OKACOM

The Biophysical and Human Environment

(Namibian Sector)

Specialist Report prepared by Chris Hines for :

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SECTION A: BIOPHYSICAL ENVIRONMENT

1. CLIMATE

1.1 The Influence Of Climate On Biological Cycles And Agricultural Production.

The climatic year can be broadly divided into a long cool, dry season (7-8 months) and a shorter, hot, wet season (4-5 months) giving a highly seasonal pattern of rainfall (90 % falls between November and March). This is further compounded by rainfall being highly variable in time and space, both within and between years. This pattern of rainfall has a direct impact on the growth of vegetation and crops, the movements of people, domestic stock and wildlife, flooding of the river and groundwater recharge.

A high level of spatial and temporal variation in rainfall results in a resource base which is patchy and not constant. This variation is evident at a number of levels. Annual rainfall totals show considerable variation between years, and "droughts" (below average rainfall) are a feature of the region. Although these "droughts" are recognised as being common, production systems tend to be geared toward "average" rainfall figures because extension services have for so long been biased toward commercial production models. Of more importance in crop and grazing resource production is the distribution of rainfall in any one wet season. Spatial variation results in patchy grazing and localised failure (or success) of crops. The number of days on which rain falls is also important in that a large number of rain-days of low falls result in better production than a few days of high falls. Peak rainfall months vary between years and affect ploughing, planting, weeding and harvesting schedules.

Potential evaporation rates are high in the Okavango (Crerar & Church 1988) and exceed average annual rainfall by up to five times. This affects crop and grazing production. For example, at Rundu there is a nett water deficit (for plant growth) in all months of the year except February. Nett annual water deficits are in the region of 1200 mm per annum which indicates that dryland crop production is a high risk undertaking even in years of high rainfall. This risk is moderated through the adoption of adaptive strategies in local farming systems.

Farmers take account of the risks and uncertainties associated with the climate of the region by having a staggered ploughing and planting season and minimising crop failure risk by planting a variety of grain crops. Even within these crops, a number of varieties offering different growth and yield characteristics, are utilised, further spreading the risks in arable production. These strategies allow for at least some crop harvesting, even in poor rain years.

2. BIOLOGICAL ENVIRONMENT

The following review of the biological environment is derived from a number of available data sources including personal experience, interviews, as well as published and unpublished reports and articles which are listed in the References below. The information derived from these sources are notable in that very little original research (with the exception of fish studies) has been done in the Okavango Region of Namibia and most of the published

material is in the form of reviews and/or annotated checklists, or as ancillary information in management and development strategies. The lack of comprehensive baselines, long-term data series and monitoring programmes relevant to developing an understanding of the biology and ecosystem functioning, is a major problem in clarifying the potential impacts of the broadscale changes that have occurred as a result of human interventions over the past 20 years. This is also a major problem in developing recommendations for mitigatory or reconstructive actions to develop the area further in the future. This large gap in original research (most notably in the fields of wildlife management, agriculture and vegetation studies), baselines, data series and monitoring programmes distinguishes the Namibian information base markedly from that pertaining in Botswana which is relatively well covered.

The extensive invertebrate and vertebrate collections of the National Museum, Windhoek, and the plant collections of the National Botanical Research Institute were not reviewed as part of this study, but may provide important insights into the historical distributions of certain taxa.

2.1 Flora

The Okavango River forms a linear oasis as it runs through a well-defined, shallow valley about 400 km long in Namibia. Physiographically, two landforms are dominant in the area under review. These are (i) the riverine landform of the Okavango River comprising the main river channel, floodplains showing evidence of a braided river system and a fluvial terrace system covered by alluvial deposits; and, (ii) the extensive sand deposits of the Kalahari system where low linear dunes and gently undulating plains are dissected by intervening shallow troughs and omarimba. These two landforms define the distribution and composition of the vegetation units associated with the river and the units are separated to reflect the influences of these two landforms.

Little detailed work has been done on the vegetation of the Okavango River system in Namibia and most of the descriptive material for the various vegetation units is derived from the following studies. Page (1980) provided a broad overview of the vegetation of the previously defined Kavango area. This study describes 10 units within which are 19 sub-units. The description of the riverine units are cursory. Correira & Bredenkamp (1987) proposed a classification of 15 land-use units on the basis of vegetation composition and structure. Hines (1987) in a paper on the avifauna of the eastern Kavango gave a brief overview of the principal vegetation types of the region. Bethune (1991) describes 5 main vegetation zones associated with the Okavango River. These broad descriptions are accompanied by a detailed checklist of all plant species known or expected to occur along the river. Hines (1996a) provides a detailed account of the vegetation associations in the planned Okavango National Park (comprising the Mahango Game Reserve and the Buffalo Section of the Caprivi Game Park). Classification systems proposed in the above references differ considerably but most reflect the influence of the river and the Kalahari sands as broadscale determinants of the composition, structure and distribution of the major units. No studies have been carried out in the Namibian sector of the river which detail the determinants and processes involved in defining the principal riverine and associated vegetation units (such as those of McCarthy *et al.* 1993). The importance of plants in the hydrological and biological

cycles of the river has not been studied in any detail.

The flora is rich in diversity with 869 species of 88 families described in Bethune (1991), but few of the vegetation units or habitats have remained intact following the accelerated clearing and over-utilisation of plant resources in recent years. As such, most habitats could be regarded as threatened to some degree, even those within proclaimed conservation areas which have been severely altered through elephant damage within the last 10 years.

2.1.1 The Riverine System

The Okavango River is a perennial endorheic system subject to annual floods of varying intensity. These floods seasonally inundate large areas of lands adjacent to the main river channel and the wetlands associated with them vary in size from 119 km^2 in the dry season to about 430 km^2 during annual floods (van der Waal, 1990). The riverine component is the most important area in terms of supporting human activities, with most human settlement, arable agriculture and livestock being centred on this part of the system. There are a number of well defined units within the riverine system. These are:

Open Water Habitats

This comprises the main channel (50-200 m) wide and the narrower side channels which remain flowing through the year. The substrate is usually sandy or rocky (e.g. in the Mukwe-Andara-Popa area) and water depths vary from 0.5-8.0m. These areas are some of the most important fisheries areas. They are, however, relatively unimportant grazing areas and the vegetation is uniform and dominated by floating macrophytes such as species of *Potamogeton, Lagarosiphon, Nymphaea* and *Trapa.* The river channel margins are generally dominated by *Phragmites* spp. and *Vetiveria* spp., which are both important species in the construction of local houses. These reed-grass fringes can be quite extensive, and form important fish breeding areas during periods of high water. In the lower reaches of the river, below Andara, the reeds are often replaced by dense, floating mats of papyrus *Cyperus papyrus* (Bethune, 1991). Reeds are readily traded and at certain times of year large quantities are stockpiled and sold along the roads between Rundu and Divundu. The reed beds are extensively burnt during the dry season even though they comprise a valuable source of cash.

Floodplains

The floodplain of the river varies considerably in width from a couple of metres to several kilometres wide, but is generally limited in extent. Bethune (1991) and Ellery (1997) map the main floodplain areas in Namibia.

The floodplains can be divided into a variety of habitats the principal determinants of which are thought to be the length of the period of inundation following the onset of flooding and the substrate. The perennial swamp systems on the floodplains are

dominated by papyrus *Cyperus papyrus* which are extensively burnt during the dry season. They are largely unaffected by fires and are not heavily utilised by man. Other areas are dominated by *Phragmites* reeds, often with a poorly developed woody component comprising species such as *Syzygium guineense* and *Rhus quartiniana.*

The seasonally flooded areas are far more diverse in composition with soil substrate and the period of inundation being important determinants. On sandy clay soils the tall, unpalatable grasses *Miscanthus junceus* and *Vetiveria nigritana* can form extensive, uniform grasslands in the "wetter" end of the spectrum. Dense floating grass mats form on similar soils where the period of inundation is longer. *Echinochloa* and *Vossia* are the most important grass types here and are very important grazing resources for domestic livestock and for wildlife. Several fish species use these floating grass mats as substrates for egg-laying and protection of young. In areas of relatively short inundation, the grass *Cynodon dactylon* is dominant and the lawns formed by this species are some of the most important grazing resources along the length of the river. They are heavily and consistently grazed throughout the year, being extremely hardy and resilient. In some areas where flooding has become reduced through terrestrialisation of the floodplain, this species has disappeared. On sandy islands and shallow deposits, the vegetation is dominated by woody, perennial grasses which are largely unpalatable and have little value as grazing resources. Characteristic species here are *Chloris virgata, Eragrotis pallens* and *Cymbopogon* spp. The tall grass species of the floodplain habitats are important thatching resources.

The role of fire and frost as determinants of the vegetation units in these seasonally flooded areas is open to question. Fires occur frequently in parts of the system, particularly the *Phragmites* and *Cyperus papyrus* reedbeds but whether these fires alter the structure and composition of these units is unclear. Most of the grasslands (with the exception perhaps of those in the Okavango National Park) remain unburned because grazer pressure on the system as a whole, lowers fuel loads to the point where few fires of any extent are recorded in any one year. No extensive peat beds are reported from along the Namibian sector of the Okavango and so peat fires are not a feature of the functioning of the ecological system.

The small ponds, backwaters and oxbows which form after the floodwaters recede are usually well vegetated and are an important source of fish during the dry season.

The grazing resources of the floodplain (particularly the *Cynodon dactylon* lawns) are some of the most important natural resources within the Okavango River basin. Fish breeding is to a large extent dependant on the integrity of these resources in that they provide important nutrient inputs into the system as well as provide numerous breeding sites for fish. The commercial (and socio-economic) value of these resources as integral support systems for the maintenance of the regional livestock herds has not been studied in any detail, but should not be underestimated. The seasonal floodplain grasslands and grazing resources warrant considerable investigation relative to the utilisation by livestock owners and the stability of the local economy.

Riparian Fringe And Riverine Terraces

Alluvial terraces form on either side of the river and are generally above the level of general flooding. These terraces and the direct riparian fringe have a very distinct assemblage of plant species. These units are characterised by tall tree species such as *Diospyros mespiliformis, Ficus sycomorus, Acacia nigrescens, Garcinia livingstoneii* and *Lonchocarpus capassa*. These trees are generally between 15 and 20 m in height. There is a distinct sub-canopy stratum of trees 4-8m in height characterised by *Croton megalobotrys, Terminalia prunioides* and *Combretum hereroense*. The soils on which these woodlands formed are alluvial loams which represent some of the best soils for arable agriculture along the river. The woodlands have been extensively cleared to make way for fields and the best examples of this vegetation type are now found in the protected areas of the lower reaches between Divundu and Muhembo, although many of these have been severely damaged by elephant in recent years.

In areas immediately adjacent to the river margin, saline accumulation in the soils is characteristic. These soils are largely occupied by palms *Hyphaene ventricosa* and trees such as *Terminalia prunioides*. Very little of this habitat remains, except within the Mahango Game Reserve.

2.1.2 The Aeolian Kalahari Sands

The vegetation of the deep, dystrophic Kalahari sands is generally not affected by levels of flooding and the annual cycle of the river, and so fall outside of the boundaries of this study. The vegetation of the sand areas is characteristically a tall, open woodland dominated by trees such as *Burkea africana, Terminalia sericea, Combretum spp., Ochna pulchra* and a well defined shrub layer. These areas are important wet-season grazing areas and a source of most of the construction wood used in building houses. The lack of surface water in these areas limits the value of the grazing resources, which are not of as high a quality as those of the floodplain areas.

2.1.3 Trends

The vegetation of the Okavango River valley is heavily utilised both as a grazing resource for domestic livestock and for other domestic uses. The extensive alteration of much of the riverine terrace system in recent years from woodlands to agricultural fields, and the lack of active management practices to improve or maintain production levels means that more and more natural vegetation is being lost. This has important implications in the maintenance of stock numbers and the relative (economic) cost of domestic wood and construction materials.

According to recent studies (IFAD, 1996) range inadequacy can be attributed mainly to the scarcity of forage within the floodplain component during the peak of the dry season. In the wet season range inadequacy is not a problem. Given the loss of *Cynodon* lawns and the conversion of some grazing lands to agricultural fields, there is

undoubtedly some reduction in the extent of the high value floodplain grasslands. The significance of these reductions over time, compounded by a slowly increasing regional livestock herd, has not been evaluated and warrants further research in the future.

2.1.4 Utilisation And Economic Importance

Other than grazing resources for domestic livestock, there are a number of uses of vegetation which have significant economic and domestic values. These are:

i) Fuelwood: The fuelwood demand in the region has not been quantified in recent years, but is undoubtedly increasing as populations increase. The fact that there is a ready trade in fuelwood around urban centres attests to the decreasing supply close to homesteads and villages. The use of dung for fuel is not well established, but a conflict for this resource in terms of fertiliser is likely to occur in the future. This aspect of resource utilisation warrants further study.

ii) Building material: Poles, reeds for walls and thatching grass are all used for the construction and maintenance of houses. There is also a need for trees from which canoes can be made. Most of the wood resources along the river have been over-exploited or cut-out to make way for fields, with most of these resources now being supplied from the dry Kalahari woodlands well away from the main areas of settlement. The demand, supply and management of these woodlands has never been studied in any detail and so changes in economic and financial values of these resources remains unclear. *Eucalyptus* plantations have been established at two sites near Rundu but these have very low rates of increase and are not used for construction material.

iii) Craft wood: There is a burgeoning woodcarving and basic furniture industry specifically aimed at the expanding tourism market in the region. The principal woods used in this industry are *Pterocarpus angolensis, Terminalia sericea* and to a lesser degree *Guibortia coleosperma*. These species are rare on the riverine fringe and most of the wood is taken out of the Kalahari sand areas to the South of the river. The carving industry was initially based on the collection of dead-fall logs, but as demand has grown for products, so has the practice of live-wood cutting. The effects of this change in practice are unknown.

iv) Non-wood forest products: This category includes plants used for food, medical uses, palms for basketry and bee-keeping. The value of plants in this category has declined markedly in recent years, with traditional taboos regarding the eradication of valued food plants being openly disregarded. Several investigative consultancies from overseas aid agencies (GtZ and ODA have both supported consultancies, but no reports could be found) have investigated the viability of bee-keeping as a supplementary income in the Okavango Region, but nothing has come of these. Although honey is highly sought after, bee-keeping is a poorly developed tradition in the region, probably as a result of the single flowering season for most plants and the fact that many species (e.g. *Burkea africana*) are wind-pollinated (C.Hines *pers. obs*). Basketry palms

(*Hyphaene ventricosa*) are a highly sought after resource, with considerable trade in the leaves between areas along the river (Hines & Cunningham, 1992). The resource has declined markedly in recent years, with the best remaining stands of palms now limited to the Mahango Game Reserve. There is considerable interest in getting local groups to grow palms around fields and the Rossing Foundation at Shankara has started field trials to assess best practices for growing these plants.

2.1.5 Invasive Alien Flora

No invasive aquatic plants have been recorded from the Namibian sector of the Okavango River although considerable potential for infestation exists, as boats are often moved from the Kwando-Linyanti system (which has heavy infestations of *Salvinia molesta*) onto the Okavango River.

A number of alien species found along the Okavango River are listed in Hines *et al.* (1985) and Hines (1996b) but the majority of these are not considered invasive. Species known to be invasive are:

Opuntia ficus-indica which has taken over large areas of rocky outcrops in the Andara area. This infestation could be controlled through the release of cochineal bugs.

Ricinus communis is widespread and occurs on disturbed sites all along the river. The seeds are used for the extraction of cosmetic oil by many local people.

Acacia mearnsii is a highly invasive species currently only known from the old military camp at Picapau south of Buffalo. This population should be eradicated before problems arise.

Sidium guajava is currently fairly limited in its distribution along the river, mostly being found near villages and other settlements. It has the potential to be highly invasive along the river.

Xanthium spinosum is a widespread invasive herb with strong burrs. It is known all along the river.

Lantana camara is planted in many gardens along the river, but it is not known whether the form grown here is invasive. A large stand of this species is known from Buffalo Camp.

Euphorbia tirucali is widely used for live-fencing along the length of the river. There is no evidence that this species is invasive in the Okavango Region but it is thought to be potentially so.

2.2 Fauna

2.2.1 Amphibians

The amphibian fauna of the Okavango River basin in Namibia is relatively well known and there have been recent reviews by Griffin & Channing (1991), Hines (1996b) and Jacobson (1997). These reviews indicate that 25 amphibian species are known or are expected to occur within the Namibian section of the basin. Of these, 13 species are largely dependant on riverine habitats, and it is the integrity of these habitats which determines the presence and abundance of these species. Most habitats are extensively degraded, with the exception of the areas within the Mahango Game Reserve. The overall result of this is a markedly impoverished amphibian fauna outside of protected areas. There are however, no Red Data species listed for the study area (Griffin, 1994).

Bullfrogs *Pixicephalus adspersus* are eaten in large numbers by local people, but are not considered threatened. This species is widespread, is a prolific breeder and is not confined to perennial water systems.

2.2.2 Reptiles

The reptile fauna of the Okavango River basin in Namibia is not as well studied as other vertebrate taxonomic groups. Griffin (1985) compiled an atlas of known records of species in the Kavango area but the results of the update have not yet been published. Recent reviews by Hines (1996b) and Jacobson (1997) provide a list of some 80 species of reptiles which are known or are expected to occur in the basin. A number (12) of species of reptiles are either entirely dependant on or are most frequently associated with riverine habitats. As with the amphibian fauna, extensive habitat degradation and persecution has lead to an impoverished reptile fauna outside of conservation areas. Several species of tortoise, python and varanid (leguaan) lizards (all listed as vulnerable by Griffin 1994, see Table xx) contribute significantly to the protein diet of the rural communities in the basin, and these animals are becoming increasingly rare outside protected areas.

Table 1 : Reptile Red Data Species in the Okavango River basin in Namibia. Status from Griffin (1994).

STATUS	SPECIES	
Vulnerable	Leopard Tortoise	*Geochelone pardalis*
	Hinged Tortoise	*Kinixys spekii*

	Serrated Tortoise	*Psammobates oculifer*
	Bushveld Monitor	*Varanus exanthematicus*
	Water Monitor	*Varanus niloticus*
	African Python	*Python sebae*

Although protected by law, Crocodiles are heavily persecuted outside protected areas and breeding for this species is now largely restricted to the Mahango Game Reserve and perhaps some of the sand deposits on islands between Mukwe and Andara. No egg collections are made in the Namibian section of the basin, but between 3000-4000 eggs are collected annually in the panhandle of the Okavango Delta in Botswana. This species represents considerable economic potential as a commercial enterprise.

2.2.3 Fish

Fish have been extensively studied in the Okavango River over many years (Barnard, 1948; Skelton & Merron, 1984, 1985, 1987; van der Waal, 1991; Hocutt & Johnson 1993). These studies have been focused on the biogeography and breeding biology of species in the system, with almost no work having been done on quantifying the value or scale of the exploitation of the fish populations.

Eighty three species have been identified within the Okavango system, 71 of which occur in Namibian waters. A comprehensive list is given in Rall (1997). Cichlids (bream species) comprise about 50 % of the species recorded in the system (Tvedten *et al.,* 1994). Fish populations have been broadly divided into three components: resident species, present throughout the year, longitudinal migrant species which move downstream from Angola which return as the floods recede, and, lateral species which inhabit isolated bays and small streams and backwaters on the floodplain (Skelton & Merron, 1985).

In general terms, fish populations are declining in the Namibia sector of the Okavango River. Using an *index of biotic integrity,* Hay *et al.* (1996) were able to show that the system as a whole is deteriorating. The main changes indicated were dwindling fish stocks as a result of high fishing pressures and habitat destruction. Siltation as a result of erosion has also been cited as further exacerbating factor in population declines (Bethune, 1991; van der Waal, 1991). This perception of declines is confirmed through interviews with local people reported in Tvedten *et al.*(1994). The importance of the local fisheries in the subsistence economy of the region is discussed under Fisheries below.

Only one Red Data species has been identified in Namibia (Holtzhausen, 1991). The Broad-headed Catfish *Clariallabes platyprosopos* is only known from the rocky areas around Popa Falls and the Mukwe-Andara area. It has a limited distribution in the Okavango and Zambezi River systems.

2.2.4 Birds

The avifauna of the Okavango River system in Namibia is relatively well known and several recent reviews (Hines, 1987; Brown & Jones, 1994; Hines, 1996; Allen, 1997) provide detailed information on the distribution and presumed abundances of species associated with the river and adjacent upland sites. A total of 430 species has been recorded along the river and adjacent woodlands representing some 68 % of the birds recorded in Namibia, making the region the most diverse in terms of birds in the country. However, extensive degradation and alteration of riverine habitats, particularly the loss of riparian forests, has reduced the ranges of many of the species to relatively well protected sites between Mukwe and Muhembo. This includes species such as Pel's Fishing Owl and African Fish Eagle.

Ninety-four species occurring in the region are listed by Brown (1993) as Red Data Species. The majority of these species (54) are not discussed here as they are designated as *Amber* [species requiring regular monitoring because of low numbers, restricted distributions, specialised requirements or because insufficient information is currently available to class them in another higher category]. Of the 25 species designated *Rare*, the majority could be considered peripheral (Table xx) and not seriously threatened by activities along the Okavango River in Namibia. The remaining rare species are all water dependant or dependant on riverine habitats for breeding and have highly restricted ranges within Namibia as a result of the general habitat degradation along the length of the Okavango River.

Ten species are regarded as vulnerable of which both species of pelicans, Black Stork, the two species of flamingo and Black Sparrowhawk can be viewed as marginal species with their major strongholds elsewhere in the sub-region. White-headed Vulture, Bateleur and Ground Hornbill are species of woodland habitats and not specifically associated with the river, although Ground Hornbill may breed in large trees on the riparian fringe, and thus may be affected through loss of breeding habitat. African Goshawk is strictly associated with the riparian fringe forests and has undergone marked declines in numbers because of habitat loss. The Okavango basin as a whole is the global stronghold of Slaty Egret. However, only relatively small numbers occur in the upper delta and the Namibian sector of the river, because of a lack of suitable habitat. Even so, this species should be considered as of the highest conservation concern in Namibia.

Of the seven species considered *Endangered*, the Cape Vulture can be considered marginal or vagrant and is not of concern here. The remaining species are all associated with wetlands or riverine habitats and have undergone considerable reductions in range and numbers in recent years, as a result of the widespread damage to and loss of riverine habitats. Most of these species are now restricted to the short stretch of river between the Mukwe-Andara islands and the southern boundary of the Mahango Game Reserve at Muhembo. The continued occurrence of these species (and Slaty Egret) in

the Namibian sector of the river is entirely dependant on the adequate conservation of the limited remaining habitat.

Table 2 : Bird Red Data Species in the Okavango River basin in Namibia (Status from Brown (1993).

STATUS	SPECIES
Rare (peripheral)	Marabou Stork, Sacred Ibis, Glossy Ibis, Hadeda Ibis, Hooded Vulture, Cuckoo Hawk, Tawny Eagle, Ayre's Hawk Eagle, Martial Eagle, Black-bellied Korhaan, Grey-headed Gull, Cape Parrot, Narina Trogon, Pygmy Kingfisher, Arnot's Chat, Natal Robin, Coppery Sunbird, Purple-banded Sunbird
Rare	Bittern, African Fish Eagle, African Marsh Harrier, Red-winged Pratincole, Wood Owl, Greater Swamp Warbler, Yellow-billed Oxpecker
Vulnerable	White Pelican, Pink-backed Pelican, Black Stork, Greater Flamingo, Lesser Flamingo, Slaty Egret, Black Sparrowhawk, White-headed Vulture, Bateleur, African Goshawk, Ground Hornbill
Endangered	Saddle-billed Stork, Cape Vulture, White-backed Night Heron, Western Banded Snake-Eagle, Wattled Crane, African Skimmer, Pel's Fishing Owl.

2.2.5 Mammals

Recent reviews of the mammalian fauna of the Okavango River basin in Namibia (Hines, 1996b; van Aarde & Ferreira, 1997) indicate that 116 mammal species have been recorded or are expected to occur in the area. This represents about 57 % of Namibia's terrestrial mammal species. However, the extensive alteration of the riverine strip, especially floodplain and riverine fringe forest habitats has led to the majority of these species being restricted to areas afforded some degree of protection in conservation areas or on isolated islands. Much of the reduction in range and numbers (particularly of large mammals) has taken place in the last 25 years. Long-time residents of Rundu still recall species such as Elephant, Impala and Greater Kudu being abundant within 30 km of Rundu in the early 1970's. Large mammal populations are now restricted to the Mahango Game Reserve area.

Griffin & Grobler (1991) provide a review of wetland associated mammals in Namibia and 31 of the 38 species identified by them occur within the Okavango System. Only one species, Shortridge's Mouse *Mastomys shortridgeii*, is found only in this part of Namibia. It is, however, also known from Botswana, Zambia and Angola. None of the species occurring along the Okavango River are endemic to Namibia (Griffin 1996).

A number of Red Data Species occur within the Okavango River basin in Namibia and these are given in Table xx. The majority of these do not occur in any significant numbers outside the small conservation area of the Mahango Game Reserve, the

Buffalo area of the West Caprivi Game Park and the islands and woodlands in the Andara-Mukwe area.

Rodent populations in the areas fringing the river can cause significant losses in stored grain crops and are also agents for the dispersal of plague, which although rare, occurs from time to time in the Okavango Region. The majority of these mice are thought to be of the genus *Mastomys*, the multimammate mice. These mice are well known for their eruptive populations following good rain seasons. There are no systematic control mechanisms in place to eradicate plagues of these mice, except at the local village level.

Other problem animals include crop-raiding elephants and occasional stock-raiding lions, in the Divundu-Muhembo area. These animals take refuge in the Mahango Game Reserve by day and leave the park at night. This has resulted in considerable tension between park authorities and the local population resident immediately outside the park.

Table 3 : Mammal Red Data Species in the Okavango River basin in Namibia

STATUS	SPECIES
Vulnerable	Aardwolf, African Wildcat, Bateared Fox, Brown Hyaena, Cape Clawless Otter, Cheetah, Chobe Bushbuck, Elephant, Giraffe, Hippopotamus, Lesser Bushbaby, Lion, Red Lechwe, Reedbuck, Roan Antelope, Sable Antelope, Sitatunga, Spotted Hyaena, Tsessebe.
Indeterminate	Serval, Large-spotted Genet, Water Mongoose
Indeterminate (Endangered)	Spotted-neck Otter
Indeterminate (Rare)	Civet, Selous' Mongoose, Striped Weasel
Endangered	Wild Dog
Extinct	Black Rhinoceros, Waterbuck, White Rhinoceros

2.3 Environmental Water Demand

Other than the generalised evaluation of environmental water requirements given by Ellery (1997) there have been no other attempts in the past to quantify or qualify environmental water demand within the Namibian section of the Okavango River. Ellery (1997) estimated that about 15 120 m^3/km/day of water is lost along the section between Rundu and the Cuito confluence with most losses going in the form of evaporation from the water surface and transpiration by riparian and floodplain vegetation. The amount of water lost as groundwater recharge is unknown, but Simmonds & Schumann (1987) and Namibian Groundwater Development Consultants (1991) felt that groundwater aquifers were largely unaffected by recharge from the river.

The amount of water required to support the natural vegetation, wildlife and processes of the riverine system needs to be clarified, especially in the light of planned water abstraction from the system. Given the high degree of dependency of the human population along the river, there is also a need to evaluate the domestic and livestock demand for water and the long-term projected trends in these demand patterns.

SECTION B : HUMAN ENVIRONMENT

1. LANDUSE STUDIES

1.1 Introduction

The Okavango Region is arguably one of the most neglected regions within Namibia, in both historical and current contexts. The independence war was never of major significance in the region and as such the region was ignored by the administration of the time. For example, much of the basic infrastructure and services installed by occupying forces in the former Owambo region (now Oshana, Omusati, Oshikoto and Ohangwena Regions) was never established in Okavango. According to Isaacson (1996) contract labour systems, with the advantages of remitted incomes, were also poorly developed and have had little impact in the region compared to former Owambo. Regional development since independence has also been slow and there are comparatively fewer development programmes in Okavango than in other northern communal areas. Per capita expenditure (in terms of foreign aid and government funding) is the lowest of the northern communal areas. The result has been a regional economy which has not been able to keep pace with regional developments elsewhere in Namibia.

1.2 Water Demand

The principal reason for settlement along the margin of the Okavango River is access to water. Water supply for human consumption is controlled by the Department of Water Affairs through Rural Water Supply. The majority of users along the river are not directly supplied but are required to collect water by hand. Despite the perennial supply of water, very few people have access to safe water supplies and most households (80%) do not have access to any safe sanitation. Donor-agencies and NGO's are starting to look at support programmes in this sector and a number of shallow-well and borehole projects are being undertaken along the margin of the Okavango River.

Of the registered users of water in the Okavango Region, the four large scale agricultural projects owned by NDC are the largest users of water (> 50 % of total water use) in the region, with one of the facilities at Shitemo using up to 2 000 m^3 of water per day.

Water demand has been poorly evaluated and quantified in the past, and the growth in demand is set to rise in the future. The only recent study was that of WTC (1997) who listed all registered water users between Rundu and Mahembo (see Table 4 below). This study did not take into account the area West of Rundu. No attempt has been made to quantify water demand for domestic and livestock use or the relative importance of unregistered users of water along the river.

1.3 Agricultural Systems

1.3.1 Commercial Agricultural Production Systems.

Commercial scale agricultural systems are limited to a number of large scale irrigation schemes and a dairy farm scattered along the Okavango River at Musese, Vungu-Vungu, Shitemo and Shadikongoro. These farms were established in the late 1970's and early 1980's through government expropriation of communal lands. The areas taken over represent some of the best arable soils along the Okavango River.

These lands were initially allocated to the parastatal First National Development Corporation (FNDC), with the understanding that they would be used for training small-scale and subsistence farmers in commercial techniques. The training component of these operations was rapidly abandoned and the farms are now heavily subsidised, commercial irrigation projects, providing few jobs and running at a major financial loss to the current parastatal, Namibia Development Corporation. For example, Vungu-Vungu ran an operational loss of N$ 901 997 during the 1995/1996 financial year, while Shitemo irrigation scheme ran a loss of N$ 429 289 in the same year. Shadikongoro, one of the largest irrigation schemes, had a net deficit of N$ 997 050 in the 1996/1997 financial year (NDC 1996). This type of operational loss is clearly unsustainable in the long term and privatisation of all these schemes (with the exception of Vungu-Vungu) is currently being considered.

The principal crops produced at the NDC schemes are maize, groundnuts, millet and cotton. Little produce is sold locally and these schemes provide almost no inputs into regional food security.

Formal commercial scale livestock enterprises are limited to areas far to the south of the Okavango River and are of no concern here. However, the boundary between these enterprises and large scale livestock owners in the Okavango is ill defined. According to IFAD (1996) and veterinary services records, livestock ownership is expanding most rapidly under those individuals within the highest income brackets. The result is that fewer owners hold more and more of the regional livestock herd. These large herd owners carry their cattle on communal land often to the detriment of small scale stock owners. A focus of current land reform in Namibia is to encourage owners of large herds to move their operations onto commercial ranches in order to preserve communal areas for poorer households. Incentives to move remain poorly defined and financially weak. The influence of large scale livestock farmers on land-use practices along the Okavango River warrants considerable further investigation.

1.3.2 Subsistence Agriculture

About 90 % of the regional population lives within 10 km of the Okavango River and of these, 82 % are engaged in rural subsistence farming. The general farming system is sedentarised, mixed farming comprising the cultivation of millet as a staple crop,

coupled with extensive livestock (principally cattle) production. Complementarity of crop and livestock production is poorly developed (Masdar, 1993), with responsibility of these sectors being separated largely on the traditional basis of gender. Surprisingly, agricultural production only accounts for about 16 % of annual household income (Yaron *et al.,* 1992).

The majority of cultivated land in the region lies within 10 km of the river, but increasingly, shifting cultivation is being practised at increasing distances from the river. The average size of arable land holdings is about 4 ha per household (Yaron *et al.,* 1992), usually with some fragmentation into 2 or more fields. With the rapid increase in population throughout the region and the concomitant increase in demand for land, fewer opportunities exist for cultivation of "new" lands along the river terraces and immediately adjacent upland sites. The depletion of soil fertility is universally recognised as a major production problem, but soil improvement practices, such as manuring and inter-cropping with grain and forage legumes, is rare.

Crop Production And Arable Practices

Agricultural statistics are poorly collated and several studies show contrasting results. Masdar (1993) estimated the total area under cultivation in the Okavango Region as high as 54 000 ha (estimated at 18 000 households with 3 ha of land (Masdar, 1993), most of which falls within 10 km of the Okavango River. This figure is, however, misleading as 10-30 % of the cultivated land is not planted in any one year (CSO, 1996; MAWRD, 1997). The 1994/95 Agricultural Census (CSO 1996) indicates that there were 12 747 fields (comprising 33 438 ha) in the Okavango region of which only 8 446 (66 %) were actually cultivated. Average land holdings within the region are estimated at between 3-4 hectares.

With rainfall of 500-600mm per annum the region has the agricultural potential to produce a variety of crops and is relatively self-sufficient in this sense (Isaacson 1995). However, potentials are seldom realised and production is characterised by unadapted farming systems and declining productivity. Agricultural output is extremely low per ha and seldom exceeds 400 kg/ha of pearl millet (*mahangu*), with production declining to 120-150 kg/ha in poor rainfall years. Isaacson (1995) compares areas in Zambia where rainfall and soils are similar, but which return yields of 1 000 - 1 500 kg per hectare.

Isaacson (1995) suggests that the low productivity is largely due to the fact that existing farming systems have not adapted to changing circumstances and are now generally highly unsuited to the present environment. Historically, fields were located near settlements along the riverine terraces. Settlement placement was determined largely by access to water for domestic use and by livestock. The rapid increases in population (140 % from 1970-1991 (CSO, 1994))has created tremendous pressures on the land in close proximity to the river. The nett result has been the abandonment of traditional crop rotational and fallowing practices, as households are compelled to cultivate and

produce on the same piece of land. However, traditional practices such as ploughing down or across contours, broadcasting of seed, hand weeding and no manuring or fertilising still persist with the nett result that there is a progressive exhaustion of the soil and a decline in agricultural productivity. Yaron *et al.* (1992) analyzed production in households along the river and in areas to the south and found no significant difference between the two. From this it was assumed that the soils along the river have been degraded through over-utilisation over time. This analysis oversimplifies the situation, as good quality, high production potential soils are limited along the river terraces and the majority of soils have low production potentials (Loxton Hunting & Associates 1971; van Rooyen 1977; Page 1980). If regional production is to be improved there is a need to develop programmes focused on intensification of production per unit under cultivation through soil fertilisation and improved labour allocations.

Pearl millet is the staple food crop grown by most rural households, with nearly 90 % of all cropped fields being planted to mahangu in any one year (MAWRD, 1997). This reduces the scope for crop rotation, especially as the other main crops are also grains (maize and sorghum). Most fields are, however, planted to a mixture of the most common crops, with more than two thirds of fields having more than one crop planted on them (MAWRD, 1997). Maize, pumpkins, sorghum, melons and beans are planted in most households. In a recent study it was found that all households planted some mahangu, 20 % planted maize and 8 % planted sorghum (MAWRD, 1997). The main source for seed is from own retained harvest, with most of the seed planted being of local, unimproved, traditional varieties. About 20 % of sampled farmers in the MAWRD study used improved seed varieties, a marked increase in usage compared to less than 5% in 1993 (Masdar, 1993). Millet production is hampered by a variety of problems, most notably soil fertility. However, ICRISAT on-farm trials indicated that 75 % of farmers never fallow fields to restore fertility, few people use legumes for intercropping or rotation and 85 % never use fertilisers (manure or chemical). There is clearly considerable room for extension programmes to improve millet production.

Relatively small areas of maize and sorghum are planted and these two crops account for 13 % and 7 % of annual harvests, respectively. Production statistics indicate low and highly variable yields, (sorghum at 4-300 kg/ha; maize at 20-150 kg/ha) (MAWRD, 1997). Maize is increasingly being planted as a green crop in small scale vegetable gardens close to homesteads.

One of the major constraints to agricultural production throughout the Okavango Region is the shortage of draught animals at critical times. As labour shortages are also a major constraint, improvement of agricultural production will have to be correlated with improved efficiencies in the use of labour and draught power increasing yields per unit of labour/power. Ownership of cattle is significantly correlated with household economic gains from crop production (MAWRD, 1997). Cattle owners have direct access to draught animals and generally have larger households from which to draw labour. The nett result is that cattle-owning households plant larger areas of crops, have

greater cash gains per household and are not dependant on outside interventions for services such as ploughing, weeding and clearing. A number of programmes are currently running in the Okavango Region to improve access to ploughing services, draught animals and improved yield varieties of crops, all with the purpose of improving household welfare in the region.

Vegetable Farming

Vegetable farming has long been proposed as a viable economic undertaking in the Okavango Region and the region has been described as potentially being "the breadbasket of Namibia" (Louw, 1977). Realistically, potentials are considerably lower. Rainfall is highly variable in time and space and soils are generally poor, precluding rainfed vegetable production, with the exception of certain bean, pumpkin and melon crops.

The potentials for irrigated production of vegetables and the cash benefits to be derived from these enterprises are generally overstated. Irrigated production involves high capital establishment costs, high labour inputs, as well as pest control, harvesting, storage, market acceptance and transport problems. Markets are predominantly local and these become saturated with a narrow range of produce such as cabbages, onions and tomatoes during peak production periods. There are currently about 300 registered members of the Okavango Vegetable Growers Association, but the scale and production outputs of these producers is unclear. Current donor programmes in the Okavango Region, such as Rossing Foundation's Community Garden Initiative at Shankara, are highly subsidised and are unlikely to be self-supporting even in the medium to long term. The emphasis in most of the support or development programmes involving vegetable farming has been on cash incentives, rather than the potential dietary and food security benefits to be gained. The high failure rate of projects can be ascribed to the narrow margin between production costs and realistic market prices.

Emphasis in vegetable farming is shifting to the establishment of small irrigated units close to the river. There are some environmental threats associated with the poor handling of fertilisers and pesticides in these gardens, with containers often being washed directly in the river. Terracing is poorly developed in a number of these sites and top-soil loss directly into the river is a problem during the wet season.

Livestock Farming And Rangeland Resources

Within the traditional agro-pastoral subsistence agricultural system pertaining in the Okavango Region, livestock, principally cattle, are an important cultural and economic focus. Cattle are an important store of wealth for most households in Okavango and a ready source of income in times of need (Isaacson 1995). Cattle have a dominant position in traditional customs and accumulating wealth as well as supplying milk, farm traction, manure and being important in barter economies. Small stock, particularly goats, are important for subsistence food production and generating cash income

(MAWRD, 1997).

Tvedten *et al.* (1994) found that 59 % of households surveyed owned stock, principally cattle. This accords with the findings of WTC (1997) who found that 65 % of households own some cattle (median herd size of 13 animals) and 43 % own some goats (median herd size of 17). The number of households owning cattle is correlated closely with the number of households using their own oxen for ploughing (65 %) as opposed to 30 % of fields where oxen and ploughs had to be borrowed (MAWRD 1997). These figures are for the entire Okavango Region including the Mukwe area. Using data from veterinary enumeration districts or zones in the region, about 70 % of the livestock (all species) occur within about 20 km of the river. Given the paucity of boreholes in this strip, all livestock can be considered to be dependant on the river for water supply. Cattle ownership patterns and herd sizes are summarised in Table x below.

No household ownership patterns could be found for small stock, but almost all small stock are goats (about 40 000 in the region), with fewer than 100 sheep recorded in a number of recent surveys (CSO, 1996; MAWRD, 1997). Goats are an important household protein source and for cash income generation. Many households keep pigs in small pens which are fed on food scraps and are occasionally free ranging. Virtually all households keep chickens, principally for chicken production and not for eggs. They are an important protein source and household cash income, especially in poorer households. Surprisingly little has been done to strengthen poultry farming in the Okavango Region (Sihova, 1994).

Table 5: The size of cattle herds, stock owner numbers and total number of cattle per herd size in the Okavango Region (including Mukwe) in 1992. Source: Veterinary Services, Rundu.

HERD SIZE	No. of OWNERS (%)	No. of CATTLE (%)
00-10	752 (21.4)	5 849 (6.3)
11-20	1 091 (31.1)	17 505 (18.8)
21-30	674 (19.2)	17 018 (18.2)
31-40	390 (11.1)	13 591 (14.5)
41-50	228 (6.5)	10 080 (10.7)
51-60	125 (3.5)	6 790 (7.3)
61-70	88 (2.5)	6 394 (6.8)
71-80	58 (1.6)	4 435 (4.8)
81-90	36 (1.0)	2 554 (2.7)
91-100	24 (0.7)	1 890 (2.1)
101+	44 (1.3)	7 268 (7.8)
TOTAL	**3 510**	**93 374**

The majority of stock owners have less than 30 cattle which is viewed by Yaron *et al.* (1992) as too few to have a sustainable cattle farming enterprise with consistent offtake opportunities (herd size required to be 35 or more). However, this figure is given for

sustainable subsistence herds for pastoralists not presumed to be dependant on cultivation. The figure for agro-pastoralists (as farmers are in the Okavango area) would be considerably lower as their dependence on income generated by cattle would be less. About 80 % of stock owners could therefore be assumed to have herds of sufficient size to allow some offtake through any one year to improve household security and cash flow, at the same time as retaining herd viability. This is further confirmed by the MAWRD (1997) study which showed that ownership of cattle is significantly correlated with gains from crop production, even though herd sizes were relatively small. Cattle ownership *per se* has greater value in terms of the subtle mix of activities engaged by agro-pastoralists than strict beef production.

Average herd composition calculated in the 1994/1995 agricultural census (CSO 1996) is: Bulls - 5.2%; Oxen - 28.4 %; Tollies - 10.4 %; Cows - 42.0 %; Heifers 14.0 %. The majority of male calves are castrated because of the paramount need for oxen as draught animals. Many households have no bulls, but this is not thought to be a constraint in breeding as the regional herd is expanding (IFAD, 1996). Although cattle ownership is at the individual level, management (herding) is generally pooled and bulls roam freely within any given herd.

Herd management is seemingly poorly developed and there is no established system of transhumant movement. There is, however, some degree of mobility in cattle herding which allows for the utilisation of the patchy nature of grazing resources following localised rainfalls. The long-term sustainability and expansion of the regional herd is currently being weakened through changing patterns of ownership (more cattle are owned by fewer people), increasing ownership by non-resident owners (increased demand for space) and the establishment of more sedentarised agricultural practices centred on boreholes and wells.

The Okavango Region is often cited as having excess grazing capacity, a statistic derived by dividing the total area by the number of cattle. This is entirely an erroneous statistic, because expansion of cattle farming activities is not limited by grazing but the availability of surface water. With about 70 % of the regional herd dependant on water and grazing along the river, the estimated stocking rate is about 1 Large Stock Unit (LSU) per hectare (Masdar 1993) which is well in excess of the estimated carrying capacity of 1 LSU per 5-8 ha (Page 1980). The floodplain system obviously has a great degree of resilience and is able to recover to some degree to be able to support such heavy grazing pressures, but the increased sedentarisation and currently expanding herd has implications for the sustainable utilisation of the riverine resources. Already there are areas which are noticeably overgrazed being largely denuded of ground cover, resulting in extensive (and expanding) erosion along the river. Considerable emphasis will have to be placed on active herd management and grazing in the future if this aspect of the regional economy is to be maintained in its current condition or improved in the future.

A fruitful avenue of development would be in the strengthening of the potentially

synergistic relationship between crop and livestock farming to increase livestock productivity. This is poorly developed in the Okavango Region, and the use of livestock for expanding, intensifying and diversifying crop production and, in turn, the use of crop by-products in more intensive livestock production, warrants further study. Agricultural production intensification through active management (in an area where extensive and generally passive management was formerly in place) has been successfully implemented in several West African countries, with similar climatic, bio-physical and socio-economic conditions to the Okavango Region (Roggeri, 1995).

1.3.3 Agroforestry And Other Vegetation Resources

Within the subsistence agricultural system pertaining along the Okavango River, traditional tree and plant foods are an important component of household food security. There is a wide use of plants for a variety of purposes, including medicine, food, alcohol production, construction and fuel.

Some of the most important plants are:

i) A variety of pot-herbs, the most important of which are indigenous and exotic species of *Amaranthus* and *Gynandropsis*. These plants are eaten fresh as a relish, but are not as widely traded as they are in the Oshana, Omusati, Oshikoto and Ohangwena Regions. Markets and infrastructure are lacking in this region and so consumption is usually at the household level. A notable exception to this is the trade in the fruits of *Hibiscus sabdarafa* (Mutete) which is cultivated around homes and in fields. The swollen calyx of this species is used as a relish and can be dried for storage. There is a wide trade in this species, especially in eastern Okavango.

ii) Fruit and nut-bearing trees such as *Ricinodendron rautanenii* (Ugongo), *Guibortia coleosperma* (Usiivi), *Parinari* sp. (Sinsansi) and *Strychnos* sp. (Uttu/Uguni). These trees are widely conserved in cultivated lands and are recognised as valuable dietary supplements, especially in times of drought. There is some cutting (against traditional laws) of *G. coleosperma* as this is a high quality fuelwood. Shrubs of the genus *Grewia* (Rupundu/Ngogo) are important as dietary supplements in children. The Marula *Sclerocarya birrea* (Uwongo) has a patchy distribution but is prized for its fresh fruit, the kernels and for making alcoholic beverages.

iii) Indigenous grain legumes such as *Vigna* sp., which although not cultivated are often found within fields and are regarded as important foods.

iv) Basketry palms *Hyphaene ventricosa* (Ngone) which have been widely overexploited. In many areas they have been eradicated through cutting for palm hearts in times of food shortages. Re-establishment of palms is currently being investigated by the Rossing Foundation at Shankara.

v) Waterplants such as water lilies *Nymphaea* sp., provide bulbs and in some cases leaves which are important food supplements.

vi) Reeds, grasses and sedges used for the construction of traditional homes and for thatching.

The increased demand for land and fuelwood, construction materials and grazing has resulted in the local denudation of some of these resources, especially where traditional control measures have been eroded. Tree tenure is, however, well established and traditional taboos regarding the cutting of food trees, conserves these resources for the most part.

Urbanisation and reinforced dependency cycles related to food aid has caused a widespread decline in the acceptance of wild plants as food items. Together with the stigma of being a "poor persons food", the conservation of wild foodplants is declining and warrants considerable attention in increasing food security within the region. The plants in question are highly adapted to local conditions, are easily cultivated (in many cases they are weeds) and often have high nutritional values. This aspect of agroforestry is currently neglected within the region, with most of the focus in programmes supported by the Directorate of Forestry and Ministry of Agriculture being on the establishment of exotic tree fodder and alley cropping species.

1.4 Fisheries

Most of the work done on fish in the Okavango has been centred on biogeographic and population biology of fish species, and little work has actually been done on the actual fisheries along the river. Tvedten *et al.* (1994) provide a comprehensive review of fishing and fisheries management along the Okavango River, but time series data is lacking, precluding any defined statements regarding the condition of the fisheries along the river.

With almost 90 % of the regional population residing within 10 km of the Okavango River, it is clear that life revolves around the river. Fishing is a central part of the livelihood and well-being of the population and some 50 % of the people here actively fish through the year, with fish providing subsistence for about 91 % of the riverine households. Small scale sales provide cash incomes to about 45% of households. As may be expected, fishing greatly enhances household food security.

Little information exists on fish yields and almost no work has been done on the productivity and fish stocks within the system. Estimates of maximum sustainable yields (MSY) vary considerably, with MSY estimated from 840-3 000 tonnes of fish per year (van der Waal, 1991; Tvedten *et al.,* 1994; Hay,1995). Greater numbers of people are fishing, with a greater frequency (Tvedten *et al.,* 1994). It is estimated that 56 000 people fish for 60 days a year, catching an average of 300 g of fish per day. There are no long-term data series for offtake

rates, productivity or population structure available although the work of Hay (1995) now provides some baseline against which future monitoring could be done.

Fishing is largely conducted using the traditional methods of passive fish traps and funnels, and active methods such as plunge baskets, fish spears and hook and line. The use of nets is under-reported in the literature. Gill nets are widely used when floodplains are inundated and in some places are used year round in quiet backwaters. Most of these nets are homemade, but the incidence of commercial nylon nets is increasing. Mosquito nets are also used, preferentially by women, in shallow waters. Their usage is known to be widespread but most respondents to questionnaires deny use (and often knowledge of their use) in fishing. Traditional methods of fishing have the advantage of being unselective for species or size and a broad spectrum of fish are thus caught. Gill nets are far more selective, the net size determining the size of the fish caught. Owners of nets preferentially go for larger mesh sizes so as to get larger fish which command a better price on local markets. Thus adult fish are selectively removed from the population. Mosquito nets are used almost exclusively in catching fingerlings and immature fish in shallow water. The affectivity and selectivity of different fishing gear type is reviewed in detail in Hay (1995).

Yaron *et al.* (1992) estimated that households generally only catch about 60% of the fish that they consume, indicating that there must be a fairly large cash purchase or barter market for fish in the region. The study by Tvedten *et al.* (1994) found that about 30 % of households bought rather than caught fish, and that 42 % of households sold fish. Sales, however, remain *ad hoc* and uncommercialised, although they are viewed as a reliable source of limited income. Problems related to the cost of transport to the main commercial centres dictate that most sales are localised. Sales of fresh fish in Rundu are further complicated by the widespread availability of marine fish, sold by commercial traders. Marine fish are considerably cheaper than locally caught freshwater fish.

As pointed out by Tvedten *et al.* (1994), fish represent an invaluable resource for social and economic wellbeing in the Okavango Region, but it is widely perceived to be a resource in decline. The lack of long-term data relevant to stocks, size and diversity of populations and productivity precludes any definitive statement of trends. However, 90 % of people involved in fishing indicated that catch rates and fish size have declined over recent years. Reasons given for the decline are manyfold but all lack supporting data. Overfishing, habitat degradation, and other environmental variables subject to human interventions all contribute in a complex way. Whatever the reasons, the declines (whether real or perceived) present massive challenges for future management. Dependency on fish as a resource is high and any further negative changes in resource availability are likely to have important repercussions within the socio-economic framework of the region. For local people the social and economic values of fish far outweigh biological threats and as such, the fish resources are only as valuable as their contribution to income and food security. Any future attempts to develop, conserve and manage this resource need to take the socio-economic values and not only the biological values as the basis of any planning.

Van der Waal (1991) estimates the financial value of the local fisheries at N$ 1.8 million, and

this figure attests to the contribution that fisheries make to household food security, through providing a limited cash income. The real economic value of the fisheries remains obscured as the value in the subsistence economy of dietary protein and food security has not been calculated. The economic value of the fisheries requires considerable further study and should form the basis of a strategic plan for fisheries management in the Okavango Region.

Aquaculture has been proposed by several governmental and development agencies as a means to supplement local fisheries, either as a source of fish stocks for the river or as a farming enterprise where fish are produced for market consumption. Most objective evaluations have shown that the cost of developing the enterprise would far outweigh the income. The capital cost of pond construction, nutrient inputs to make up for the nutrient poor water, preparation and marketing infrastructure and the purchase of breeding stock, all contribute to the poor viability of this type of enterprise. The use of commercial high production breeds of fish would pose a considerable threat to the natural system along the river if they were to escape.

1.5 Protected Areas

The Mahango Game Reserve, what remains of the Caprivi Game Park and the small site at Popa Falls are the only formal conservation or protected areas on the Okavango River in Namibia. All these sites are in the lower section of the river, in the Mukwe Constituency of the Caprivi Region. This is the only area along the length of the Okavango River where the perennial riverine and seasonal floodplain habitats, which are essential to the functioning of the river system, are afforded any protection. These sites contain the only viable populations of large mammals along the river and as such have very high conservation and potential tourism values.

There is considerable conflict between wildlife and subsistence farmers around the Mahango Game Reserve, where crop-raiding elephant and stock-raiding lions are a constant problem in the surrounding villages. As people are not legally able to hunt game or control raiding animals, the costs of stock and crop losses have to be carried without recompense. As such, wildlife and these reserves are seen as a liability and viewed as wasted grazing lands.

The Ministry of Environment and Tourism is currently working on development planning in the region and on new legislation that will give rights of exploitation to communities within communal lands in much the same way as farmers have rights on commercial farm land. The idea is to improve attitudes towards wildlife and conservation through providing economic opportunities and incentives related to the parks. However, the government has already threatened to expropriate one community-based tourism development opposite Popa Falls for the further expansion of a prison, which does not bode well for the development of this policy in the future.

Administration and logistical support of these reserves is poor and staff are generally ill equipped to deal with anything but the most menial tasks. No monitoring of wildlife

populations takes place and very little active management occurs. Poaching is increasing in both the Mahango and the Caprivi Game Park and no fire control is effected in either reserve leading to a general degradation of grazing and woodland resources.

Tourism potentials are high and proposals have been made at several levels to allow development of private facilities within the parks (Hines, 1996b; Deloitte & Touche, 1997). The possible positive spin-offs of these facilities have the potential to improve local community attitudes towards wildlife and the parks in general through the provision of jobs and other economic opportunities. The MET has engaged a further round of planning, even though a comprehensive management plan for both areas has already been submitted (Hines, 1996b).

Conservation and community-based tourism NGO's are involved directly with activities on the East bank of the river (i.e. Caprivi Game Park) but none are directly involved with developing community liaison structures or institutional development in the Divundu area. There are no community-based conservation areas along the river at present, but there is considerable potential for such activities, especially if linked to tourism facilities.

1.6 State Lands

Other than the protected areas mentioned above, state land allocations are limited to Ministry of Agriculture farm at Mashare, a Ministry of Prisons and Correctional Services facility at Divundu and a number of educational and school facilities along the river. The Ministry of Health has a number of small facilities from which they operate their anti-malarial spraying campaigns, scattered along the entire length of the river.

1.7 Tourism

Tourism activities and potentials have been reviewed by Deloitte & Touche (1997). This report also makes recommendations regarding future developments in the tourism sector, but includes almost no reference to the potential impacts of expanded tourism facilities and services on the Okavango River. There is considerable interest in the whole Okavango-Caprivi Region by tourism developers and should the area be opened up in future, considerable attention will have to be given to management planning to ensure that the riverine system is not negatively impacted.

Tourism activities are largely confined to the area between Rundu and Mahembo on the Botswana border and are all centred on the Okavango River. As far as could be ascertained, there is only one small tourism operation west of Rundu. There are currently 15 tourist lodges and camps operating, with another currently being constructed in Rundu itself. About 350 beds are available, but many of these establishments operate at very low occupancies and are marginal operations. Greiner (1997) estimates a total income generation of about N$ 18 million with occupancies at 60 % (but recognised only 11 operations). All of these operations

are non-consumptive, focused mainly on providing accommodation for the transit tourism trade running through to Victoria Falls and the photographic safari opportunities around the Mahango Game Reserve.

Consumptive use of wildlife along the river is limited to a number of hunting concessions in the Divundu area. Three concessions have been granted for shooting up to 4 Elephant each in the Mahango Game Reserve and a further concession has been granted for 4 Elephant and 2 Buffalo in an area of the Caprivi Game Park opposite the Mahango Game Reserve. The cost of these concessions was in the region of N$ 200 000 each. The overall input into the local and regional economies is unclear.

The Namibia Community-Based Tourism Association (NACOBTA) is becoming increasingly involved in tourism development along the river and is working in close association with the Ministry of Environment and Tourism's Community-based Natural Resource Management (CBNRM) programme. Funding is provided principally by the LIFE programme (US-AID) and is used for training courses in management of tourism establishments, craft production, tour guides and market support. Present community projects exist at Kayova, Kangongo and on the east bank of the river opposite Popa Falls (Ndwalashaa). Funding for these enterprises was supplied by Oxfam-Canada and Integrated Rural Development and Nature Conservation (IRDNC), a conservation NGO active in the West Caprivi.

1.8 Mining

Covered as it is by deep, aeolian sand deposits of the Kalahari system and with very little surface expression of geology, mining opportunities in the area are extremely limited. There are currently no mineral based mines in this part of Namibia. The only operations covered by the Minerals and Exploration Act are the large scale quarries developed for providing crush material for road developments in the region. Most of these have closed down and have been rehabilitated.

1.9 Urban And Industrial Development

The only recognised urban centre along the Okavango River in Namibia is Rundu, which is the regional administration centre. The current population is in excess of 19 000 and is rapidly increasing. Other administrative centres are found along the river and generally coincide with former mission stations. Yaron *et al.* (1992) estimate that 15 000 ha are occupied by urban developments most which are found along the Okavango River.

There is little industrial development along the river and water demand is largely for domestic use in most centres. Rundu has some small engineering works, wood products factories and a wide range of retail stores, none of which is an intensive water user.

No water recycling is done in Rundu or other centres. At Rundu, domestic waste water is put

through several stages of treatment at a sewerage works just to the East of the town. Excess water at the site is discharged into a series of small ponds and dams which are subject to overflow during the wet season. Discharge from these ponds goes directly into the river. Other than this seasonal discharge, pollution levels are low.

1.10 General Conclusion:

A noticeable feature of the region under review is that 90 % of the population lives within 10 km of the Okavango River. There is consequently a high demand for land and natural resources in this narrow belt. The rapid population expansion since the start of the Angolan civil war, the increased sedentarisation of livestock and people, and the poor agricultural practices along the river margin have led to a general loss of productivity of the riverine system. The resource base supporting the highest human population densities in Namibia is being compromised through overexploitation, poor extension and no management. There is an urgent need to address the overall management issues involved if continued utilisation is to be sustainable. There is an urgent need to manage the river as a *system* and not view it as a variety of separate components subject to ill-defined sectoral responsibilities. The ultimate challenge for policy makers, managers and users of the system is to maintain or improve productivity in the face of ever increasing resource demands and human pressures.

Some of the major issues which warrant further investigation, support and management assistance are:

The development of cross-sectoral extension programmes emphasising the inter-related nature of the defining processes within the river basin. For example, the fact that upslope agricultural practices affects fisheries production through siltation, loss of floodplain habitats and pollution.

The development of a farming systems research programme with its focus on the whole issue of agricultural practices within the river basin and how they could be adapted or improved to safeguard river system functioning. It is imperative that agricultural development programmes reinforce and improve systems rather than replace them.

The development of an understanding of the extent of the fisheries component of the local economy. There is currently a need to understand demands on the system, as well as defining the production capacity of the system to clarify sustainable yields. The non-financial values of fisheries in the economy also need to be better defined. The results could be used to influence decision makers at all levels to be pro-active in conserving the system in such a way that off-takes are sustainable in the long-term.

The development of incentive schemes for the rehabilitation of riverside and upslope agricultural lands. There is a need to improve production levels through fertilisation, reduce runoff through terracing, tree planting and slope stabilisation.

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