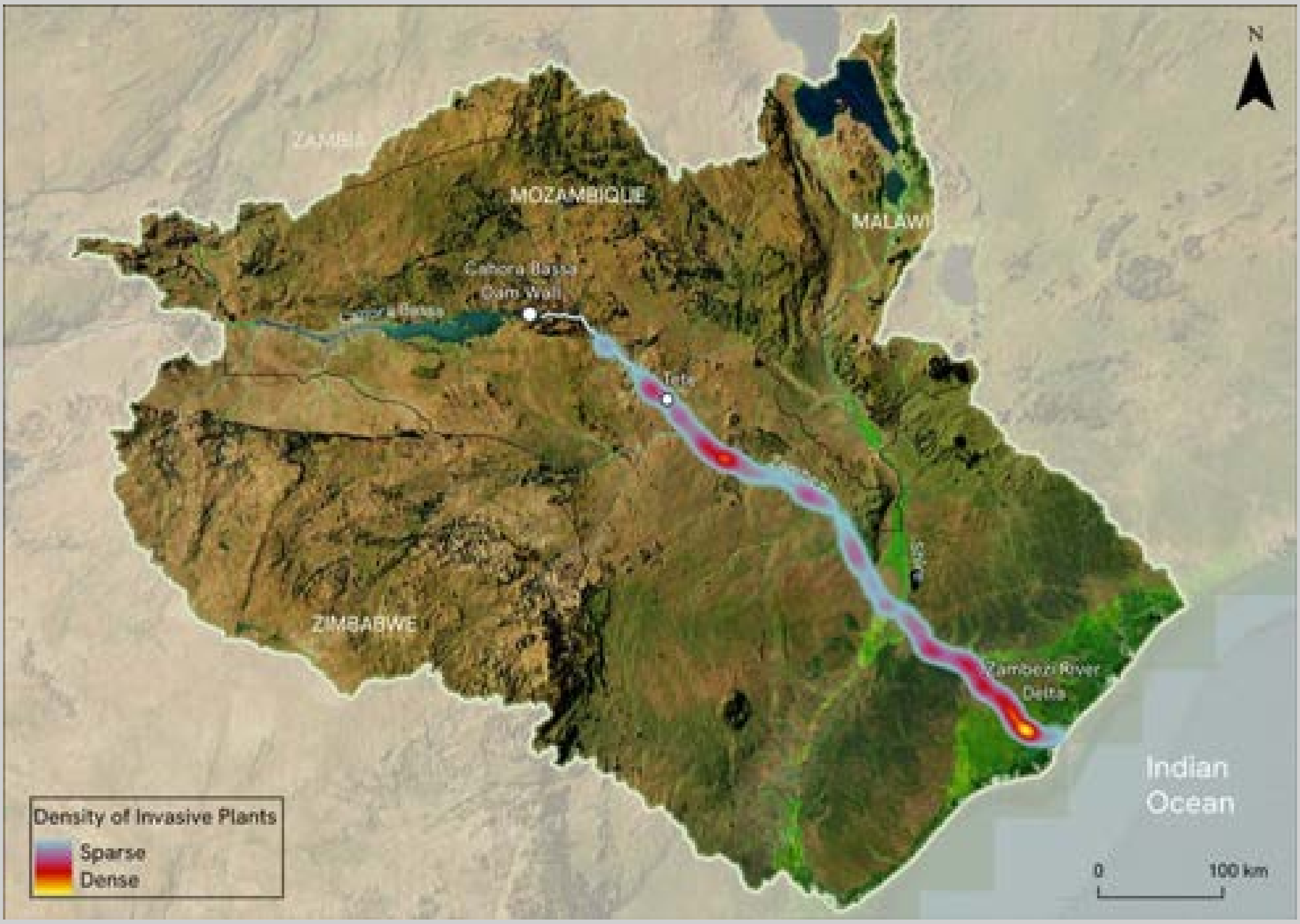
Landcover	1960 (km2)	2000 (km2)	% change
Wetlands and aquatic plants	16.68	25.51	53%
Dune thicket and coconut plantations	973.23	958.77	-1%
Forest and Thicket	2632.47	2659.95	1%
Grassland	6252.26	5774.53	-8%
Mangroves	1730.72	1734.76	0%
Sand bars	74.36	12.65	-83%
Savanna	2479.61	2977.77	20%

RESULTS

INVASIVE SPECIES

Alien invasive plants (AIPs) are known to have several impacts on river systems in Africa. These include the displacement of native vegetation and changes in nutrient cycling, which have detrimental impacts on native biodiversity[13]. In addition, AIPs can reduce water quality by increasing evaporation rates and reducing stream flow and dilution capacity[14]. The continuous monitoring of AIPs allows for early detection of threats to riverine ecosystems.

The most prevalent species were water hyacinth (*Eichhornia crassipes*) and giant sensitive plant (*Mimosa pigra*). Water hyacinth abundance increased substantially after the Shire River tributary, and controlling this species can only occur if it is simultaneously controlled on the Shire. Giant sensitive plants were particularly prevalent between Tete and Tambara, and then had a patchy distribution between Mutarara and the start of the delta. Encouragingly, we did not detect a single redclaw crayfish (*Cherax quadricarinatus*), a pervasive invasive threatening other sections of the Zambezi.



The distribution of alien invasive plants along the transect.

SHIRE RIVER

Locally 'Chiri': The River with Steep Banks

The Shire River is the largest tributary of the Zambezi River in Mozambique, joining near Caia, directly upstream of the Zambezi Delta. The Shire is also the sole outflow of Lake Malawi, and has three major hydropower dams along its course: Nkula Dam, Tedzani Dam and Kapichira Dam. In addition, two more large hydroelectric dams are planned at Mpatamanga. Whilst there are several flow stations on the Shire River, most of these are in disrepair following cyclone damage over the course of the last decade.

To assess the contribution of the Shire to the Lower Zambezi, an acoustic doppler current profiler (ADCP) was used to measure flow at several sites. These included i) the Zambezi River, above the Shire; ii) the Shire River, near the confluence with the Zambezi; and iii) the Zambezi River, below the Shire confluence.

The results of these measurements indicate that the Shire River accounted for approximately 25% of the flow of the Lower Zambezi River in September 2024. This water is vital to the health of wetlands at the Shire-Zambezi confluence, and further downstream at the Zambezi Delta. Flow releases from the cascade of dams on the Shire River — including Nkula, Tedzani, Kapichira, and the planned Mpatamanga — should therefore consider the seasonal ecological requirements of the Lower Zambezi floodplain and delta ecosystems. Strengthen transboundary coordination of Shire–Zambezi flow management: Given the Shire River's substantial contribution to Lower Zambezi flows, coordinated flow management among Malawi and Mozambique, hydropower operators on the Shire River, and basin-level institutions such as ZAMCOM is important to support downstream floodplain and delta ecosystems.

Details of flow measurements recorded on the 2024 Lower Zambezi survey

ADCP Site	Date	Latitude	Longitude	Measured Q (m^3/s)
Zambezi Upstream	22/09/2024	16.38969°S	33.99191°E	1535.12
Shire River	27/09/2024	17.68987°S	33.99191°E	493.57
Zambezi Downstream	28/09/2024	18.02698°S	3.99191°E	1933.92

WATER QUALITY

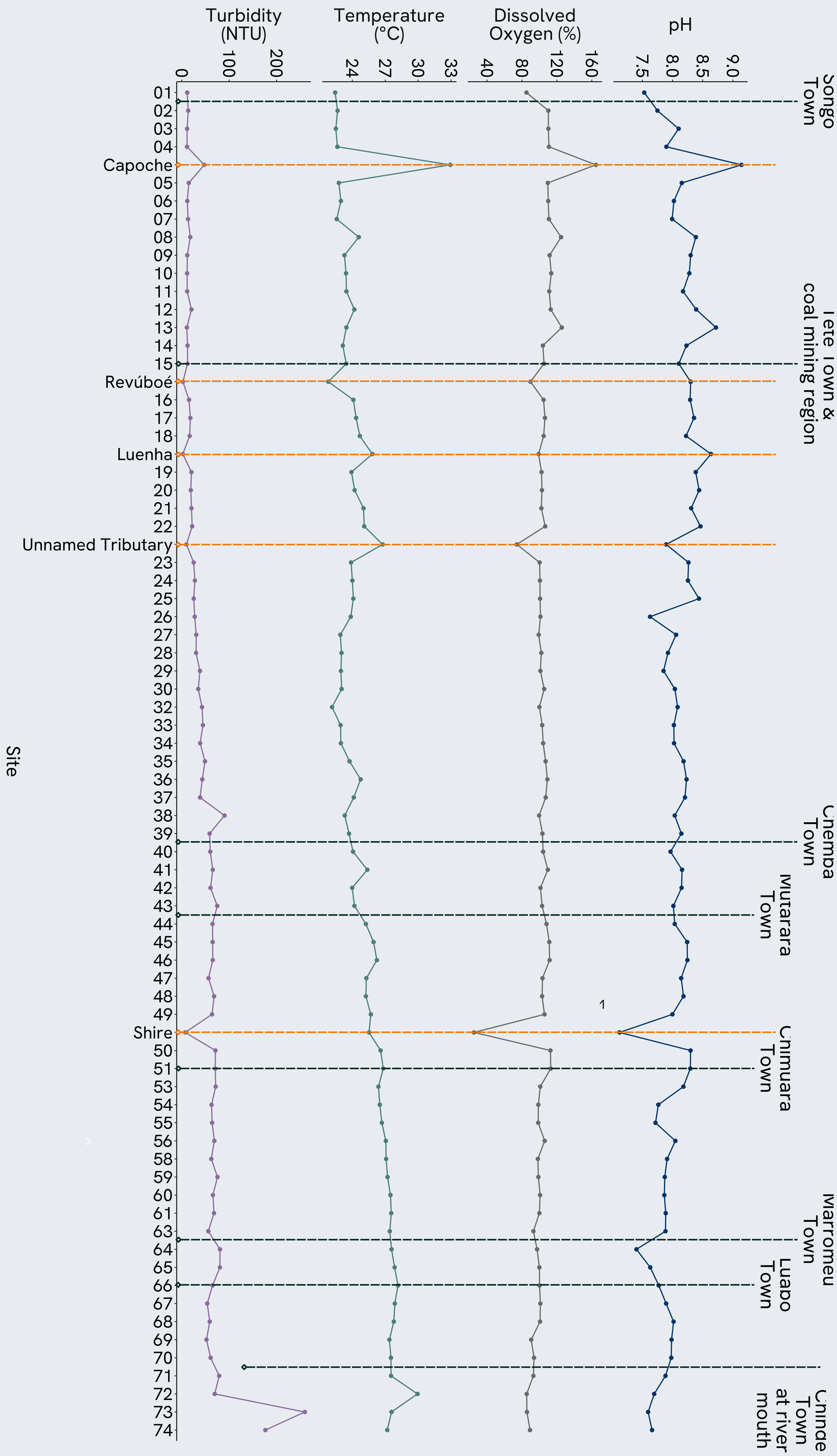
Water quality along the Zambezi was generally within World Health Organisation (WHO) guidelines, except for turbidity and pH. Turbidity was consistently elevated (~46 NTU) throughout the transect, well above the recommended guideline for drinking water (<5 NTU). Although turbidity — which describes the cloudiness of water — does not necessarily have direct health implications, it can mask disease-causing bacteria and pathogens. At site 13, the pH exceeded the WHO limit of 8.5, indicating a localized disturbance in water quality.

Overall, the water quality parameters of tributaries indicate better water quality than in the mainstem Zambezi, except for pH, which was elevated in both the Capoche and Luenha rivers (>8.5). The stagnant conditions in the Capoche contributed to its poorer water quality compared to Ruvuboe, Luenha, and Shire tributaries.

A major pattern seen across most water chemistry parameters was the influence of the ocean. Conductivity, salinity, resistivity, and turbidity were vastly different at the river mouth, with marine influence extending at least 30 km inland. Water quality in the delta region is therefore likely to vary considerably depending on tidal conditions.

Although chemicals and potentially toxic substances such as mercury and cyanide are sometimes used in gold mining, no evidence of their use was observed during this expedition, and in-field water quality techniques used may not directly detect their presence. However, the team collected water quality samples for laboratory analysis, which may ascertain the impact of mining operations on water quality.

WATER QUALITY



RECOMMENDATIONS

Hydrological Monitoring Stations

To improve monitoring of flow and water quality in the Lower Zambezi River, more fixed hydrological stations should be established, particularly downstream near the delta.

These stations would:

- Improve our understanding of the Lower Zambezi's seasonal and interannual flow dynamics.
- Serve as an early warning system for flooding and drought by tracking upstream water levels in real time. This information would enable downstream authorities to anticipate inflows, adjust dam releases, and prepare for climatic extremes.

Invasive Species Management

The spread of invasive plant species, particularly *Mimosa pigra*, poses a growing threat to the ecological integrity of the Lower Zambezi. If unmanaged, these invasions could alter hydrological processes, displace native vegetation, and reduce the capacity of wetlands to support biodiversity and water regulation. To mitigate these risks:

- Eradicate invasive species to prevent establishment and long-term ecological impact.
- Apply a combination of mechanical removal and, where feasible, biological control methods informed by successful international practice. In particular, this includes the seed-feeding beetle *Acanthoscelides puniceus* and the stem-boring moth *Carmenta mimosa* for *Mimosa pigra,* as well as the mottled water hyacinth weevil *Neochetina eichhorniae* and planthopper *Megamelus scutellaris* for water hyacinth.
- Strengthen monitoring and prevention efforts to detect new invasions quickly and avoid further introductions.

Water Management

Localised deviations in pH suggest that site-specific land-use or hydrological conditions may influence water quality, underscoring the importance of coordinated water and land management by responsible Mozambican authorities.

RECOMMENDATIONS

Restore riparian vegetation

Current agricultural practices are destabilizing the riverbank and causing the river to widen. Reestablishing riparian vegetation and creating a buffer zone between the river and agricultural areas will help mitigate these impacts and promote more sustainable land use.

Strengthen riparian corridors

The Zambezi River is a vital riparian connection between the Zimbabwe Mozambique Zambia Transfrontier Conservation Area (ZIMOZA TFCA) and the Marromeu Complex, including the Zambezi Delta. Further support for the communities along the Lower Zambezi River in protecting hippos and their wetland habitats will help strengthen this area as an important corridor for biodiversity movement across the landscape.

Assess Gold Mining Impacts

Examine gold mining activities in the gorge below the dam wall to assess their potential impacts on water quality. Understanding the affects of mining on the river ecosystem, particularly sedimentation, chemical runoff, and overall water health, is crucial for maintaining water quality in the Zambezi.

Targeted Land-Use Planning

The markedly higher building density along the Lower Zambezi River highlights the need for spatially informed land-use planning and sustainable development strategies that account for cumulative pressures on floodplain and wetland ecosystems. Using spatially-informed land-use strategies that differentiate between floodplain and upland areas would protect the integrity of wetland ecosystems from mounting anthropogenic stress. For instance, cropland distribution indicates intensive use of fertile floodplain areas and limited cultivation in upland regions, suggesting that sustainable land management strategies should be tailored to contrasting environmental conditions across the basin

Long-Term Ecological Baselines

Incorporate multi-decadal hydrological and vegetation data into Delta management decisions. Authorities, specifically ANAC, should utilize these historical baselines to inform conservation planning and ensure resilience against long-term ecological change.

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