



THE
WILDERNESS
PROJECT

EXPEDITION OVERVIEW

CAHORA BASSA

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.

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INTRODUCTION

Cahora Bassa is the fourth largest reservoir in Africa (2,700 km²), located on the lower Zambezi River in Mozambique. It was created in the early 1970s with the construction of the Cahora Bassa Hydroelectric Dam to harness the river's flow for hydropower generation. Today, it supplies electricity to South Africa, Mozambique and Zimbabwe, forming a vital component of the region's energy security^{1,2}.

The Cahora Bassa hydropower plant has a capacity of 2,075 MW and can produce up to 18,000 GWh of electricity annually³. Around 60% of this power is exported to South Africa, while revenues from Cahora Bassa make a major contribution to the national economy, with profits of nearly 14 billion MT (equivalent to US\$230 million) recorded in the first nine months of 2024 and projected contributions of more than 18 billion MT (US\$290 million) to the 2025 state budget^{4,5}.

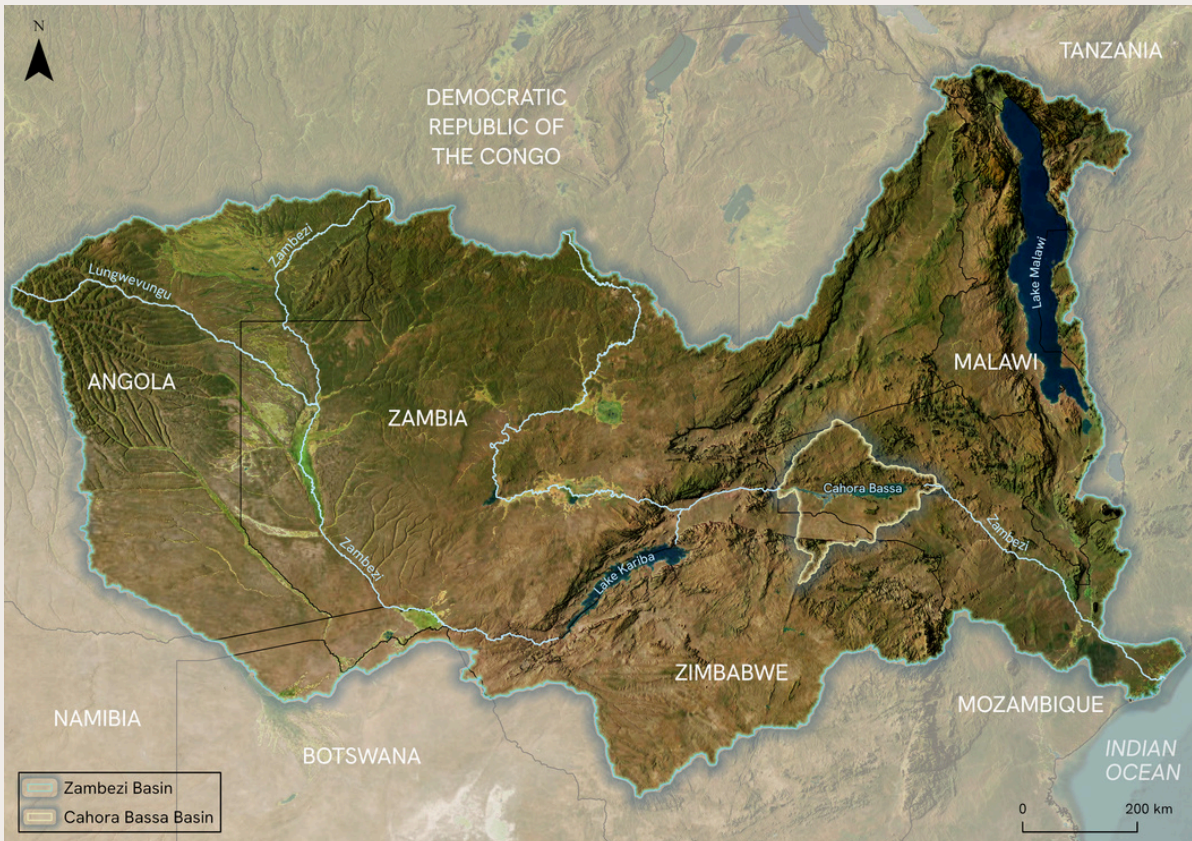
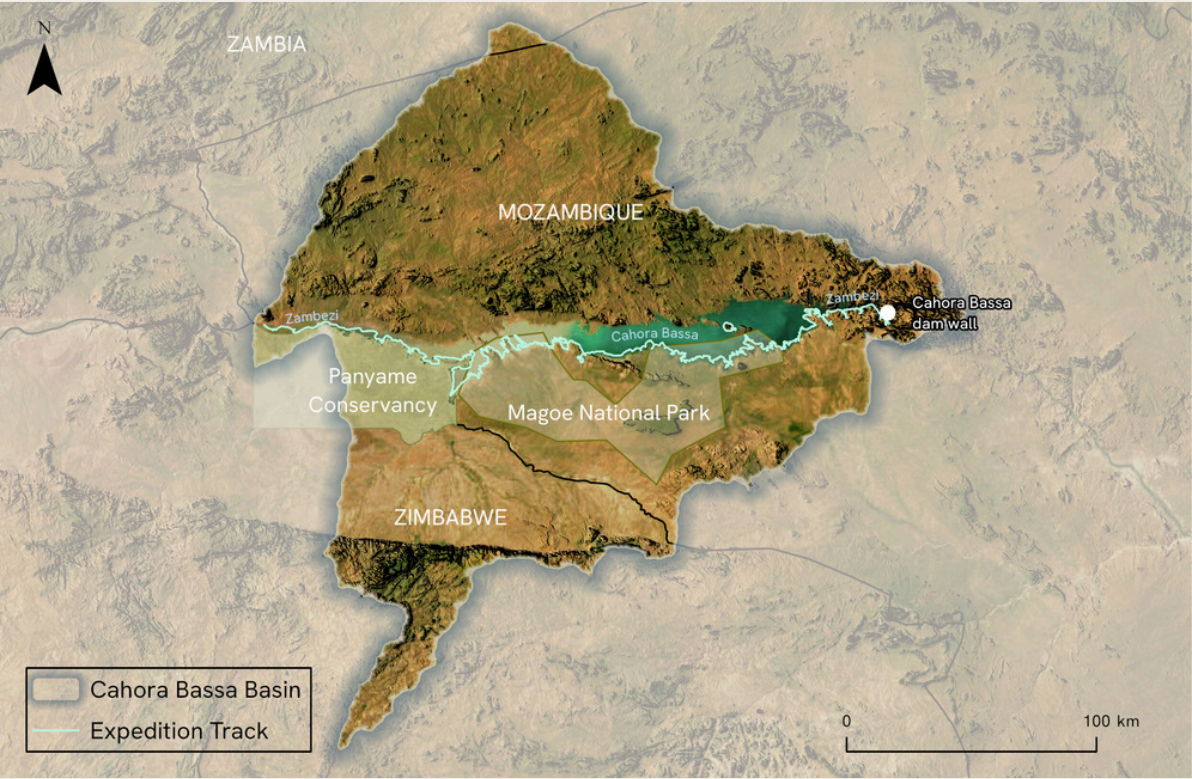
Beyond energy, Cahora Bassa sustains an important inland fishery that underpins the local economy in Tete Province. Kapenta (*Limnothrissa miodon*), originally introduced from Lake Tanganyika to Lake Kariba, were subsequently introduced to Cahora Bassa in the 1970s following the success of the Kariba fishery. The species now dominates catches, averaging around 10,000 tonnes annually and supporting the livelihoods of more than 10,000 people. Alongside the kapenta fleet, artisanal fishers target tilapias (*Oreochromis* spp., *Tilapia rendalli*) and catfishes (*Clarias* spp.)⁶. In recent years, kapenta catches have declined by more than 40% (from 11,915 t in 2016 to 6,969 t in 2017), driven by weak regulation, cross-border smuggling⁷, fluctuating water levels, and illegal fishing. This has raised concerns over the long-term sustainability of the fishery, and risks to food security of local communities^{8,9}.

The importance of Cahora Bassa for both electricity generation and fisheries production makes it highly sensitive to climate variability. During the 2024 drought, reservoir levels dropped to just over 20% of useable storage, the lowest in three decades^{10,11}. Operators restricted non-essential releases and rationed power generation, while declining water levels disrupted fisheries, intensifying conflicts between fishing communities. Over coming decades, climate change will increase the frequency and severity of droughts in the Zambezi Basin, posing an urgent threat to the energy and food security of those livelihoods connected to Cahora Bassa Dam.



CAHORA BASSA BASIN

Cahora Bassa lies within the Zambezi Basin — southern Africa’s largest transboundary river system. More specifically, it forms part of the Lower Zambezi, the stretch of river extending from the Mozambican border to the Indian Ocean.



THE EXPEDITION

741 km

travelled by boat

10

team members
from four African
countries

75

research sites
established

26

days on
expedition

The Wilderness Project (TWP) conducted a 741 km research transect along the southern shoreline of Cahora Bassa from 17th July to 11th August 2024 . The aim was to collect baseline data on hydrology, water quality, biodiversity, and human activity to inform future monitoring and support sustainable management. The study also identified key conservation insights, including ongoing threats to the river. The expedition team consisted of researchers, boat captains, and a land support team.



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 shoreline — up to 100 m from the edge — identifying biodiversity and human activity. 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, 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 reservoir conditions and insights from visual surveys, they deployed overnight bat recorders, set traps for freshwater fish and crustaceans and collected water and soil samples. This approach enabled more detailed assessments of the reservoir's hydrochemistry and biodiversity.



RESEARCH SITES

64 fixed sites

89

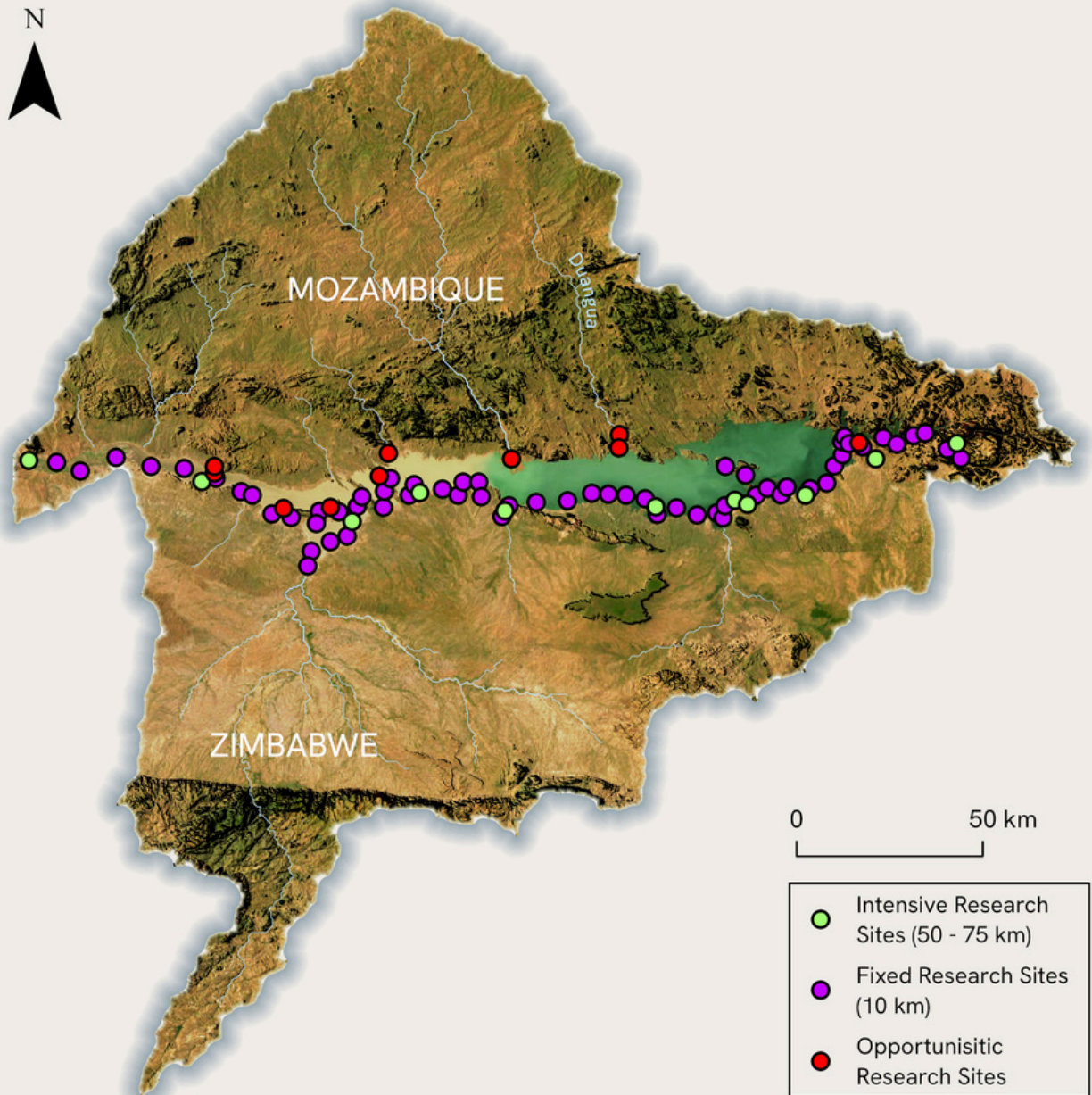
water quality
measurements

74

aerial drone
surveys

62

bird
species recorded



The locations of 64 fixed, 13 intensive, and 10 opportunistic research sites.

HUMAN FOOTPRINT

Human activity is widespread along the southern bank of Cahora Bassa, while the northern shore supports far fewer people due to limited road access. Fishing forms a significant component of local livelihoods, complementing subsistence agriculture. Given the low water levels during the survey period, small areas of opportunistic cultivation were observed, particularly at tributary mouths and near the Zambezi inflow in the west.

Patterns of human presence were similar across protected and unprotected zones. Notably, Mago National Park exhibited slightly higher levels of lakeshore activity than neighboring areas, indicating that protected status has had limited influence on settlement patterns. This minimal difference likely reflects the park's recent establishment in 2013 and ongoing challenges in enforcing restrictions on habitation and resource extraction.

The presence of more than 35,000 households within the park's boundaries, combined with drought conditions associated with the El Niño climate phenomenon, has intensified human-wildlife conflict as elephants and other species move into riverside and agricultural areas in search of food and water. These pressures illustrate the difficulty of achieving conservation outcomes in landscapes where livelihood dependence on natural resources and climatic variability converge, highlighting the need for integrated management approaches that balance human use with biodiversity protection.

Panyame Conservancy	Inside Mago National Park	Outside Protected Areas
10 people/km	13 people/km	11 people/km



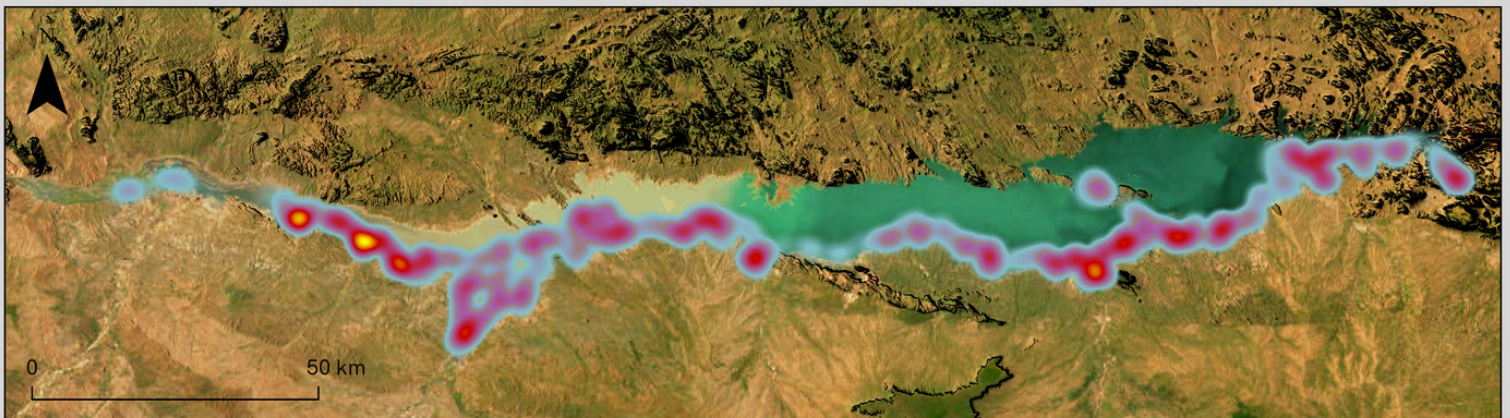
Distribution of people along the transect (below). The summary of observations (above) shows several indicators of human activity, averaged per 10 km along the transect.

FISHING ACTIVITY

Cahora Bassa supports two main fisheries: a semi-industrial kapenta fishery, centred on *Limnothrissa miodon*, and artisanal operations targeting tilapia, catfish, and other nearshore species using gillnets and traditional gears. These fisheries provide a crucial source of protein and income for thousands of lakeshore communities and are central to both local and regional food systems^{12,13}.

Together, they produce an estimated 16,000 tonnes of fish annually, with kapenta accounting for over 60 percent of total landings. Around 2,000–3,000 fishers and processors depend directly on the resource, which underpins much of the Magoe sector economy^{13,14}. However, stocks have been declining amid growing pressure from illegal and unregulated fishing. Surveys recorded extensive use of undersized or banned nets, over 90 unlicensed vessels, and numerous lost or abandoned “ghost nets” that entangle wildlife and damage gear^{15,16,17}. Licensed operators report that these practices, coupled with gear conflicts and smuggling of kapenta across borders, have contributed to catch declines exceeding 40% in some areas^{15,18,19}.

Recognising these pressures, the government has introduced measures such as licence caps, zoning schemes, and a ban on night artisanal fishing to reduce overlap with the kapenta fleet^{19,20}. Yet, enforcement capacity and monitoring remain limited, weakening management effectiveness^{19,21}. Sustaining Cahora Bassa’s fisheries will depend on strengthening community-based governance, restoring spawning habitats, and improving compliance—essential steps to protect both livelihoods and the ecological integrity of the reservoir.



Fishing Activity

Sparse
Dense

| The density of fishing activity along the southern shoreline of Cahora Bassa.

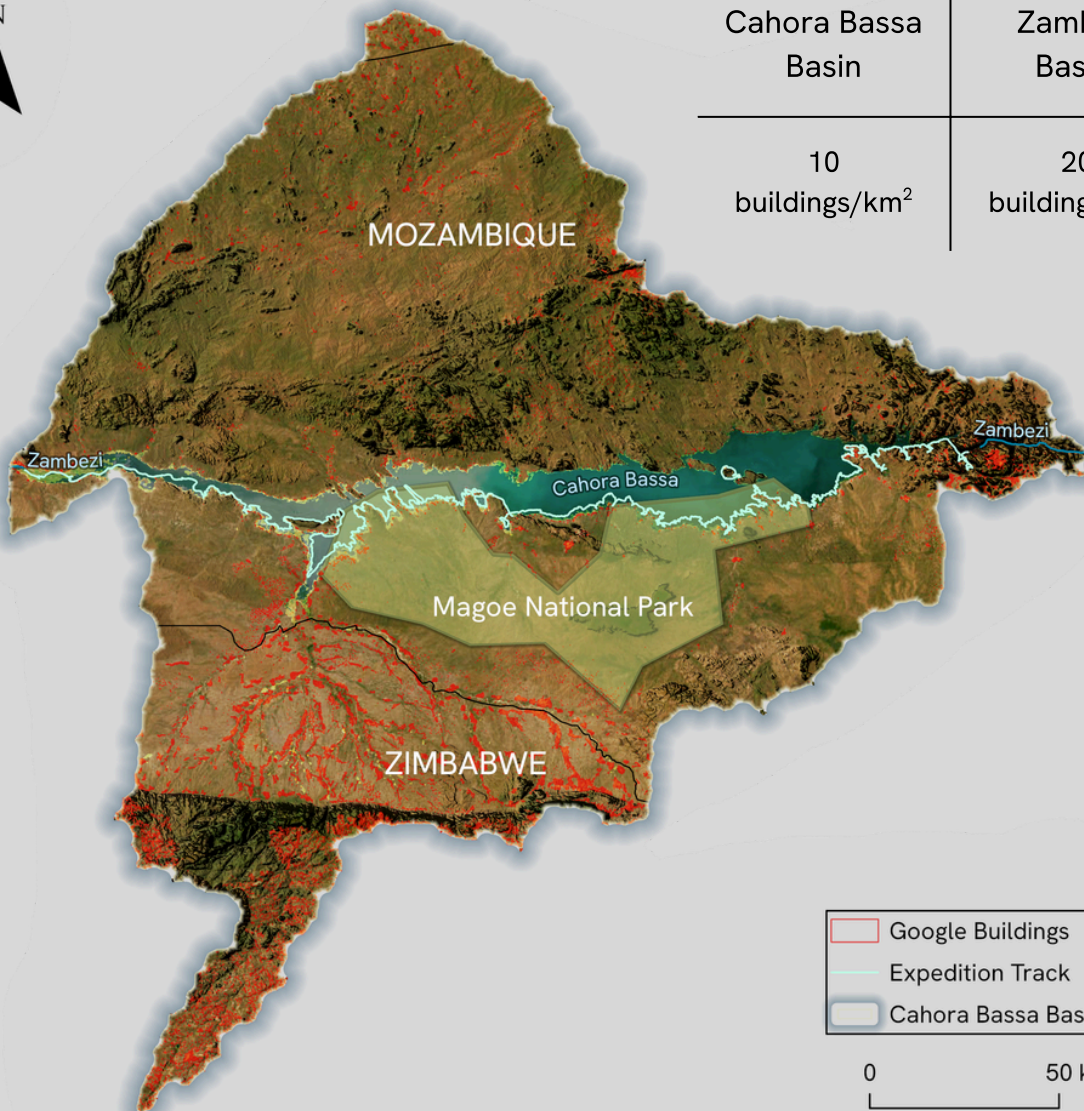


Confiscated unlicensed and illegal Kapenta fishing gear. The blue netting (above) consists of repurposed mosquito nets, while the yellow drums (below) are used to float LED light strips that attract fish. Each of these improvised float systems has the potential to harvest as much Kapenta as a licensed fishing rig.

BUILDING ANALYSIS

Google's Open Buildings dataset is a global mapping resource that uses high-resolution satellite imagery to identify and outline individual building footprints²². By mapping the location and density of buildings, the data provides a landscape-wide view of human settlement.

The Cahora Bassa Basin, with a building density of just 10 buildings/km², has fewer permanent settlements than the Zambezi Basin average (see table below). This is attributed to a lack of urban centers. Instead, settlements are distributed along drainage lines in the south of the basin, emphasising the importance of water networks for human settlement. The banks of the reservoir were also densely populated, although predominantly with temporary settlements.



| The distribution of buildings within the Cahora Bassa Basin.

WETLAND BIRDS

Birds are among the most responsive indicators of habitat availability. Wetland birds in particular depend on healthy, intact waterways to forage, breed, and roost, making them particularly sensitive to habitat degradation. Continuous monitoring of birds can reveal early warning signs of environmental degradation and help to identify critical nesting and foraging areas that require conservation attention.

Construction on Cahora Bassa was completed in 1974, flooding a 2,700 km² area of rapids, gorge margins, tributary mouths, and riparian corridors. The impoundment transformed a fast, rocky, 'lotic' river reach into a deep, stratifying lake. While the lake margins offered new wetland habitat, the regulated outflows from the dam resulted in a flattening of the flow regime downstream. This limited the seasonal inundation and sediment transport in the Zambezi Delta, reducing the extent of this Ramsar wetland.

The TWP survey was conducted during a period of severe drought, when the lake extent was markedly reduced compared to non-drought years. A total of 17,715 wetland-associated birds, representing 62 species, were recorded along the transect. This wetland bird density is high within the Zambezi Basin, indicating that Cahora Bassa supports a substantial wetland bird community.

The 10 most common wetland bird species along the transect:

Bird Species	Count
African Openbill	3,223
Reed Cormorant	2,821
Black Winged Stilt	1,986
Egyptian Goose	1,252
Little Egret	1,130
Western Cattle Egret	1,093
Glossy Ibis	899
Great Egret	610
Grey Headed Gull	589
Grey Heron	538



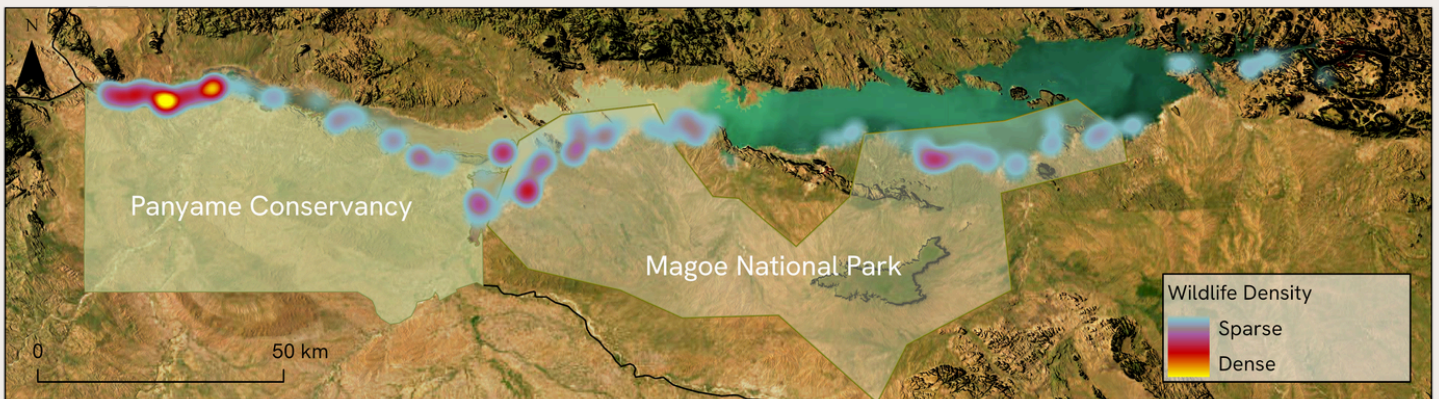
WILDLIFE

Cahora Bassa supports a large population of hippos and crocodiles; however, wildlife diversity is low, with only seven species recorded on this survey. A total of 2,420 individual animals were observed, the majority being hippos (N = 1,695) and crocodiles (N = 542). Most sightings were concentrated in the upper transect within the Panyame Conservancy, with additional observations in Magoe National Park. A 2025 study indicate that the overall hippo population in Cahora Bassa exceeds 4,000 individuals, underscoring the reservoir's regional importance for the species²³.

Many hippos around Cahora Bassa were in poor condition during the survey, appearing thin and likely affected by drought-related reductions in food availability. Longer distances to forage, together with competition from people and livestock, placed additional pressure on already limited habitat. As cultivation expanded along the shoreline of the reservoir due to drought, hippos were reported to raid crops more frequently, increasing the risk of conflict with surrounding communities.

Hippos are also directly targeted as a protein source by local communities. On this survey, several groups of people were noted either hunting or butchering hippos for their meat. This indicates that hunting is a significant factor influencing hippo populations within the impoundment. However, the hippo population in the lake is under-studied, and the sustainability of this practice is unclear.

Panyame Conservancy	Magoe National Park	Outside protected areas
58 animals/10 km	22 animals/10km	24 animals/10 km

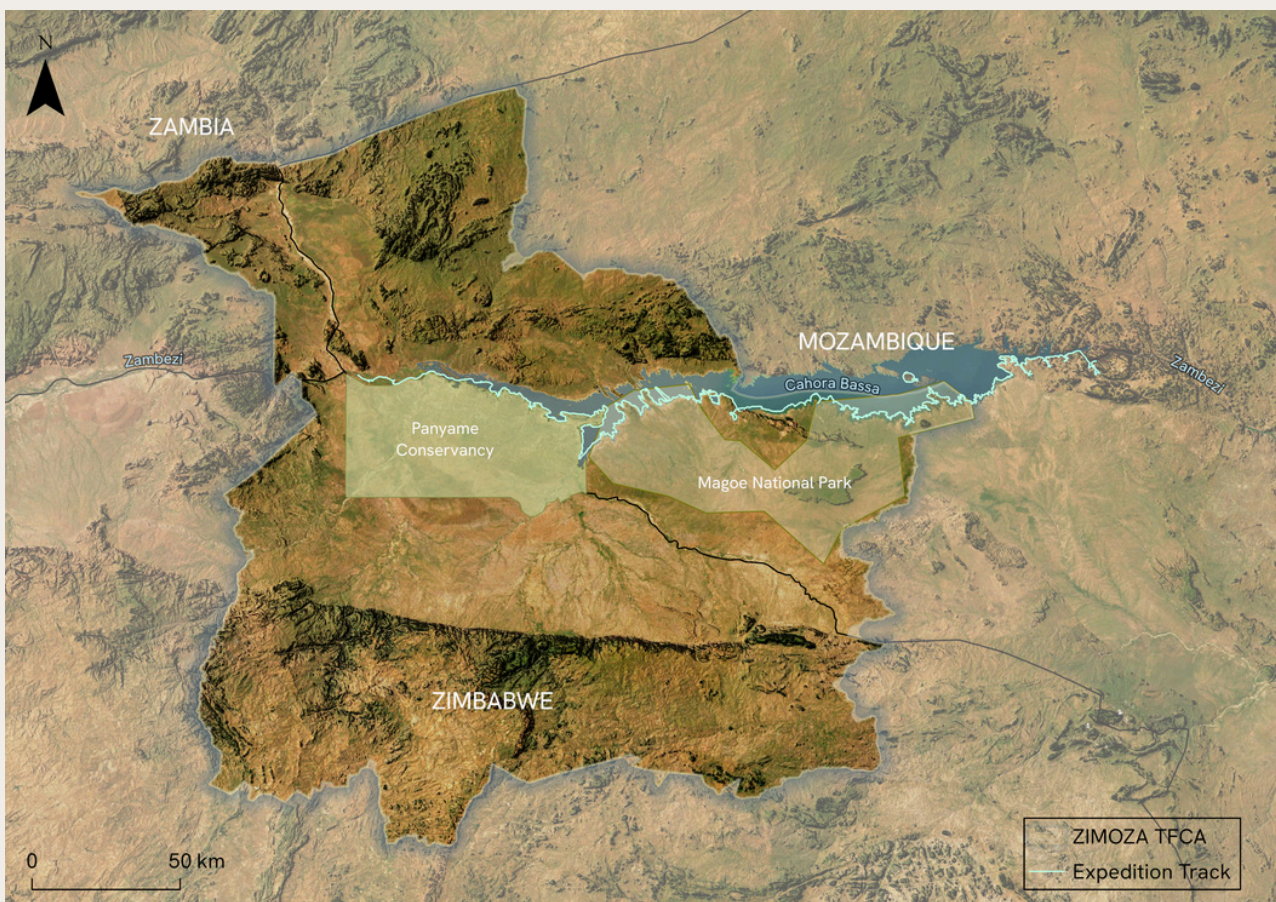


Wildlife distribution along the southern shoreline of Cahora Bassa. Note the hotspot of wildlife in the Panyame Conservancy.

ZIMOZA TFCA

Approximately 60% of the Cahora Bassa catchment falls within the Zimbabwe–Mozambique–Zambia Transfrontier Conservation Area (ZIMOZA TFCA), which spans the border region between Mozambique, Zimbabwe, and Zambia. Formally established in July 2024, the TFCA covers over 39,000 km² 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^{24,25}.

The establishment of ZIMOZA holds considerable implications for the future conservation of Cahora Bassa. As cross-border collaboration develops, joint management of water resources, fisheries, and wildlife corridors will be vital to maintaining the integrity of the basin. The TFCA framework encourages harmonised land-use planning and community-based conservation, aligning local livelihoods with ecosystem protection. Within this broader landscape, Cahora Bassa serves as both a hydrological and ecological anchor—its sustainability increasingly dependent on the collective management and shared conservation vision that define the ZIMOZA landscape.

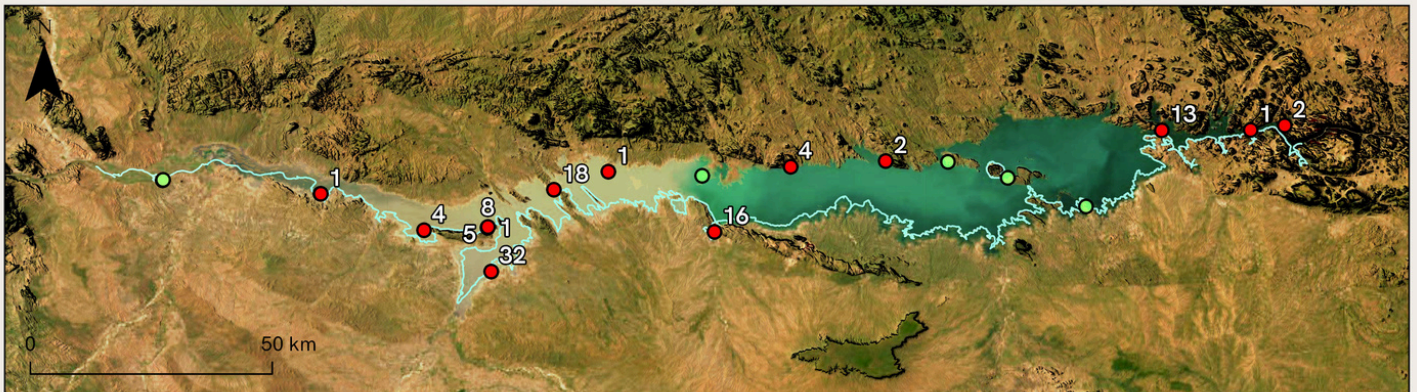


INVASIVE CRAYFISH

Redclaw crayfish, native to northern Australia and Papua New Guinea, have become widely established across southern Africa. Introduced into the Zambezi and Kafue river systems in the early 2000s, they are now present in Cahora Bassa^{26,27}. Invasion dynamics elsewhere in the basin illustrate their potential impacts: in Lake Kariba, redclaw crayfish have been associated with substantial socioeconomic losses, with fishers reporting annual reductions of more than 200 tonnes of fish worth over half a million US dollars due to crayfish damaging gillnets and reducing catches^{27,28}.

Ecologically, they compete with native freshwater crabs (*Potamonautes* spp.), consume a wide range of organic matter and invertebrates, and may act as vectors for parasites affecting other aquatic species²⁹. While the full scale of impacts at Cahora Bassa is not yet known, the species' rapid establishment and effects in Lake Kariba suggest similar risks for subsistence fisheries, local economies, and aquatic biodiversity.

Crayfish were captured at 14 of the 21 sampling sites along Cahora Bassa, with a total of 108 individuals recorded. This made redclaw crayfish the most common invasive species observed during the expedition. Their widespread occurrence across a majority of sites indicates that the species is well established in the reservoir and likely to have growing ecological and fisheries impacts if left unmanaged.



- Redclaw crayfish site (captured)
- Redclaw crayfish site (no capture)

Locations of Redclaw Crayfish sampling sites, labelled with the amount of crayfish captured.

Note: Redclaw Crayfish were found at 14 of the 21 sites.

WATER QUALITY

Temperature, pH, dissolved oxygen, conductivity, and turbidity are key physical and chemical properties that can indicate the suitability of water for human consumption and aquatic life. Monitoring these indicators provides insight into ecosystem health, supports the detection of pollution sources, and highlights spatial variation in water quality. To this end, water quality in Cahora Bassa was measured every 10 km along the transect using an In-Situ Aquatroll multiparameter sonde.

Overall, the results show stable water quality, and all parameters fall within the expected range for freshwater ecosystems. Temperature was consistent across sites, with only limited variation. Dissolved oxygen (DO) concentrations were generally high, indicating good oxygen availability for aquatic organisms. Total suspended solids and turbidity remained low overall, but intermittent spikes point to sediment disturbance, likely from wind action.

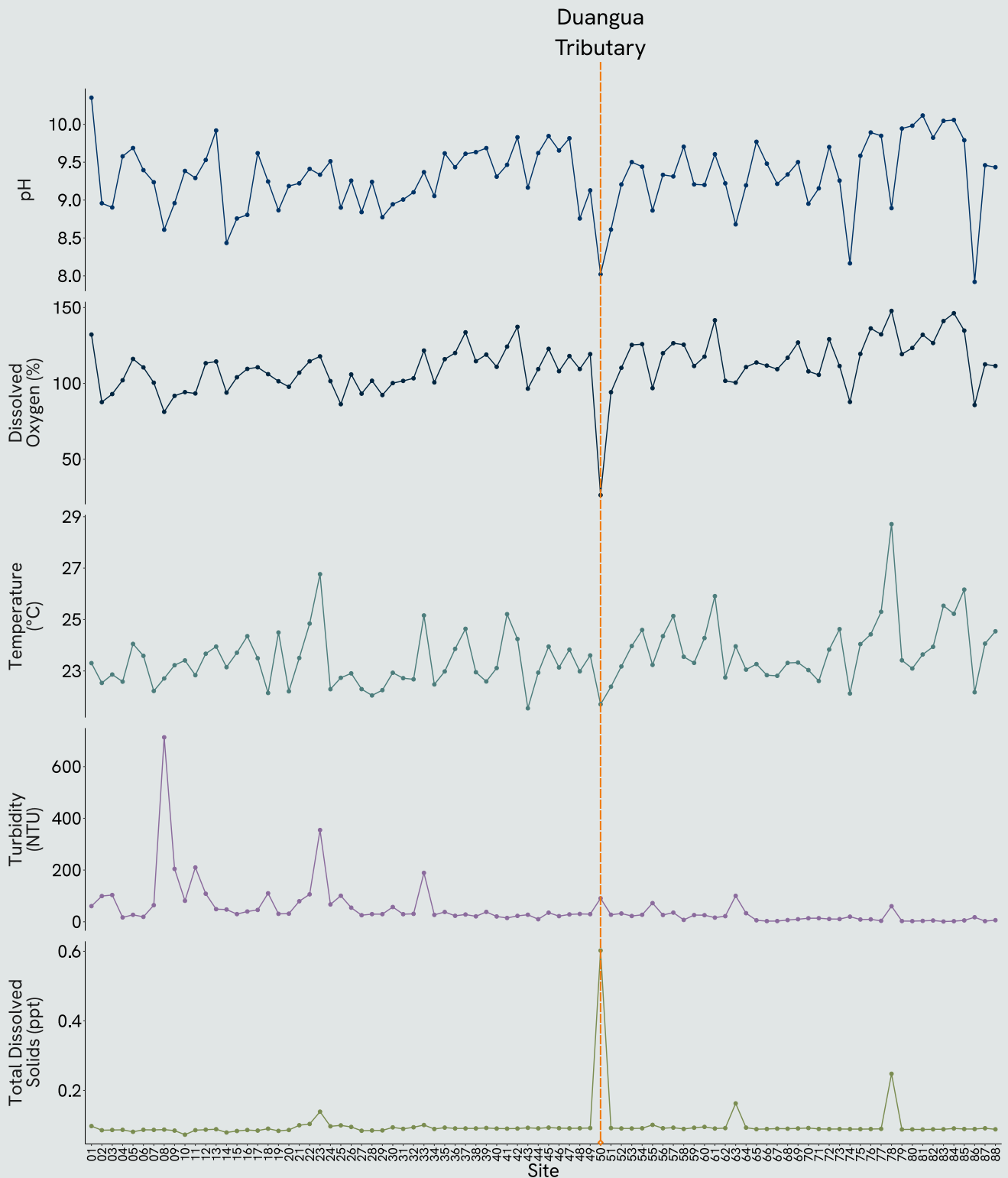
At site 63, the Duangua tributary, parameters diverge from those recorded along the Cahora Bassa shoreline, reflecting the transition from lake to riverine conditions. Here, dissolved oxygen declined sharply, while turbidity and total dissolved solids increased, indicating the influence of inflowing river water rather than the more stable, open-lake environment.

A notable trend in the dataset is the elevated pH, with measurements commonly exceeding the World Health Organization (WHO) guideline range for acceptable water quality. This alkalinity may be linked to algal blooms (see section below), where intense photosynthetic activity reduces dissolved carbon dioxide and drives pH upwards. Beyond shifting water chemistry, algal blooms can disrupt ecosystems by reducing light penetration, clogging fish gills, and depleting dissolved oxygen as biomass decays.

Water samples were also taken for heavy metals and analysed in the lab, with all concentrations found to be within WHO safe drinking-water limits. No immediate health concerns were identified, though continued monitoring is recommended to ensure values remain within safe thresholds.



WATER QUALITY



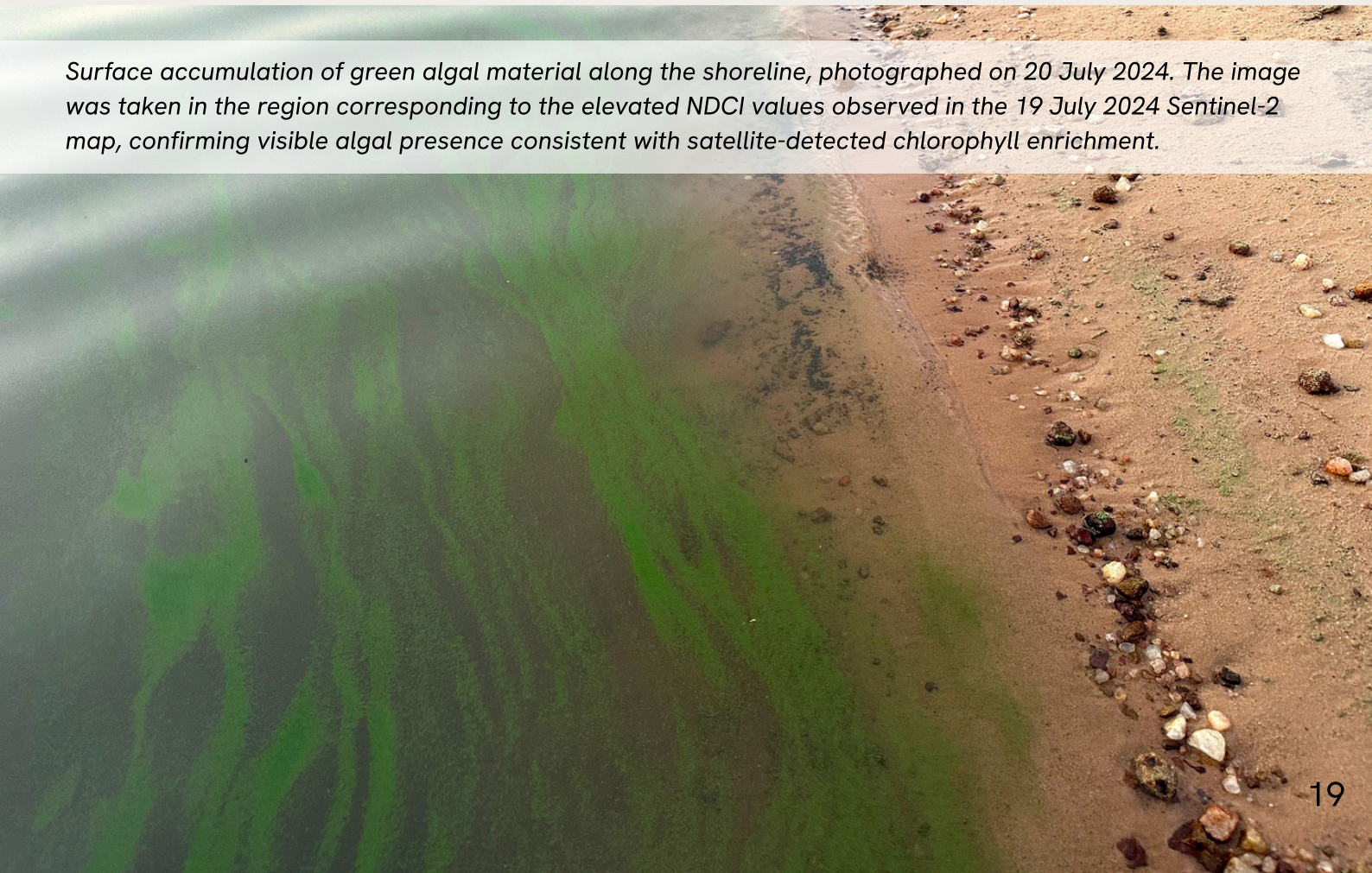
It's important to note that these findings represent a snapshot of water quality during the time of sampling, and conditions may shift seasonally or in response to land use changes, rainfall, or other environmental factors.

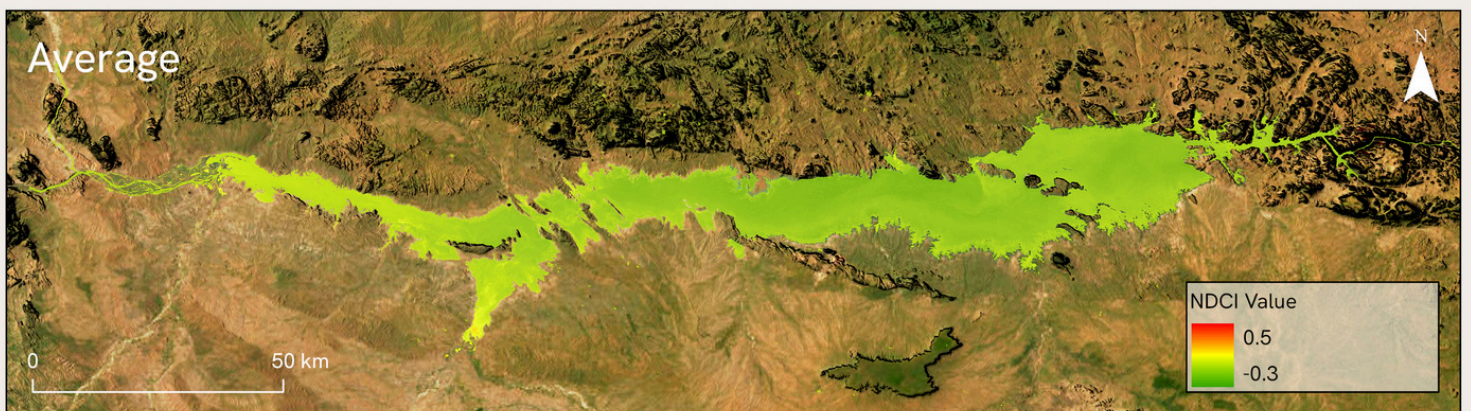
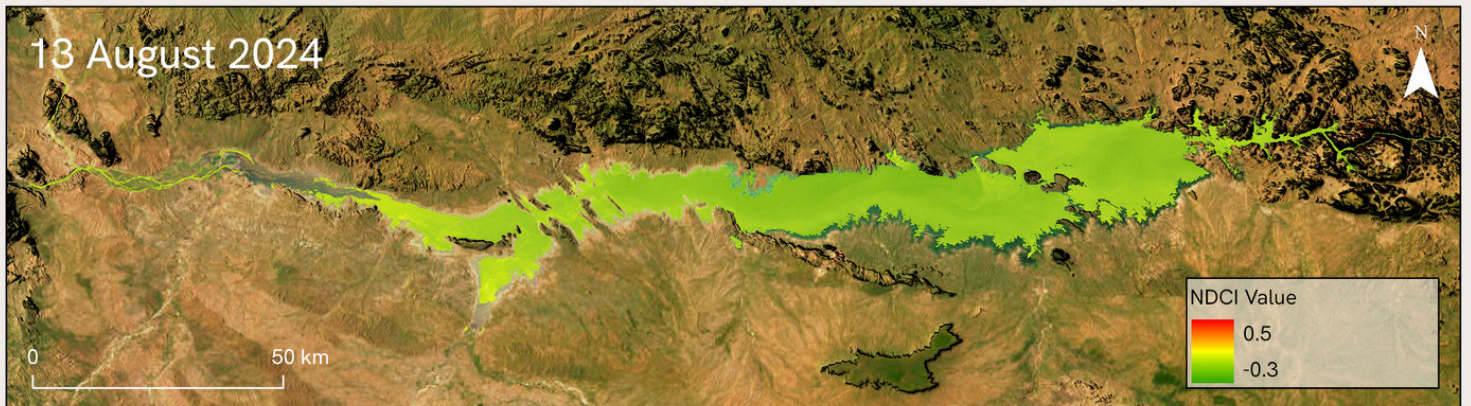
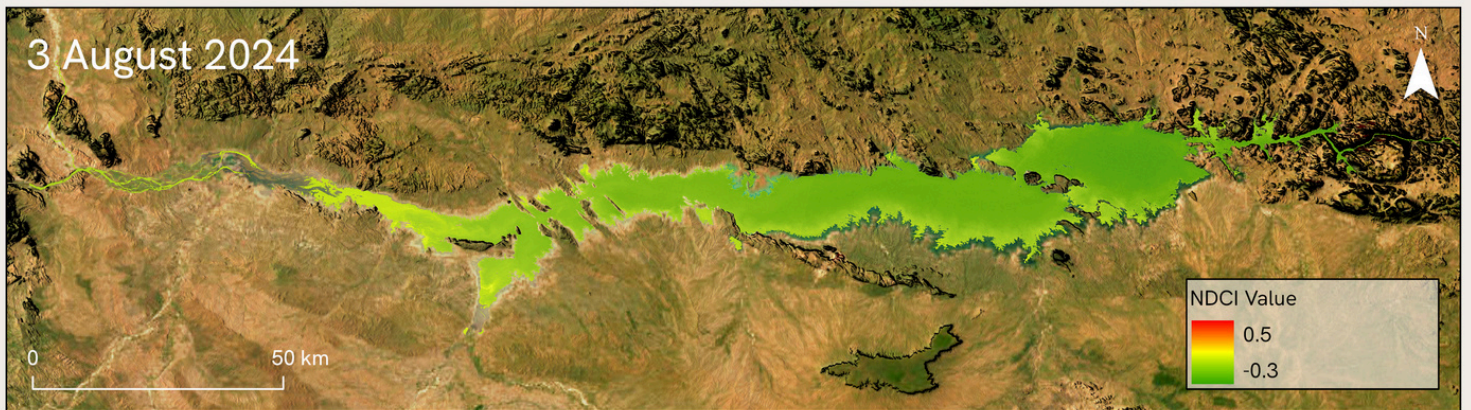
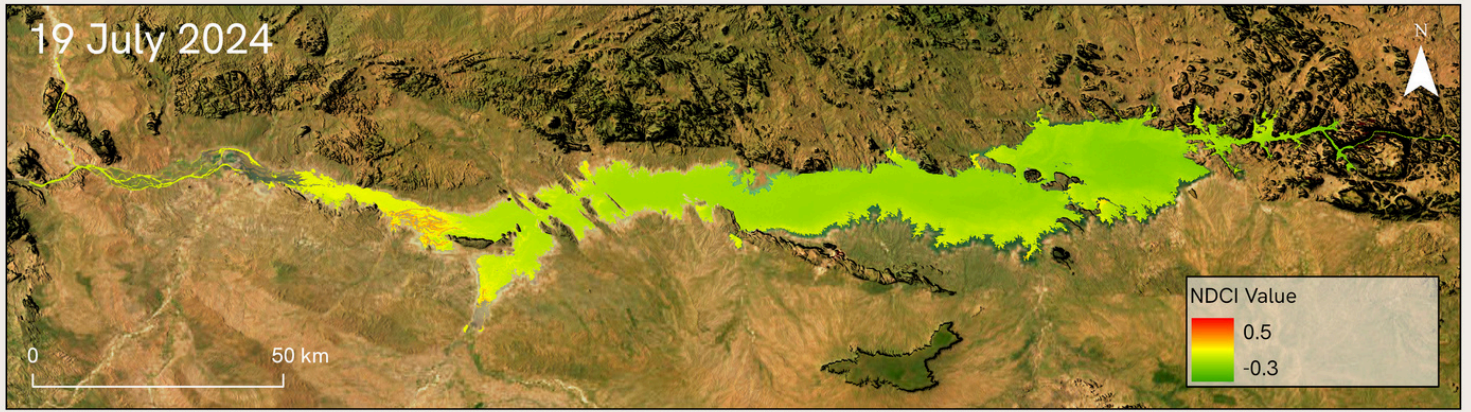
ALGAL BLOOMS

Remote sensing provides an effective way to track algal dynamics at large spatial scales. Sentinel-2 imagery from July–August 2024 was used to assess chlorophyll-a distribution in Cahora Bassa Reservoir. The analysis applied the Normalized Difference Chlorophyll Index (NDCI), which combines Sentinel-2's red-edge (B5) and red (B4) bands to estimate chlorophyll-a concentrations in surface waters. Higher NDCI values indicate greater chlorophyll-a levels, which may suggest algal bloom activity, while lower values correspond to clearer, less productive water conditions.

Across the three observation dates, the Zambezi River inflow region shows marked variability, with elevated NDCI values on 19 July and continued high levels visible through 3 and 18 August. By mid-August, the extent of high NDCI areas decreases slightly, though localized hotspots persist in the western basin. The average map highlights consistently elevated NDCI along the southern shoreline, possibly reflecting chronic nutrient enrichment from nearby settlements, livestock, and agricultural runoff. NDCI values approaching 0.5 correspond to very high chlorophyll-a concentrations (often exceeding $100 \mu\text{g L}^{-1}$) and therefore indicate a high likelihood of bloom conditions in these areas. While NDCI is a robust proxy for chlorophyll-a, it can also be influenced by suspended sediments or colored dissolved organic matter. Nonetheless, field observations confirmed visible surface accumulations of algae in areas corresponding to high NDCI (see image below).

Surface accumulation of green algal material along the shoreline, photographed on 20 July 2024. The image was taken in the region corresponding to the elevated NDCI values observed in the 19 July 2024 Sentinel-2 map, confirming visible algal presence consistent with satellite-detected chlorophyll enrichment.






Spatial and temporal variation in chlorophyll-a across Cahora Bassa Reservoir derived from Sentinel-2 NDCI imagery on 19 July, 3 August, and 18 August 2024, along with the mean distribution for the period. NDCI values below 0.1 correspond to low chlorophyll-a concentrations ($<25 \mu\text{g L}^{-1}$), while values approaching 0.5 indicate very high concentrations ($>100 \mu\text{g L}^{-1}$) typical of bloom-level conditions.


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