

EXPEDITION OVERVIEW

LUAPULA RIVER

ZAMBIA





THE WILDERNESS PROJECT

About The Wilderness Project

By 2035, in partnership with local communities, governments, researchers and NGOs, The Wilderness Project (TWP) aims to explore, study and better protect 1.2 million km² 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. To achieve this, TWP has conducted baseline surveys across ~9,000 kilometres of freshwater environments within Zambia since 2022, and continues to expand this work across the region.

Acknowledgements

The Luapula River research transect was made possible through the commitment and collaboration of our valued partners. We extend our sincere appreciation to the Department of National Parks and Wildlife, the Ministry of Fisheries and Livestock, the Water Resources Management Authority, and the Zambezi River Authority for their continued support, including the provision of the necessary permits and permissions. Copperbelt University and the University of Zambia for their continued research collaboration, and we acknowledge the Wild Bird Trust for their ongoing partnership and steadfast support of baseline research across Africa.



**Ministry of
Fisheries and
Livestock**



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INTRODUCTION

The Luapula River is the primary outflow of the Bangweulu Wetland — Zambia's second-largest wetland — and forms a critical headwater section of the Congo Basin. From its outflow near the Tuta Bridge, the Luapula River flows for ~560 km before draining into Lake Mweru. Along much of its course, the Luapula forms the border between Zambia and the Democratic Republic of Congo, making it an important transboundary feature in the landscape.

The Luapula River lies at the heart of one of Zambia's most important fisheries, forming part of the wider Chambeshi-Bangweulu-Luapula-Mweru system. This combined area includes more than 40% of the country's fishing population and directly supports nearly 400,000 people¹². The Mweru-Luapula fishery alone sustains ~364 fishing villages and a population of almost 200,000. These river-dependent livelihoods are not only linked to fisheries productivity, but to the seasonal ebbs and flows of the Luapula River, which provides myriad ecosystem services that support the regional economy.

The flow of the Luapula River is regulated by the Bangweulu Wetland. In the rainy season, the expanse of submerged grasses and papyrus attenuates high flows from the Chambeshi River and other tributaries, storing water that is released gradually into the Luapula River throughout the dryer months of the year. This natural buffering function not only maintains perennial baseflow, but also reduces the risk of flash flooding³. In this way, the Bangweulu acts as a source wetland, underpinning ecological productivity, food security, water availability, and biodiversity across northern Zambia and deep into the Congo Basin.

Beyond its ecological and economic importance, the Luapula River also has cultural and spiritual value. Local communities recognise the river both as an ancestral boundary and as a sacred water source. One of the most prominent cultural traditions associated with the river is a ceremonial ritual performed by the Mwata Kazembe, during which river water is symbolically splashed to signify purification, renewal, and the community's connection to its ancestral lands⁴⁵.

The riparian forests lining the Luapula — known locally as *mushitu* and *mateshe*⁶— are disproportionately important for biodiversity. These forests serve as a vital linkage between the upland miombo woodlands of northern Zambia and the lowland rainforests of the Democratic Republic of Congo, promoting dispersal and enhancing biodiversity along

¹ Chibwe C, Nyambe N, Kasabila JA, Sichingabula H, Nyambe IA, Banda K. 2024. Assessment of river health ecological health status and interbasin water transfer potential: case study of Luapula River Basin in Zambia. *Physics and Chemistry of the Earth, Parts A/B/C*, 136, 103761.

² Kazekule J. 2025. Characterisation of surface water quality in the Luapula river basin and developing a WQImin model for potential inter-basin water transfer to the Kafue river basin. Doctoral dissertation, University of Zambia.

³ Nyambe N, Chibwe C, Banda K, Sichingabula H, Nyambe I. 2025. Ecosystem health assessment of the Luapula River Basin in Zambia using macroinvertebrate assemblage: a potential for inter-basin water transfer. SSRN.

⁴ Mufuya C. 2020. Rituals of water and power: the Mutomboko Ceremony and the Luapula River. University of Zambia

⁵ Ministry of Tourism and Arts (Zambia). 2022. Annual Cultural Events Calendar.

⁶ Taylor, G., & Peel, R. 2020. Kasanka National Park: Protecting threatened evergreen forests and their unique wildlife in central Zambia. Kasanka Trust Limited / African Bird Club, conservation article.

the productive river corridor. However, as the human population in the region continues to grow, riparian forests have become increasingly fragmented and degraded, particularly driven by fires, selective harvesting, and charcoal production⁷⁸.

Following a 2024 survey of the Chambeshi River and the Bangweulu Wetland, The Wilderness Project (TWP) returned to the region in September 2025 to conduct a comprehensive survey of the Luapula River. The survey aimed to assess water quality, biodiversity, human activity, invasive species, and riparian habitat conditions, providing a snapshot of the Luapula's ecological state. Under growing pressure from hydropower development, inter-basin transfer, and a rapidly growing human population, this baseline will inform sustainable management of the Luapula River for generations to come.



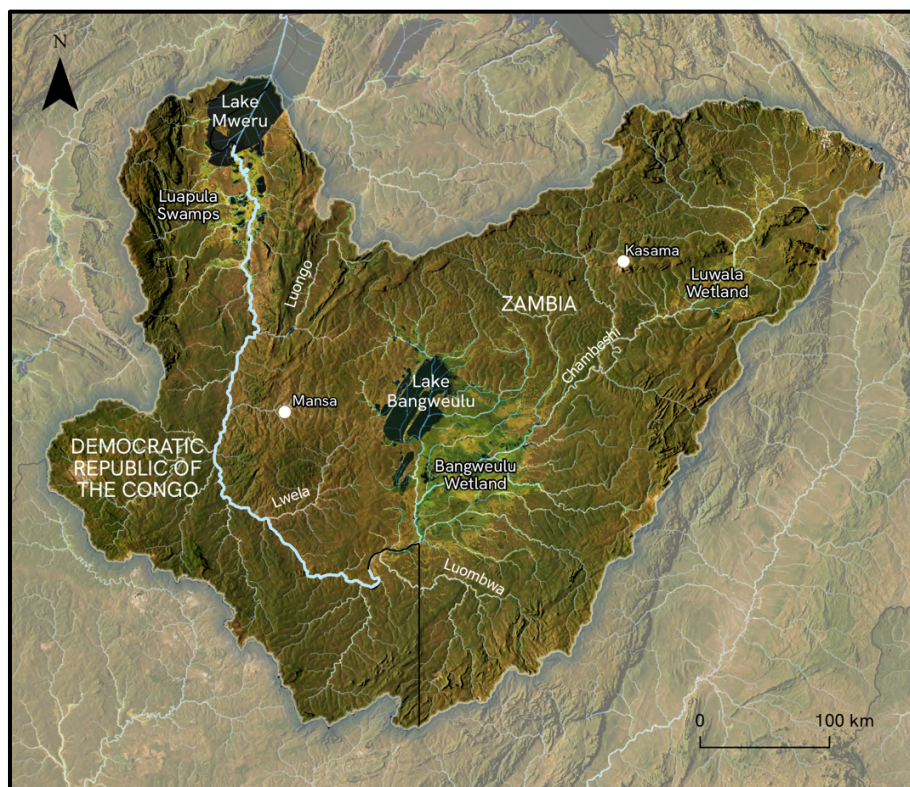
⁷ Chungu S. 2021. Land use dynamics in the Luapula Floodplains. *Zambian Journal of Geography and Development*.

⁸ WWF Zambia. 2023. Forest fire monitoring in the Luapula Basin landscape.

THE BASIN



Figure 1. The Luapula Expedition surveyed approximately 624 km of the Luapula River, from the Tuta bridge at the outflow of the Bangweulu Wetlands, to Lake Mweru.



EXPEDITION SUMMARY

Total distance travelled on the expedition: 624 km

The number of people in the expedition team: 9 people from 5 African countries

The number of days spent on the water: 17 days

The number of fixed survey sites established: 74 fixed research sites, 83 total sites

Expedition details

Over 624 km, The Wilderness Project (TWP) paddled from the Tuta Bridge — where the Bangweulu Wetlands give rise to the Luapula River — to its confluence with Lake Mweru, collecting vital baseline data to assess the river's health at this snapshot in time. This expedition built upon a previous survey of the Chambeshi River, which concluded at Tuta Bridge, thereby ensuring a comprehensive baseline survey was completed of the entire river system. Read the *Chambeshi River Report* [here](#).

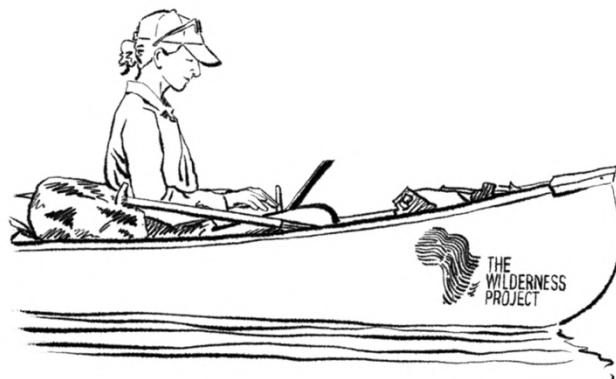
Fixed research sites were established at 74 locations along the river, including at confluence of the three major tributary - Lwela, Kafubu, and Mansa – inflows and at the entrance of the river into Lake Mweru (Figure 4). Several additional sites were sampled opportunistically which allowed the team to document features of interest such as mine discharges and geothermal springs. At these research sites, the data was collected on hydrology, water quality, biodiversity, and human activities to support the government authorities and conservation initiatives invested in the long-term sustainability of the Luapula River. Given the importance freshwater as a resource, this baseline information is critical for informing future water management and conservation planning.

METHODS

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 using the Zambian Invertebrate Scoring System (ZISS), microplastics sampling, and further testing provided a foundation of river health and biodiversity.



Continuous Monitoring

Whilst paddling down the river, researchers continuously collected survey data and 360° imagery. Each boat included an observer and a recorder. Observers scanned the river and both banks — up to 100 m from the edge — identifying 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.



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

Number of research sites: 74

Total number of water quality measurements: 70

Total number of aerial drone surveys: 74

Total number of wetland birds recorded: 1,980 observations across 138 species

Total number of wildlife recorded: 35 observations across 3 species

Total number of fish collected: 35 specimens from 17 genus

Total number of eDNA samples collected: 10

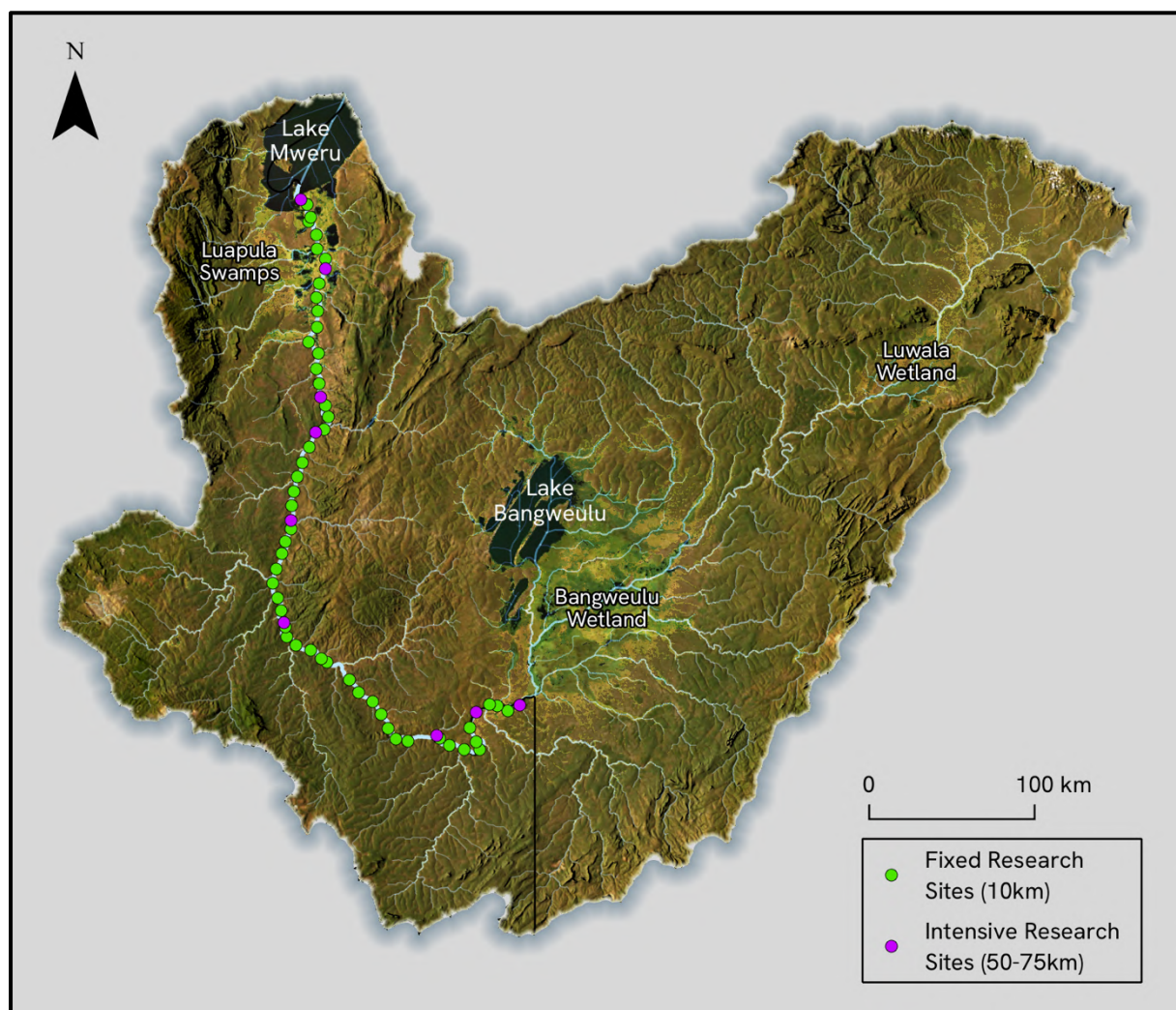


Figure 2. Research sites along the transect.

HUMAN FOOTPRINT

Human presence is a defining feature of the Luapula River landscape. The river flows through a densely settled and heavily utilised basin, supporting fishing, agriculture, transport, and domestic water use for communities along its entire length. As a result, population density counted along the Luapula River was notably higher than other rivers in the region.

Approximately 125 people were recorded every 10 km along the river. This is the highest population density recorded by TWP in Zambia to date. It is also substantially higher than surrounding rivers, including the Lufira (70 people/10 km), Kalungwishi (43 people/10 km), Lufubu (14 people/10 km), and Luombwa (25 people/10 km).

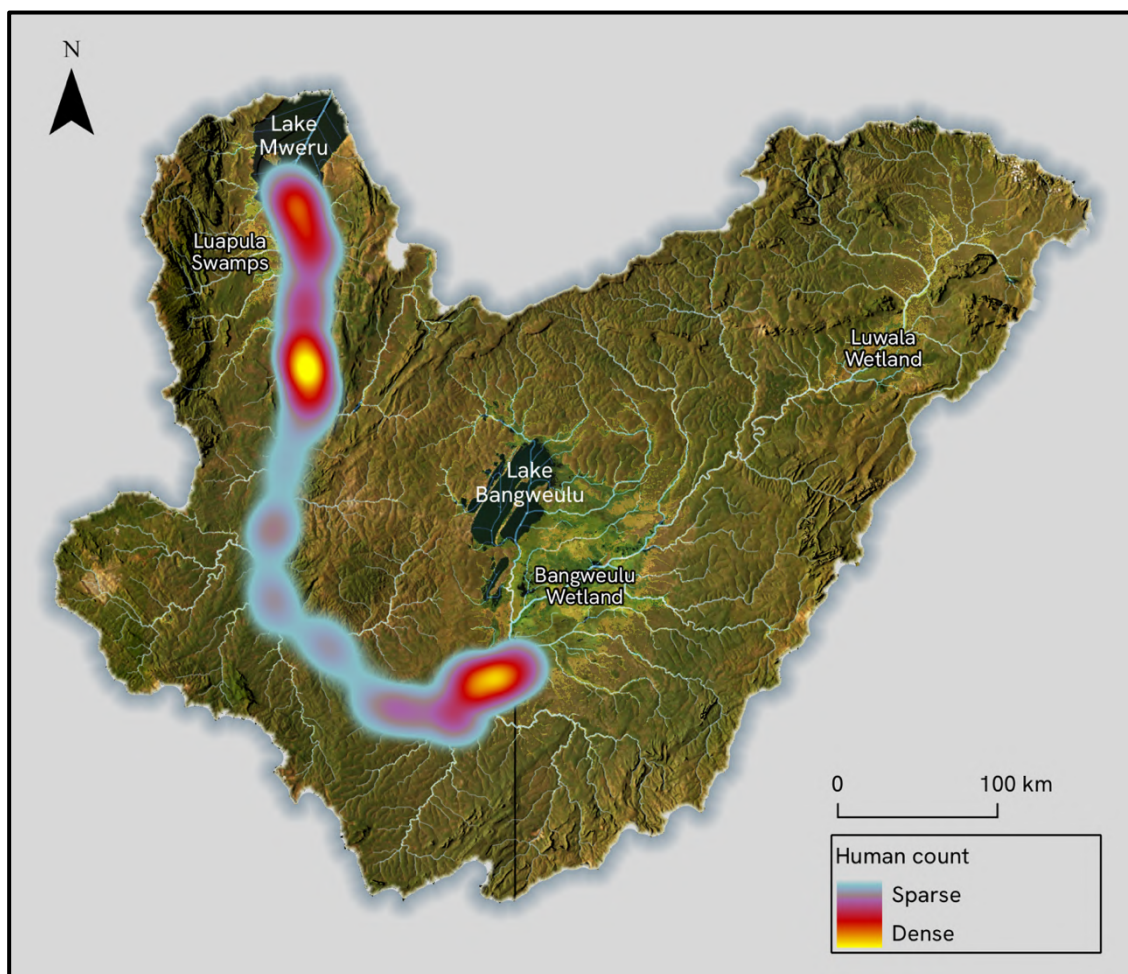


Figure 3. Distribution of people observed along the transect.

Most people were located within the river's productive wetlands, particularly the Bangweulu and Lake Mweru floodplains. While there is an average density of 10 fisher/10 km along most of the river, this rises to 67 fisher/10km within the wetland areas, reflecting a strong spatial variability in fishery utilisation that should be an important consideration in local fisheries management.

Table 1. Human footprint on the Luapula River, as compared to the Chambeshi River and regional average.

	<i>Luapula River</i>	<i>Chambeshi River</i>	<i>Regional Average⁹</i>
People /10 km	125	34	58
Fishers / km	10.5	0.38	0.58
Fishing gear / km	1.24	1.18	2.51
Vessels / km	0.77	1.02	1.10
Livestock / km	0.14	0.10	1.17
Riparian cropland (%)	6	8	7

⁹ The Regional Average is calculated from TWP river surveys on the Chambeshi Luapula, Kalungwishi, Lufubu, Luombwa and Lufira Rivers.

Building analysis

To further contextualise the high densities of people recorded along the Luapula, two complementary landscape-scale analyses were conducted: building footprint mapping and land-use and land-cover (LULC) change detection.

Building footprint data were derived from Google's Open Buildings dataset, which uses high-resolution satellite imagery to identify and outline individual structures. This dataset provides a basin-wide perspective on the spatial distribution of human infrastructure, enabling consistent spatial analysis that complements the on-the-ground survey findings.

Land-use and land-cover change was also analysed using 300 m resolution maps from the European Space Agency's Climate Change Initiative. Maps from 1992 and 2020 were reclassified into broader land-use categories to facilitate meaningful comparison between the two time periods.

Together, these analyses revealed patterns consistent with the field data. Settlement area across the Luapula Basin increased by more than 305% between 1992 and 2020, a trajectory that helps explain the high population densities now recorded along the river (Appendices: Figure A1 and A2). Much of this growth has been driven by the expansion of urban centres, particularly Lubumbashi in the Democratic Republic of Congo, with development clustering around these towns and radiating outward into the wider basin.



Figure 3. Local house located on the banks of the Luapula River.

FIRE

Importance of fire

Fire plays an important ecological role in shaping the landscape, vegetation structure, and biodiversity of the Luapula River Basin, particularly within its miombo woodlands, grasslands, and seasonally flooded savannas. Low-intensity seasonal fires help maintain open-canopy woodlands and fire-adapted grassland mosaics by limiting woody encroachment¹⁰¹¹. Many native species — including *Brachystegia* trees — are adapted to fire regimes and depend on periodic burning for regeneration, nutrient cycling, and habitat maintenance. However, increasing the natural frequency and scale of burning can carry significant ecological implications.

Excessively frequent fires can suppress vegetation recovery, reduce vegetation density and drive a shift in species composition towards fire-tolerant taxa. Over time, these changes may reduce habitat complexity and limit the recovery of fire-sensitive species, particularly within riparian and woodland ecosystems.



Figure 4. Anthropogenic fire along the banks of the Luapula River.

¹⁰ Chungu S. 2021. Land use dynamics in the Luapula Floodplains. *Zambian Journal of Geography and Development*.

¹¹ WWF Zambia. 2023. Forest fire monitoring in the Luapula Basin landscape.

Observational data

At the time of the survey, ~31 km of the riverbank showed evidence of fire. This represents ~5% of the riparian habitat along the Luapula River. This is high compared to surrounding rivers, likely attributed to the timing of the survey in the late dry season, and the regular burning of the landscape by local communities (see below).

MODIS Burned Area Analysis

To assess the frequency and seasonality of fires across the entire Chambeshi-Bangweulu-Luapula Basin, the MODIS burned area dataset (2000-2023) was extracted. Burned pixels for fires larger than 500 m were counted using Google Earth Engine to quantify long-term fire patterns across the river basin.

Fires were widespread and recurring across 88% of the Chambeshi-Bangweulu-Luapula Basin, with spatial and temporal patterns shaped by both seasonal cycles and human land use (Appendices: Figure A3 and Figure A4). In the remaining 12% of the basin, where burns were not detected, permanent waterbodies or wetlands inhibit burning.

Over the 23-year period of the analysis, almost 50% of the basin burned every two years. This is similar to the nearby Kavango-Zambezi landscape, where fires occur every 2 – 4 years, with shorter intervals typically associated with more open woodland and grass-dominated systems¹².

Further analysis of fire seasonality in the Chambeshi-Bangweulu-Luapula Basin showed that very few fires occur during the wet season (January–April). However, fire occurrence increases as conditions become drier, with peak activity in August and September. Together, these two months account for nearly 80% of fires.

While some level of burning in the miombo woodlands of northern Zambia is natural and expected, regular, high-intensity burning can have important long-term ecological consequences. Repeated fires can limit the recruitment and survival of tree seedlings and saplings, reduce average tree size and aboveground woody biomass, and favour grasses and resprouting species that are more tolerant of repeated disturbance. Over time, these processes can shift vegetation structure toward more open woodland or savanna states, altering habitat structure, carbon storage, and ecosystem productivity across the landscape.

¹² Pricope, N.G. and Binford, M.W., 2012. A spatio-temporal analysis of fire recurrence and extent for semi-arid savanna ecosystems in southern Africa using moderate-resolution satellite imagery. *Journal of Environmental Management*, 100, pp.72–85.

RIVER FLOW

Effective river basin management depends on understanding where water enters and leaves a basin, and how different parts of the system are interconnected. Developing knowledge on these systems is therefore essential for predicting river flow dynamics, managing water resources sustainably, and assessing how environmental or human pressures may alter hydrological processes.

Above-average wet-season rainfall in the Luapula basin in 2025 resulted in elevated discharge at the primary outflow of the Bangweulu Wetlands, where the Luapula River originates¹⁰. River discharge recorded using an Acoustic Doppler Current Profiler (ADCP) reached 165 m³/s (Table 2), more than double the remotely sensed historical September average of 64 m³/s reported in the [TWP 2024 Chambeshi River Report](#).

Further downstream, approximately 330 km from the wetland outflow, the flow of the Luapula was 150 m³/s — a 9% reduction from upstream levels. This likely reflects cumulative dry-season water losses, including evaporation, groundwater recharge, and localised agricultural abstraction, particularly near the RN36 corridor.

Tributary inflows then partially offset these losses: combined contributions from the Lwela, Kafubu, and Mansa rivers increased discharge to approximately 180 m³/s at the final measurement site upstream of Lake Mweru (Table 2). Together, these observations provide important insight into water availability within the Luapula River system and help quantify flows that support agriculture, urban supply, and ecosystem functioning¹³¹⁴



Figure 5. An Acoustic Doppler Current Profiler (ADCP) was used to measure flow on the transect.

¹³ ¹¹WWF World Bank. 2022. Climate risk assessment for southern and central Africa

¹⁴ Perera D, Seidou O, Agnihotri J, Rasmy M, Smakhitin V, Coulibaly P, Mehmood H. 2019. Flood Early Warning Systems: A review of benefits, challenges and prospects. UNI-INWEH Report Series, Issue 8. United Nations University, Institute for Water, Environment and Health, Hamilton, Canada.

Table 2. River flow along the course of the Luapula River.

Site	Latitude	Longitude	Discharge (m ³)
1	-11.52495531	26.58712274	165.27
2	-12.32686293	29.01399676	159.08
3	-11.75562073	28.44901968	153.03
4	-10.53348754	28.64753995	180.49

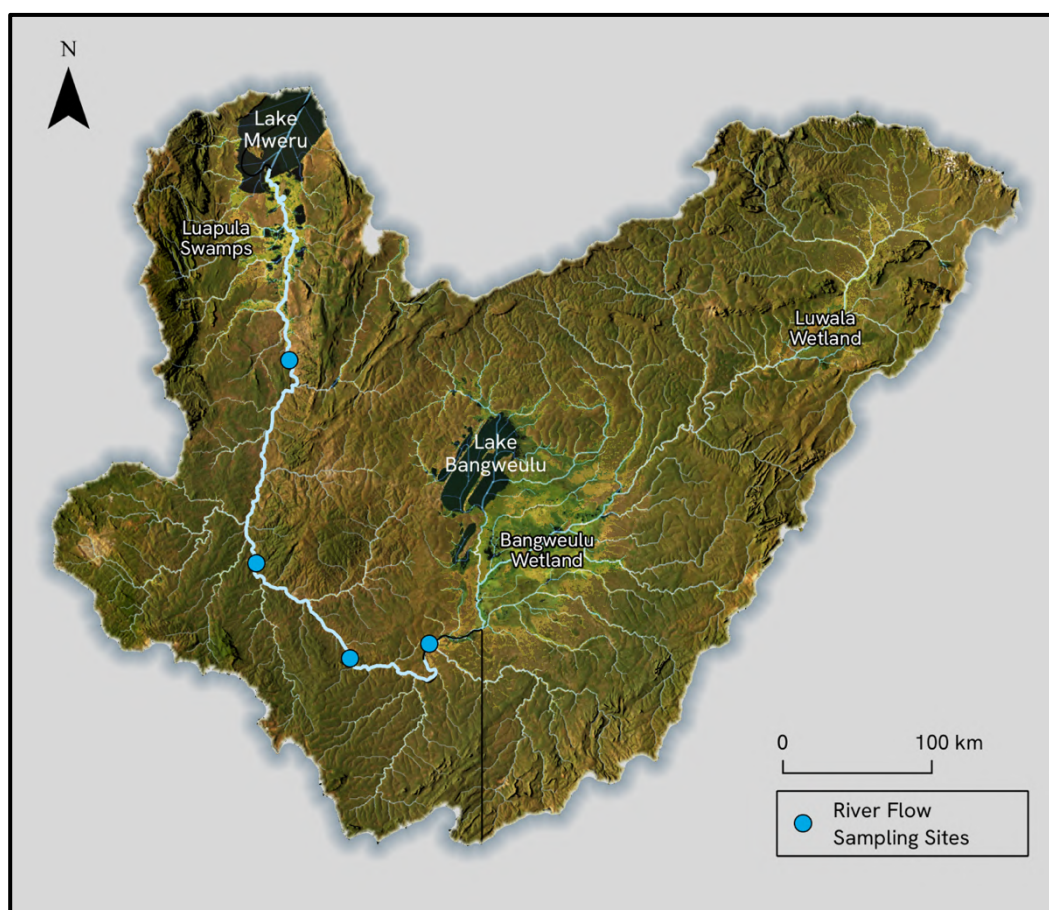


Figure 6. Research sites for measuring the river flow on the Luapula River.

The Luapula Inter-Basin Transfer

An inter-basin transfer (IBT) refers to the engineered movement of water from a donor basin to a recipient basin to address water scarcity, support hydropower generation, or enable irrigation. While IBTs can enhance water security in the receiving basins, they may also have significant environmental, hydrological, and economic impacts on both donor and recipient basins, as well as downstream systems¹⁵¹³.

The proposed Luapula IBT is currently being explored in Zambia, with the aim of transferring water from the Luapula River, which forms part of the Congo Basin, to the Kafue River basin, a tributary of the Zambezi River. The transfer is intended to help address increasing water demand in the Kafue catchment, and improve water security, hydropower, and agriculture, particularly surrounding the Copperbelt and Lusaka^{161714,15}. However, as the proposal is still in its early stages, the unintended consequences that may arise have not yet been researched and addressed.

Reduced flows in the Luapula could lead to significant ecological degradation, including habitat loss, disrupted fish migration, and declining biodiversity. Similar impacts have already been observed on the Kafue River following the construction of the Itzhi-tezhi Dam, where altered flow regimes disrupted the seasonal flood pulse that supports productivity in the Kafue Flats. This has reduced nutrient availability and constrained fish breeding habitats will ultimately diminish fish production and catch rates. The likely outcome for the Luapula river will be a reduction in fisheries productivity that will almost certainly come at a cost to the thousands of fishers within the Lake Mweru floodplains, who rely almost exclusively on these fisheries for their livelihoods.

A similar unintended consequence may arise from physicochemical differences between the two rivers. Data collected by TWP in 2024 and 2025 in the Bangweulu Wetlands and the Luapula River suggest that water flowing from the wetlands has a lower pH than that of the Kafue River. If water transfer from the Luapula lowers the pH of the Kafue, it could trigger the partial remobilisation of heavy metals from contaminated sediments, potentially exposing water users to the cumulative impacts of decades of mining activity.

The Zambian government has initiated studies to evaluate the feasibility of the project and has worked with engineering partners to assess its technical and environmental viability. The stated objective is to strengthen national water and energy security in response to drought and rising economic demand. However, to fully understand the implications of IBTs between the Luapula and Kafue river systems, a detailed assessment of the biological, physicochemical, and livelihood trade-offs is needed. This assessment should demonstrate whether these social and environmental costs outweigh the economic benefits associated with an increased water budget in the Kafue Basin.

¹⁵ Emanuel, R. E., Buckley, J. J., Caldwell, P. V., McNulty, S. G. & Sun, G. Influence of basin characteristics on the effectiveness and downstream reach of interbasin water transfers: displacing a problem. *Environmental Research Letters* 10(12), 124005 (2015).

¹⁶ Chibwe, C., Nyambe, N., Kasabila, J.A., Sichingabula, H., Nyambe, I.A. and Banda, K., 2024. Assessment of river ecological health status and interbasin water transfer potential: Case study of Luapula River Basin in Zambia. *Physics and Chemistry of the Earth, Parts A/B/C*, 136, p.103761.

¹⁷ Kazekula, J., Hantambo, S., Banda, K. and Nyambe, I., 2026. Characterization of surface water quality in the Luapula River Basin and developing a WQImn model for potential inter-basin water transfer to the Kafue River Basin in Zambia. *Water Practice & Technology*.

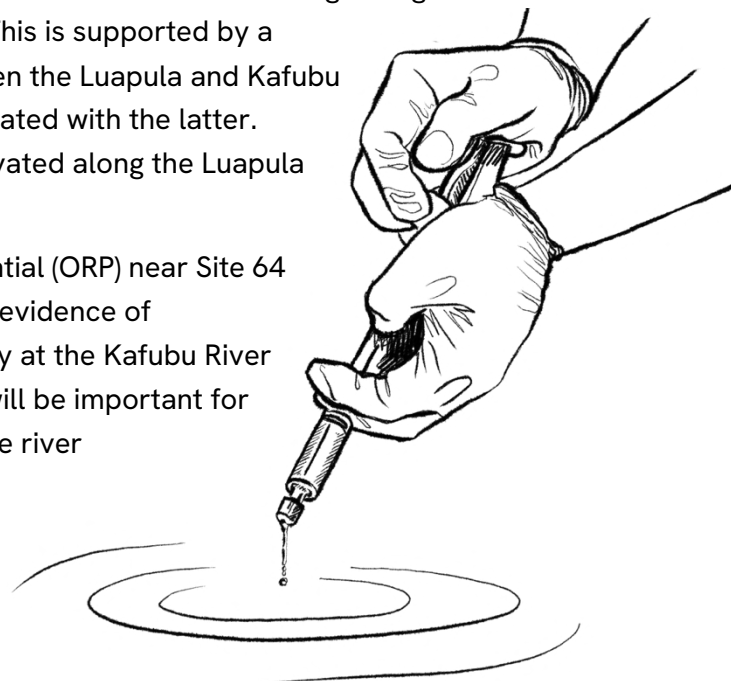
WATER QUALITY

Water quality along the Luapula River was assessed regularly to evaluate ecosystem condition and identify potential sources of contamination. Standard physicochemical parameters were measured at approximately 10km intervals using a multi-parameter sonde, including pH, dissolved oxygen, oxidation-reduction potential (ORP), temperature, turbidity, and total dissolved solids (TDS). Together, these indicators provide insight into the river's suitability for sustaining aquatic life and help identify changes associated with tributary inflows and land-use pressures.

Overall, water quality along the mainstem of the Luapula River fell within ranges typical of large tropical freshwater systems, consistent with previous basin assessments^{18 16}. pH values were relatively stable, although slightly more alkaline conditions were recorded near the Kafubu River confluence. Dissolved oxygen concentrations increased progressively downstream, likely reflecting enhanced mixing and aeration in wider and faster-flowing sections of the river (Figure 7).

Turbidity remained low across most of the transect which is consistent with dry-season conditions. Localised increases were observed in sections where rapids occurred within the river channel. Similarly, total dissolved solids (TDS) concentrations remained low until Site 39, where inflow from the Kafubu River likely introduces contaminants originating from upstream mining activities around Lubumbashi. This is supported by a roughly tenfold difference in conductivity between the Luapula and Kafubu rivers, indicating significant contamination associated with the latter. Following this confluence, TDS levels remain elevated along the Luapula until it discharges into Lake Mweru (Figure 9).

A localised increase in oxidation-reduction potential (ORP) near Site 64 coincided with increased turbulence rather than evidence of contamination. Continued monitoring, particularly at the Kafubu River where upstream mining contamination is likely, will be important for detecting emerging trends and informing adaptive river management.



¹⁸ Trenberth KE. 2005. The impact of climate change and variability on heavy precipitation, floods and droughts. *Encyclopedia of Hydrological Sciences*, 17,1-11.

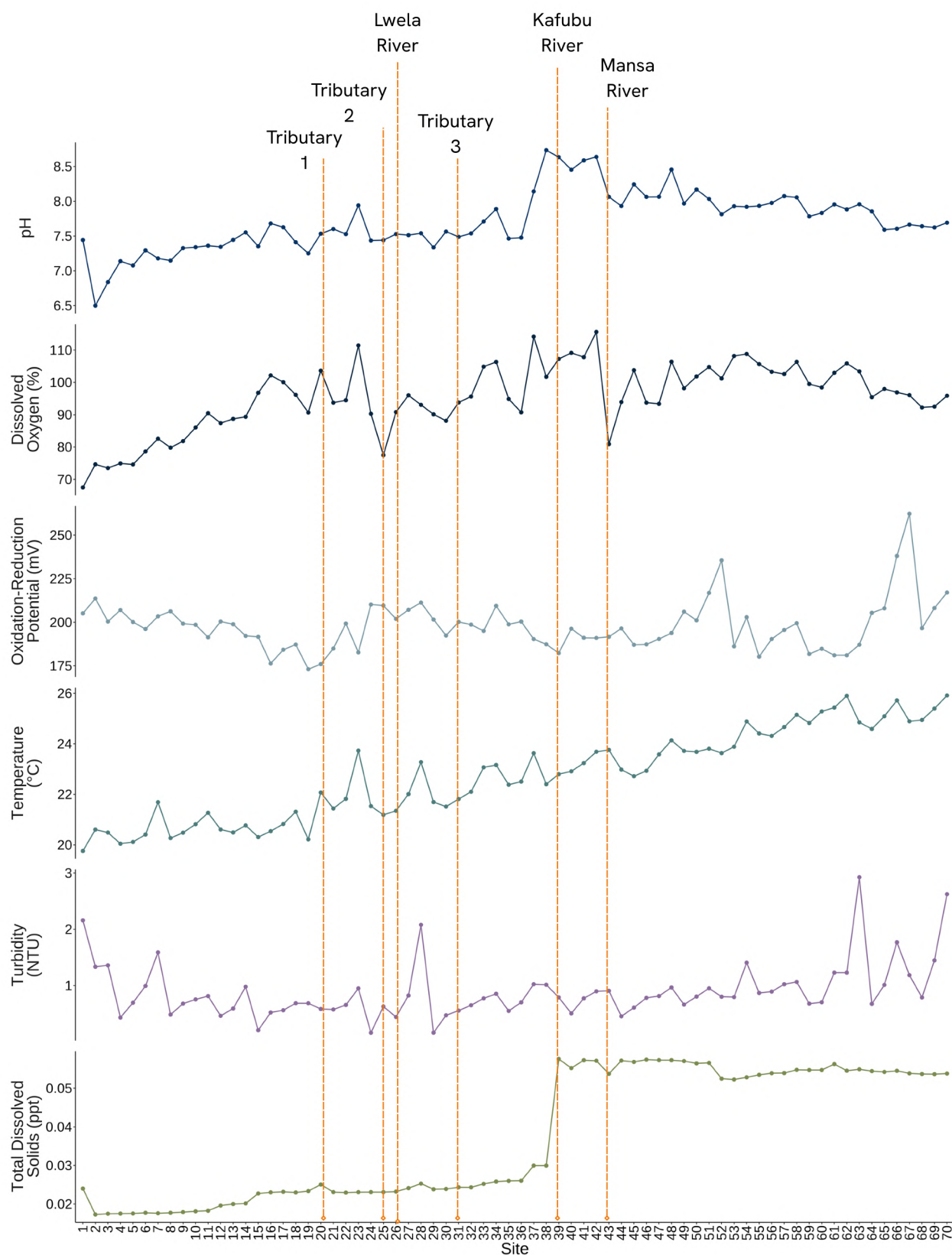


Figure 7. Water samples were collected from 70 sites for isotope, heavy metal trace element, and anion analyses. Ongoing monitoring will be essential to track long-term trends, and support effective conservation and land-use planning along the Luapula River.

KAFUBU RIVER

The Kafubu River is a tributary of the Luapula River, originating near Lubumbashi within the Democratic Republic of Congo (Figure 10). The river forms part of the Mweru-Luapula system within the Congo River Basin, contributing water and sediments to the transboundary river system. The location of the Kafubu river within the Central African Copperbelt — one of the world's largest copper-cobalt mining regions — means the river is strongly influenced by mining activities and associated industrial discharge.

Metal contamination linked to these mining operations has been documented downstream of several mines, including the Kipushi underground mine. Cadmium and zinc concentrations in the river have been recorded to exceed the European Union water quality standards in 83.3% and 66.7% of samples, respectively, and surpassed Democratic Republic of Congo mining effluent standards in several instances^{19 17}.

The raised electrical conductivity and total dissolved solids in the Kafubu River, alongside the high incidence of mining in the catchment, suggests that the river is carrying a high heavy metal load from the Democratic Republic of Congo Copperbelt into the Luapula River. This is particularly concerning given the location of the contamination, upstream of the highly productive and transboundary Mweru-Luapula fishery. Further research, including the assessment of sediment heavy metal concentrations in the Kafubu River, will be important to determine the extent of this contamination.

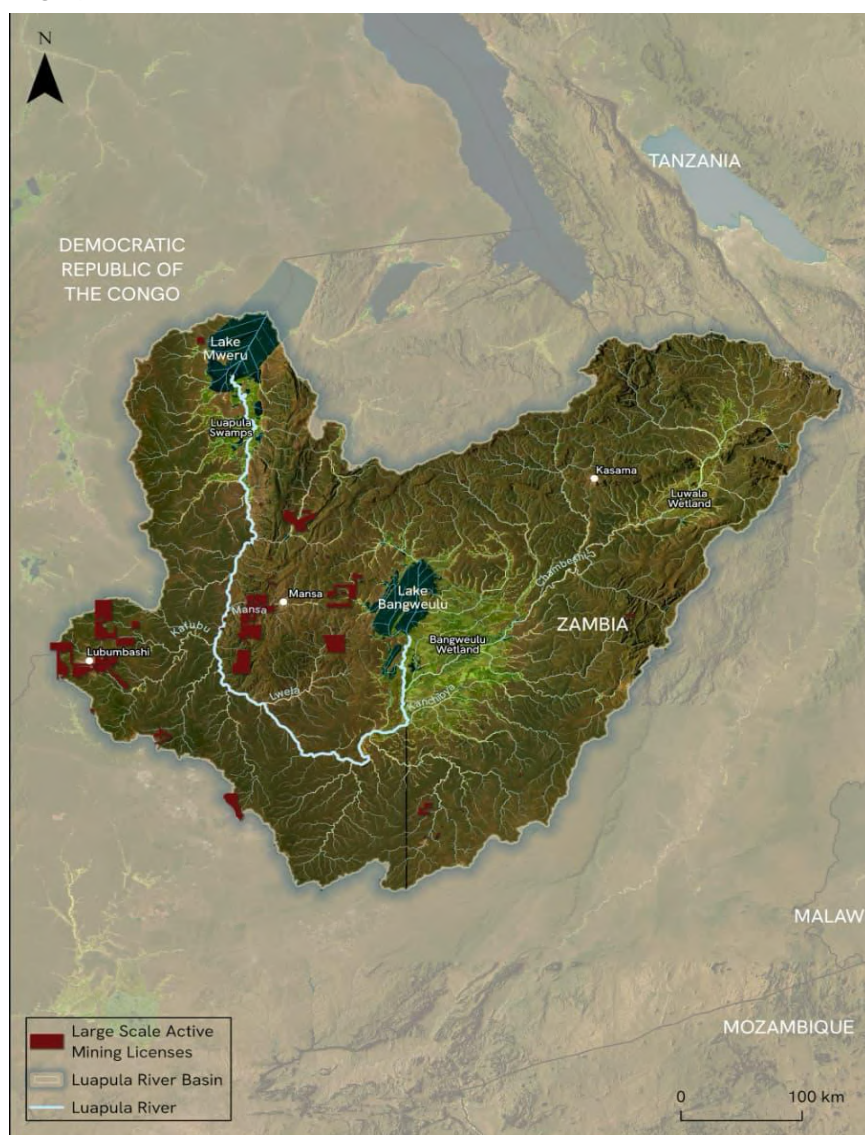


Figure 8. Active mining areas in Luapula River Basin.

¹⁹ Muyumba Nonga, W., Kapasi Kambuyi, V., Kalonda Mutombo, E., Marsi Mbayo, M., Tshisand, P., Kayemb, F., Ngoy Kihuya, E. and Lumbu Simbi, J., 2016. Contribution of trace metals in water from the underground mining of Kipushi in Kafubu River (DR Congo). *International Journal of Innovation and Applied Studies*, 15(4), pp.864-871.

BIODIVERSITY

Wildlife

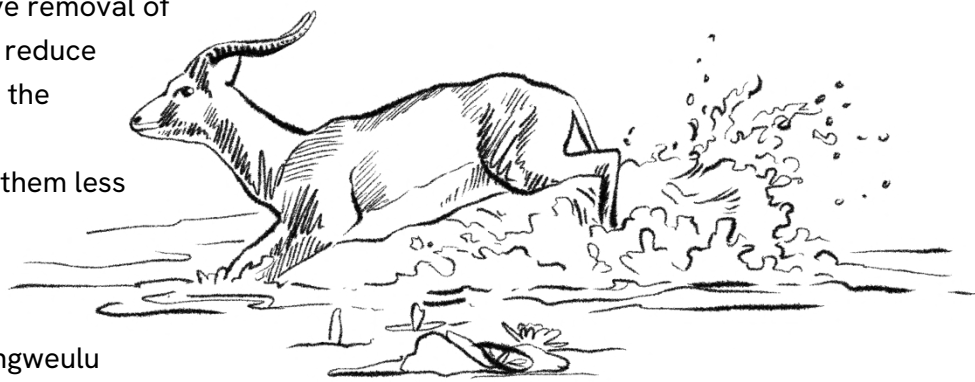
Reports from the early 20th century indicate that the Chambeshi-Bangweulu-Luapula basin was once a thriving wildlife stronghold. Leopards (*Panthera pardus*), lions (*Panthera leo*), elephants (*Loxodonta africana*), buffalo (*Syncerus caffer*), zebra (*Equus quagga*), and a diversity of antelope species including black lechwe (*Kobus leche smithemani*), sable (*Hippotragus niger*), kudu (*Tragelaphus strepsiceros*), reedbuck (*Redunca arundinum*), impala (*Aepyceros melampus*), tsessebe (*Damaliscus lunatus*) and eland (*Taurotragus oryx*) were all found in the region²⁰.

Over the past century, widespread hunting and land conversion has driven population declines. Conservation efforts by the Bangweulu Wetlands Project have facilitated the partial recovery of species such as the sitatunga (*Tragelaphus spekei*) and black lechwe within the Bangweulu Swamps, and several translocations have since bolstered the genetic diversity of local wildlife populations, including zebra, impala, puku (*Kobus vardonii*), waterbuck (*Kobus ellipsiprymnus*) and buffalo¹⁹.

The Luapula River, therefore, forms an important ecological corridor linking the recovering species populations in Bangweulu Wetlands and Lake Mweru. As such, the river should play a key role in maintaining ecological connectivity between these habitats. However, wildlife observations during the 2025 expedition were limited, with just seven hippopotamuses recorded along the river.

Other notable wildlife included 27 spotted-necked otters and one crocodile (Figure 9). This is consistent with findings from a 2024 survey of the Chambeshi River, where wildlife was similarly scarce, despite this area being earmarked as an important wildlife area by the Department of Parks and Wildlife (DNPW). Together, these observations suggest that low wildlife abundance may be a basin-wide pattern and likely reflect the cumulative effects of anthropogenic pressure across the system.

Regular burning and the selective removal of mature riparian hardwoods can reduce habitat complexity and degrade the structural integrity of riverine ecosystems, potentially making them less suitable for biodiversity. Given the historical richness of this basin and the encouraging, if partial, recovery seen in the Bangweulu Swamps, establishing long-term biodiversity



monitoring

²⁰ Hughes JE. 1933. Eighteen Years on Lake Bangweulu.

programmes across the Luapula system could provide valuable insights into ecosystem condition, habitat quality, and the broader impacts of land-use change and resource use within the basin.

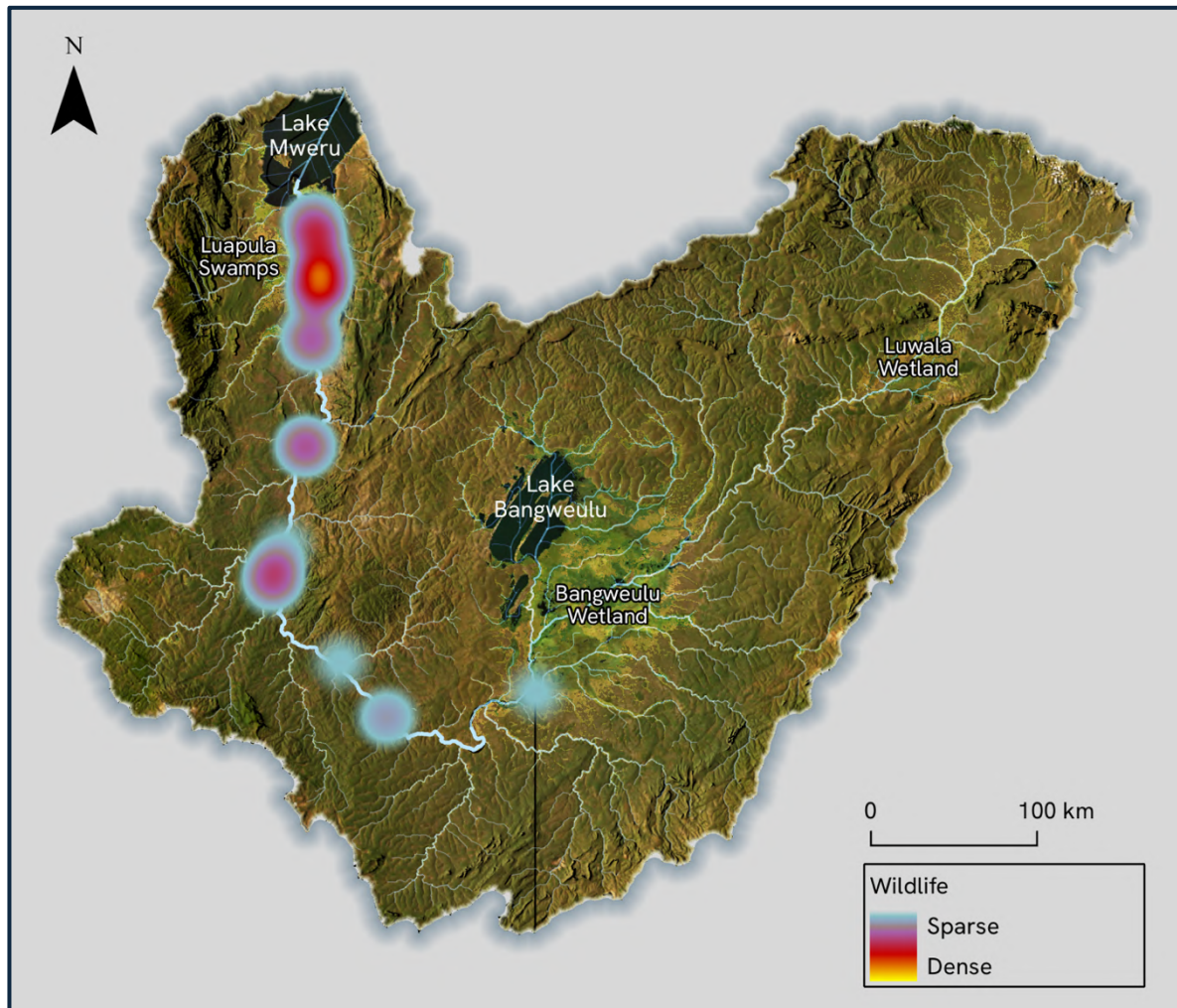


Figure 9. Wildlife sightings on the Luapula river

Birds

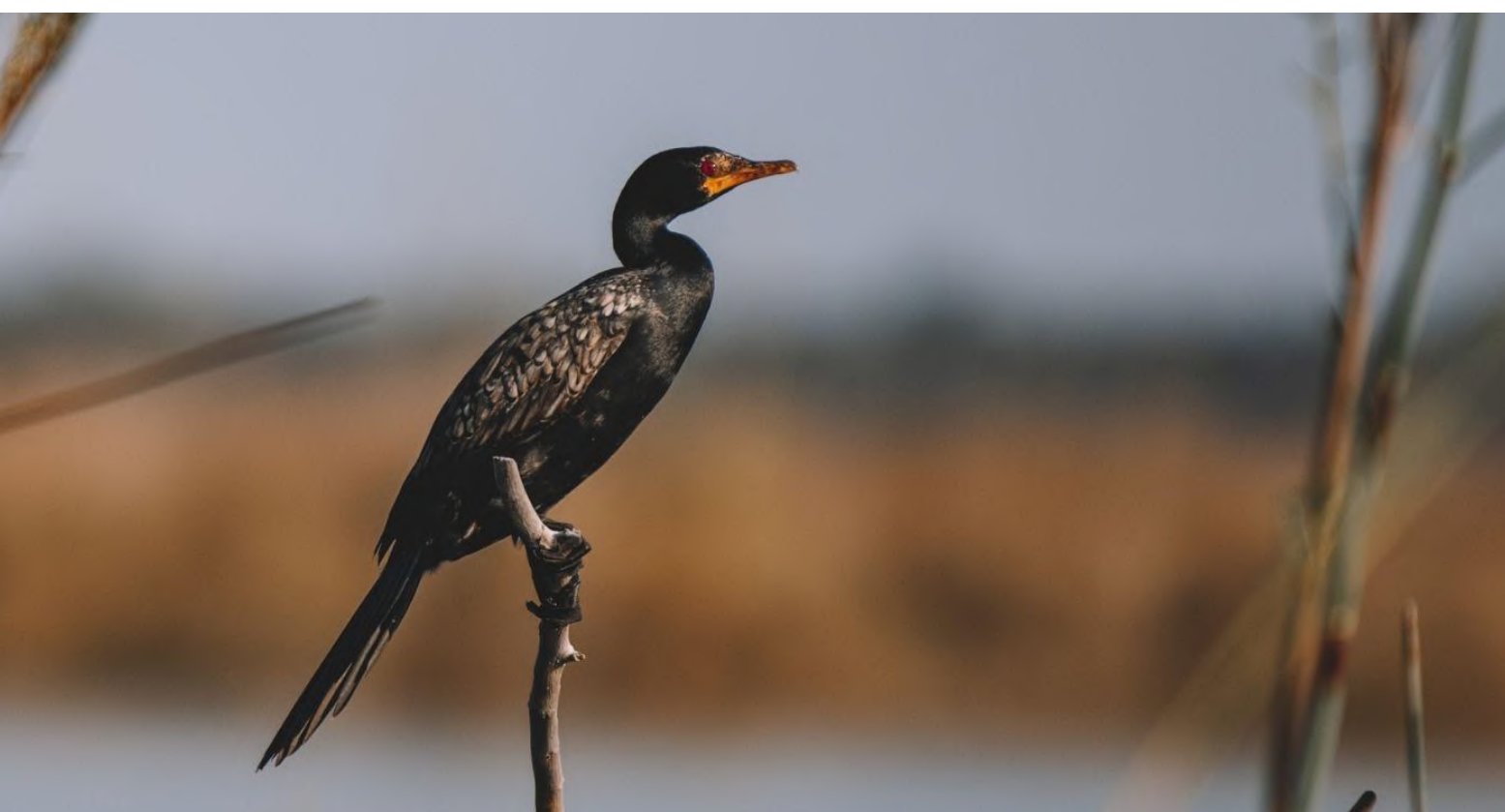
Birds are sensitive indicators of environmental change, particularly in wetland systems where their distribution often reflects habitat condition and availability. A relatively high

bird diversity was identified on the Luapula, with 139 species, compared to the 71 species record on the Chambeshi River expedition. These included specialists such as the striped kingfisher (*Halcyon chelicuti*) and the western banded snake eagle (*Circaetus cinerascens*). Additionally, a sighting of a wattled crane (*Bugeranus carunculatus*) was particularly notable given their threatened status in the region.

Despite the overall species richness recorded, wetland-associated bird density along the Luapula's bird abundance was significantly lower (32 birds/10km) than recorded during the 2024 expedition in the Chambeshi Flats (85 birds/10km), and the Bangweulu Swamps (49 birds/10km). Bird abundance also declined progressively downstream, corresponding with increasing distance from the Bangweulu Wetlands, a major regional breeding and foraging habitat. This pattern suggests that the Luapula River functions largely as an ecological extension of the Bangweulu wetland system, rather than supporting high species richness independently. Regular monitoring of bird populations along the Luapula River could provide an important tool for detecting ecological change and identifying emerging conservation priorities.

Table 3. Ten most common bird species counted on the transect.

Species	Count
Reed Cormorant (<i>Microcarbo africanus</i>)	470
Yellow-billed Kite (<i>Milvus aegyptius</i>)	189
African Openbill (<i>Anastomus lamelligerus</i>)	108
Grey-headed Gull (<i>Chroicocephalus cirrocephalus</i>)	74
Bronze Mannikin (<i>Spermestes cucullata</i>)	72
White-faced Whistling Duck (<i>Dendrocygna viduata</i>)	65
Fulvous Duck (<i>Dendrocygna bicolor</i>)	58
Glossy Ibis (<i>Plegadis falcinellus</i>)	56
Common Sandpiper (<i>Actitis hypoleucos</i>)	47
Western Cattle Egret (<i>Bubulcus ibis</i>)	47



Fish

The Luapula River supports a highly diverse fish community due to its connectivity with both Lake Mweru and the Bangweulu Wetland. This diversity is further enhanced by the river's complex geological structure, which creates a wide range of aquatic habitats. To sample the fish communities, a combination of dip nets, fyke nets and gill nets were employed.

A variety of ecological guilds were recorded across different habitat types. Fast-flowing and structurally complex sections supported rheophilic and benthic species such as *Labeo*, *Chrysichthys*, and *Auchenoglanis*. Open-water and floodplain habitats were dominated by characiforms including *Alestes* and herbivorous *Distichodus*. Swampy and slow-flowing reaches supported diverse cichlid assemblages (*Coptodon*, *Pseudocrenilabrus*, and *Tylochromis*), alongside pelagic and nocturnal catfishes such as *Schilbe* and *Clarias*.

The presence of these diverse taxa underscores the importance of the Luapula River as a significant reservoir of freshwater biodiversity and highlights the need for continued taxonomic and genetic research to better understand species composition and conservation priorities within the basin.

Table 4. Fish genus collected throughout the transect.

Genus Name	Count
<i>Alestes</i>	1
<i>Auchenoglanis</i>	1
<i>Campylomormyrus</i>	1
<i>Clarias</i>	1
<i>Coptodon</i>	1
<i>Crysichthys</i>	2
<i>Distichodus</i>	3
<i>Enteromius</i>	4
<i>Labeo</i>	1
<i>Micralestes</i>	3
<i>Petrocephalus</i>	1
<i>Pharyngochromis</i>	1
<i>Pseudocrenilabrus</i>	3
<i>Schilbe</i>	1
<i>Serranochromis</i>	3
<i>Synodontis</i>	7
<i>Tylochromis</i>	1



Figure 10. TWP expedition team alongside local women using local fishing techniques within the Luapula River.

Invasive Species

The Luapula River Basin is increasingly affected by alien invasive plants (AIPs), which pose significant risks to both aquatic and terrestrial ecosystems. These species alter habitat structure, disrupt ecological processes, and can negatively affect water quality, fisheries, and access to river resources.

During the expedition, the most prominent invasive species recorded was the giant sensitive plant (*Mimosa pigra*). This highly aggressive species forms dense, thorny thickets in wetlands, floodplains and agricultural areas, where it outcompetes native vegetation, restricts access to waterways, and reduces habitat availability for wildlife and fish.

Red water fern (*Azolla filiculoides*) was also prominent at multiple locations along the river. This species forms floating mats that smother native aquatic plants, reduce light penetration, and deplete dissolved oxygen, creating unsuitable conditions for fish and aquatic invertebrates. In addition, Mexican sunflower (*Tithonia rotundifolia*) was noted along disturbed riparian areas and floodplain edges, where it forms dense stands that can suppress native plant communities.

The spread of alien invasive plants in the Luapula Basin is facilitated by land disturbance, nutrient-rich runoff, and seasonal hydrological variability. Continued expansion of these species is likely to increase ecological pressure on already modified habitats. Regular monitoring and active management will therefore be essential to limit further expansion and support coordinated basin-scale responses to invasive species management²¹²².

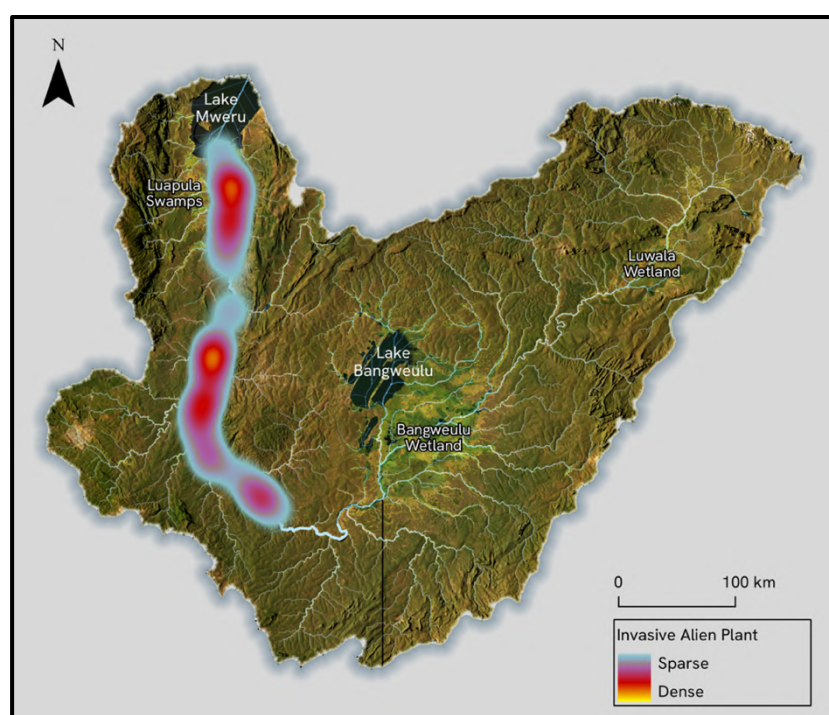


Figure 11. Map of invasive species along the Luapula river.

²¹ Trenberth KE. 2005. The impact of climate change and variability on heavy precipitation, floods and droughts. Encyclopedia of Hydrological Sciences, 17,1-11.

²² Ecological impacts of invasive alien plants: a meta-analysis of their effects on species, communities and ecosystems. Ecological Letters, vol. 14, pp. 702-708, 2011.

Micro-invertebrates Assessments

The Zambian Invertebrate Scoring System (ZISS) is a standardised, rapid, field based bioassessment tool that scores macroinvertebrate fauna at family level to indicate the health of a river. Each site receives a total score based on the pollution sensitivity of the taxa present; higher scores indicate healthier, more diverse aquatic habitats. Additional metrics include the total number of taxa recorded and the average score per taxon (ASPT).

Macroinvertebrate sampling at 10 sites along the Luapula River returned an average ZISS score of 58.4 (± 16.3), with 11.2 taxa per site and a mean ASPT of 5.2. Scores varied considerably along the transect, from 38 to 89. The highest scores were recorded in the upper river (e.g. site LUAP25_007: 89, 16 taxa), suggesting relatively good water quality and habitat diversity, while the lowest values (sites LUAP25_036 and LUAP25_067) may reflect localised pressures such as altered habitat structure, water chemistry, or surrounding land use. Overall, these results demonstrate the value of biomonitoring tools like ZISS in detecting spatial differences in ecological condition and identifying reaches that may benefit from further assessment.

Table 5. Summary of aquatic macroinvertebrate sampling results along the Luapula River.

Site	Latitude	Longitude	No. of Taxa	ASPT	ZISS Score
1	-12.11589	29.84699	13	4.85	63
7	-12.24190	29.49034	16	5.56	89
14	-12.36433	29.27760	12	5.58	67
25	-12.04956	28.78570	12	5.42	65
36	-11.75551	28.44923	8	4.75	38
46	-11.20143	28.48635	8	5.38	43
53	-10.72147	28.62204	9	4.89	44
57	-10.53348	28.64744	11	6.27	69
67	-9.83613	28.67469	8	5.13	41
74	-9.46311	28.53826	15	4.33	65

KEY INSIGHTS

1. Extreme Fire Frequency and Landscape Transformation

The Luapula Basin is experiencing exceptionally high fire frequency compared with other rivers surveyed by TWP. Satellite analysis shows that 88% of the basin has burned since 2000, with nearly half of the landscape burning almost annually. These predominantly anthropogenic fires are a major driver of landscape change and pose a significant threat to ecologically important riparian forests. Field observations during the expedition confirmed the widespread extent of recent burning.

2. Resource Utilisation

Population density along the Luapula (124 people/10 km) is considerably higher than on other rivers in the Congo Basin surveyed by TWP, including the Chambeshi. Similarly, fishing pressure is also high, with an average of one fisher every km. This highlights the importance of the river and its natural resources for local communities, who may be adversely impacted by inter-basin transfers or dam developments along the river.

3. Biodiversity Connectivity and Declining Abundance

Wildlife observations along the Luapula were limited, and wetland-associated bird density was roughly half that recorded in the nearby Bangweulu Wetlands. The progressive downstream decline in bird abundance indicates that the Luapula likely functions primarily as an ecological extension of the Bangweulu Ramsar site rather than supporting large, independent wetland populations.

4. Escalating Threat of Alien Invasive Plants (AIP)

Highly aggressive invasive species — including giant sensitive plant (*Mimosa pigra*) and red water fern (*Azolla filiculoides*) — are spreading along the river corridor. Without effective control, these species could expand pose a significant threat to native vegetation and wetland ecosystem functioning. Moreover, inter-basin transfer from the Luapula to the Kafue may encourage the spread of these species throughout the already heavily-invaded Kafue Basin.

5. Tributary Vulnerability to Industrial Pollution

Although water quality in the main river channel remains stable, tributaries such as the Kafubu, Lwela, and Mansa rivers may act as pathways for contamination associated with expanding mining activity near Lubumbashi (Democratic Republic of Congo) and Mansa (Zambia). Continued monitoring of these tributaries will be critical for detecting emerging pollution risks. The Kafubu River is likely the main contaminant source along the Luapula River, with potential to degrade water quality upstream of the Mweru-Luapula fishery.

RECOMENDATIONS:

Developing a Robust Baseline

The 2025 survey forms the most comprehensive, multi-disciplinary picture of the state of the Luapula River to date. By integrating water quality, sediment chemistry, biodiversity, human activity, invasive species mapping, and open-source spatial data, this work provides a critical snapshot of the current condition of the two systems at a time of intensifying pressures. However, as a single temporal assessment, the 2025 survey cannot on its own capture the dynamic nature of river processes or distinguish short-term variability from longer-term trends.

It is therefore strongly recommended that these surveys are repeated at regular intervals (ideally every 3-5 years). Periodic re-surveys would contribute to a robust baseline, enabling detection of changes in water and sediment quality, shifts in biodiversity and invasive species distributions, and emerging risks linked to extreme flood and drought events. By using consistent methodologies, data cross-comparison would allow trend analysis, and provide an evidence base for adaptive, basin-wide decision-making. In a river system as socially, ecologically, and economically important as the Zambezi, repeated surveys are essential to move from descriptive assessment toward proactive, long-term stewardship.

Integrated Fire Management and Forest Protection

Fire represents the most significant driver of landscape change within the basin, with 88% of the land area having burned at least once since 2000. Promoting a broader range of land management techniques alongside existing practices could help reduce the frequency and intensity of anthropogenic fires, particularly during the peak burn months of August and September. Given the ecological importance of *mushitu* and *mateshe* riparian forests for biodiversity, there may be value in directing such efforts towards these habitat types, where reducing repeated burning and the selective harvesting of mature hardwoods could have a meaningful impact on the long-term forest integrity and the species that depend on it.

Improved Water Quality Monitoring

While mainstem water quality is currently stable, the ongoing expansion of mining activities represents a potential threat to the system. Establishing permanent monitoring stations at key tributary confluences — particularly the Lwela, Kafubu, and Mansa rivers — could provide an early warning capability and enable timely detection of changes in water quality before they propagate further into the Luapula system and the ecologically sensitive habitats downstream.

A detailed survey of the Kafubu River is needed to assess the pathways of mining contamination. This includes collecting sediment samples, which will indicate the levels of heavy metal contamination originating from mines in Lubumbashi. Should heavy metal

contamination be detected, a study of the interaction of these effects on water quality and local livelihoods will improve capacity for adaptation and inform further interventions.

Sustainable Management of the Chambeshi-Bangweulu-Luapula System

Acting as the water tower of the basin, the Bangweulu Wetlands store and gradually release water to sustain the Luapula in the dry-season flow and buffering it against flash floods. By regulating the availability and quality of water moving through the system, the Bangweulu Wetland underpins downstream biodiversity and livelihoods, including those within the productive Mweru-Luapula fishery. Protecting the Bangweulu Wetland from crop encroachment, draining, contamination or overfishing should be a priority given the interconnection of the system.

Biodiversity Connectivity and Invasive Species Control

Bird densities recorded during the expedition were significantly lower than those of the Bangweulu Wetlands and the Chambeshi Flats, likely reflecting the cumulative loss of wetland habitats through repeated burning. Further research should be undertaken to determine the reason for the low bird abundance.

Prioritising the restoration of wetland habitats, alongside targeted invasive species management, could be conservation efforts to help improve bird abundance and support wildlife movement through the basin.

Fisheries Management

The increasing pressure on local fish populations may be contributing to long-term decline in the available catches along the Luapula. The establishment of seasonal fish sanctuaries or fishing-controlled areas at ecologically important points along the river could provide refugia for native fish populations that support their recovery and reduce pressure on the broader system.

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Appendix A: Satellite Analyses

BUILDING ANALYSIS

Method

The Google Open Buildings dataset, which provides building footprints derived from satellite imagery, was used to calculate the number and total area of buildings within a 4 km buffer zone around the Luapula River. Additionally, the number and total area of buildings were also calculated for the entire Luapula Basin. This dataset complements and improves the observational data from the September 2025 river survey, offering a more comprehensive understanding of building distribution and size beyond the river's riparian zone. By highlighting the proximity of human settlements to these key ecological areas, the dataset also aids in assessing human impact on these critical ecosystems.

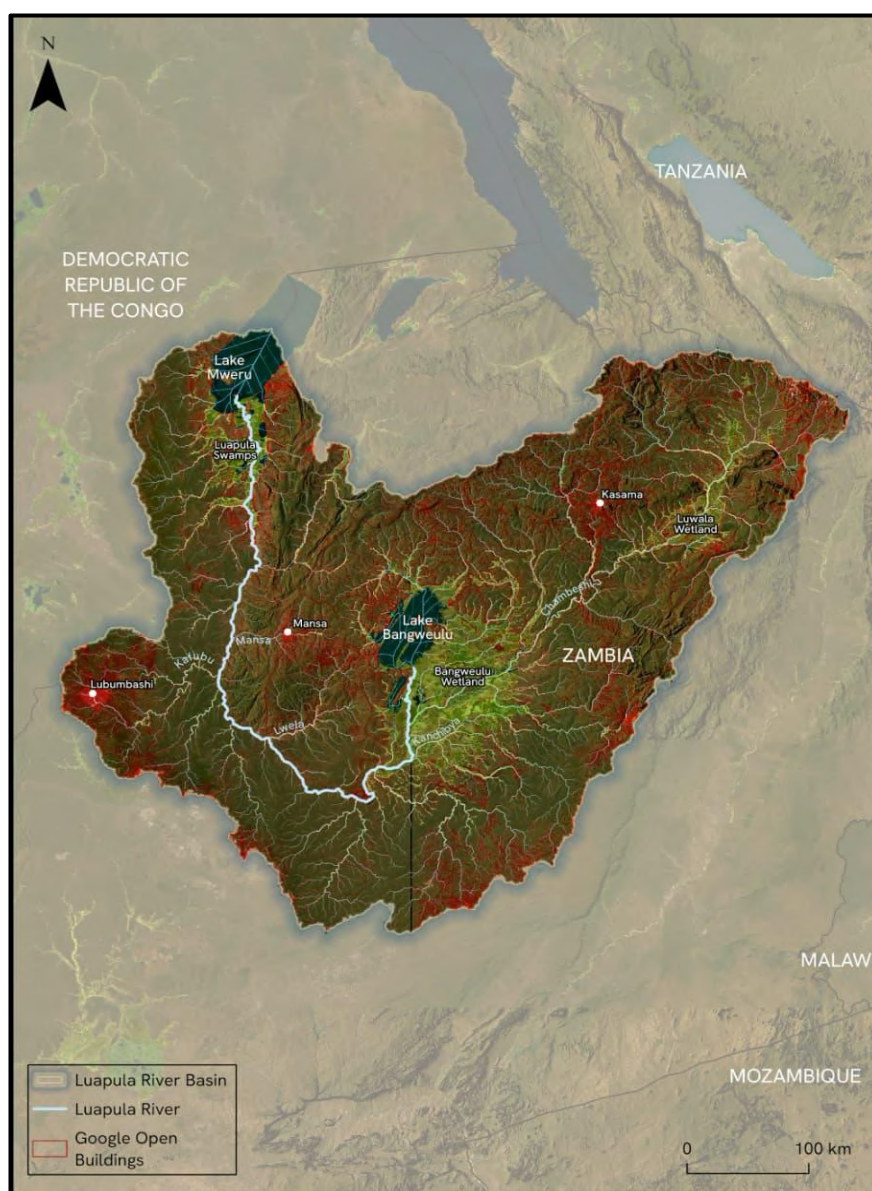


Figure A1. Analysis of human settlement patterns in the Luapula Basin completed using the Google's Open Buildings dataset.

LAND-USE CHANGE ANALYSIS

Methods: LULC change analysis

The land-use and land-cover (LULC) change analysis for the Luapula River Basin was conducted using 300 m resolution maps from the European Space Agency Climate Change Initiative. These maps, covering 1992 and 2020, were reclassified into broader categories based on user guidelines for change detection.

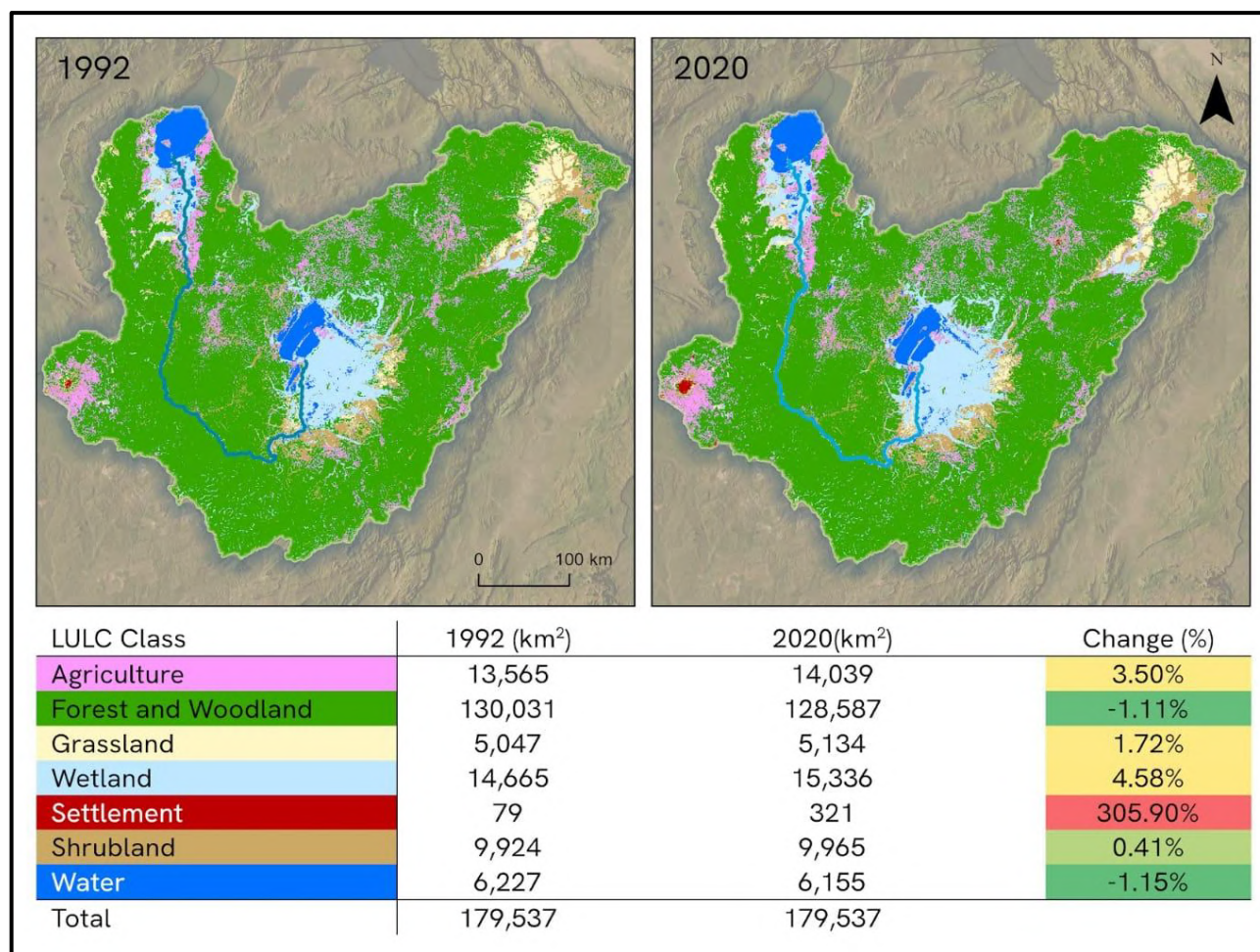


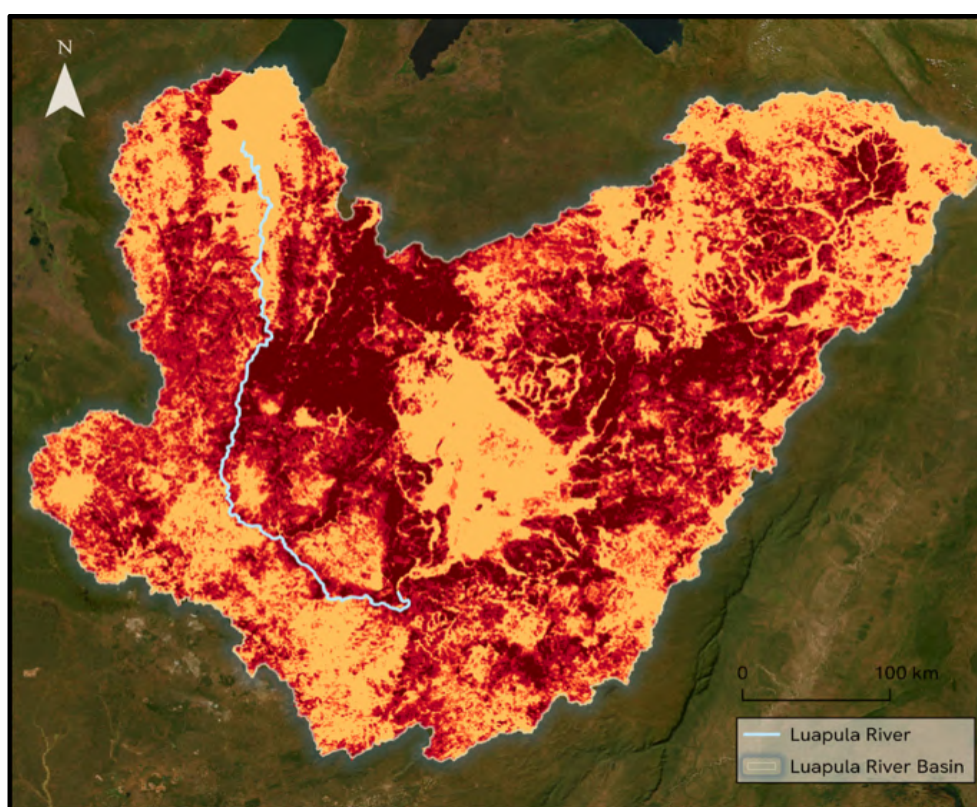
Figure A2. The land-use land change analysis of the Luapula Basin from 1992 to 2020.

MODIS BURNED AREA ANALYSIS

Methods: MODIS Burned Area Analysis

To quantify historical fire patterns within the Luapula Basin, burn frequency was extracted from the MCD64A1.061 MODIS Monthly Global 500m dataset. This analysis spans the 2000–2023 period and categorizes fire occurrences into six distinct frequency levels to identify long-term ecological trends.

While this dataset provides a robust and accurate estimation of burned areas, its 500m spatial resolution acts as a detection threshold; consequently, smaller, localized burn scars may not be recorded, meaning the results represent a conservative estimate of total fire impact. This satellite-derived frequency data complements the 2026 river survey by offering a macro-level perspective on fire-driven land cover changes that extend well beyond the immediate riparian zones.



Legend	Burn Frequency (2000 -2023)	Area (km ²)	Proportion (%)
	No Burn	22,172	12%
	1-5 Burns	43,116	23%
	6-10 Burns	32,146	17%
	11-15 Burns	28,990	16%
	16-20 Burns	27,928	15%
	21-23 Burns	32,633	17%
	Total Area Burnt	186,971	-

Figure A3. Analysis of areas burnt by fire between 2000 – 2023 using the MODIS Monthly Global 500m dataset.

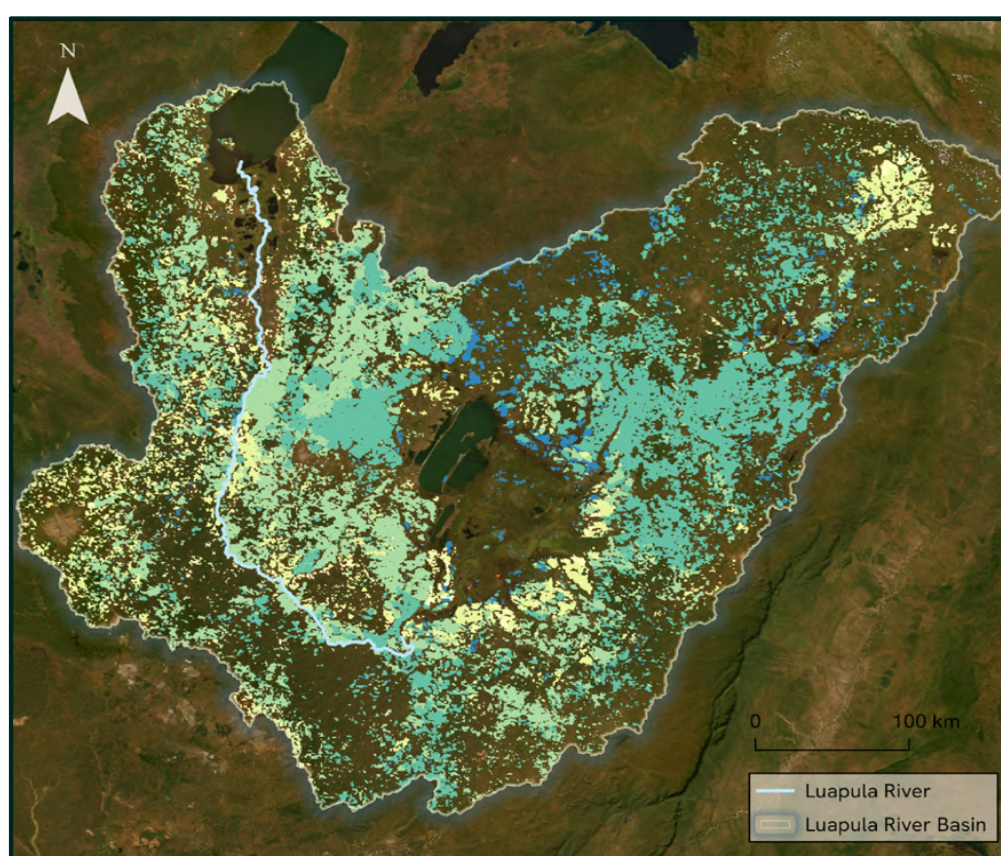
MODIS SEASONAL BURN ANALYSIS

Method

To determine the seasonality of fire within the Luapula Basin, monthly burned area data was extracted from the MCD64A1.061 MODIS 500m product.

This analysis quantifies the proportion of the basin burned each month, allowing for the identification of peak fire activity and its correlation with dry season cycles.

By tracking these temporal shifts, the dataset provides a high-resolution timeline of fire intensity that complements field observations, offering a broader ecological context for how seasonal burning impacts vegetation structure and carbon cycling across the landscape.



Legend		2023 Area (km ²)	Burn Proportion (%)
	No Burn	119,916	-
	January	5	0.007%
	February	1	0.001%
	March	13	0.019%
	April	5	0.007%
	May	84	0.125%
	June	1,637	2.435%
	July	8,975	13.348%
	August	25,900	38.521%
	September	27,505	40.908%
	October	2,855	4.246%
	November	89	0.133%
	December	168	0.250%
Total Burn Area		67,236	-

Figure A4. Analysis of areas burnt by fire between 2000 – 2023 using the MODIS Monthly Global 500m dataset.

