Okavango River Basin Transboundary Diagnostic Analysis Technical Report

OKACOM

The Permanent Okavango River Basin Water Commission

Report

Transboundary Diagnostic Analysis

Basin Ecosystems Report

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June 2009

Environmental protection and sustainable management of the Okavango River Basin

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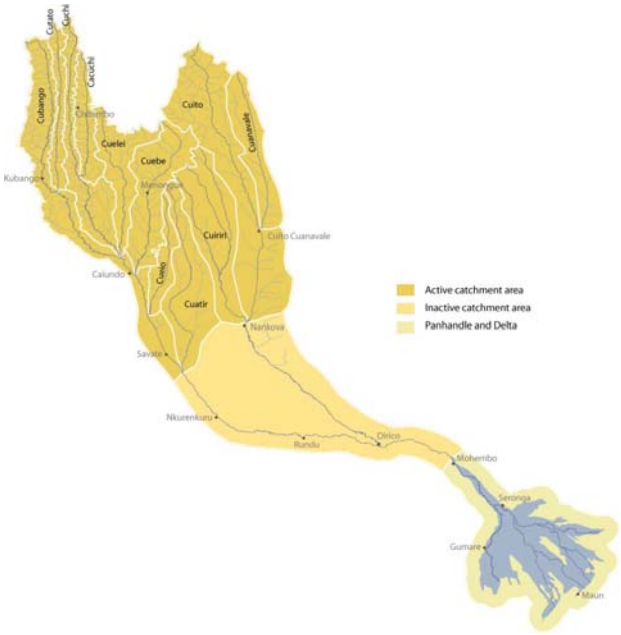
ENVIRONMENTAL PROTECTION AND SUSTAINABLE MANAGEMENT OF THE OKAVANGO RIVER BASIN (EPSMO)



Report

TRANSBOUNDARY DIAGNOSTIC ANALYSIS

BASIN ECOSYSTEMS REPORT

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NOVEMBER 2009

EXECUTIVE SUMMARY

The natural wetland resources of the Namibian section of the Okavango River Basin are important both nationally and internationally. At national level they contribute positively to the livelihoods of the people living alongside the Okavango River and its floodplains. Any alternations to the timing, intensity or duration of the flood cycle in the river will influence the ecological functioning of the system and reduce the available resource base.

Four main ecosystems were identified by the Environmental Flows Assessment river delineation exercise by the Namibian team of specialists:

- The mainstream and floodplain section from Katwitwi westwards to the Cuito confluence and on to Mukwe. This is a typical meandering mainstream with large seasonally-inundated floodplains on both sides of the river, often with a reed bed fringe. In the dry season, the floodplains provide grazing and fertile soils for "Molopo" farming. When flooded they provide shallow, safe, well-vegetated breeding, nursery and feeding areas for fish, frogs, birds and other aquatic animals and support a rich, diverse fauna and flora.
- The Cuito confluence and the river section immediately downstream of it. It covers a permanently swamped area with large islands, meanders, ox-bow lakes and waterlogged floodplains, typically fringed with papyrus and reeds containing permanent pools and swamp vegetation.
- The southwards flowing rocky, braided section from Mukwe to just below Popa Rapids.
- The protected area from Popa to the border with Botswana at Mohembo. This section includes the newly declared Bwabwata National Park with conservation areas on either side of the river, the Buffalo and Muhango Core Areas.

These ecosystems support a diversity of plants and animals, many of which are of conservation importance. This report discusses the endangered species, their habitat preferences and threats, identifies biodiversity hotspots and where known gives the conservation status of vulnerable species.

Vegetation: The riverine forest along the Okavango River has the highest tree biodiversity in Namibia. Here the Andara/Popa Rapids area has 130 taxa/quarter degree square – an area of about 27km x 27 km. Nine species found in this area downstream of Mukw meet the IUCN criteria for red data listing. Of these the ground orchid, *Bonatea steudneri* found on the islands near Andara is critically endangered, another ground orchid, *Eulophia livingstoniana* is endangered. Vulnerable species include two more ground orchids and three other orchids. Vulnerable trees include the Zambezi teak, *Baikiaea plurijuga,*and the Kiaat, *Pterocarpus angolensis*, both common in the Kalahari woodlands.
Aquatic Invertebrates: The abundance and diversity of aquatic macro-invertebrates clearly shows the excellent water quality and sound ecological health of the Okavango river section in Namibia. Based on museum records, Curtis (1990a) lists 256 species of aquatic invertebrates from the Okavango system in Namibia, that include 27 snail species, 6 crustacean species and 203 insect species of which 40 occur only in the Okavango in Namibia. Only one known endemic has been identified, it is the snail *Bellamya monardi*, found only in the rocky rapids at Andara and Popa. Despite this work, little beyond their occurance is known of this important invertebrate fauna. Currently, some work is being undertaken by a researcher at the Department of Water Affairs whois investigating using changes in the invertebrate assemblages to detect water quality and environmental degradation in the Okavango and elsewhere.

Aquatic, semi-aquatic and wetland vertebrates:
Twenty–eight frog species are thought to occur along the Okavango in Namibia although none are endemic. Very little is known of their habitat needs. Elsewhere in the world amphibians are considered to be important indicators of wetland health.

The fish in the system are very diverse and abundant due to the wide habitat diversity the Okavango River, its floodplains and rapids provide. Of the 83 species recorded within the Okavango River system, 79 occur in the Namibian section, but none are endemic. Hay (1995) found a decline in fish resources that he attributed to habitat destruction and over-fishing in the last 10 years. This is confirmed by the fact that fewer large specimens are being caught. The only exception is within the protected waters of the Muhango Core Area. The habitat specialists, especially the rheophilic fish living in the rocky rapids are of conservation importance. These include two rare red-data species, the broad-head catfish, *Clariallabes platyprosopos* and the oscillated spiny eel, *Aethiomastacembelus vanderwaali* (Skelton 1987, Hay 1995). Both are migratory species and as such are very vulnerable to the construction of dams or weirs in the rocky section of the river.

Reptiles found include land tortoises, terrapins, snakes, worm-lizards, skinks, lacertids, plated lizards, leguaans, agamas, a chameleon, geckos and the Nile crocodile. Of these the three tortoises, *Geochelone pardalis, Psammobates oculifer,* and *Kinixys belliana* are protected, as is the rock python, *Python sebae,* both leguaans, *Varanus exanthematicus, Varanus niloticus* and the crocodiles, *Crocodylus niloticus.*

There are 390 birds known to occur in the section of the river from Rundu to Mahango (Hines 1987, 1996). Of these several wetland birds are of conservation importance. Pel's fishing owl, little bitterns and Wattled cranes are considered critically endangered; Slaty egrets, Saddle-billed storks, Rock pratincoles, and Rufous-bellied herons are endangered; African fish eagles and African skimmers are vulnerable, whilst Maribou storks and Black-winged pratincoles are considered to be near threatened species (Simmons and Brown in prep). The main threats to birds are degradation of their wetland habitat by humans caused by reed harvesting, wood cutting, over-fishing and the use of pesticides. The few protected areas such as the Mahango and Buffalo core areas offer some limited sanctuary to wetland birds.

Mammals found along or near the river include 113 species or subspecies. These include shrews, 26 different bats, 3 primates, the Pangolin, Aardvark and Savanna hare, 25 rodents, 11 mongooses, the Plains zebra and 20 species of Artiodactyla including the rare bushbig, warthogs, hippopotamus, giraffe and 16 types of antelope.
The specially protected mammals are the Pangolin, African elephant, Plains zebra, Hippopotamus, Giraffe and impala, whilst protected mammals are the Southern lesser bushbaby, Lion, Bat-eared fox, African clawless otter, Spotted necked otter, Honey badger, Aardvark, Blue wildebeest, Tsessebe, Duiker, Oribi, Roan, Sable, Sitatunga, Bushbuck, Eland, Reedbuck and Waterbuck.

The main biodiversity hotspots are the Riparian woodlands between Mukwe and Popa rapids, the islands, Popa rapids and the small conservation section. The only protected areas are within the Bwabwata National Park and a small area at Popa. Reedbeds are possibly the most threatened habitat and essential to the breeding and feeding of many bird and fish species. Previously reed beds on the Angolan side ensured that this habitat remained available but now communities that have moved back to resettle along the Angolan bank have cleared large areas, often with the assistance of Namibians who cross illegally to harvest reeds too. Sandbanks scattered alongside the slower flowing sections are important to both crocodiles and birds such as the African Skimmer and Carmine bee-eaters that nest there. These are very vulnerable to predation or flooding when water levels change and flood regimes are altered.

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1. INTRODUCTION

The Okavango River is a perennial river shared by three countries. The river basin extends across Angola, Namibia and Botswana, covering an area of 700 000 km^2 of which about 192,500 km^2 (only 28.5%), actively contributes to surface flows (Mendlesohn and El Obied 2004). In Namibia, the Okavango River, also called the Kavango River, flows eastwards through the Kavango Region for 415 km before turning abruptly southwards at Mukwe from where it forms the border with the Caprivi Region for the next 55 km, until it enters Botswana at Mohembo (Bethune 1991). For most of the Namibian section the altitude is about 1000m ASL. Most of the basin is overlain by thick, Kalahari sand allowing rapid drainage. The combination of the very gradual gradient and sandy substrate has resulted in a river section typified by floodplains all the way up to Mukwe. Beyond this a quartzite dyke causes the river to turn southwards, the riverine ecosystem changes to become rocky and to braid around a series of both rock and sand based islands. One advantage of the very sandy substrate is the excellent water quality. Okavango River water is typically clean, clear and low in nutrients (Bethune 1991). Downstream in the Delta this nutrient-poor water favours the growth of papyrus, so important in maintaining the dynamics of the Delta ecosystem (Ellery and Ellery 1997).

The Okavango River system is a dynamic system, dependent on seasonal floods. The seasonal floodplains in the middle section of the river in Namibia and Angola and the seasonal swamps, in the lower alluvial fan in Botswana, typically alternate between annual dry and wet periods. In the dry season, these seasonal floodplains provide grazing and relatively fertile soils for molopo farming. When inundated by the annual floods they provide shallow, safe, well-vegetated breeding and nursery areas for fish, amphibians, birds and other aquatic animals and support a diverse flora. (Barnard *et al* 1998). Any alternation in the timing, intensity or duration of the flood will disrupt the ecological functioning of the system (Bruton and Merron 1985).

Across the basin, rainfall decreases markedly from north to south. At its source in Angola the annual average precipitation is above 1200 mm, whereas by the time it reaches Namibia, rainfall has decreased to between 600 and 700 mm/a. As a result of this disparity in rainfall, the catchment in Angola contributes almost two thirds of the water entering the system whilst Namibia contributes virtually nothing. Of the 9 000 – 10 000 Million m^3 that flows out of the Namibian section at Mohembo each year, the Rio Cubango sub-catchment (88 700 km^2) contributes about 55% and the Rio Cuito sub-catchment (60 000 km^2), 45% (Bethune and Van Wyk, 2004). The further south, the more variable the rainfall not only within seasons but also from season to season. The lowest flow ever measured at Mohembo was 6 000 Million m^3 for the 1992/93 season and the highest flow recorded was ten years later in the 1983/84 season when 13 640 Million m^3 was recorded, more than twice as much (Bethune and Van Wyk, 2004). Although figures are not yet available it is likely that the present 2009/10 season flows may be higher. Thus it becomes increasingly difficult to predict where, when and how much rain to expect. As a result the southern catchment is not only drier than the headwater areas but also more vulnerable to both droughts and floods.

Although several ephemeral river channels drain towards the Okavango River in Namibia, they do not provide any real runoff to the river. The largest of these tributaries is the Omuramba Omatako, which has not flowed beyond Kanovlei in living memory (Bethune and Skelton, unpublished) and is therefore considered to be a fossil drainage basin. As this sub-basin does not contribute to river flows, the ecosystems within it will not be dealt with in this report.

As rainfall decreases, with distance downstream, the climate changes from tropical and humid to semi-arid and evaporation rates increase. As may be expected, vegetation cover reflects the changing rainfall patterns and the diversity of habitats supported by the seasonal flooding of the river. Much of the catchment supports open or dense woodlands of mixed tree species. In Angola, the highland *Planalto* grasslands (Mendelsohn and el Obied 2004), are a boggy area at the source of the river from which numerous, mostly well-defined, swift-flowing tributaries flow southward through the miombo, *Brachystegia* and *Burkea* woodlands. As the gradient decreases, the ecosystems change to a quieter meandering river with large floodplains. The Namibian section includes extensive, annually inundated floodplain areas as well as some of the most species rich riparian woodlands in the country (Curtis and Mannheimer 2005). Five main riparian ecosystems can be distinguished within the Namibian section of the river: the deep, swift flowing, open river, with reed fringed banks; the well-vegetated floodplains; the more permanent swamp at the Cuito confluence; and the island and rocky rapid section downstream of Mukwe (Bethune 1991). In Botswana the Okavango forms a defined panhandle fringed by woodlands, reeds, papyrus and grasses and then opens out into an alluvial fan of permanently and seasonally flooded channels and lagoons fringed with papyrus reeds around grassy or wooded islands (Ellery and Ellery 1997).

According to Mendlesohn and Obied (2004), wildlife numbers are low in most of the catchment in Angola and Namibia, yet high in protected areas like the Muhango and Moremi parks. Dense human settlement and increasing clearing alongside the Namibian banks account for this paucity of game. Yet the overall species richness along the Okavango River in Namibia is considered high for smaller animals such as molluscs, insects, fish, frogs and birds (Curtis *et al* 1998) due to the rich diversity of habitats.

In a county as arid as Namibia, the natural wetland resources of this perennial river contribute positively to the livelihoods of the rural poor living alongside it. Although not yet calculated for the Namibian section of the river, recent wetland resource accounting done in 2005 for the Okavango Delta Management Plan in Botswana, shows substantial contributions. For example, the natural resources harvested (fish, wood and reeds) are worth over eleven and a half million Pula a year whilst the value of wildlife to tourism and hunting was estimated to be worth 362.75 million Pula annually (Department of Environmental Affairs, 2009, Bethune, Shaw, Roberts & WWGN, 2007). Similarly high figures have been calculated for the Zambezi River wetlands (Turpie, Smith, Emerton & Barnes, 1999). Despite this it can be argued that the climatic variability particularly in the southern half of the basin and the mostly infertile Kalahari sands within the most of the basin, make agriculture in the area a marginal and risky enterprise (Mendlesohn and el Obied 2003, 2004).

2. MAIN ECOSYSTEMS IN THE NAMIBIAN SECTION

A series of Integrated Units of Analysis (IUA) were identified as an initial step in the determination of the preliminary environmental flows assessment for the Okavango River Basin (Bethune, Mazvimavi & Quintino, Unpublished). These IUA reflect the main ecosystems that can be identified within the Okavango River system.

The specialist teams from each of the three basin countries were asked to select representative study sites for the preliminary environmental flows assessment with each site being representative of a wider area or ecosystem. These were termed Integrated Units of Analysis and aimed to provide the greatest possible range of environmental and social conditions characteristic of that IUA or part of the river basin. The Namibian team of 14 specialists was tasked to identify Integrated Units of Analysis along the Namibian section of the river and later to scale this down to only the two most important ones. Due to logistical and financial constraints the number so sites for the EFA were limited to 3 in Angola, 2 in Namibia and 3 in Botswana.

Initially four distinctly different ecological zones, with distinctive fish communities based on Hay *et al.* (2000) were identified for the Namibian section of the Okavango River and include for a short distance the confluence of the Cuito and the Okavango rivers which is a zone shared with Angola. These were:

- The river section from a little upstream of the border with Angola at Catambue to Bunya which is characterized by shallow water with sandy or rocky substrate;
- The section of better developed floodplains, oxbow lakes and backwaters from Bunya to Katere and againe beyond Katere to Mukwe;
- The Cuito confluence at Katere where the Cuito River joins the Okavango River, both Angolan and Namibian ecologists recognized a distinct area either side of the confluence (on the Angolan side from Lumeta to Dirico and on the Namibian side from Katere for some distance downstream) characterized by sandy islands, large meanders, papyrus fringes and large backwater;
- The rocky river and island section flowing southward from Mukwe to below the Popa Rapids characterized by boulders, rapids, sand and gravel substrate and dense riparian vegetation, an area with endemic fish and rare birds.

Added to this was the protected section just before the river enters Botswana which on account of its protective status supports a distinctly more diverse and productive fauna and flora. For many species this conservation area is the only area they are still found.

- The largely protected section from below the Popa Rapids to the border with Angola at Mohembo where the river widens, is less rocky, has a wider floodplain and some shallow backwaters. The protected areas are the Bwabwata National Parks with the Buffalo Core Area on the eastern bank, the Mahango Core Area on the western bank as well as the emerging conservancy at Kamatjonga on the edge northen edge of the Mahango Park.

Although the fish biologists distinguish more mainstream habitats the team agreed to consolidate all the river sections with floodplains into one IUA, and to divide the more rocky, braided river section without floodplains into the unprotected section south of Mukwe and the last protected section of the river within the Bwabwata National Park where the river borders on the Buffalo and Muhango Core Areas.

Initially the social scientists identified only two distinct areas within Namibia based on human use of riverine resources, the protected and the unprotected sections of the river. After discussion they agreed the rocky rapid and island section from Mukwe downstream was sufficiently different to warrant its own IUA. The Cuito confluence was recognized as an individual IUA, but within Angola because one IUA (in this case the Cuito confluence) cannot intersect another IUA (in this case the mainstream with floodplains that extends from north of Katwitwi to Mukwe).

Based on this, the following three Namibian IUA and one IUA shared with Angola were agreed:

1. Catambue to Mukwe – characterized by a clear mainstream with floodplains.
2. Mukwe to Popa – characterized by a narrower, rocky mainstream with braided sections around islands.
3. The protected area at Popa and within the Bwabwata National Park to Mohembo.
4. The Cuito confluence site Lumeta-Dirico in Angola that in reality extends some distance downstream into Namibia (Katere to Mukwe).

As only two study sites were allowed within Namibia, the IUA were prioritized according to their human population density, rare habitats and species, development plans, tourist value and threats, as well as the ecological and social impacts of these threats particularly on the flow regime. The two EFA sites finally selected were Kapako floodplains as representative of the floodplain ecosystem upstream of Mukwe, and, the Popa Rapids as representative of the rocky, braided river ecosystem.

The results of the delineation exercise and scores assigned out of five for each are given in Table 1 which sums up the main ecosystem characteristics of each.

Table 1: Four Main Ecosystem identified within the Namibian section of the Okavango River and the main criteria of each. Based on similar table in the delineations report.

Ecosystem (IUA)	Population	Conservation status	Potential Development	Tourism	Threats + Flow regime	Social impacts
Mainstream with floodplains: Flowing, clear river, Reed fringe Floodplains Channels Sandbars **27**	60 000 within 10 km of river + 40 000 in Rundu 5	↓ tigerfish ↓reedbeds ↓wildlife ↑ deforestation 4	Tar road north Irrigation incl. *Jeotropha* Tourist Lodges Urban expans. Aquaculture Water abstract to supply Wdk Settlement on Angolan bank 5	Several lodges many near Rundu J Mbamba Conserve. 3	Changes in W Quality & Quantity Vulnerable floodplains Fish breeding Sandbars Over fishing Bank + reed clearing 5	Trans-boundary conflicts resources Groundwater availability Resettlement Floodplains drying Pump nfrastructure W Quality, Fire ↓wetland resources fish, reeds, grazing 5
Cuito confluence: Swamp, permanent water, well vegetated **20**	12 000 3	Swamp spp. e.g. otters High productivity ↓reedbeds ↑deforestation 3	Tourism Water abstract to supply Wdk Irrigation incl. *Jeotropha* Development in Angola 3	Lodges Potential lodge dev. on island Angola Wildernes s aspect Angling + birding 4	Sandbars Vulnerable Swamps & Floodplains ↓W Quality & Quantity ↓Riparian vegetation – trees & reeds 4	Trans-boundary conflicts resources Groundwater availability Resettlement, Fire Floodplains drying Pumps + water infrastructure ↓Water Quality, ↓wetland resources – fish, reeds etc 3
Rocky, with islands: Confined braided	22 000, mainly Mukwe, Andara,	Otters Rock pratincoles Island &	Aquaculture Irrigation esp to East of river	Lodges Scenic Angling, boating	Vulnerable rapid fauna Alluvial + rocky islands	Wildlife- conflicts Rapids - loss of scenic attraction ↓ river resources – fish, riparian

channels, rapids, riparian woodland **21**	Divundu 2	rapids specialist spp. Endemic fish Riparian forest 3	Popa HydroP. Urban expans. Divundu Water abstract. 4	 5	Sandbars Vulnerable sand-nesting birds + crocs WQ & Quant 5	trees Fire 2
Protected Area: Bwabwata National P Riparian woodland, grass plains +floodplains **20**	6 000 in villages on west bank 1	Rare birds e.g. Afr. skimmers High wildlife High production Riparian forest 5	Aquaculture KIFI research Tourism infrastructure At Buffalo 2	Wilderness Aspect Birding Game Scenic 5	Vulnerable habitats, rare fauna & flora Floodplains Sandbars Illegal fish-poaching 5	↑ Tourism Access to lodges Wildlife conflicts –crocodiles, lion, elephants, buffalo. Fire 2

↓ decreasing ↑ increasing

The floodplain ecosystem rated highest whilst the scores for the other three were similar. It was agreed to select the rocky ecosystem for the present EFA and that the Cuito swamp and protected park area be included in future more detailed EFA studies. Potential EFA study sites within each chosen ecosystem were further assessed to ensure that they were could be considered representative and contained most of the habitats within each ecosystem. (See the EFA delineation report 4/2009).

Thus, the following four main ecosystems were identified by the Environmental Flows Assessment river delineation exercise by the Namibian team of specialists.

a) The mainstream and floodplain section from Katwitwi to the Cuito confluence and again beyond the confluence to Mukwe. An ecosystem with a typical meandering mainstream and large seasonally- flooded floodplains on either side, often fringed by reedbeds.

b) The Cuito confluence and river section immediately downstream with its permanently swamped areas, large islands, meanders, ox bow lakes and water-logged floodplain area typically fringed with papyrus and containing permanent pools and swamp vegetation.

c) Southward flowing rocky, braided section from Mukwe to just below the Popa Rapids. In this section the river is confined to clear braided channels around sand and rock islands, over rocky rapids with dense, species-rich, riverine woodland on either side.

d) Protected Area from Popa to the border with Botswana at Mohembo that includes the newly declared Bwabwata National Park with its two core conservation areas Buffalo and Muhango.

Broadly these agree with the ecosystems defined twenty years ago (Bethune 1991) and it can be argued that although often linked, the open water, mainstream ecosystem, can be considered a different ecosystem to the well vegetated floodplains.

Each ecosystem contains a variety of riverine habitats. These were further refined during the recent EFA vegetation study by Curtis (Unpublished). She identified 9 distinct habitats according to differences in periods of inundation, depth of flooding and the vegetation typical of each:

- The permanent river itself or aquatic mainstream or channel habitat, typically with a sandy substrate, clear, flowing water and with rooted submerged plants e.g. *Lagarosiphon* and sometimes floating-leaved vegetation e.g. *Potamogeton* that may be rooted in shallower, sections of the river. In the rocky, braided section of the river, the mainstream includes the rocky rapids and island habitats.
- The shallow margins of the river, also called the lower wet bank that is always wet where rooted floating leaf and some submerged plants grow such as hippo grass *Vossia cuspidata.* In the rocky section of the river this habitat is characterized by the papyrus fringe *Cyprus papyrus* and the fern *Thelypteris interupta.*
- The reed fringe of *Phragmites* species, also called the upper wet bank usually found at the edge of the low flow water level or immediately above the papyrus fringe.
- Beyond this the tree and shrub upper wet bank at the edge of the high water level, these are shrubs and trees that can survive short periods of inundation and occur either alongside the main river and channels or alongside the floodplains and floodplain channels e.g. *Searsia quartiniana* and *Ziziphus mucronata* and further downstream in the rocky section by *Syzygium* species.
- On slightly higher ground that is very seldom flooded is the typical dry bank habitat of riparian tree species that need to be near water but cannot withstand long periods of inundation e.g. *Albizia versicolor* and jackalberry trees, *Diospyros mespiliformis.*

- Within the floodplains several more habitats can be identified including floodplain pools deep enough to permanently remain wet, or floodplain residual pools that typically support waterlilies or *Nymphaea spp.*
- There are two types of floodplain channels, those on the inner margins of the floodplain that are usually deeper and may retain water even in the dry periods that support plants such as *Persicaria* and *Ludwigia* that can grow both on land and extend floating branches out over the water and
- The drier habitat on the outer margins of the floodplain furthest from the river or shallow enough to dry out and support floodplain grasses such as *Setaria, Vetiveria, Panicum, Sporobolus* and *Eragrostis* species, that wildlife and livestock graze on in the dry season.
- There are 'islands' of higher ground within the floodplains that are seldom flooded and thus support a more dryland flora e.g. *Acacia hebeclada* subspecies *chobensis* and *Searsia quartiniana*.

Obviously the last four habitats are not found in the rocky section of the river. Because the preliminary EFA study looked only at those habitats directly related to flows, none of the inland habitats such as the woodlands, river terraces, dunes nor fossil dunes are included. These are all important habitats for the terrestrial plants and fauna that occur within the Kavango Region. Further, as the preliminary EFA study was limited to on two IUA it did not include the swamp ecosystem at the Cuito confluence nor the protected areas within the Bwabwata National Park. Therefore habitats such as the papyrus swamp, shallow, slow meanders, sandbanks and the ox bow lakes at the Cuito confluence and seasonally flooded grasslands, sandbanks and riverine woodlands found in the last 50 km before the river enters the panhandle in Botswana are not described. Hines (1987) gives good descriptions of all the habitats found in the river section from Mukwe to Mahango.

3. ENDANGERED SPECIES, HABITAT PREFERENCES AND THREATS.

a) *Vegetation*

The only published work on the vegetation of the area is the habitat descriptions by Hines (1987, 1996) and the species list of plants associated with the riparian fringe and wetlands by Bethune (1987, 1991, 1992). Hines prepared a detailed vegetation map that was published in the Caprivi profile and includes the section of the Okavango River that crosses the Caprivi Strip (Mendlesohn & Roberts, 1997). This is also included in the vegetation maps in the Atlas (Mendlesohn, Jarvis, Roberts & Robertson 2002). Eleven major vegetation types are shown in the maps for the Kavango Region (Mendelsohn & El Obied, 2003) with only two alongside the river, one called floodplain and open water and the second from Mukwe to Mohembo as Riverine forest.
This riverine forest has been identified as the area having the highest tree biodiversity in the country (Curtis and Mannheimer, 2005). The area with the highest number of tree taxa per quarter degree square is the Andara/Popa rapids area which has 130 taxa per square, an area of about 27 km x 27 km. This is attributed to the high rainfall compared to the rest of Namibia, the diversity of habitats that include "riverine forest, floodplains, dunes, rocky outcrops and islands" and nutrient rich sediments deposited by river flows. Unfortunately this area is severely threatened by deforestation and human settlement. Divundu is one of the fastest growing settlements alongside the river and should the diamond and coal exploration prove successful these riparian forests will soon be lost.

According to the red data species list on the NBRI (Windhoek) database, nine plant species found mainly in the river section downstream of Mukwe, meet the criteria for IUCN red data listing. The only Critically Endangered species is the ground orchid, *Bonatea steudneri* found on islands near Andara. The only Endangered species is another ground orchid, *Eulophia livingstoniana,* although it is widespread in tropical Africa. Both these species are protected to some extent by the limited access to the islands in the river, but would be vulnerable to water level rises e.g. as a result of a hydropower impoundment at Popa that could flood these islands. There are several Vulnerable species, three are orchids, the leopard orchid, *Ansellia africana* which is rare on the islands between Mukwe and Divundu and elsewhere in Namibia and two ground orchids, *Habernaria epipactidea* also limited to the Mukwe-Divundu area and *Eulophia leachii* that also occurs in Caprivi. Vulnerable trees include the Zambezi Teak, *Baikiaea plurijuga,* and Kiaat, *Pterocarpus angolensis,* both common in the Kalahari woodlands. These are vulnerable to timber harvesting and too frequent fires, which do not allow the saplings to reach a size able to survive forest fires. Maps of fire frequency show how very vulnerable this region is to frequent burning (Mendlesohn & el Obied 2003, 2004).

An interesting species, although assigned to the red data category of Data-deficient, is the endemic African protea, *Protea gaguedi*. This is a species with an extremely limited range, that used to occur on the rocky outcrops near Andara but which has not been recorded since 1986 despite intensive efforts. It is thought to be locally extinct although some traditional leaders claim that some survive on the islands near Mukwe and Divundu. As these are traditional burial grounds of chief's, access to the islands is limited. The species has been seen in the woodlands in southern Angola. (personal observation).

b) *Aquatic Invertebrates*

Aquatic macro-invertebrates are processors of organic matter, vital in the self-purification processes of rivers and a valuable food source for larger animals. Each river system or section within it, has particular aquatic invertebrate communities and any reduction or increase in water flows, sediment or nutrient inputs will change the structure and effectiveness of these communities and cause some species to be lost and others to increase (de Moor 1997, de Moor *et al* 2002). The abundance and diversity of aquatic macro-invertebrates can be used as an indication of both water quality and the ecological health of a river (Palmer *et al.* 2002). Changes can help track water quality and general environmental degradation. Despite their importance, little is known of the aquatic invertebrate fauna of the Okavango River in Namibia and so far only one known Endemic has been identified, the snail, *Bellamya monardi,* found only at Andara and Popa.

According to an earlier TDA Okacom report (WTC1997, Curtis 1997) little research had been done on the ecology and habitat requirements of the aquatic invertebrates of the Okavango River. Despite some limited studies since then by Taylor on the application of SASS to assess water quality in the 1990s (Chutter, 1997)and recent collections at the two selected EFA study sites by Nakanwe (Unpublished) for the environmental flows assessment, there are still no detailed systematic surveys of the aquatic invertebrate fauna.

Based on museum records, Curtis (1990a) listed some 256 species of aquatic macro-invertebrates (mainly insects) from the Okavango River system. There are at least 27 snail species, 6 crustacean species, and 203 insect species found in the Okavango River (Curtis *et al.* 1998) of which 40 are found only in the Okavango. According to Piney (reported in Water Transfer Consultants, 1997), the Okavango Delta in Botswana is one of the richest and most interesting areas in southern Africa in terms of dragonflies (Odonata). This is confirmed by Curtis *et al.* (1991) who found high species richness for the Odonata as well as Diptera recorded from the Namibian section. Yet, very few Crustacea have been recorded. This may simply reflect low sampling as was the case in the Kunene River. Prior to a series of joint surveys, by the Department of Water Affairs and the Albany Museum, on the macro-invertebrates of the Kunene, only 58 aquatic invertebrate species had been recorded from the Kunene River (Curtis 1991). A single three week survey increased the number to over 216 species (De Moor, 1997, 2000). It can be assumed that the situation in the Okavango system is similar and that a detailed, dedicated survey should be undertaken to look more closely at the true diversity of aquatic invertebrates in the system.

An interesting finding by de Moor and his team (1997, 2000) is that the operation of the run-of-the-river hydro power scheme at Ruacana since the 1970s has had a major impact on the aquatic biota downstream. Due to the irregular water surges caused by daily releases from the power plant, large areas of the river bed are irregularly inundated and exposed, by water level changes of more than a meter making them unsuitable for colonization by macro invertebrates and aquatic plants. This unpredictable flow variations periodically leaves large sections of the river substrata either flooded or lying high and dry, significantly reducing the surface area available for macro-invertebrates to colonize, subsequently reducing the self purification capacity and natural ecological functioning of the river. It is the resultant decrease in the numbers of filter feeders and processors of organic matter that impairs the self-purification potential of the river.

More attention has been given to the snails of the Okavango River, particularly those of medical or veterinary importance and this is well documented (Curtis 1990a, 1990b, 1997, Curtis and Appleton 1987, Curtis *et al* 1998, Brown *et al* 1992). These confirm the diversity of snail species in the Okavango and that bilharzia is prevalent in the area.

One of snails, *Bellamya monardi*, is thought to be endemic to the Okavango River and has been found only at Andara and Popa Falls (Curtis 1990). Some of the other snails are endemic to the northern river systems. *Bellamya monardi* occurs only in the Okavango and Kunene rivers. *Pila occidentalis*, a large edible apple snail, is found only in the northern Namibian rivers and pans. The freshwater mussel, *Caelatura kunenensis,* is limited to the Kunene, Okavango and Cuvelai river systems and *Aspatharia pfeifferiana* is limited to the Kunene, Okavango and upper Zambezi rivers (Appleton 1996).

c) *Amphibians*

Namibia has about 50 species of frogs, with the highest species richness found along the perennial rivers. This is because these areas include both riverine and wetland species as well as more arid-adapted frogs.

A checklist of amphibians recorded from the Okavango River by Mike Griffin (Bethune 1987, 1991, 1992) lists 24 species. Since then this number has been revised to 28 different frog species which is still fewer than the 34 found in the Eastern Caprivi wetlands (Curtis *et al.* 1998). Work on a red data list of the frogs of Namibia is in progress but attempts to obtain information on this from Mike Griffin proved unsuccessful.

To date, no endemics have been recorded from the Okavango in Namibia. Namibia's endemic frogs are two desert adapted species and one wetland endemic, the Mpacha grass frog, *Ptychadena mpacha* found only in the Caprivi (Curtis *et al.* 1998)

d) *Fish*

The fish fauna in the Okavango River system is diverse and abundant as the river provides a wide habitat diversity to support this. Some 83 species have been recorded from the river system, including 79 in Namibia but none are endemic (Hay *et al*., 1996, Curtis *et al.* 1998).

Three fish species are considered to be Rare, red-data species. They are the broad-head catfish, *Clariallabes platyprosopos* and the oscillated spiny eel, *Aethiomastacembelus vanderwaali,* found only in rocky rapids and the rare *Ctenopoma microtenopoma,* or blackspot climbing perch, that occurs only in shallow marginal waters at the Cuito confluence (Skeleton 1987, Hay 1995). Although the catfish and spiny eel also occur in the Zambezi River, they are restricted to rocky rapid habitats which are uncommon in the Namibian sections of either of these rivers.

There is a wealth of literature on the fishes of the Okavango River System pertinent to this assessment (Bethune and Roberts 1991, Bethune and Skelton 1984, Hay 1995, Hay *et al* 1996, Holtzhausen 1991, Skelton 1987, 1993, Skelton and Merron 1984, 1985 1987, Skelton *et al* 1985 and Van der Waal 1990). Some of the species are sufficiently tolerant of changing conditions to survive water flow changes even as drastic as impoundment and to flourish there, whilst others with more specific requirements for flowing water, certain substrates such as vegetation or rocks, oxygen or temperature would die out.

Fish distribution in the Okavango River, is mainly determined by the duration and timing of floods, habitat preferences and food supplies. The seasonal flood cycle has a major influence on fish breeding and has been shown to directly stimulate spawning and the seasonally inundated shallow waters provide safe, shallow, well-vegetated nesting and nursery areas for fish. Migration is also triggered by these floods. Essentially fish behaviour is driven by the seasonal flooding of the river system. This link between river flows, flooding and fish was investigated more closely during the recent EFA study (van der Waal Unpublished)

Three distinct fish communities can be distinguished (Skelton and Merron 1984):

- a resident component of species found in the river throughout the year,
- a longitudinal component of fishes that migrate downstream with rising water levels to feed, spawn or breed and return upstream when water levels recede, and
- a lateral component that move into the floodplains to breed and feed when these are inundated, returning to the mainstream as the floodplains dry out.

Hay (1995) found a decline in fish resources in the river that he attributed to habitat destruction and over-fishing, his results show a steady decline in catch per unit effort over the last decade and that fewer large specimens are being caught in most areas. The only exceptions were within the protected area of the Mahango National Park. The most vulnerable species are the specialized feeders, the habitat specialists and those species dependent on the annual flood for successful reproduction.

Using fish to assess the biological status or index of biotic integrity of the aquatic environment of the Okavango River, Hay, van Zyl and Steyn (1996) noted a definite decline in the decade since 1984. The main changes being decreasing fish stocks, particularly of rheophilic species, and habitat deterioration together with an increase in turbidity attributed to increasing soil erosion as river banks are denuded. Of the seven sites surveyed along river, the only one where fish remained abundant was at Kwetze, within the Mahango National Park, emphasizing the importance of protection for both the fish resource and ecosystem.

Of conservation importance, are the habitat specialists or specific rheophilic species living in the rocky rapids habitats that extend from Mukwe to the Popa Falls. These are mainly small clarids or catfish adapted to rocky habitats and fast flowing water. They include species such as *Clarias stappersii, Clarias dumerilli,* the rare, solitary bagrid species, *Parauchenoglanis ngamensis*, the Common stargazer mountain catfish, *Amphilius uranoscopus,* the Long-tailed spiny eel, *Aethiomastacembelus frenatus,* the Okavango suckermouth or Rock catlet *Chiloglanis fasciatus,* the Slender stonebasher, *Hippopotamyrus ansorgii*, the Red-eye labeo *Labeo cylindricus,* as well as the two rare red-data species, the Broad-head catfish, *Clariallabes platyprosopos* and the Oscillated spiny eel, *Aethiomastacembelus vanderwaali* (Skeleton 1987, Hay 1995).

The designation of “rare” is given to species with small or restricted populations which are not at present endangered or vulnerable but which are at risk. In the “Red-data book on Fishes” Skelton (1987), warns that the Broad-head catfish and the Oscillated spiny eel are particularly vulnerable to the construction of dams and weirs, as are the migratory species that rely on flowing water and a free passage along the river.

The Oscillated spiny eel, is rare because of its very restricted habitat preferences, it lives in holes and crevices in rocks and needs well-oxygenated flowing water and is found only in a few localities in the Okavango and upper Zambezi rivers. Changes in water level and flow velocities would potentially destroy the specialist niche occupied by this species.The Broad-head catfish, is similarly rare and adapted to living in rocky rapids. Hay considers a third rheophilic species, the Rock catlet, as “vulnerable” in the Okavango River in Namibia and a possible candidate for red data status. These small rock catlets are seldom found, occurring only in the Okavango and Kwando rivers and would be threatened by soil erosion and impoundment. Another red-data species, the Rare *Ctenopoma microtenopoma,* is also vulnerable to water level or flow changes and occurs only in “the shallow marginal waters east of the Cuito confluence” (Hay 1995).
Migrations are the movement of whole populations or sections of populations for the specific purpose of breeding, feeding or dispersal. Several of the Okavango fish species are known to migrate in response to seasonal flood cycles in the river. These migrations, often occur by night and may be triggered by the first rains, by rising water levels or by flood pulses. They would be effectively stopped by any barrier across the river such as the proposed weir. The

rare Barred minnow, *Opsaridium zambezense,* occurs in clear rapidly flowing water in the pools below rapids and is known to migrate. In South Africa the construction of weirs and dams has led to its disappearance from several rivers (Skelton 1987).

Several of the fish species, particularly the larger predatory fish regularly migrate up and downstream as well as in and out of the floodplain areas. Any dams or weirs on the river in future would cut off these migrations, so essential to breeding success unless an effective fish-by-pass designed by fish specialists familiar with local conditions and the behaviour of local species is incorporated into the design of the weir or dam.

d) *Reptiles*

An annotated checklist of the reptiles expected to occur alongside the Okavango River in Namibia and their habitat preferences was drawn up based on Branch (1988) and included in the baseline Department of Water Affairs report on the Okavango River (Bethune 1997, 1991, 1992). This list records 3 species of land tortoises, 3 terrapin species, 32 snakes, 5 worm lizards, 3 skinks, 4 old world lizards or lacertids, 2 plated lizards, both the rock and water monitors, 2 agamas, one chameleon, 5 geckos and the Nile crocodile. Protected species are:

- the three tortoises, the Leopard tortoise, *Geochelone pardalis,* the Kalahari tent tortoise, *Psammobates oculifer,* and Bell's hinged tortoise *Kinixys belliana;*
- the African rock python, *Python sebae;*
- the two leguaans, the Rock monitor, *Varanus exanthematicus* and the Water monitor, *Varanus niloticus*; and
- the Nile crocodile, *Crocodylus niloticus*

Work is in progress to compile an annotated list of Namibian reptiles and their status.

e) *Birds*

Hines (1987, 1996) lists 390 bird species according to their habitat preferences in the section of the Okavango River from Rundu to Mahango and gives an overview of previous bird studies along the Okavango River in Namibia.

As part of the EIA on the downstream impacts of linking the Eastern National Water Carrier to the Okavango River at Rundu, Allen (1997) recorded 280 bird species in the river section downstream of Rundu extending into the panhandle and Delta in Botswana. Of these, 86 were counted as wetland birds and 23 were listed on the then provisional Namibian Red Data list. Critically Endangered species were: White-backed Night Heron, Saddlebilled Stork, Wattled Crane, Crowned Crane, African Finfoot, and Pel's Fishing Owl. The Endangered species found were, White Pelican, Pink-backed Pelican, Slaty Egret and African Skimmer. The Vulnerable category included, Red-faced Cisticola, Great Swamp Warbler, Coppery-tailed Coucal, Rock Pratincole, Redwinged Pratincole, African Marsh Harrier, African Fish Eagle, Hadeda Ibis, Glossy Ibis, Sacred Ibis, Yellowbilled Stork, Marabou Stork and Bitten. Not all occur in the Namibian section.
Since then the red data list of bird species for Namibia has been gradually revised. The preliminary list for the Okavango is given in Table 2. This shows that wetland birds such as Pel's Fishing Owl and Little Bittens are considered Critically Endangered. The Wattled Crane is listed as Critically Endangered by Simmons and Brown (in Prep), yet as Endangered based on the IUCN criteria. Other Endangered wetland species are the Slaty Egret, Saddle-billed Stork, Rock Pratincole, and Rufous-bellied Heron, whilst the African Fish Eagle and African Skimmer are considered Vulnerable. The Maribou Stork and Black-winged Pratincole are considered to be Near Threatened species.

The main threats to these birds are wetland degradation due to dense human pressure, reed harvesting, wood cutting, over-fishing and the use of pesticides such as DDT. Fortunately protected areas such as Mahango offer some sanctuary to these birds.

The Namibian red data list, rare and endemic birds are described in Simmons & Brown (in prep). Some of the interesting facts are outlined briefly:

- The Bittern, for example, is a Critically Endangered species with fewer than 50 birds estimated to occur in Namibia. It is threatened by loss of its reed habitat and is now confined mainly to the Mahango.
- Pel's Fishing Owl, Critically Endangered with fewer than 120 birds remaining, is heavily reliant on quiet backwater habitats with overhanging trees on the banks of large rivers such as the Okavango. These nocturnal birds now occur mainly in the last 20 km of the river and have been recorded in the dense riparian woodlands at Andara and Max Mukushu School. Both areas being increasingly deforested.
- Wattled Cranes, the rarest cranes in Africa, are Critically Endangered because of their very slow reproductive rate, only one chick is reared at a time and it only matures after 8-9 years. Only 300 birds are estimated to live in Namibia, they prefer floodplain areas and are threatened by fire and wetland degradation.
- Rock Pratincoles, an Endangered species, are restricted to their specialized habitat of rocky rapids and outcrops where they breed, feed and live. Although numbers are estimated to be about a thousand birds there has been a 20% decline over the last decade. Threats include over-fishing and wetland degradation.
- African Marsh Harriers, also Endangered, are found mainly along riverbeds with floodplains. In suitable habitat densities of 8 birds per 10 km have been counted alongside the Okavango River, but nationally there are only about 600 individuals.
- Saddle-billed Storks, also Endangered, prefer an open grassland habitat away from disturbance. There are 200 country-wide including those in Mahango Park.
- Rufous-bellied Herons too are Endangered, with about 300 of the 1000 estimated to be in Namibia, occurring along the Okavango River. They prefer habitats with floodplains, with reed or papyrus fringes. They are assumed to be very vulnerable to changes in water flow patterns as this will affect the shallow waters where they hunt for frogs and small fish.
- Slaty Egrets number fewer than 300 birds and are also Endangered, breeding in shallow, well vegetated swamp areas. They are threatened by reed harvesting, flood disruption, fire and climate change.
- Blackwinged Practincoles occur along the Okavango often in the same area as Rock Pratincoles, these are considered Near Threatened by the loss of grassland

Table 2: Red Data list of birds found along the Okavango River

SPECIES*	1998 listing	Current IUCN listing	*
Little Bittern	Vulnerable	Critically Endangered	Critically End.
Blue Crane	Endangered	Critically Endangered	
Pel's Fishing Owl	Critically Endangered	Critically Endangered	Critically End.
African Marsh-Harrier		Vulnerable	
Endangered		Endangered	
Bateleur	Endangered	Endangered	
Black Stork	Endangered	Endangered	
Booted Eagle	None	Endangered	
Martial Eagle	Vulnerable	Endangered	
Rock Pratincole	Vulnerable	Endangered	
Endangered			
Rufous-bellied Heron	None	Endangered	
Endangered			
Saddle-billed Stork	Critically Endangered	Endangered	
Endangered			
Slaty Egret	Endangered	Endangered	
Endangered			
Southern Ground Hornbill	Endangered	Endangered	
Tawny Eagle	Vulnerable	Endangered	
Violet Woodhoopoe	None	Endangered-Endemic	
Wattled Crane	Critically Endangered	Endangered	Critically End.
Yellow-billed Oxpecker	Vulnerable	Endangered	
African Fish-Eagle	Vulnerable	Vulnerable	Vulnerable
African Skimmer	Endangered	Vulnerable	Vulnerable
Little-necked Grebe	None	Near Threatened	
Black-winged Pratincole	None	Near Threatened	
Crowned Crane	Critically Endangered	Near Threatened	
Lesser Kestrel	None	Near Threatened	
Marabou Stork	Vulnerable	Near Threatened	Near Threaten.
		None	Near Threatened
Pallid Harrier	None	Near Threatened	
White-backed Vulture	None	Near Threatened	
Black-winged Practincole		Near Threatened	

Table 2 is based on a list received from Anne and Mike Scott that compares the 1998 Red data list and the current IUCN list. There was no Near Threatened category in the 1998 listings. All bird species in this list met one or more of the criteria set by the IUCN for inclusion into Namibia's first Red Data book (Anne & Mike Scott personal communication). The list is not limited to wetland species.

* The last column is the status according to Simmons & Brown (in Prep) and may well have been amended since the 2006 version on which it is based.

- African Skimmers with an estimated number of about 1200 in the country are considered Vulnerable particularly to any disturbance of the sandbanks they breed on. The wash of a passing motorboat can flood nests and drown chicks. They are particularly vulnerable to water level changes that could either inundate the sandbanks or if water levels drop make them accessible to predators. Breeding has been recorded in Mahango but so has trampling of nests by elephants and buffalo.

f) *Mammals*.

Although several older lists exist, the most recent is an annotated checklist of the mammals of Namibia is by Griffin and Coetzee (2005) that also gives provisional information on the national conservation status of each of the 211 species listed. This list will form the basis for the Namibian red data list for mammals (Griffin & Coetzee, 2005). For this TDA report, the list was studied to identify the 113 mammal species/subspecies of the Kavango and western Caprivi regions particularly along or near the Okavango R.

The Insectivora include four shrew species and the Short-snouted elephant shrew, *Elephantulus brachyrhycnchus.* There are 26 species of bats and three Primates, the Southern lesser bushbaby, *Galago moholi*, the Vervet monkey, *Chlorocebus pygerythus,* and the Chacma baboon, *Papio ursinus.* The Pangolin, *Manis temminckii*; and the Savanna hare, *Lepus victoriae herero* are the only members of their orders. There are 25 rodents including the Porcupine, *Hystrix africaeaustralis,* the Springhaas, *Pedetes capensis capensis* and the Greater cane rat, *Thryonomys swinderianus* as well as the Damara molerat, *Cryptomys damarensis,* the Woodland dormouse, *Graphiurus murinus griselda*, the Bush squirrel, *Paraxerus cepapi* , a variety of rats and mice and two gerbils.

The thirteen different Carnivora species include the Aardwolf, *Protelis cristatus,* the Spotted hyaena, *Crocuta crocuta* , possibly also the Brown hyaena, *Parahyaena brunnea;* seven members of the cat family, the protected Cheetah, *Acinonyx jubatus, L*eopard, *Panthera pardus pardus,L*lion, *Panthera leo*, the rare Small spotted cat, *Felis nigripes nigripes,* the African wildcat, *Filis lybica,* the Caracal, *Caracal caracal* and the Serval, *Leptailurus serval;* three of the dog family including the endangered Wild dog, *Lycaon pictus pictus,* the Bat-eared fox, *Otocyon megalotis megalotis* and the Side-striped jackal, *Canis adustus;* as well as five mustelidae which are the two otters, the African clawless otter, *Aonyx capensis* and the Spotted-necked otter, *Lutra maculicollis*, the Honey badger or ratel, *Mellivora capensis capensis,* the Striped polecat, *Ictonyx striatus* and the rare African striped weasel, *Poecilogale albinucha albinucha.*

There are eleven different Viviveridae including mongooses, the African civet, *Civettictis civetta* , the Rusty-spotted genet *Genetta maculata* and Small spotted genet, *Genetta genetta.* The Aardvark or antbear, *Orycteropus afer afer* and the African elephant, *Loxodonta africana africana* are each alone in their respective orders, whilst the Plains zebra, *Equus burchelli chapmani* is the only Perissodactyla in the area.

There are twenty species of Artiodactyla that include the rare Bushpig, *Potamochoerus larvatus nyasae*, theWarthog, *Phacochoerus africanus shortridgei*, the Hippopotamus, *Hippopotamusamphibius capensis* and the Giraffe, *Giraffa camelopardalis* as well as 16 different bovidae or antelope. The Bovidae are the blue wildebeest, *Connochaetes taurinus taurinus,* the internationally endangered Tsessebe, *Damaliscus lunatus lunatus,* the Duiker, *Sylvicapra grimmia,* the Oribi, *Ourebia ouribi rutila*, the Steenbok, *Raphicerus campestris steinhardti,* the Impala, *Aepyceros melampus melampus,* the Roan, *Hippotragus equinus cottoni*, the Sable *Hippotragus niger niger*, the African buffalo, *Syncherus caffer caffer*, the Greater kudu, *Tragelaphus strepsiceros strepsiceros*, the vulnerable Sitatunga, *Tragelaphus spekei selousi,* the Chobe bushbuck, *Tragelaphus scrptus ornatus*, the Eland, *Taurotragus oryx oryx,* as well as the wetland dependent Southern reedbuck, *Redunca arundinum*

arundinum, vagrant or introduced Common waterbuck, *Kobus ellipsiprymnus ellipsiprymnus* and the Red lechwe, *Kobus leche leche.*
Mammal species of conservation importance have in the past been designated Protected and Specially Protected status. This legal status is defined in the Nature Conservation Ordinance No 4 of 1975.

- The Specially Protected species found within the Okavango basin in Namibia are Pangolin, African elephant, Plains zebra, Hippopotamus, Giraffe and Impala.
- Those with Protected status are, Southern lesser bushbaby, Lion, Bat-eared fox, African clawless otter, Spotted-necked otter, Honey badger, Aardvark, Blue wildebeest, Tsessebe, Duiker, Oribi, Roan, Sable, Sitatunga, Bushbuck, Eland, Reedbuck and Waterbuck.

This outdated ordinance is expected to soon be replaced by the Parks and Wildlife Management Act which contains revisions of the protective status of many species.
In the new Act many more species will be Protected, for example all Insectivora, all bats, the Damara molerat, the Porcupine, the Springhaas, the Woodland dormouse, the Southern ground squirrel, the gerbils, Grey's climbing mouse, the Spotted Hyaena, the Side-striped jackal, Striped polecat, most of the Viverriddae and the Red lechwe will also be Protected. The status of Cheetah, Leopard, Lion, Waterbuck and Sitatunga will be upgraded to Specially Protected and the hitherto unprotected Small spotted cat, Bushpigs and African Buffalo will become Specially Protected. In contrast, Impala, Giraffe and African elephant are expected to be down-graded to Protected status. Species not mentioned such as the Hippopotamus, will retain their present status.

Where appropriate Griffin and Coetzee (2005) assign provisional red data status. Of the species living in the Okavango basin, only the Wild dog is designated as Endangered, while the following are considered Vulnerable: Swamp musk shrew, Southern lesser bushbaby, Pangolin, African elephant, Giraffe, Blue Wildebeest, Oribi, Roan, Sable, Tsessebe, Eland, Sitatunga, Bushbuck, Reedbuck and Red lechwe.

- In 2008 Namibia's Wild dog population was estimated to be only 160 – 259 animals and despite its specially protected status is still declining by 10% a year. The number recorded by the R Lines of the Namibian Wild dog project in Kavango and Bwabwata National Park are 25 and 20 respectively (Jarvis, 2009). As 95% of them live outside protected areas their main threats are persecution by livestock owners mainly due to prejudice and disturbance during their breeding season. Increasing rural densities and livestock numbers decrease the available space for wild dogs and increase the number of conflicts with farmers.
- The Swamp musk shrew, *Coridura mariquensis shortridgei* is wetland dependent and very susceptible to wetland habitat loss, which increases as more people settle in areas close to the rivers and floodplains.
- The Southern lesser bushbaby, is arboreal and thus threatened by deforestation.
- As elsewhere, Pangolins are threatened by the traditional medicine trade.
- Of the 3 570 Giraffe in the country, a third, 1100 occur in the Kavango districts.
- Oribi are associated with perennial rivers and 20% of their range is within Namibia, despite this theoccur only in very low numbers and rarely in Kavango.
- Sitatunga, are wetland dependent and require a reed habitat, they are vulnerable to reed harvesting and their numbers have declined since 1991 when 200 were estimated to be in the Kavango, Kwando and Linyanti systems together.

- Elephant numbers in Namibia exceed 22 000 animals of which the north eastern population is over 18 000 and increasing (Jarvis & Martin, 2008a) often with devastating impacts on vegetation as can be seen by damage to the riparian vegetation in the Mahango. Many move seasonally often crossing into neighbouring

countries. Although classified as "Threatened" globally, Namibia maintains a healthy population. This increasing trend in Elephant numbers is also clearly apparent in a comparison of five aerial game counts done of the Buffalo core area from 1985 to 1994 where numbers increase steadily from one seen in 1985, to 868 in 1987, to 1085 in 1990, 1209 in 1993 and 1533 in 1994 (Rodwell, Tagg and Grobler, 1995).

- Roan, Sable and Tsessebe are all water dependent grazers found in open savanna woodlands near the north eastern perennial rivers in Namibia. High proportions of the national populations of these species are found in the Kavango e.g. of the 1600 Roan in Namibia 1250 occur in the Kavango and Bushmanland area of he 450 Sable in the country 100 are in Mahango, whilst 60 of the 170 Tsessebe are also in Mahango (Griffin & Coetzee, 2005). As all are very selective feeders and have specific habitat requirements they are sensitive to habitat and climate change and their numbers are declining (Jarvis 2008a). Sable numbers in the Buffalo core area declined steadily from 52 in 1985 to only 16 in 1993 but had increased dramatically to 97 the next year (Rodwell *et al.* 1995). During the same period Roan decreased from 16 seen in 1987 to only 3 in 1994 and Tsessebe were not noted at all after 6 were counted in 1985.
- Chobe Bushbuck are vulnerable, secretive, wetland dependent species. In 1991 there were 500 in the northeast, since then their numbers have declined as settlement increased and riverine forest habitat decreased.
- Red lechwe, Waterbuck and Reedbuck are all Vulnerable wetland dependent antilope with specific habitat requirements. Reedbuck need tall grass and reedbeds close to water, Waterbuck must be near water and have good quality grass, they prefer open areas with reedbeds or woodland cover, whilst Red lechwe like shallowly flooded areas edged with papyrus, reeds or grasses(Jarvis 2008 b). Their numbers are declining and threats are thought to be competition with cattle that also destroy their habitats, burning, high elephant densities, poaching and the veterinary fences (Jarvis 2008 b). Waterbuck populations are no longer considered to be viable and recently new herds were introduced into Mahango from Botswana.
- Although their numbers increased steadily between 1985 to 1994 from 200, through, 250, 307, 380 to 401 in the Buffalo Core Area (Rodwell et al, 1995) and they are legally classified as huntable game, Griffin and Coetzee (2005) now recommended that Buffalo be designated as Specially Protected and note that only 15 of the 900 in Namibia were counted in the Mahango. Larger herds,, however still occur at least seasonally on the opposite bank in the Buffalo Core Area (personal observation). They need readily available surface water and good grazing often competing with other wildlife such as Elephants and with cattle. They are threatened by poaching and their range is limited by veterinary fences (Jarvis 2008c).
- The Hippopotamus subspecies occurring in the Okavango is a specially protected species, whilst the one found in the Kunene is Endangered. Hippos are semi-aquatic and must have permanent water deep enough to submerge in.

Each needs sufficient grazing of 150 kg per day. Of the 1 387 counted in the north eastern rivers, 247 or 18% were in the lower Okavango River, several more are known to live upstream near Nkurenkuru and at the confluence with the Cuito (Jarvis 2008c). Their main threats are loss of suitable grazing areas due to human settlement and cattle, while poaching is a problem even from neighbouring countries.

- The Bushpig, *Potomochoerus larvatus nyasae* is considered to be Rare and peripheral although it is classified as huntable game.

The only Endemic species is one of the two subspecies of the dwarf mongoose *Helogale parvual nero.* Semi-aquatic species such as the Hippopotamus and the wetland dependent species such as Roan, Sable, Tsessebe, Reedbuck, Waterbuck, Lechwe, and to a lesser extent Buffalo are likely to be affected by any changes in water levels and flows (Roberts, unpublished). The EFA recently completed further shows that in addition to these species

two other very wetland dependent species that can be considered to be at risk of habitat loss should flow regimes alter are the Greater canerat, *Thryonomys swinderianus* and Shortridge's mouse *Mastomys shortridgei,* found only in the Okavango wetlands.

4. BIODIVERSITY HOTSPOTS AND CONSERVATION STATUS IN THE NAMIBIAN SECTION

Based on the information available on the fauna and flora of the Okavango River in Namibia, their habitat preferences, their conservation status as well as the threats they face the following main biodiversity hotspots can be identified in the Namibian section:

a) *The Riparian woodlands* between Mukwe to below Popa Rapids and on the islands. This area has been identified by the Namibian Tree Atlas project as the section of Namibia that has the highest tree biodiversity in the country (Curtis and Mannheimer, 2005) and as an arboreal habitat providing fruit, browse, shelter, nesting sites and hiding places and perches is important to birds, reptiles and mammals such as the Chobe bushbuck. Overhanging trees such as those found near Andara are essential for rare birds such as the Pel's Fishing Owl (Simmons and Brown, in prep). A healthy riparian zone further prevents erosion and so protects water quality and provides shaded marginal waters where fish can hide from predators.

b) *The protected areas within the Bwabwata National Park – Popa as well as the core conservation areas at Buffalo and Mahango.* These together with the emerging and declared wildlife and forestry community conservancies afford much needed protection to many valuable plant and animal species and as seen in the discussion on endangered fauna are often the only refuge for many wetland dependent mammal species and clearly support the only fish populations along the river that are not declining (Hay *et al.* 2000).

c) *The Popa rapids and islands in the braided section*, are home to several rare and endemic fish species and aquatic invertebrates not found elsewhere in the river. Rapids are a relatively rare habitat in the perennial rivers of north eastern Namibia and thus limit the distribution of several species. The Endangered Rock pratincole is entirely dependent on this habitat (Simmons & Brown in prep). Due to their limited accessibility the islands in the braided section (used as traditional burial sites of chiefs) give protection to vegetation, reptiles and birds and small mammals and provide protection to many endangered and vulnerable plants species while many protected tree species are part of the riparian woodland community. Both protected otter species are found here.

d) *Reedbeds* are possibly one of the most threatened habitats all along the river and essential to the breeding and feeding of many wetland birds (Ndelliimona unpublished) as well as to many fish species that use the shelter of the reedbeds to hide from visual predators such as the Tiger fish by day and as safe breeding and feeding areas (Skelton and Merron 1984, 1987). For many years despite bank clearing on the Namibian side, the low population densities on the Angolan side provided dense reedbeds where fish could hide, wetland birds could nest and small mammals and amphibians could find shelter. In recent years with peace, communities have moved back to settle along the river bank and Namibians can safely cross to illegally harvest reeds on that side too (personal observation). This ecosystem is declining rapidly with adverse impacts of the natural biota. Fishermen in the areas adjoining the parks admit that they sneak in to set their nets along the edges of reedbeds in the Mahango Park where the bigger fish hide.

e) *Swamps at Cuito confluence.* Although little studied, this is seen as an important birding and fish breeding area (Mark Paxton personal communication) and as the only upstream section with papyrus fringes has a different vegetation to elsewhere. One rare fish species the Rare *Ctenopoma microtenopoma,* occurs only in the quiet waters immediately east of the Cuito confluence (Hay 1995). This ecosystem has been identified as unique by both the Angolan and Namibian EFA specialists (Bethune *et al*. unpublished and is still relatively

inaccessible and thus to some extent protected. It warrants more detailed research and affords an excellent opportunity for transboundary cooperation.

f) *Sandbanks* scattered alongside most of the length of the slower flowing and wider sections of the river are important nesting sites for both crocodiles and ground nesting birds such as African Skimmers and Carmine bee-eaters. These are very vulnerable to any potential changes in water levels or flood regimes (Paxton, unpublished).

The formally protected areas within the Namibian section of the Okavango River are rather limited with less than 4% of the river frontage currently within protected areas. As with the different vegetation zones, the conservation goal in Namibia is to protect approximately 10% of each important ecosystem (Barnard *et al.* 1998) and perennial rivers, their floodplains and banks is arguably an ecosystem type still under-represented within Namibia's protected area network. The small Mahango Game Park was originally declared in 1983 and in 2008 , together with the Buffalo core conservation area on the opposite bank, became part of the much larger Bwabwata National Park that covers an area of 61 000 km(Olivier 1993, Mayes 2008, Kanjore, 2008). Many of the protected species are reliant on the band of riparian vegetation, floodplains and riparian woodlands. High elephant numbers within this relatively small riparian zone already impact on the vegetation to the detriment of species like the vulnerable Chobe bushbuck.

Of the 50 registered conservancies in Namibia in 2006 only four relatively small ones were in the Kavango Region, Joseph Mbambangandu (only 36 km^2) on the river itself and three inland, George Mukoya (486 km^2) , Muduva Nyangana (615 km^2) and Shamungwa (53 km^2)`. Several more are slowly emerging including one on the river adjacent to the Mahango park at Kamatonja. (NACSO, 2007). In addition there are now five larger registerd community forests in the Kavango: Ncaute (120 km^2), Ncumcara (152 km^2), Ncamagoro (263 km^2), Mbeyo (411km^2) and Hans Kanyinga (277 km^2), that afford some protection to the woodland ecosystem (NACSO, 2007). Good progress has been made to by communites to jointly manage adjacent wildlife and forestry conservancies.

5. CONCLUSION

The relative lack of development along the Okavango River in Angola and the Delta has allowed the river to remain comparatively pristine. This can be attributed to: years of conflict in Angola, the remoteness of the areas, the lack of mineral resources, low population numbers, the relative infertility of the soils and because much of the area has been designated as communal land. Yet this is not true for most of the Namibian section of the river and the panhandle in Botswana, where dense human settlement in a ribbon all along the river has altered the natural ecosystems by bank clearing, reed harvesting, over fishing, agriculture and has just about wiped out the larger reptiles and mammals. This impact is very clear in all comparisons with the core protected areas at Mahango and Buffalo within the Bwabwata National Park and the protected island habitats in the lower section of the river. It is hoped that with time the establishment of more wildlife and forestry community conservancies will improve the natural resource situation alongside.

The main ecosystem threats in this section are loss of wildlife habitat due to human pressure and the resultant erosion, water quality deterioration due to siltation and increasing use of Agricultural fertilizers and pesticides, deforestation, over-exploitation of wetland resources such as fish, reeds, timber, thatching grass, an increase in alien invasive species and the impacts of too frequent fires and clearing or reedbeds. The second important threat to what is left of the natural riverine ecosystems is any alteration of the natural watercourses and natural flow patterns due to future developments within the basin such as the construction or impoundment, hydropower developments, increased irrigation and increasing settlement upstream and anywhere along the Namibian section of the river. This in turn will also impact on the sensitive Delta ecosystem downstream. For example fertilizers used in agriculture alongside the wetlands upstream of the delta pose a threat to this water purity. Care must be taken in the proposed expansion of irrigated agriculture in Namibia and Angola to avoid contamination by chemicals, both fertilizers and pesticides. Already DDT, a known bio-accumulator, used to control malaria in Namibia, can be detected in fish tissues and is known to soften egg shells thus reducing the breeding success of fish eating birds. A further threat to water quality is increased siltation caused by erosion as a result of bank clearing alongside the river in Namibia and by deforestation as the upper catchment in Angola is resettled. Conversely, cutting off sediment transport downstream e.g. by the construction of a hydro power dam poses an even greater threat as the dynamics of the delta that depend on a regular input of sediment (McCarthy1992, NamPower 2004).

Despite this, some the area is still undeveloped the natural resource base remains relatively good but is threatened by the myth that agricultural development should be promoted in the area. Mendelsohn and el Obied (2003, 2004) argue that the agricultural potential over most of the area remains poor and is contributing to the high urbanization of settlements such as Rundu, Divundu and Nkurenkuru that are rapidly expanding as people seek better lives in towns.

The Okavango River Basin is rich in renewable natural resources. Yet, three factors make these resources vulnerable: the variability of rainfall particularly in the lower, drier portions, making water supply unpredictable and droughts more likely, and the ever-increasing human pressure on the on these natural wetland resources and any potential alterations in the natural flow regime of the river that supports both the people and the ecosystems found alongside the river in Namibia.

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The Okavango River Basin Transboundary Diagnostic Analysis Technical Reports

In 1994, the three riparian countries of the Okavango River Basin – Angola, Botswana and Namibia – agreed to plan for collaborative management of the natural resources of the Okavango, forming the Permanent Okavango River Basin Water Commission (OKACOM). In 2003, with funding from the Global Environment Facility, OKACOM launched the Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO) Project to coordinate development and to anticipate and address threats to the river and the associated communities and environment. Implemented by the United Nations Development Program and executed by the United Nations Food and Agriculture Organization, the project produced the Transboundary.

Diagnostic Analysis to establish a base of available scientific evidence to guide future decision making. The study, created from inputs from multi-disciplinary teams in each country, with specialists in hydrology, hydraulics, channel form, water quality, vegetation, aquatic invertebrates, fish, birds, river-dependent terrestrial wildlife, resource economics and socio-cultural issues, was coordinated and managed by a group of specialists from the southern African region in 2008 and 2009.

The following specialist technical reports were produced as part of this process and form substantive background content for the Okavango River Basin Trans-boundary Diagnostic Analysis

Final Study Reports	**Reports integrating findings from all country and background reports, and covering the entire basin.**		
		Aylward, B.	*Economic Valuation of Basin Resources: Final Report to EPSMO Project of the UN Food & Agriculture Organization as an Input to the Okavango River Basin Transboundary Diagnostic Analysis: Final Draft*
		Barnes, J. et al.	*Okavango River Basin Transboundary Diagnostic Analysis: Socio-Economic Assessment Draft Final Report*
		King, J.M. and Brown, C.A.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment Project Initiation Report (Report No: 01/2009)*
		King, J.M. and Brown, C.A.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment EFA Process Report (Report No: 02/2009)*
		King, J.M. and Brown, C.A.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment Guidelines for data collection, analysis and scenario creation (Report No: 03/2009)*
		Bethune, S. Mazvimavi, D. and Quintino, M.	*Okavango River Basin Environmental Flow Assessment Delineation Report (Report No: 04/2009)*
		Beuster, H.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment Hydrology Report: Data And Models (Final Draft) (Report No: 05/2009)*
		Beuster, H.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment Scenario Report : Hydrology (Report No: 06/2009 (Draft))*
		King, J.M. and Brown, C.A.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions (Volume 1 of 4)*
		King, J.M. and Brown, C.A.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions (Volume 2 of 4: Indicator results)*
		King, J.M. and Brown, C.A.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions: Climate Change Scenarios (Volume 3 of 4)*
		King, J., Brown, C.A., Joubert, A.R. and Barnes, J.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment Scenario Report: Biophysical Predictions (Volume 4 of 4: Climate Change Indicator Results) (Report No: 07/2009)*
		King, J., Brown, C.A. and Barnes, J.	*EPSMO-BIOKAVANGO Okavango River Basin Environmental Flow Assessment Project Final Report (Report No: 08/2009)*
		King.J.M, Brown.C.A, and Barnes.J.	*Environment protection and sustainable management of the Okavango River Basin: Preliminary Environmental Flows Assessment: Project Final Report*
		Malzbender, D.	*Environmental Protection And Sustainable Management Of The Okavango River Basin (EPSMO): Governance Review*
		Vanderpost, C. and Dhliwayo, M.	*Database and GIS design for an expanded Okavango Basin Information System (OBIS)*
		Veríssimo, Luis	*GIS Database for the Environment Protection and Sustainable Management of the Okavango River Basin Project*
		Wolski, P.	*Assessment of hydrological effects of climate change in the Okavango Basin*
Country Reports ***Biophysical Series***	**Angola**	Andrade e Sousa, Helder André de	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina:*

			Sedimentologia & Geomorfologia
		Gomes, Amândio	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Vegetação*
		Gomes, Amândio	*Análise Técnica, Biofísica e Socio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final:Vegetação da Parte Angolana da Bacia Hidrográfica Do Rio Cubango*
		Livramento, Filomena	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina:Macroinvertebrados*
		Morais, Miguel	*Diagnóstica Transfronteiriça da Bacia do Análise Rio Cubango (Okavango): Módulo da Avaliação do Caudal Ambiental: Relatório do Especialista País: Angola Disciplina: Ictiofauna*
		Morais, Miguel	*Análise Técnica, Biófisica e Sócio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final: Peixes e Pesca Fluvial da Bacia do Okavango em Angola*
		Pereira, Maria João	*Qualidade da Água, no Lado Angolano da Bacia Hidrográfica do Rio Cubango*
		Santos, Carmen Ivelize Van-Dúnem S. N.	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório de Especialidade: Angola: Vida Selvagem*
		Santos, Carmen Ivelize Van-Dúnem S.N.	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango:Módulo Avaliação do Caudal Ambiental: Relatório de Especialidade: Angola: Aves*
	Botswana	Bonyongo, M.C.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Wildlife*
		Hancock, P.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module : Specialist Report: Country: Botswana: Discipline: Birds*
		Mosepele, K.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Fish*
		Mosepele, B. and Dallas, Helen	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Aquatic Macro Invertebrates*
	Namibia	Collin Christian & Associates CC	*Okavango River Basin: Transboundary Diagnostic Analysis Project: Environmental Flow Assessment Module: Geomorphology*
		Curtis, B.A.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report Country: Namibia Discipline: Vegetation*
		Bethune, S.	*Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO): Transboundary Diagnostic Analysis: Basin Ecosystems Report*
		Katjimune, M. and Cristellus, G.	*[Hydrogeology]*
		Nakanwe, S.N.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Aquatic Macro Invertebrates*
		Paxton, M.	*Okavango River Basin Transboundary Diagnostic Analysis: Environmental Flow Module: Specialist Report:Country:Namibia: Discipline: Birds (Avifauna)*
		Roberts, K.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Wildlife*
		Waal, B.V.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia:Discipline: Fish Life*
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