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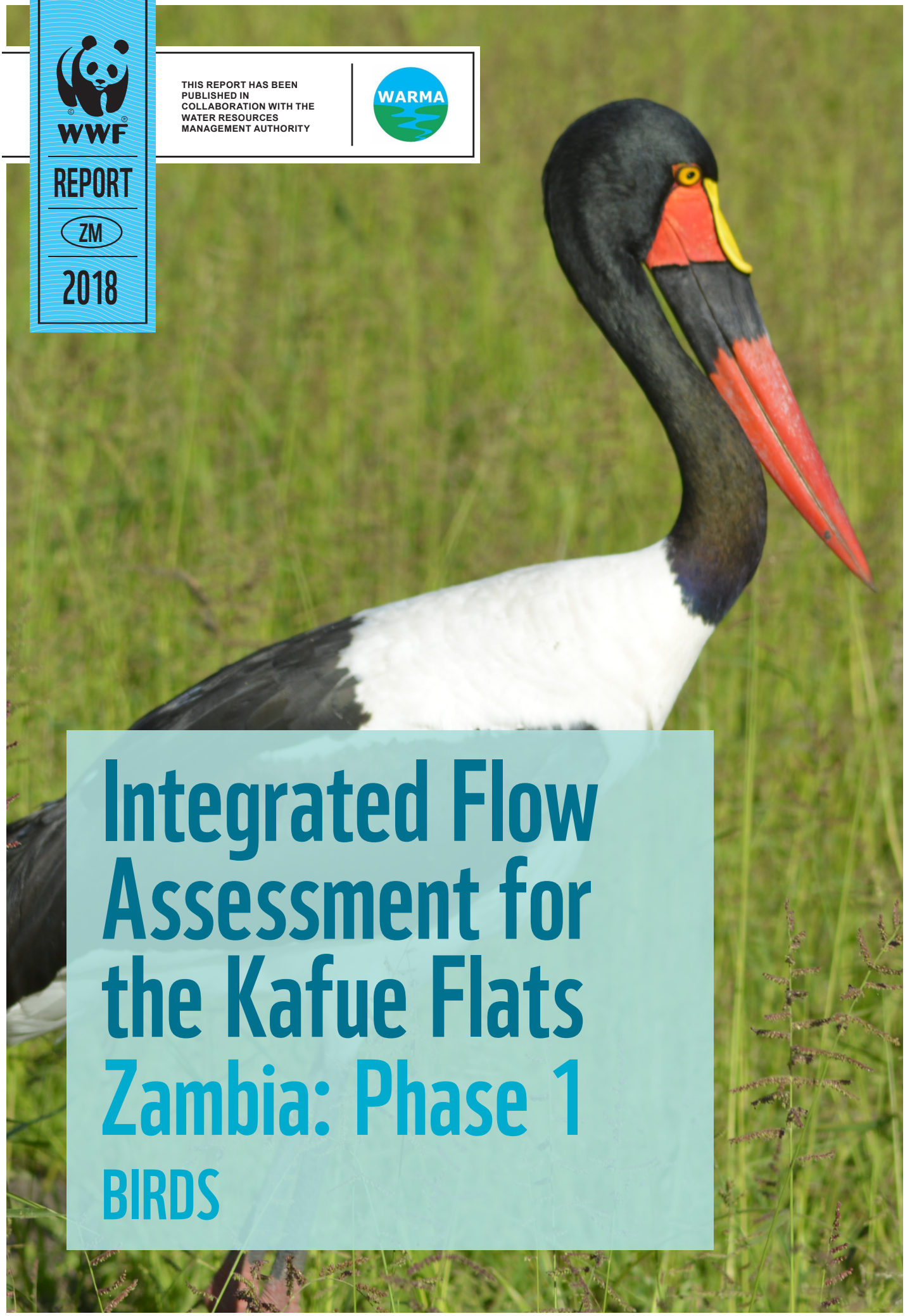

Integrated Flow Assessment for the Kafue Flats Zambia: Phase 1

BIRDS

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WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by: conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

BIRDS

March 2018

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ABBREVIATIONS

BLNP	Blue Lagoon National Park
DNPW	Department of National Parks and Wildlife (formerly Zambia Wildlife Authority)
EFlow	Environmental Flow
GMA	Game Management Area
ICF	International Crane Foundation
ITT	Itezhitezhi Dam
LNP	Lochinvar National Park
MCA	Mwanachingwala Conservation Area
WARMA	Water Resources Management Authority
WWF	World Wide Fund for Nature

This document is number 8 in a series of reports produced in Phase 1, in the series

02 Water Resource Developments
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THANK YOU

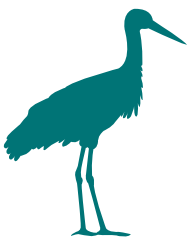
We are grateful to the International Crane Foundation/Endangered Wildlife Trust for supporting our involvement in this Integrated Flow Assessment for the Kafue Flats, and Dr. Jackie King for her review of a previous draft of this manuscript.

EXECUTIVE SUMMARY

The Kafue Flats in Southern Zambia is among the most important areas in sub-Saharan Africa for the conservation of aquatic and terrestrial birds, including residents, inter-African migrants, and Palearctic migrants, with more than 470 species recorded. The Kafue Flats is designated a Wetland of International Importance for the Conservation of Waterbirds under the Ramsar Convention, and an Important Bird Area under Birdlife International, due to the high biodiversity of waterbirds, including many rare, threatened, and endemic species.

The Flats hosts a wide range of wetland bird species of international conservation concern, including Endangered Grey Crowned Crane *Balearica regulorum* (breeding resident), Vulnerable Wattled Crane *Bugeranus carunculatus sp* (breeding resident), Vulnerable Madagascar Squacco Heron Ardeola idea (rare visitor), Vulnerable Slaty Egret *Egretta vinaceigul*a (rare visitor), Vulnerable Corncrake *Crex crex* (regular non-breeding visitor), Near-Threatened African Skimmer *Rynchops flavirostris* (regular, possibly breeding resident), Near-Threatened Great Snipe *Gallinago media* (regular non-breeding visitor), Near-Threatened Lesser Flamingo *Phoenicopterus minor* (rare visitor), Near-Threatened Pallid Harrier *Circus macrourus* (regular non-breeding visitor), Near-Threatened Denham's Bustard *Neotis denhami* (regular breeding resident), and Black-winged Pratincole *Glareola nordmanni* (scarce non-breeding visitor). The population of Wattled Cranes on the Kafue Flats is the largest in Africa – accounting for >30% of the global population of this highly wetland-dependent species.

THE FLATS HOSTS A WIDE RANGE OF WETLAND BIRD SPECIES OF INTERNATIONAL CONSERVATION CONCERN, INCLUDING ENDANGERED GREY CROWNED CRANE



Overall the Kafue Flats waterbird population is abundant and diverse. Many species are resident, others are migratory (intra-African, Palaearctic, and some nomadic). Several species are rare and/or regionally or globally threatened. All waterbirds on the Flats are dependent on the floodplain ecosystem and its associated water regime (including the magnitude, timing, duration, and/or extent of surface waters, as well as the nature of groundwater regimes) at some time of the year. Many species spend their entire life cycle in close association with the floodplain—feeding, roosting, loafing, nesting, and provisioning their chicks on the floodplain. Some waterbird species depend on specific floodplain conditions to secure their nests and chicks from predation, trampling or fire, or to provide safe roosts. Many species require the rank growth of various wetland sedges and grasses for nesting materials or cover. Different species of waterbirds feed on a range of wetland food sources to meet their nutritional requirements for reproduction and migration, including underground rhizomes (tubers), seeds, and shoots of various aquatic and emergent plant species and animal protein such as snails, frogs, fish and insects (adults and larvae). The flow regime is a major driver of the seasonal availability and abundance of these food items.

DIFFERENT SPECIES OF WATERBIRDS FEED ON A RANGE OF WETLAND FOOD SOURCES TO MEET THEIR NUTRITIONAL REQUIREMENTS

Hence, there are many important connections between waterbirds and the water conditions on the floodplain.

Waterbirds serve as useful indicator species for the diversity of water conditions required to maintain avian biodiversity on the Kafue Flats. The most important and iconic birds include the Wattled Cranes, Spurwinged Goose, Goliath Heron, African Skimmer, Common`Pranticole, Kittlitz's Plover and African Openbill Stork. Collectively, these species represent an important suite of waterbird indicators for further investigation with respect to EFlow assessments. Other waterbird species occurring on the Kafue Flats may warrant consideration due to their specialized diets linked to flood pulse conditions, their rare or endangered status, population trends corresponding to the period of river regulation, or other factors. These may especially include globally threatened waterbird species (e.g., Grey Crowned Crane, Madagascar Squacco Heron, Slaty Egret, Corncrake, Great Snipe, Lesser Flamingo, Denham's Bustard, and Black-winged Pratincole), species of regional conservation concern (e.g., Eurasian Bittern, Saddlebilled Stork, and African Marsh Harrier), and/or some of the many species with globally important congregations on the Kafue Flats.

Because of the very strong link between abundance and diversity of bird life on the Kafue Flats and the flow regime that maintains the floodplain, managed environmental flows to sustain the ecological health of this freshwater system are critically important. The Flats receives a seasonal pulse of floodwaters from the Kafue River and its major tributaries, and the ebb and flow of water levels drives the productivity of the wetland ecosystem. The breeding, foraging and nesting requirements of many species of waterbirds are closely linked to the timing, depth, duration, extent, and quality of these seasonal floodwaters. Alterations to these natural hydrological conditions, due to large dams, water diversions, commercial agriculture operations, and other factors, are having a profound impact on floodplain birdlife, and exacerbating the impacts of other human impacts to floodplain birdlife in ways such as habitat loss, nest disturbance, hunting, and many other threats.

For more than 40 years, the flooding regime of the Kafue Flats has been highly modified by the water regulation for hydropower development upstream and downstream of the Flats. The dam at Kafue Gorge, downstream of the Flats, was completed in 1971, resulting in the upstream inundation of an area of approximately 1,000 km^2 of the Flats. Because of the low topography, the reservoir is very shallow and has a live storage capacity of just 785 Mm^3. The power plant requires a minimum flow of 120 m^3s-1 to maintain its firm energy target of 450 MW. In order to guarantee this flow throughout the year, in the second phase of the project, another dam was built at Itezhi-tezhi (ITT), 450 km upstream from Kafue Gorge and just upstream of the

Kafue Flats. This dam was completed in 1977. The resulting reservoir has an area of about 300 km² and a live storage capacity of 4,925 Mm³, which is equivalent to 56% of the long-term mean annual flow into the reservoir. The Zambia Electricity Supply Corporation (ZESCO) operates both dams.

FOR MORE THAN 40 YEARS, THE FLOODING REGIME OF THE KAFUE FLATS HAS BEEN HIGHLY MODIFIED BY THE WATER REGULATION FOR HYDROPOWER DEVELOPMENT UPSTREAM AND DOWNSTREAM OF THE FLATS

Serious concerns about the impact of water resources development on the ecological functioning of the Kafue Flats (vegetation and wildlife) were raised at a national level prior to and immediately following Kafue River regulation. The topic has received considerable attention since that time, including the necessity for EFlow releases from ITT Dam and integrated river basin management to mitigate impacts.

There is evidence that changes in the flooding regime have affected both the total population and the distribution of waterbirds and other animals on the Flats by modifying their habitats in three ways. First, grazing has been reduced because of altered vegetation distribution and quality of forage. This is particularly the case immediately downstream of ITT Dam where there is increasing encroachment onto the floodplain of dryland species (e.g. thickets of Dichrostachys cinerea and Acacia polycantha). Second, increased inundation of the eastern end of the Flats is estimated to have reduced suitable habitat on the floodplain at (now) Chunga Lagoon from 1078 km² prior to dam construction to 970 km² after construction. Third, the natural breeding system has been disturbed as a consequence of the changes to the flood regime. Furthermore, it is suspected that changes in aquatic plant species, invertebrate and fish populations arising as a consequence of the altered hydrological regime, have had an impact on waterbird populations.

These impacts on the birds are exacerbated by concurrent changes in vegetation (species diversity, cover, and productivity; invasive species) and wildlife (especially large herbivores) on the Kafue Flats associated with these hydrological alterations. Understanding the interaction of hydrology, soils, vegetation, large herbivores, invertebrates and waterbirds on the Kafue Flats is important for the long-term management of this wetland ecosystem. However, very few studies have assessed the link between the Kafue Flats water regime and waterbird diversity and abundance. The limited ecological research that has been conducted has focused on the interactions between the hydrology, vegetation and herbivores, especially the Kafue Lechwe. In general, there is inadequate information at present to conduct a detailed integrated flows assessment for waterbirds on the Kafue Flats, even for relatively well-studied species such as the Wattled Crane. Further research is needed before such an assessment can be used to evaluate the impact of different flow scenarios on waterbird population and distribution on the Kafue Flats. This should be broadly supported by semi-annual aerial surveys, ground surveys, and other activities.

1. INTRODUCTION

1.1 BACKGROUND TO THE PROJECT

Zambia's Water Resources Management Act of 2011 brings into being a new Water Resources Management Authority (WARMA), paving the way for the nationwide formation of Basin Councils responsible for water resource management of their areas. As a priority, each Council has to develop its basin management strategy and water allocation plan. In a piloting approach, the Kafue Basin appears to be the first where WARMA will establish such a Council.

There is a substantial body of knowledge on the Kafue Basin, its dams and the Kafue Flats. The Flats, in particular, have been the subject of many water-related investigations. WWF, in agreement with WARMA, has initiated a new project focusing on water, land and reservoir management of the Kafue Flats. Because of the body of work on the Flats already existing and stretching back for several decades, Phase 1 of this project will be to locate, collate, assess and synthesise all relevant information and data. Building on this, Phase 2 will be a detailed analysis of past and projected future water availability and use, dam design and operation, and linked conservation and social aspects. Its purpose will be to provide a tool that can aid government and stakeholder discussions and decisions regarding water management of this important area.

1.2 ROLE OF BIRDS IN THIS ASSESSMENT

The Kafue Flats in Southern Zambia is among the most important areas in sub-Saharan Africa for the conservation of aquatic and terrestrial birds, including residents, inter-African migrants, and Palearctic migrants, with more than 470 species recorded (Dowset and de Vos, 1963; Douthwaite, 1974; Leonard, 2005). The Kafue Flats is designated A Wetland of International Importance for the Conservation of Waterbirds under the Ramsar Convention, and an Important Bird Area under Birdlife International, due to the high biodiversity of waterbirds, including many rare, threatened, and endemic species (Leonard, 2005). The Kafue Flats hosts a wide range of wetland bird species of international conservation concern, including Endangered Grey Crowned Crane[1] *Balearica regulorum* (breeding resident), Vulnerable Wattled Crane Bugeranus carunculatus sp (breeding resident), Vulnerable Madagascar Squacco Heron *Ardeola idea* (rare visitor), Vulnerable Slaty Egret *Egretta vinaceigula* (rare visitor), Vulnerable Corncrake *Crex crex* (regular non-breeding visitor), Near-Threatened African Skimmer *Rynchops*

THE KAFUE FLATS IN SOUTHERN ZAMBIA IS AMONG THE MOST IMPORTANT AREAS IN SUB-SAHARAN AFRICA FOR THE CONSERVATION OF AQUATIC AND TERRESTRIAL BIRDS

flavirostris (regular, possibly breeding resident), Near-Threatened Great Snipe *Gallinago media* (regular non-breeding visitor), Near-Threatened Lesser Flamingo *Phoenicopterus minor* (rare visitor), Near-Threatened Pallid Harrier *Circus macrourus* (regular non-breeding visitor), Near-Threatened Denham's Bustard *Neotis denhami* (regular breeding resident), and Black-winged Pratincole *Glareola nordmanni* (scarce non-breeding visitor). The population of Wattled Cranes on the Kafue Flats is the largest in Africa – accounting for >30% of the global population of this highly wetland-dependent species (Shanungu et al. 2015; IUCN Crane Specialist Group, 2016).

Other threatened species associated with the Kafue Flats include Vulnerable Cape Vulture *Gyps coprotheres*, Vulnerable Lappet-faced Vulture *Torgos tracheliotus*, Vulnerable Lesser Kestrel *Falco naumanni*, and Near-Threatened Chaplin's Barbet *Lybius chaplini* (Leonard 2005). Additionally, the Kafue Flats and surrounds support 11 species of regional conservation concern in southern Africa, including waterbirds such as Eurasian Bittern *Botaurus stellaris*, Goliath Heron *Ardea goliath*, Saddlebilled Stork *Epippiorhynchus senegalensis*, and African Marsh Harrier Circus *ranivorus* (Leonard, 2005).

The Kafue Flats hosts globally important concentrations (regularly holding >1% of biogeographic population) of many waterbird species, including Reed Cormorant *Phalacrocorax africanus*, White Pelican *Pelicanus onocrotalus*, Black Heron (Egretta ardesiaca), African Openbill *Anastromus lamelligerus*, African Spoonbill *Platalea alba*, Fulvous Duck *Dendrocygna bicolor*, White-faced Duck *Dendrocygna viduata*, White-backed *Duck Thallassornis leuconotus*, Egyptian Goose *Alopochen aegyptiaca*, Spur-winged Goose *Plectroptetrus gambensis*, Knob-billed Duck *Sarkidiornis melanotus*, African Pygmy Goose *Nettapus auritus*, Red-billed Teal *Anas erythrorhyncha*, Hottentot Teal *Anas hotetentota*, Southern Pochard *Aythya ferina*, Collared Pratincole *Glareola pratincola*, Kittlitz's Plover *Charadrius pecuarius*, Caspian Plover *Charadrius asiaticus*, Long-toed Plover *Vanellus crassirostris*, Black-tailed Godwit *Limosa limosa*, Little Stint *Calidris minuta*, Curlew Sandpiper *Calidris ferruginea*, Ruff *Philomachus pugnax*, and Whiskered Tern *Chlidonias hybrida* (Leonard 2005).

The exceptional abundance and diversity of bird life on the Kafue Flats is highly dependent on the hydrological regime of the floodplain, and environmental flows are of paramount importance to sustaining the

[1]For this report, we follow the International Ornithological Congress (IOC) convention of capitalizing full common names for individual bird species (http://www.worldbirdnames.org/english-names/spelling-rules/capitalization). For consistency, we apply this rule to full common names for mammals as well.

ecological health of this freshwater system. The Kafue Flats receive a seasonal pulse of floodwaters from the Kafue River and its major tributaries, and the ebb and flow of water levels drives the productivity of this wetland ecosystem (Ellenbroek, 1987; Blaser, 2013; Mumba, 2005). The breeding, foraging, and nesting requirements of many species of waterbirds are closely linked to the timing, depth, duration, extent, and quality of these seasonal floodwaters. Alterations to these natural hydrological conditions, due to large dams, water diversions, commercial agriculture operations, and other factors, are having a profound impact on floodplain birdlife, and exacerbate the impacts of other human impacts to floodplain birdlife (habitat loss, nest disturbance, hunting, and many other threats). These impacts on the birds are exacerbated by concurrent changes in vegetation (species diversity, cover, and productivity; invasive species) and wildlife (especially large herbivores) on the Kafue Flats associated with these hydrological alterations. Understanding the interaction of hydrology, soils, vegetation, aquatic invertebrates, large herbivores and waterbirds on the Kafue Flats is crucial for the long-term sustainability of this wetland ecosystem.

THE KAFUE FLATS RECEIVE A SEASONAL PULSE OF FLOODWATERS FROM THE KAFUE RIVER AND ITS MAJOR TRIBUTARIES

1.3 TERMS OF REFERENCE

1.3.1 Task 1

1.3.1.1 Review existing data and knowledge on bird species of the Kafue Flats

Acquire and collate existing information on the bird species of the Kafue Flats, as follows.

- Historical and present distributions of the bird species on the Flats. Pay special attention to species that have direct links to water, and to species that are endemic, or under threat.

- The geographical distributions of bird species in relation to areas of inundation or non-inundation. Where available, provide maps and shapefiles of these distributions for future integration with other datasets.

- The temporal presence of bird species in relation to seasons, including timing of breeding, links to food sources and breeding requirements.

- Requirements of the different species/communities in terms of length and timing of inundation, and necessary groundwater levels.

- Critical habitats for the various bird species and communities.

- The use of birds by local people and the perceived economic and cultural importance of this in their lives.

- Where possible, provide a temporal analysis of changes in bird species, communities and distributions on the Kafue Flats since the mid-1900s.

- Complete a critical assessment of the above body of work, focussing particularly on the degree to which it enhances understanding of the relationship between the birds and surface or groundwater.

- Identify important knowledge gaps that could help an Integrated Flow Assessment, and alert the Project Leader to future needs in order to better understand and aid management of water-related aspects of the birds of the Middle Kafue River and the Flats.

1.3.1.2 Write a summary report of your findings, with key details in appendices

During your investigations, bear in mind that other investigations on the Flats will be proceeding in parallel, and alert the Project Leader to any important literature, maps, shapefiles or other relevant information that you come across. The other investigations will be covering the fields of hydrology, hydraulics, geomorphology, sediments, vegetation, water chemistry, aquatic invertebrates, herpetofauna, mammals and social use of the water and water-related resources of the Flats.

After review of your report by the Project Leader, WWF and ICF, complete one round of reasonable revisions.

1.3.1.3 Submit all reference material

Provide electronic versions of any key documents that you possess. If you locate documents that exist only in hard copy, which you feel are essential to this work, then alert the Project Leader so that arrangements can be made to scan them.

Collate and submit all available distribution maps and shapefiles or indicate where they are lodged and how they can be accessed by others.

1.3.2 Task 2

1.3.2.1 Planning for Phase 2 of the Integrated Flow Assessment for the Kafue Flats

Work with the Project Leader to identify options for a Phase 2 high confidence Integrated Flows study for the Kafue Flats, providing recommendations, a workplan and budget for the ornithological work.

1.3.3 Task 3

1.3.3.1 Phase 1 Final Report

Make input to the Phase 1 Final Report as required by the Project Leader.

1.4 GEOGRAPHIC SCOPE

The main area for Phase 1 of the Kafue Flats Flow Assessment is the Kafue Flats between the Itezhi-Tezhi and Kafue Gorge Dams (Figure 1.1), and north-south to the outer edge of typical floodplain vegetation. The wider drainage basin of the Kafue Flats, including its small northern streams, should be included to the extent that literature is available.

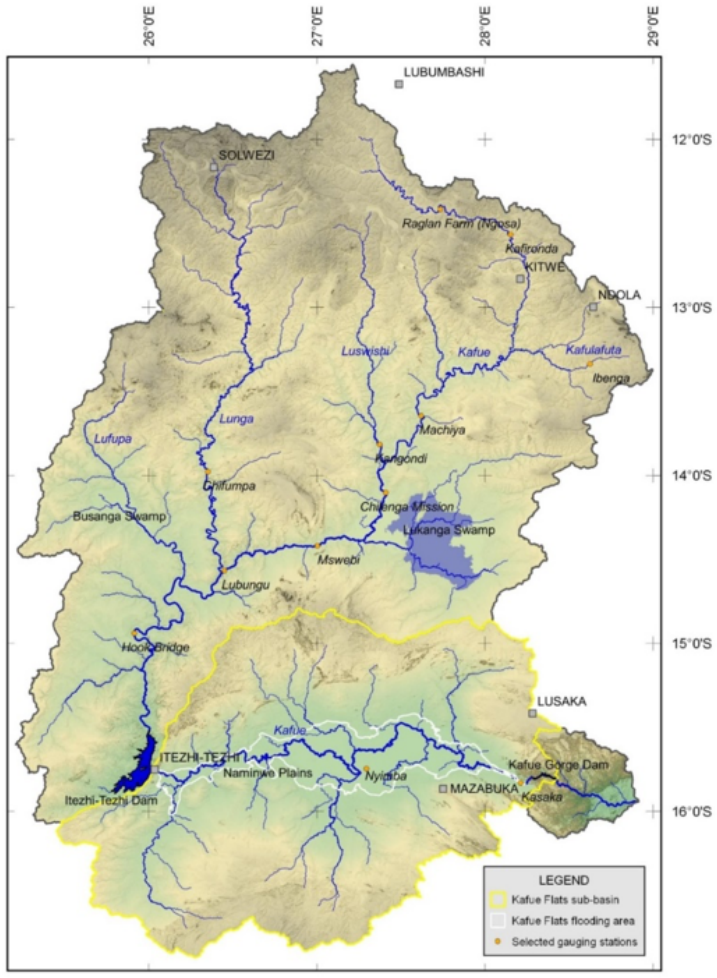


Figure 1.1

The Kafue River Basin in Zambia, showing the Kafue Flats with the maximum extent of flooded area outlined in white, the upstream Itezhi-tezhi Dam and the downstream Kafue Gorge Dam. The Kafue Flats sub-basin is outlined in yellow.

1.5 KEY DELIVERABLES AND REPORT LAYOUT

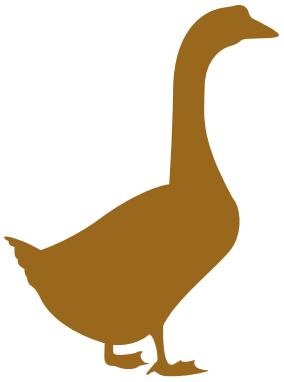
This Specialist Report is the key deliverable. After this Introduction, Section 2 describes the methods used to locate and review literature, data and any other relevant knowledge. Section 3 provides background information on waterbird species, abundance, and utilization of the Kafue Flats. Section 4 summarizes the major factors affecting waterbird distribution and abundance on the Kafue Flats, and their link to water resources degradation and management. Section 5 then identifies and describes key waterbird species recommended as indicators to be used in a deeper Integrated Flows Assessment. Finally, Section 6 provides recommendations for Phase 2 of the Integrated Flows Assessment for the Kafue Flats.

Accompanying products include electronic copies of catalogued reference material and data.

2. APPROACH

2.1 DATA ACQUISITION AND STORAGE

STUDIES FOCUSED ON THE ECOLOGY OF WATERBIRDS, AND HABITAT PREFERENCES OF DUCKS, GEESE, AND WATTLED CRANES



Primary data used for this analysis were derived from repeat aerial surveys and observations of the Kafue Flats dating back to the early 1970s (Douthwaite, 1974; Howard and Aspinwall, 1984; Howard, 1989; Malambo, 1990; Jeffery et al. 1993; Dodman, 1996; Kamweneshe and Beilfuss, 2002; Chansa, 2005; Shanungu et al. 2016; Beilfuss and Shanungu, 2016), the African Waterbird Census conducted by Wetlands International and partners dating back to the early 1990s (http://www.wetlands.org), annual ground counts of waterbirds conducted by the Zambia Wildlife Authority/ Zambia Department of Parks and Wildlife since 2005, and other monitoring initiatives (e.g. boat and field monitoring reported in Shanungu and Smith (2013)). The Kafue Basin Research Project undertook several studies that provided baseline information on waterbirds on the Kafue Flats prior to construction of Itezhitezhi Dam (Douthwaite, 1973a,b). These studies focused on the ecology of waterbirds, and habitat preferences of ducks, geese, and Wattled Cranes - including baseline information on the historical distribution of Wattled Cranes across the Flats (Douthwaite, 1974). Shanungu et al. (2016) mapped the current spatial distribution of Wattled Cranes and other large waterbirds based on recent aerial surveys.

Additional data used in this report were acquired through internet searches on Google Scholar and ResearchGate, while others were sourced from the International Crane Foundation library services and the online library of the Kafue River Trust (kafuerivertrust.org). Raw data were acquired from unpublished data from the authors' collective research on waterbirds, vegetation, and ecology of the Kafue Flats wetlands, dating back to 2001. All of the data and reports acquired for this assessment are stored in the International Crane Foundation archives, which are available upon request, and are being placed in the WWF Freshwater/EFlows database for long-term storage.

3. WATERBIRDS, ABUNDANDANCE, AND UTILIZATION OF THE KAFUE FLATS

3.1 WATERBIRD DIVERSITY AND ABUNDANCE

At least 470 species of birds are known to occur on the Kafue Flats, more than 60% of the total bird species found in Zambia, and most of these species depend on the waters of the Kafue River Basin (Dowset and de Vos, 1963; Douthwaite, 1974; Leonard, 2005). Aerial and ground surveys of waterbirds dating back to the 1970s indicate that the Kafue Flats are consistently occupied by up to 74 species of resident waterbirds belonging to 24 families and 10 orders. The most abundant among these are the Anatidae family (ducks and geese), with globally important concentrations (regularly holding >1% of biogeographic population) of Fulvous Duck, White-faced Duck, White-backed Duck, Egyptian Goose, Spur-winged Goose, Knob-billed Duck, African Pygmy Goose, Red-billed Teal, Hottentot Teal, and Southern Pochard. Other globally important waterbird concentrations meeting the 1% population threshold include Reed Cormorant, Great White Pelican, Black Egret, Openbill Stork, African Spoonbill, Collared Pratincole, Kittlitz's Plover, Caspian Plover, Long-toed Plover, Black-tailed Godwit, Little Stint, Curlew Sandpiper, Ruff, and Whiskered Tern (Leonard, 2005). Overall, the Kafue Flats regularly supports more than 20,000 waterbirds throughout the year as well as many non-breeding Afrotropical and Palearctic migrant shorebirds.

Approximately 30% of the global population of Vulnerable Wattled Crane (breeding resident) occurs on the Kafue Flats (Shanungu et al. 2015; Crane Specialist Group, 2016). Other waterbird species of conservation concern occurring on the Flats, but not meeting the 1% global population threshold, include Endangered Grey Crowned Crane (breeding resident), Vulnerable Madagascar Squacco Heron (rare visitor), Vulnerable Slaty Egret (rare visitor), Vulnerable Corn Crake (regular non-breeding visitor), Near-Threatened African Skimmer (regular, possibly breeding resident), Near-Threatened Great Snipe (regular non-breeding visitor), Near-Threatened Lesser Flamingo (rare visitor), Near-Threatened Pallid Harrier (regular non-breeding visitor), Black-winged Pratincole (scarce non-breeding visitor), Common Bittern (possibly breeding), Goliath Heron (common breeding resident), Saddlebilled Stork (regular breeding resident), and African Marsh Harrier (regular breeding resident) (Leonard 2005). Slaty Egret numbers are known to fluctuate, but are regularly recorded, and flocks of up to 30 birds have been observed (Leonard, 2005). The status of African Skimmer is unclear, but flocks of several hundred birds have been recorded (Leonard and Peters, 1998).

AT LEAST 470 SPECIES OF BIRDS ARE KNOWN TO OCCUR ON THE KAFUE FLATS

The exceptional abundance and diversity of bird life on the Kafue Flats is highly dependent on the hydrological regime of the floodplain.

3.2 WATERBIRD UTILIZATION OF THE KAFUE FLATS

The Kafue Flats can be broadly divided into three ecological zones---Floodplain, Termitaria Grassland, and Woodland (Douthwaite and Van Lavieren, 1973; Ellenbroek, 1987; Blaser et al. 2013). The Floodplain zone occurs on lower elevations directly flooded by the Kafue River and local rainfall-runoff, and remains inundated from December to June in most years. The Termitaria Grassland zone occurs at mid elevations; it is seasonally waterlogged from local rainfall-runoff and can have impeded drainage depending on water levels on the floodplain, but is not inundated with standing water (Ellenbroek, 1987). The Woodland zone occurs at higher elevations and does not flood or have impeded drainage; its vegetation is influenced by local rainfall and is not strongly linked to the hydrological regime of the Kafue River (Ellenbroek, 1987; Douthwaite and van Lavieren, 1973).

Waterbirds on the Kafue Flats move within and among these ecological zones in response to the seasonal rise and fall of water levels (Dowset and de Vos, 1963). Many waterbird species require shallow water with ample feeding conditions, and deeper water to which to retire for rest or escape from predators (Dowset and de Vos, 1963; Douthwaite, 1989). The floodplain zone undergoes remarkable seasonal changes in water depth between the wet and dry season, directly affecting the availability of these feeding, resting, and roosting sites, as well as the suitability of breeding sites.

WATERBIRDS ON THE KAFUE FLATS MOVE WITHIN AND AMONG THESE ECOLOGICAL ZONES IN RESPONSE TO THE SEASONAL RISE AND FALL OF WATER LEVELS

During the rainy season, much of the floodplain is deeply inundated and the diversity and abundance of waterbirds is relatively low. Many species migrate to the waterlogged areas in the Termitaria and Woodland zones of the Flats. These provide suitable feeding and nesting habitats for large numbers of ducks and geese until water levels recede on the floodplain. As the water levels drops, during the dry season from May – August, the floodplain provides abundant food (including but not limited to vegetative tubers, seeds, crustaceans, insects, benthic invertebrates, amphibians, reptiles, and small mammals) for diverse species that feed in the shallow water and along the edge of receding floodwaters. This period marks the highest abundance and diversity of waterbirds. In the dry months of September – Late November, permanent streams and lagoons provide suitable feeding areas for birds until the water levels rise again with the onset of rains in Late November. Seasonal flooding also signals the arrival and departure of some migratory bird species.

The highest, outer edge of the floodplain is normally flooded to a shallow depth of 50 cm or less and is not flooded during dry years (Douthwaite and

THE LOWEST-LYING PART OF THE FLOODPLAINS CONSISTS OF GRASSLANDS THAT ARE DEEPLY INUNDATED SEASONALLY

Van Lavieren, 1977). This 'littoral zone' is composed of open grassland with a variety of annual and perennial herbs, and provides a wealth of food for a wide range of waterfowl, including the sedge Eleocharis dulcis that provides the key food source for Wattled Cranes (see below). When water levels recede during the prolonged dry season, the underlying swollen clay soils (vertisols) crack, creating crevices for ground nesting birds such as Kittliz's Plover and Common Pratincole. These cracks are enhanced by the trampling of large herbivores such as Kafue lechwe and Plains zebra. Plovers and Lapwings pluck invertebrates from the exposed ground surface.

The intermediate-lying floodplain is seasonally inundated to a shallow depth of about 50-100 cm during all but exceptionally dry years, and is composed of water meadow communities with small, weak stemmed grasses that barely keep pace with rising floodwaters and collapse completely as flooding subsides (Ellenbroek, 1987). Thick mats of collapsed vegetation cover the soil during the dry season, maintaining moist conditions at that time. This grassland is grazed heavily by Kafue lechwe when flooded, enhancing feeding conditions for thousands of Spurwing Geese, many species of ducks, and other waterbirds including Wattled Cranes.

The lowest-lying part of the floodplains consists of grasslands that are deeply inundated seasonally, with water levels often exceeding 1.5 m at high flood; this is the most extensive plant community on the Kafue Flats. The grasslands include coarse, thick stemmed grasses that float in the water, rise above peak flood levels, and remain upright when floods recede. The composition of plant species changes from year-to-year depending on flooding conditions. The period of inundation often exceeds six months, and the area may be perennially flooded during very wet years. Soil conditions remain moist throughout the dry season and stimulate new vegetative growth. After floodwaters recede, these grasses provide valuable grazing grounds for Kafue lechwe, hippopotamuses and cattle, and sustain the floodplain fishery by providing shelter for young fish and food for herbivorous fishes. Diverse wading birds, including Saddlebilled Storks, Goliath Herons, and various egrets, herons, and ibises feed on the abundant fish, amphibians and other aquatic life as floodwaters recede across the low and intermediate-lying plains. Secretive rails and crakes move with the receding floodwaters, foraging in dense vegetative cover for aquatic insects, other invertebrates, seeds and plant materials.

Permanent floodplain water bodies such as lagoons, oxbow lakes and backwater swamps support various communities of aquatic macrophytes. Lagoons are dead arms of the main river channel that remain connected to it throughout the year at their downstream end, with significant fluctuations in water level. Oxbows and swamps, only connected to the river during

PAPYRUS IS ALSO WELL KNOWN FOR ITS PRODUCTIVITY (THOMPSON, 1975) AND SUPPORTS A HIGH DENSITY OF BIRDS

overbank flooding events, have more stable hydrological conditions. Fish-eating pelicans occur in large concentrations of several hundred in these areas, wandering through the open water. In shallow, open waters, African Spoonbills forage for crustaceans and molluscs with their spatula-shaped beaks. Flamingos invert their bent beaks upside down to filter feed on algae and small crustaceans in shallow water. Diving species, including ducks and cormorants, feed in open water of small lakes and lagoons. Dabbling species focus their feeding activity on shallow pools and the edges of inundated areas, feeding on seeds of water lilies, sedges, grasses, and other herbaceous plants. Diving species feed in open water of small lakes and lagoons.

Papyrus swamps typically occupy these deep-water zones, with reed swamps common in more drought-prone or brackish environments (Thompson, 1985). As floodwaters recede, islands of floating papyrus Sudd often become stranded on the floodplain grasslands. The papyrus is also well known for its productivity (Thompson, 1975) and supports a high density of birds, including passerines such as Greater Swamp Warbler and Swamp Flycatcher (Leonard, 2005).

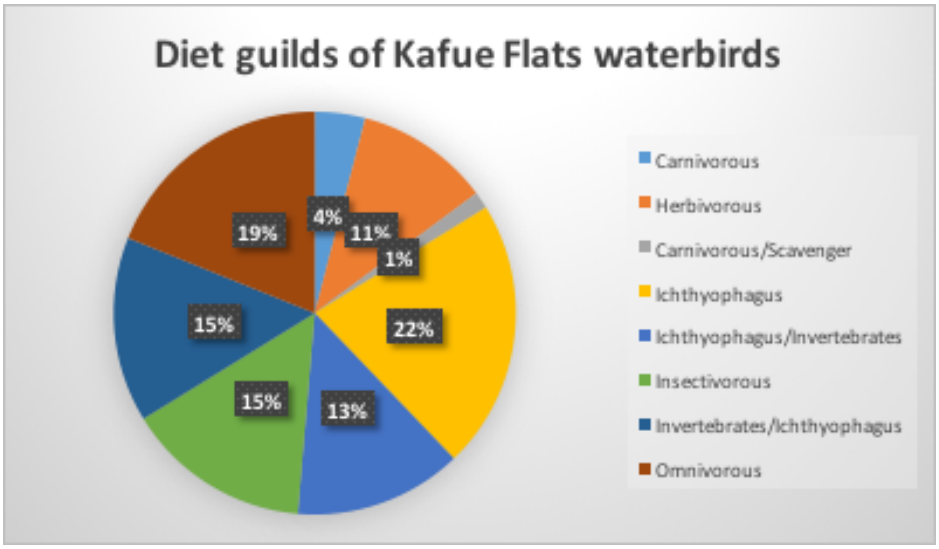
Immediately above the high-flood level, the floodplain margin is ringed by an extensive grassland dotted with termite mounds. This Termitaria zone may range from several hundred meters to more than 15 km in width. Dominant grasses include Acroceras macrum in rain-flooded depressions, Panicum spp., Setaria sphacelata on the intermediate plains, and Setaria incrassata-Hyparrhenia rufa at the escarpment ecotone in association with widely scattered woody species (Ellenbroek, 1987). Trees and shrubs may also be present on the higher termitaria. Many bird species migrate to the waterlogged areas in the Termitaria and woodland zones of the Flats, which provide suitable feeding and nesting habitats for large numbers of ducks and geese. Insectivorous birds, include lapwings, plovers and cattle egrets, are found on the termitaria grasslands and the edge of the floodplain. Egrets occur in shallowly inundated floodplains and on dry grassland areas, mainly following large herds of lechwe and zebra and feeding on insects flushed by trampling of the ground by these mammals. When dry, the Termitaria zone and drier floodplain areas support upland species such as the Red-capped Lark, Chestnut-backed Sparrow Lark, Grey-rumped Swallow, Richard's Pipit, Capped Wheatear and Quail Finch (Leonard, 2005).

Palm savannas occur at the floodplain-escarpment ecotone where the water table is high throughout the dry season. Rising above the Kafue Flats on the escarpment, associations of Acacia spp.-Combretum spp. (munga woodland), Colophospermum mopane woodland, Kalahari woodland, and miombo woodland dominate the surrounding landscape. Riparian woodland and forest occur along some of the tributary watercourses.

Shanungu (unpublished data) summarized the various diet guilds on the Kafue Flats (Figure 3.1). About 22% of waterbird species of the Kafue Flats are piscivorous. Omnivorous birds, feeding on seeds and tubers, as well as small insects and invertebrates, account for 19% of the waterbird species on the Kafue Flats. Strict herbivores account for only 11% of the total number of waterbird species, but they include most ducks and geese and are numerically the most abundant.

Figure 3.1

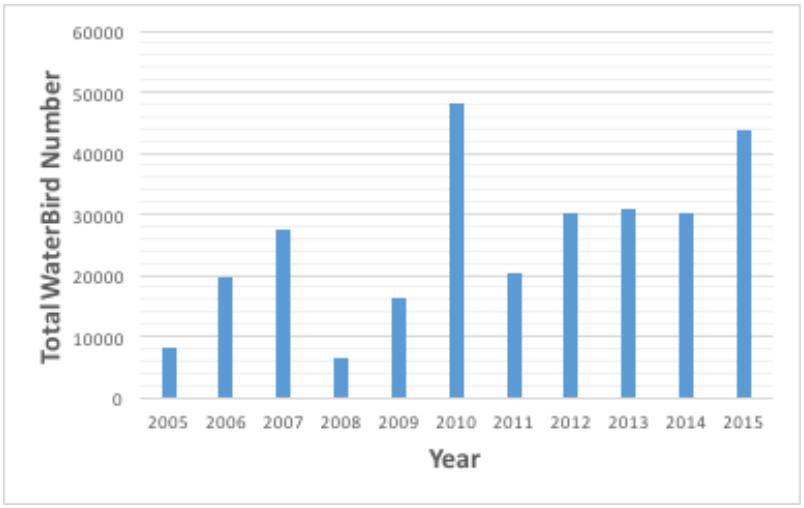
Feeding guilds of common waterbirds on the Kafue Flats. (Shanungu unpublished data).



The overall population of waterbirds on the Kafue Flats appears to fluctuate from year to year. Consistent monitoring of waterbird species has been conducted by the Department of National Parks and Wildlife (DNPW), formerly known as Zambia Wildlife Authority (ZAWA), and BirdWatch Zambia from 2005 to date. These surveys have been conducted every year in January and July as part of the BirdLife International Waterbird census. These data – although unpublished and intended for publication elsewhere – show that there have been annual fluctuations in waterbird abundance and diversity over the past ten-year period (Figure 3.2).

Figure 3.2

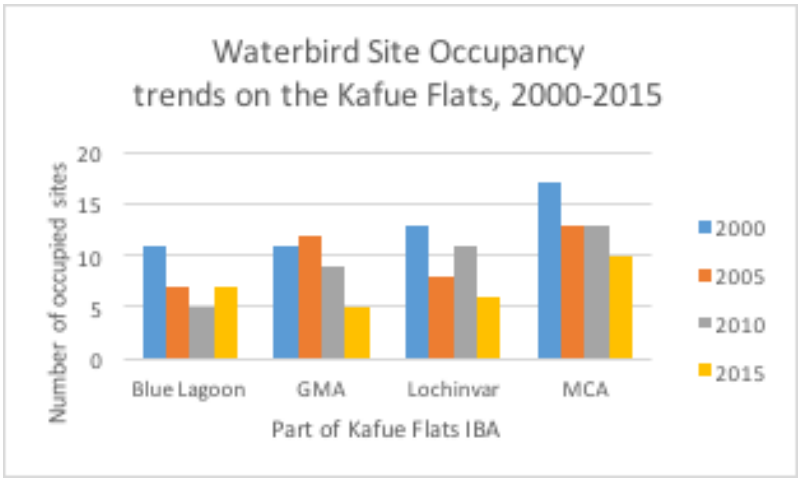
Waterbird numbers in Lochinvar National Park from July 2005 – July 2015. The graph shows annual fluctuations of numbers of all species counted in Lochinvar Park (Shanungu, unpublished data).



The number of sites occupied by waterbirds on the Kafue Flats appears to be decreasing over time (Figure 3.3). In Blue Lagoon National Park, for example, of the 11 sites occupied by waterbirds in 2000, only seven sites were occupied in 2015. The same trend occurs for Lochinvar NP, the Kafue Flats Game Management Area (GMA), and the Mwanachingwala Conservation Area (MCA).

Figure 3.3

Graph showing trends of site occupancy by waterbirds on the Kafue Flats for Important Bird Areas (IBAs), including Blue Lagoon and Lochinvar National Parks, the Kafue Flats Game Management Area (GMA), and Mwanachingwala Conservation Area (MCA) (Source WWF, Kafue Flats Status Report).



The apparent reduction in site occupancy for waterbirds suggests that some sites may no longer provide suitable habitat. This reduction in habitat suitability for waterbirds was apparent at the local (field monitoring) level, but is difficult to detect at a landscape (aerial survey or remote sensing) level. Observed factors affecting waterbird habitat availability include changes in hydrology (rainfall patterns, flooding regime), changes in vegetation (shrub encroachment and spread of invasive alien species), and human disturbance (influx of people onto the Kafue Flats for artisanal fishing). The following section provides an overview of these key factors. Section 5 then examines specific waterbird species that may serve as excellent indicator species for assessing the impact of integrated flow management for the Kafue Flats.

4. MAJOR FACTORS INFLUENCING WATERBIRD DISTRIBUTION AND ABUNDANCE ON THE KAFUE FLATS

4.1 HYDROLOGICAL DEGRADATION

For more than 40 years, the flooding regime of the Kafue Flats has been highly modified by the water regulation for hydropower development upstream and downstream of the Flats.

The dam at Kafue Gorge, downstream of the Flats, was completed in 1971, resulting in the upstream inundation of an area of approximately 1,000 km^2. Because of the low topography, the reservoir is very shallow and has a live storage capacity of just 785 Mm^3. The power plant requires a minimum flow of 120 m3s-1 to maintain its firm energy target of 450 MW. In order to guarantee this flow throughout the year, in the second phase of the project, another dam was built at Itezhi-tezhi (ITT), 450 km upstream from Kafue Gorge and just upstream of the Kafue Flats. This dam was completed in 1977. The resulting reservoir has an area of about 300 km^2 and a live storage capacity of 4,925 Mm^3, which is equivalent to 56% of the long-term mean annual flow into the reservoir. The Zambia Electricity Supply Corporation (ZESCO) operates both dams.

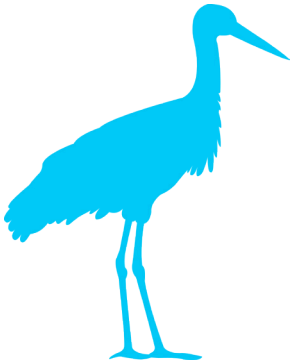
THE POWER PLANT REQUIRES A MINIMUM FLOW OF 120 M^{3}S-1 TO MAINTAIN ITS FIRM ENERGY TARGET OF 450MW

Serious concerns about the impact of water resources development on the ecological functioning of the Kafue Flats (vegetation and wildlife) were raised at a national level prior to and immediately following Kafue River regulation (e.g., FAO, 1968; Douthwaite, 1974; Kafue Basin Research Committee, 1977; Douthwaite and van Lavieren 1977; Howard and Williams, 1982). The topic has received considerable attention since that time (Sharma, 1984; Handlos and Williams, 1985; Chabwela and Siwela, 1986; Chabwela and Ellenbrook, 1990; Kapungwe 1993; Kamweneshe and Beilfuss, 2002; Mumba and Thompson, 2005; McCartney et al. 2006), including the necessity for EFlow releases from ITT Dam and integrated river basin management to mitigate impacts (Burke et al. 1994; Scudder and Acreman, 1996; Beilfuss, 2000; Schelle and Pittock, 2006).

There is evidence that changes in the flooding regime have affected both the total population and the distribution of waterbirds and other animals on the Flats by modifying their habitats in three ways. First, grazing has been reduced because of altered vegetation distribution and quality of forage. This is particularly the case immediately downstream of ITT Dam where there is increasing encroachment onto the floodplain of dryland species (e.g. thickets of Dichrostachys cinerea and Acacia polycantha) (Chabwela et al. 2000). Second, increased inundation of the eastern end of the Flats is estimated to have reduced suitable habitat in floodplains at (now) Chunga Lagoon

from 1078 km² prior to dam construction to 970 km² after construction (Kapungwe, 1993). Third, the natural breeding system has been disturbed as a consequence of the changes to the flood regime (Nefdt, 1992). Furthermore, it is suspected that changes in aquatic plant species, invertebrate and fish populations arising as a consequence of the altered hydrological regime, have had an impact on waterbird populations.

Before construction of the ITT Dam, seasonal runoff from the Kafue River and its tributaries inundated the Kafue Flats to create a mosaic of floodplain grassland and permanent lagoons (Handlos, 1982). Most of the Kafue Flats is underlain by heavy (montmorillonite) vertisols or 'black clays' derived from deep Quaternary sediments. Water levels on the Flats start to rise in late November or early December, shortly after the onset of rains in the lower Kafue Basin, and the clay soils expand and become impermeable. At this time, a flood crest would normally have formed at the western end of the Flats downstream of ITT Gorge, spilling overbank across the floodplain. Floodwaters would have proceeded slowly eastwards, taking 80-90 days to traverse the flat, densely vegetated plain. Between December and February, runoff from local tributaries would have contributed to the widespread shallow flooding throughout the Flats (Shawinigan Lavalin and Hidrotécnica Portuguesa, 1990a). Floodwaters typically would have peaked at the eastern end of the Kafue Flats in April/May, well after the local rains had ended. The historical peak annual flood was about 500 m³ s-1, with a 100-year flood of about 3000 m³ s-1 (Sichingabula, 2000). During very wet years, up to 5650 km² of floodplain was inundated covering the whole of the Kafue Flats including the drier termitaria zones.



IT IS SUSPECTED THAT CHANGES IN AQUATIC PLANT SPECIES, INVERTEBRATE AND FISH POPULATIONS ARISING AS A CONSEQUENCE OF THE ALTERED HYDROLOGICAL REGIME, HAVE HAD AN IMPACT ON WATERBIRD POPULATIONS

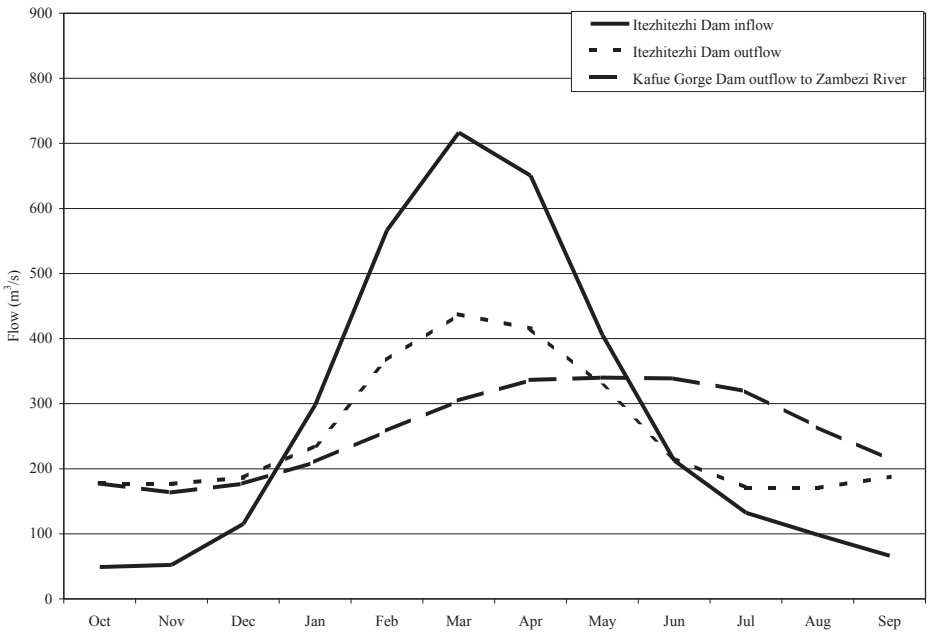
Since regulation, water availability on the Kafue Flats is largely dictated by releases from ITT Dam, based on power generation needs at the downstream Kafue Gorge Dam. Typical outflow from ITT Dam is about 168 m³ s-1, except during periods of exceptional runoff from the upper catchment areas. During a four week period each March an ecological freshet of 300 m³ s-1, is supposed to be released (DHV, 1980), but this has rarely occurred in recent years. As a result, the extent of flooding in the western portion of the Kafue Flats near ITT Dam has been greatly reduced (Sharma, 1984). Before impoundment, flow in the western flats ranged from 30-1400 m³ s-1, with a mean maximum inundated area of 4820 km² (Minderhoud, 1982). Under current conditions, only intermittent flooding occurs in the western part of the Flats, with erratic dry season flows (Chabwela, 1992) that may be out of synchronisation with natural flows. In 1991-92, for instance, maximum monthly flows in the lower Kafue occurred at the end of the dry season in October (Sichingabula, 2000).

The direct effects of hydropower generation on Kafue runoff since 1977 are illustrated in Figure 4.1. ITT Reservoir reduces downstream flows by 37%

on average during the peak runoff months of February-April. Peak releases from Kafue Gorge Dam, delayed 2-3 months by Kafue Flats and the Kafue Gorge Reservoir, show significantly lower seasonal variation (163-340 m^3 s-1) than unregulated Kafue River inflows to ITT Dam (49-717 m^3 s-1). Dry-season flows show a three-fold increase relative to unregulated conditions. Additional recent infrastructure development on the Kafue River system, most notably the 120 MW ITT power plant with peak-power generation and downstream fluctuations, will further exacerbate these changes (Harza Engineering and Rankin Engineering Consultants, 1999).

Figure 4.1

Hydrographs of mean monthly inflows and outflows at Itezhitezhi Reservoir, and outflows at Kafue Gorge Dam, 1977-98 (from Beilfuss and Santos, 2002).



4.2 ENCROACHMENT OF INVASIVE WOODY SPECIES

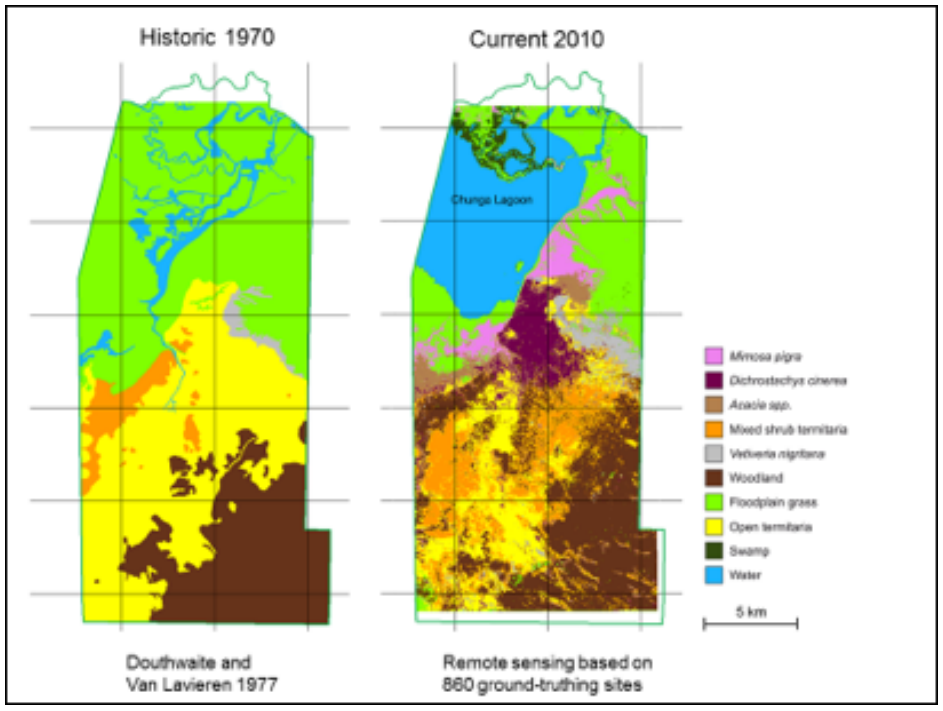
Over the last four decades, the Kafue Flats have experienced significant encroachment of native and invasive shrubs on the Termitaria and Floodplain Zones respectively (Blaser, 2013; Shanungu, 2013; Berhanu, 2006; Thomas, 2006) (Figure 4.2). These changes are attributed to changes in the flooding regime brought about by the operation of ITT and Kafue Gorge Dams in the 1970s (Blaser, 2013; Mumba, 2004).

The advancement of Mimosa Mimosa pigra across open floodplain areas has reduced suitable habitat for the herbivores such as the endemic Kafue Lechwe (Blaser, 2013) and for waterbirds on the Kafue Flats (Shanungu, 2009; Schmidt-Leverkuhne, 2015). For example, 24% of the floodplain grassland in Lochinvar National Park has been occupied by M. pigra, forming thick impenetrable and monospecific stands that excludes most of the native flora

and fauna including birds (Shanungu, 2009; Schmidt-Leverkuhne, 2015) and replaces the characteristic shallowly flooded grasslands (Blaser, 2013). The water bird species depend on this shallow grassland for nesting and many migratory and resident birds rely on the area for feeding (Leonard, 2005). The invasive shrub outcompetes plant species such as Echinochloa stagnina, Oryza longstaminata (Mumba and Thompson, 2005) and Eleocharis dulcis (Triet et al. 2004), the latter being one of the preferred food sources of Wattled Cranes (Ndirima, 2006). The continued spread of M. pigra and other encroaching woody species poses a serious threat to the diversity of bird species on the Kafue Flats (Shanungu, 2009; Schmidt-Leverkuhne, 2015) (Figure 4.2). Despite the problem posed by this invasive species and the continued expansion of the native Dichrostachys cinerea, the Kafue Flats remains an important conservation area for waterbirds and a long-term integrated approach to conserve the habitat for these species is needed.

Figure 4.2

Changes in vegetation composition around Chunga Lagoon in Lochinvar National Park, Kafue Flats from 1970 – 2010: Significant areas of open floodplain grasslands and termitaria grasslands have now been encroached by the invasive Mimosa pigra and the native woody species, Dichrostachys cinerea. (Source: Blaser, 2013).



THE KAFUE FLATS IS AN IMPORTANT GRAZING ECOSYSTEM THAT SUPPORTS LARGE NUMBERS OF HERBIVORES INCLUDING PLAINS ZEBRA, BLUE WILDEBEEST AND KAFUE LECHWE

4.3 REDUCED GRAZING INTENSITY

The Kafue Flats is an important grazing ecosystem that supports large numbers of herbivores including Plains Zebra, Blue Wildebeest and Kafue Lechwe. Historically, these and other herbivores occurred across the entire Kafue Flats in large numbers. Recent studies have shown that their numbers are in sharp decline, with the once abundant lechwe population declining by >70% from the late 1970s to date.

The intensive grazing regime of large floodplain systems like the Kafue Flats has an important role in maintaining diverse feeding niches for waterbirds. For example, Wattled Cranes feed on underground tubers of the sedge Eleocharis. Large grazers remove the above ground vegetation, increasing accessibility to the tubers. Trampling activities of the lechwe also encourage the presence of other species such as ducks, geese and ground nesting waders, because they expose various prey organisms such as worms, snails, frogs and similar (Dowset and de Vos, 1965; Douthwaite, 1973). Reductions in the lechwe populations, observed since the 1970s, have thus reduced the available food for waterbirds. Large mammals are addressed in another report in this Phase 1 integrated flows assessment, but their decrease can be attributed in part to changes in the hydrological regime of the Flats (reduced flooding) that has allowed increased (nearly year-round) human access to the floodplain. This can result in direct threats (higher rates of poaching) and indirect threats (human disturbance).

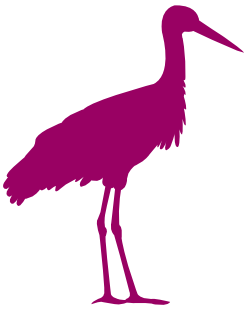
4.4 INCREASED HUMAN DISTURBANCE

The presence of numerous fishing camps on the Kafue Flats, in GMAs bordering the Lochinvar National Park and Blue Lagoon National Park pose a threat to the nesting and roosting sites there for cranes and other waterbirds (Shanungu et al. 2015). These areas are prone to fire in the dry season, likely impacting on the distribution of waterbirds – especially through affecting food availability and destroying nests. Furthermore, the expansion of fish camps and humans across the Flats has resulted in the displacement of waterbirds from their preferred habitats. There is also evidence of trapping waterbirds for food.

5. KEY WATERBIRD INDICATOR SPECIES FOR KAFUE FLATS INTEGRATED FLOW ASSESSMENT

The Kafue Flats waterbird population is abundant and diverse. Many species are resident, others are migratory (intra-African, Palaearctic, and some nomadic). Several species are rare and/or regionally or globally threatened. All waterbirds on the Kafue Flats are dependent on the floodplain ecosystem and its associated water regime (including the magnitude, timing, duration, and/or extent of surface waters, as well as the nature of groundwater regimes) at some time of the year. Many species spend their entire life cycle in close association with the floodplain—feeding, roosting, loafing, nesting, and provisioning their chicks on the floodplain. Some waterbird species depend on specific floodplain conditions to secure their nests and chicks from predation, trampling or fire, or to provide safe roosts. Many species require the rank growth of various wetland sedges and grasses for nesting materials or cover. Other species of waterbirds feed on a range of wetland food sources to meet their nutritional requirements for reproduction and migration, including underground rhizomes (tubers), seeds, and shoots of various aquatic and emergent plant species and animal protein such as snails, frogs, fish, and insects (adults and larvae). The river's flow regime is a major driver of the seasonal availability and abundance of these food items on the Flats. Hence, there are many important connections between waterbirds and the water conditions on the floodplain. The following waterbirds serve as useful indicator species for the diversity of water conditions required to maintain avian biodiversity on the Kafue Flats.

5.1 WATTLED CRANE—FLOOD PULSE INDICATOR



THE WATTLED CRANE IS A VULNERABLE SPECIES

The Wattled Crane is a Vulnerable species (BirdLife International, 2000), resident in sub-Saharan Africa. It is among the most floodplain-dependent waterbirds in Africa. Wattled Cranes feed predominately on tubers of Eleocharis spp., the sedges Cyperus spp. and water lillies, which are rich in carbohydrates. Tuber productivity is closely related to the seasonal inundation of the floodplain, with carbohydrate reserves stored underground during the long dry season to stimulate new shoot growth at the onset of the next flood season. Experience from Asia, Australia, and elsewhere in Africa suggests that tuber productivity declines when hydrological conditions, including failed flooding and/or permanent inundation, are altered (Beilfuss, 2000; Bento et al. 2007). Wattled cranes are stimulated to breed by the onset of the annual flood. Eggs are laid, often near the time of peak inundation, on a giant platform nest constructed of rank grasses and sedges and surrounded by water to protect against predators and fire. Wattled crane pairs rear only one chick per brood, which is fed on the burst of plant and animal protein

associated with the recession of floodplain waters during the dry season. Wattled crane ecology is covered extensively in Meine and Archibald (1996), and specifically for the Zambezi Delta in Bento (2002) and Bento et al. (2007). Douthwaite (1974) described Wattled Crane breeding biology in relation to hydrological changes in the Kafue Flats.

Historically and at present, the Kafue Flats hosts the single largest population of Wattled Cranes in Zambia (Shanungu et al. 2015). Population estimates for Wattled Cranes on the Kafue Flats are highly variable within and among years, however. Table 5.1 provides a time series of population estimates for Wattled Cranes, based on aerial surveys dating back to June 1972. Four surveys conducted in the late wet and late dry seasons of 1972 and 1973 resulted in population estimates ranging two-fold, from 1601 to 3085 (Douthwaite, 1974). The high counts each year were not consistent with respect to season, with a late wet season high count in 1972 and a late dry season high count in 1973. Surveys in the 1980s and early 1990s continued to result in highly variable population estimates, ranging from as few as 809 individuals (May 1993) to the highest counts on record in May 1982 and August 1989 (Howard and Aspinwall, 1984; Howard, 1989; Malambo, 1990; Jeffery et al., 1993; Dodman, 1996). A 2001 survey by Kamweneshe and Beilfuss (2002) produced another very low count (809 individuals), but more recent surveys, conducted in 2005 and 2015, suggest significantly higher numbers, reaching near-historic high population estimates in 2015 with an estimated population of 2,962 individuals (Shanungu et al. 2015).

Table 4.1

Wattled Crane population estimates on the Kafue Flats: 1972 to 2015. Surveys based on the core area of the Kafue Flats covering Lochinvar and Blue Lagoon National Parks and the Kafue Flats Game Management Area.

Year	Month	Estimate	Source
1972	June	1,601	Douthwaite,1974
1972	November	2,932	Douthwaite,1974
1973	May	3,085	Douthwaite, 1974
1973	August	2,336	Douthwaite, 1974
1982	May	3,282	Howard and Aspinwall, 1984
1987	November	2,508	Howard, 1989
1988	May/June	2,724	Malambo, 1990
1989	August	3,273	Malambo, 1990
1993	January	1,373	Dodman, 1996
1993	May	809	Jeffery et al., 1993
1993	July	1,268	Dodman, 1996
2001	November	967	Kamweneshe and Beilfuss, 2002a
2005	October	2,454	Chansa, 2005
2015	April	2,962	Shanungu, Kaumba, and Beilfuss, 2015

It is unclear whether these population shifts over time represent a true decline and recovery for the species as a whole; regional shifts in population numbers away from, and back to, the Kafue Flats; or in part to possible changes in survey techniques and coverage. There is no physical evidence of high crane mortality at any time during this period. The trends are especially confounding given that the health of the Wattled Crane population is considered to be strongly linked to seasonal water level fluctuations, the resulting availability of food resources such tubers of Eleocharis spp (Douthwaite, 1974), and access to food supply (soil penetrability) created by the trampling and grazing activity of floodplain herbivores (Bento et al. 2007). Seasonal water level fluctuations on the Kafue Flats have remained significantly damped/degraded by the stable year-round outflow of water from ITT Dam for hydropower production at Kafue Gorge throughout the period of record. Concurrently over this period, the population of Kafue Lechwe, the most abundant herbivore grazing the Kafue Flats floodplain where Wattled Cranes feed, has substantially declined, from an estimated population of nearly 110,000 Kafue Lechwe in 1973 (Osborne et al. 1973) to fewer than 30,000 in 2015 (Shanungu et al. 2015). More studies clearly are needed in order to understand how the fluctuations in Wattled Crane population are (or are not) linked to the hydrology, vegetation and the movement patterns and abundance of large grazing herbivores on the Flats, or other factors (such as human disturbance) yet to be determined.

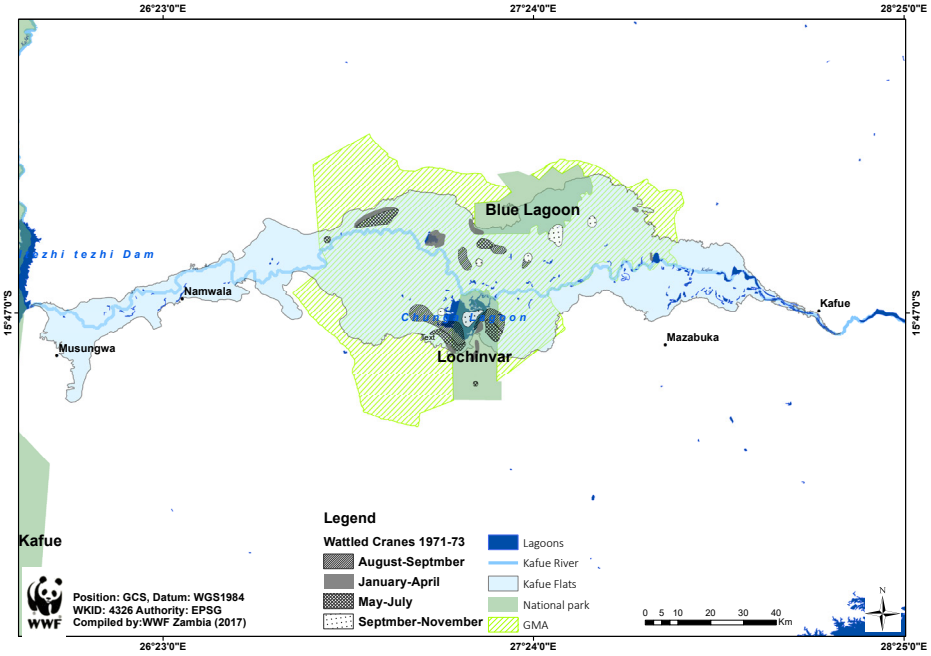
WATTLED CRANES OCCUR ACROSS THE ENTIRE FLATS BUT THE MAIN CONCENTRATION IS WITHIN THE PROTECTED AREA BOUNDARIES OF LOCHINVAR AND BLUE LAGOON NATIONAL PARKS AND THE KAFUE FLATS GAME MANAGEMENT AREA (GMA)

Wattled Cranes occur across the entire Flats but the main concentration is within the protected area boundaries of Lochinvar and Blue Lagoon National Parks and the Kafue Flats Game Management Area (GMA) (Figure 5.1). North of the Kafue River, Wattled Cranes occur in large numbers on the north-western edge of the Flats near Muwezwa's Courts and on the floodplain grassland from the Chawembe Lagoon to the Luwato Lagoon on the eastern edge of the floodplains. South of the Kafue River, Wattled Cranes are limited to areas northwest of Namalio fishing village and the east of Chunga Lagoon in Lochinvar National Park.

Historically, during the flood season, Wattled Cranes were observed to move from the northern half of Lochinvar National Park and occupy the saline grasslands adjacent to the Gwisho and Bwanda Hostprings in the southern half of Lochinvar (Doutwaite, 1974). As the flooding receded, the cranes moved back on the floodplains and occupied the wetland areas on the western edges of the Chunga lagoon near Namalio Fishing Camp. Similarly, Wattled Cranes showed seasonal movement on the northern floodplains of the Flats, with large flocks occurring south-east of Chawembe Lagoon and west of Boot Lagoon with populations reaching more than 3000 during the latter half of the dry season between September and November (Douthwaite, 1974). These flocks moved outwards towards the Muwezwa Court and the Luwato Lagoon as the water levels rose on the floodplain (Douthwaite, 1974). When water levels were above average, Douthwaite (1974) observed that Wattled Cranes stayed on the edges of the floodplains until they subsided, and then moved onto and occupied the floodplains on the northern section of Lochinvar and towards the Lubwato lagoon in Blue Lagoon National Park. From these studies, Douthwaite (1974) concluded that Wattled Crane movement was determined primarily by the rise and fall of water levels on the Kafue Flats.

Figure 5.1

Historic seasonal distribution of Wattled Cranes on the Kafue Flats as recorded by aerial surveys covering Lochinvar and Blue Lagoon National Parks and the Kafue Flats Game Management Area, 1971–1973 (Source: Douthwaite, 1974).



A wet-season aerial survey covering all floodplains areas of Blue Lagoon and Lochinvar National Parks and the Kafue Flats Game Management Area was conducted in April 2015 (Shanungu et al. 2015). Most of the Wattled Crane population was observed within the middle section of the Kafue Flats between Lochinvar and Blue Lagoon National Parks (Figure 5.2). The majority of the crane population occurred between Chewembe Lagoon and Luwato Lagoon on floodplains north of the Kafue River (about 80% of the population), with the remaining 20% occurring south of the Kafue River - including floodplain areas around Namalio Fishing Camp, the grasslands of Bwanda and Gwisho hot springs, and floodplains east of Chunga Lagoon (Shanungu et al. 2015).

Dry-season ground counts on the floodplains of Lochinvar National Park (Smith and Shanungu, 2014) indicated that the cranes are mostly confined to the western and eastern edges of the Chunga Lagoon (Figure 5.3). On the northern floodplains, the cranes are distributed along the high flood line west of the Lubwato Lagoon. Wattled Crane are mostly widespread and evenly distributed in the wet season but form large congregations and are confined to the National Parks and just beyond their boundaries in the dry season.

Figure 5.2

Spatial distribution of Wattled Cranes on the Kafue Flats (covering Lochinvar and Blue Lagoon National Parks and the Kafue Flats Game Management Area) in the wet season, based on an aerial survey in April 2015. Abundances of Wattled Cranes are denoted by the size of the dots, reflecting pairs (1-2), family groups (3), and small (4-8), medium (9-20), and large flocks (>20). (Source: Shanungu et al. 2015).

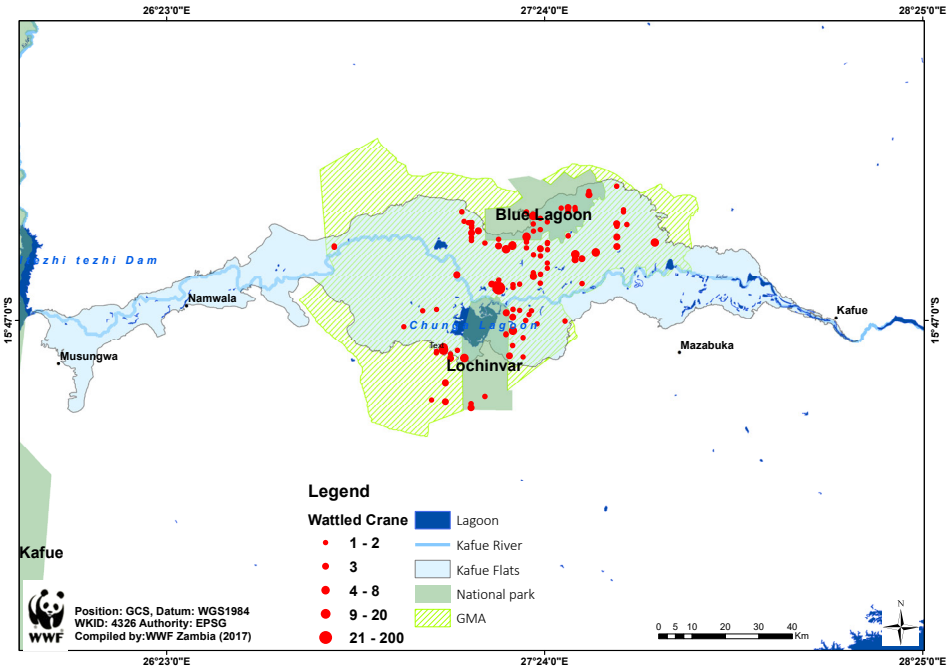
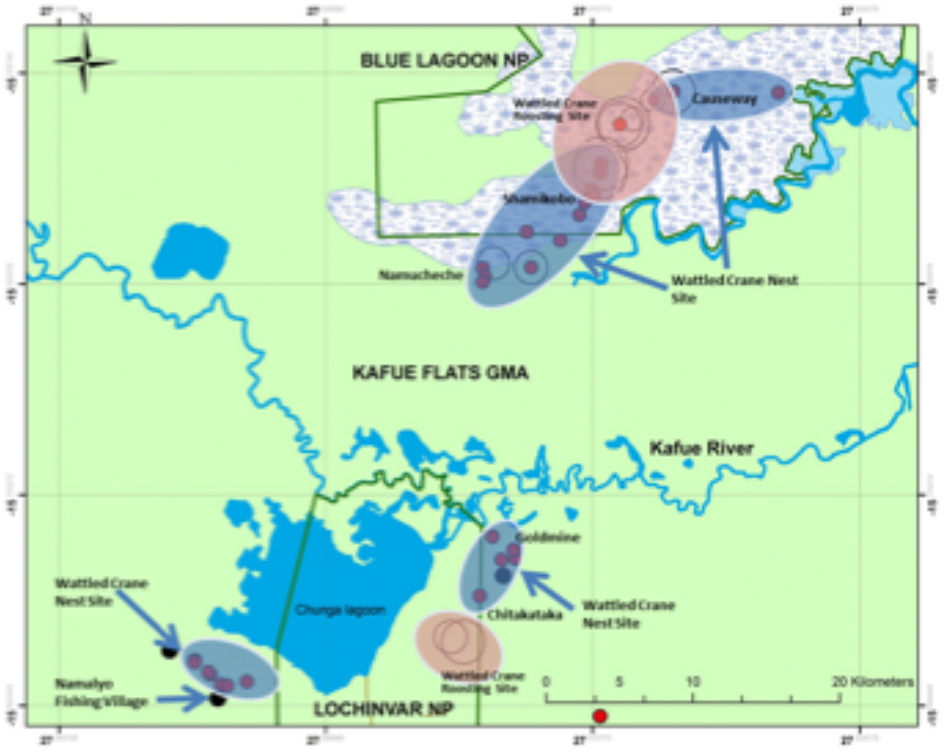


Figure 5.3

Dry-season distribution of Wattled Cranes, showing nesting sites and occupancy in Lochinvar and Blue Lagoon National Parks (Smith and Shanungu, 2014).



Some important differences in the Wattled Crane distribution are discernible from the historic distribution map (based on 1971-73 data) and most recent distribution map (2015), which can be directly related to river regulation. Chunga Lagoon, created by backwater impoundment of downstream Kafue Gorge Dam, was formerly a productive open floodplain used by Wattled Cranes during the dry and the wet seasons (Douthwaite, 1974). This area is now permanently inundated as a shallow, unvegetated lake, and is unsuitable for Wattled Cranes and other floodplain-feeding species. Furthermore, the encroachment of invasive species in Lochinvar National Park, especially the alien shrub M. pigra, has eliminated additional habitat for Wattled Cranes and other waterbirds species on the southern and eastern perimeter of Chunga Lagoon.

In undisturbed floodplain systems elsewhere in Africa, the breeding cycle of Wattled Cranes is intimately linked to the natural flood cycles of rivers. Wattled Crane pairs are 'triggered' to nest as floodwaters begin receding after peak flooding. By nesting in deep, open water after the major flood peaks, they ensure that nests will be protected from predators and wildfires but will not be drowned by further rising floodwaters. As floodwaters slowly recede, Wattled Cranes pairs raise their single chick on the pulse of exposed plant and insect life (Konrad, 1981).

Observations from the Lower Zambezi system, with its present erratic and mis-timed flooding due to releases from Kariba and Cahora Bassa Dams, revealed that Wattled Crane pairs may not be induced to initiate nesting or may nest at sub-optimal times. Where nesting is attempted, unanticipated water level rises can drown nests and food sources. Rapid drawdown of the water level on the floodplains may expose nests to wildfires and predators, and limit food availability. Observations from the Kafue Flats support this explanation. Douthwaite (1974) observed that whereas 40% of Wattled Crane pairs attempted to breed in a year of normal flooding conditions, only 3% of all pairs breed in a year of negligible flooding conditions due to drought. When the hydrological regime of the Kafue Flats was altered by the ITT Dam, Konrad (1981) predicted a dramatic reduction in Wattled Crane nesting sites and feeding area. Supporting this, Dodman (1996) observed limited breeding activity on the Kafue Flats in 1992 (a drought year) and 1993 (normal precipitation year).

Overall, given their endangered status, the importance of the Kafue Flats to their survival (supporting more than 30% of the global population), and their high dependency on appropriate hydrological conditions for feeding, breeding, and seasonal movements on the Kafue Flats, Wattled Cranes are considered to be the most important waterbird indicator species for an EFlows Assessment.

5.2 SPURWINGED GOOSE—FLOOD PULSE INDICATOR

THE SPURWINGED GOOSE IS ALSO A WETLAND-DEPENDENT SPECIES, WITH SIMILAR HABITAT REQUIREMENTS TO THE WATTLED CRANE

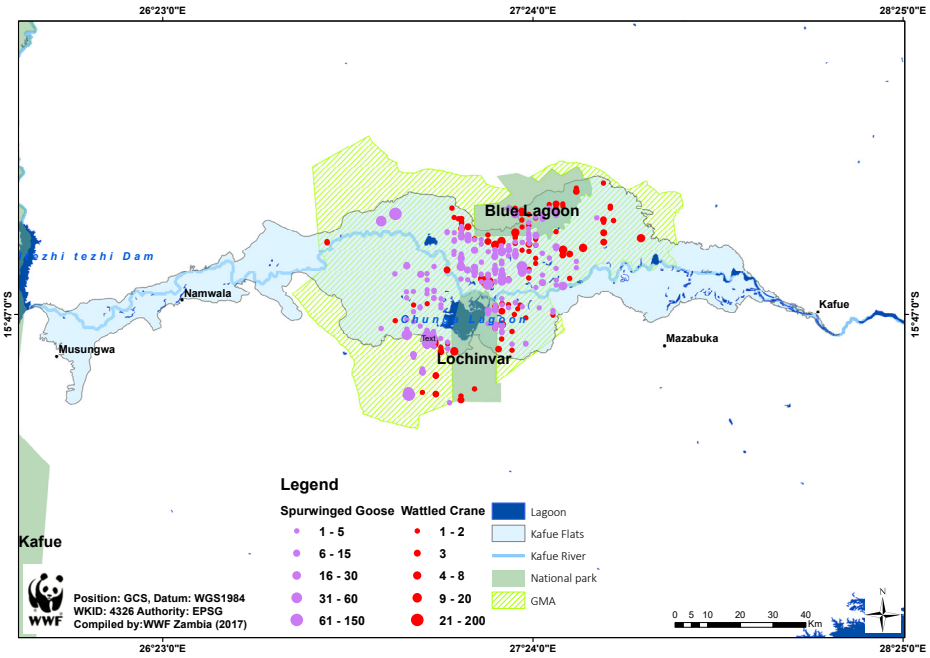
The Spurwinged Goose is also a wetland-dependent species, with similar habitat requirements to the Wattled Crane. Based on his waterbird research of the Kafue Flats, Douthwaite (1974) wrote "in seasonal occurrence, distribution and diet it was similar to the Wattled Crane although Spurwing were usually found in wetter areas...the two species also differed in the chronology of breeding and wing-molt." Although Spurwinged Geese feed on underground tubers, they have a more diverse diet than Wattled Crane that includes agricultural grains, fruits, grass shoots and seeds, and aquatic vegetation. The Spurwinged Goose depends on wetlands for nesting and roosting, but may rear 6-14 chicks per brood and is significantly less vulnerable to predation and drought. Thus, the Spurwinged Goose is a good example of a species that is affected by hydrological changes but to a somewhat lesser degree than the Wattled Crane. The biological attributes of the Spurwinged Goose are most recently detailed in Hockey et al. (2005).

Historically, the Spurwing Goose population on the Kafue Flats was estimated at more than 100,000 birds in November 1972 (Leonard, 2005). Beilfuss and Kamweneshe (2002) estimated a reduced population of >20,000 Spurwinged Goose, but the species remained the most abundant waterbird on the Kafue Flats. Spurwing Geese were observed in close association with Wattled Cranes on the floodplain, and their population decline mirrored that of the Wattled Crane over this same time period. More recently, Shanungu et al. (2015) estimated the population at 11,561: still the most abundant waterbird on the Kafue Flats, but with an almost 10-fold decrease from recorded historic levels. Figure 5.4 shows their distribution on the Kafue Flats, and their close association with Wattled Cranes, based on comprehensive coverage of Lochinvar and Blue Lagoon National Parks and the associated Kafue Flats Game Management Area.

The numerical importance of Spurwing Geese on the Kafue Flats, their dependence on the nature of its hydrological conditions albeit to a lesser extent than Wattled Cranes, and their long-term decline corresponding to the period of water regulation, suggest they are a good waterbird indicator species for EFlow assessments.

Figure 5.4

Spatial distribution of Spurwinged Goose on the Kafue Flats (covering Lochinvar and Blue Lagoon National Parks and the Kafue Flats Game Management Area), overlain with the spatial distribution of Wattled Cranes. Based on the April 2015 aerial survey (Shanungu et al. 2015). Species abundance is indicated by the size of the dots: Wattled Crane = red; Spurwing Goose = purple.



THE MASSIVE GOLIATH HERON IS HIGHLY DEPENDENT ON WETLANDS AND IS RARELY FOUND AWAY FROM WATER

5.3 GOLIATH HERON—FLOOD PULSE (FISHERIES) INDICATOR

The massive Goliath Heron is highly dependent on wetlands and is rarely found away from water. It inhabits shallow waters of rivers and lakes, marshes, tidal estuaries, reefs, and occasionally mangrove swamps, and is most common on the shores of large lakes. Goliath Herons are territorial, and solitary feeders with a diet that almost exclusively comprises fish, although frogs and other amphibians are occasionally taken. Goliath Herons tend to feed on the largest fish prey available, often ignoring smaller fish. They build a large nest of sticks and reed stalks, usually on the ground or beside dense, flattened reeds, sedges, or papyrus, and feed their young with regurgitated fish. The significant dependence of Goliath Herons on large fish prey makes them vulnerable to negative changes in the hydrological regime of the floodplain that reduce fish availability – especially the loss of the annual flood pulse (e.g. Welcome, 1975). The ecology of Goliath Herons was described in detail by Hancock and Kushlan (1984). No research has been conducted on the species on the Kafue Flats. It is consistently recorded on aerial and ground surveys of the Kafue Flats, but has not been enumerated.

The high visibility of Goliath Herons on the Kafue Flats, and their close association with (and dependence on) the status of its floodplain fisheries, suggest they are good additional waterbird indicator species for an EFlow Assessment.

5.4 AFRICAN SKIMMER, COMMON PRATINCOLE, AND KITTLIZ'S PLOVER—FLOOD PULSE (ESPECIALLY LOW FLOW) INDICATOR

African skimmers require seasonal low-flow conditions that expose river sandbars, where they build their nests. Breeding occurs during the dry season of July to October when flood waters recede. Eggs are incubated for 21 days, and nestlings remain on the sandbars for an additional 5-6 weeks until fledging. If a mistimed flooding event occurs at any time during this period, nests, eggs and chicks could be washed away. As a result, African skimmers – an endangered species in South Africa -- have all but disappeared from regulated rivers in Africa because of the increased dry-season flows associated with year-round hydropower production; irregular surges of water for generating diurnal peaking-power; and/or late dry-season releases to increase reservoir storage capacity for the coming rains.

Coppinger et al. (1988) described the distribution and breeding ecology of African Skimmers in the Upper and Middle Zambezi River, but no research has been conducted on the species specifically for the Kafue Flats. In large, unregulated rivers, water levels rise many metres during the annual flood, conveying heavy loads of suspended silt from upstream. As floodwaters recede, the silt is deposited and sandbars are formed. African Skimmers nest and roost on these exposed, open sandbars. At present the sediment load of the Kafue Flats is trapped by Itezhitezhi Reservoir and upstream floodplains. Most of the natural load of sandy sediments is no longer deposited downstream on the Flats, and the sandbars that depend on this

THE AFRICAN SKIMMER IS RESIDENT ON THE KAFUE FLATS, BUT ITS NUMBERS ARE POORLY UNDERSTOOD AND ITS BREEDING STATUS IS UNCLEAR

may be eroding. These sandbars are used as nest sites by Skimmers and other species but over time are being lost in two ways: by shrinkage of open sandy areas and by vegetation covering older sandbars. Nesting waterbirds abandon the vegetated sandbars (Dennis & Tarboton 1993).

The African Skimmer is resident on the Kafue Flats, but its numbers are poorly understood and its breeding status is unclear (Leonard, 2005). Given its strong dependence on the ebb of floodwaters and flush of sediments, the African Skimmer may be a good waterbird indicator species for EFlows Assessments.

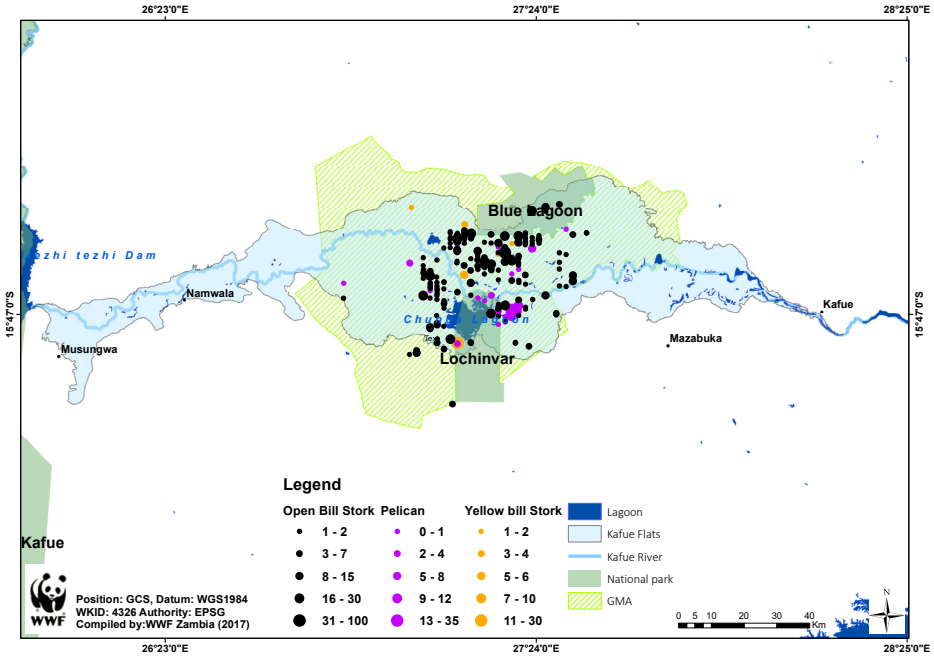
Alternatively, the Red-winged Pratincole and Kittlitz's Plover, both with globally important and potentially declining numbers on the Kafue Flats, might serve as better indicator species due to their relatively higher abundance and known breeding occurrence. Historical population estimates for the Red-winged Pratincole are >50,000 individuals (April 1972, May 1980) but more recent surveys place the estimate at about 17,000 based on a July 2000 survey (Leonard, 2005). The estimated population of Kittlitz's Plover is 5,000-6,000 based on an October 2000 survey (Leonard, 2005). Both species nest on the Kafue Flats when water levels recede during the prolonged dry season, exposing the underlying swollen clay soils (vertisols) that crack and create crevices for these ground nesting birds. These cracks are enhanced by the trampling of large herbivores such as Kafue Lechwe and Plains Zebra.

5.5 AFRICAN OPENBILL STORK – FLOOD PULSE (MOLLUSC) INDICATOR

African Openbill Storks concentrate in large numbers on the Kafue Flats to feed on freshwater snails and mussels. Leonard (2005) reported an astounding historical population of 500,000 African Openbill Stork on the Kafue Flats in November 1970 (although this number should be confirmed with the author for legitimacy). In October 1999, Leonard (2005) estimated 15,000-20,000 African Openbill Storks on the Flats, and Beilfuss and Kamwenshe (2002) estimated the population at >10,000.

Figure 5.5

Spatial distribution of Openbill Storks, African white pelicans, and Yellowbilled Storks on the Kafue Flats (covering Lochinvar and Blue Lagoon National Parks and the Kafue Flats Game Management Area) based on an aerial survey April 2015 (Source: Shanungu et al. 2015). Open Bill Stork = black; Pelican = purple; Yellow Billed Storks = orange.



OTHER WATERBIRD SPECIES OCCURRING ON THE KAFUE FLATS MAY WARRANT CONSIDERATION DUE TO THEIR SPECIALIZED DIETS LINKED TO FLOOD PULSE CONDITIONS

Hancock et al. (1992) described the biology of the African Openbill Stork in detail, emphasizing their highly specialized diet of molluscs. The species is considered to be highly gregarious in its breeding, foraging, flying, and roosting. The abundant supply of snails that follows very heavy rains and flooding events, often results in large concentrations of this species appearing in an area and breeding. Figure 5.5 shows the distribution of African Openbill Storks, White Pelicans and other waterbird species, during an April 2015 aerial survey of the Kafue Flats (Shanungu et al. 2015).

Their relative abundance but potentially dramatic decline in numbers on the Kafue Flats over the period since hydropower production affected flooding patterns, and their highly specialized diet linked to the annual flood pulse, suggest that African Openbill Storks may be a good waterbird indicator species for EFlow Assessments.

Collectively, these species represent an important suite of waterbird indicators for further investigation with respect to EFlow assessments. Other waterbird species occurring on the Kafue Flats may warrant consideration due to their specialized diets linked to flood pulse conditions, their rare or endangered status, population trends corresponding to the period of river regulation, or other factors. These may include especially globally threatened waterbird species (e.g., Grey Crowned Crane, Madagascar Squacco Heron, Slaty Egret, Corncrake, Great Snipe, Lesser Flamingo, Denham's Bustard, and Black-winged Pratincole), species of regional conservation concern (e.g., Eurasian Bittern, Saddlebilled Stork, and African Marsh Harrier), and/or some of the many species with globally important congregations on the Kafue Flats

6. RECOMMENDATIONS

The Kafue Flats is a Wetland of International Importance for waterbirds, supporting one of the densest concentrations of waterbirds in Africa and many species of global and regional conservation concern. Waterbirds are an important indicator of the ecological health of this wetland ecosystem.

WATERBIRDS ARE AN IMPORTANT INDICATOR OF THE ECOLOGICAL HEALTH OF THIS WETLAND ECOSYSTEM

Over the past half century, water-resources developments in the Kafue River Basin have fundamentally altered the timing, depth, duration, and frequency of flooding on the Kafue Flats. These changes threaten the future of waterbirds and their habitats across the Kafue Flats, both directly (through changes in the water regime) and indirectly (through changes in required habitat, invasive species, grazing activity, and human activity including fire and nest disturbance).

Despite these concerns, very few studies have assessed the link between the Kafue Flats water regime and waterbird diversity and abundance. The limited ecological research that has been conducted has focused on the interactions between the hydrology, vegetation, and herbivores, especially the Kafue Lechwe. Therefore, only limited data are available at present, much of these anecdotal, to assess the relationship between flows and Kafue Flats waterbirds. The following recommendations seek to increase our understanding of the ecological requirements of different waterbird indicator species of the Kafue Flats, and the potential for integrated flow management to maintain or enhance waterbird diversity, abundance, and distribution on the Kafue Flats.

- Conduct semi-annual aerial surveys (wet and dry season) to assess population status and trends, distribution, and threats on the Kafue Flats for four waterbird indicator species (Wattled Cranes, Spurwing Goose, Goliath Heron, African Openbill). Additional indicator species may be included if time and funding allows.

- Conduct monthly ground surveys to assess population status and trends, distribution, and threats on the Kafue Flats for three waterbird indicator species (African skimmer, Common pratincole, Kittliz's's plover) and supplement information from aerial surveys for the other four indicator species.

- Determine key factors influencing the selection of habitat by indicator species on the Kafue Flats for breeding, feeding, and roosting, as a function of water condition (e.g. depth, duration, onset of flooding), food source (e.g. Eleocharis spp.; tuber density for Watted Cranes; mussels for African Openbill), soil condition (e.g. soil penetrability for Wattled Cranes), grazing intensity (e.g. Kafue Lechwe grazing density for Wattled Cranes), and/or other factors (e.g. impact of fire timing and intensity on nesting and chicks; impact of M. pigra on habitat availability).

- Create seasonal maps of habitat suitability for each indicator species based on key factors affecting habitat selection, and map the monthly/seasonal distribution of the species relative to the habitat-suitability maps.

- Determine the link between different water conditions and factors affecting habitat suitability for each indicator species. For example, ascertain the relationship between water condition and fire (with respect to frequency, intensity, and timing of these events), soil penetrability, grazing intensity and the distribution of M. pigra.

- Determine the link between different flow management practices (such as ITT Dam outflows) and the spatial/temporal distribution of hydrological conditions affecting the availability of suitable habitat for each indicator species.

In general, there is inadequate information at present to conduct a detailed integrated flows assessment for waterbirds on the Kafue Flats, even for relatively well-studied species such as the Wattled Crane. Further research is needed before such an assessment can be used to evaluate the impact of different flow scenarios on waterbird population and distribution on the Kafue Flats. The above recommendations would be well suited to a series of MSc studies by graduate students, each study focusing on one or more of the indicator species with a careful EFlows-focussed schedule of data collection. This should be broadly supported by semi-annual aerial surveys, ground surveys, and other activities; independent projects are currently underway to map M. pigra, for example.

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Kafue Flats in numbers

44%

The Kafue River supplies 44% of Lusaka's domestic and industrial water

50%

The Kafue Gorge dam accounts for 50% of total hydropower production in Zambia

1 MILLION

Almost 1 million people depend directly on the Kafue Flats for their Livelihoods

WWF

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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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