Lake Cahora Basa

Lake Cahora Basa is a human made reservoir in the middle of the Zambezi River in Mozambique, which is primarily used for the production of hydroelectricity. Created in 1974, this 12 m (39 ft) deep lake has been strategically built on a narrow gorge, enhancing the rapid collection of water and creating the pressure required to drive its giant turbines. The lake's dam has a production capacity of 3 870 megawatts, making it the largest power-producing barrage on the African continent.

After the construction of Cahora Basa Dam, its water level held constant for 19 years, resulting in a near-constant release of 847 m^3 (1 108 cubic yards) over the same period. Observations before and 20 years after the dam's impoundment, however, reveal the following negative impacts, some of which may also have been caused by other dams on the river (e.g. Kariba), as well as the effects of the country's 20-year civil war—but nearly all of which have been directly influenced by the over-regulation of a major river system:

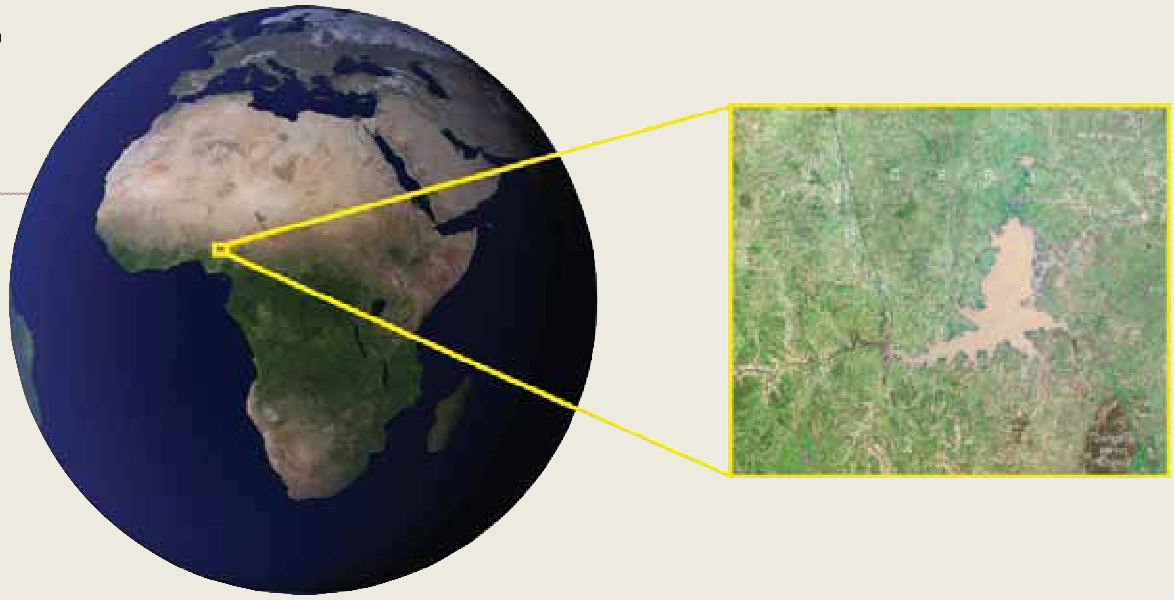
- Many of the mangroves in the delta have dried out and died back
- The community structure of the floodplain vegetation has changed, with a substantial increase in trees
- Meanders and oxbows, once a major feature of the floodplain, have become clogged with reeds and trees
- Productive, flood-dependent grasslands have been depleted of grasses, the favoured food of herbivorous mammals
- Large mammals, including the once-abundant buffalo, have almost disappeared from the delta
- The abundance of waterfowl has declined significantly
- Floodplain 'recession agriculture' has declined significantly
- Vast vegetated islands have appeared in the river channel, many of which have been inhabited by people
- Dense reeds have lined the sides of the river channels
- Erosion of the coastal zone has increased, probably more as a result of the release of sediment-hungry water from Cahora Basa Dam than of changed flow patterns
- Water levels in the lower Shire River, the largest tributary of the Zambezi downstream of the dam, have dropped, prohibiting navigation of this river (Chenje & Jonson 2002).

The majority of power generated by the Cahora Basa Dam is used in Mozambique, with some sold to South Africa and Zimbabwe. Lake Cahora Basa can actually be seen as a 'powerhouse' of Southern Africa, although damage to the generators during the civil war in 1972 has kept the plant from functioning at its originally anticipated levels. The construction of the dam has been opposed by communities down the Zambezi River, where it reduced the annual flooding on which they rely for cultivation. The Zambezi used to overflow its riverbanks, creating rich floodplains ideal for cultivation. However, the Cahora Basa has proved important as the major source of hydroelectrical power in Southern Africa. In 2005, the Southern African Development Community (SADC) member states agreed on a regional power generation initiative, which aims to boost the power supply generated by Cahora Basa, as well as building a second plant 60 km (37 miles) downstream (SADC Today 2005).

Reservoir behind the Cahora Basa Dam

Unknown/UNEP/The Water Page

Challawa Gorge Reservoir



Challawa Gorge Dam on the Challawa River in Nigeria is designed to release water into the Hadejia River for subsequent storage behind the barrage of the Hadejia Valley Project (Thompson 2005). The dam was built for securing supplies of potable water and irrigation for agricultural land around the state capital Kano.

With 1 000 million m^3 (1 308 million cubic yards) capacity, the Challawa Gorge Dam is the second-largest dam supplying water to the city of Kano. The dam is 7.8 km (5 miles) long and 42 m (138 ft) high, and required 5.1 million m^3 (6 671 million cubic yards) of filling material. The reservoir thus created has an area of 100 million m^2 (120 million square yards). The project essentially consisted of a homogeneous dam of decomposed rock. Core drilling performed at the dam's center, however, detected the existence of various seams in the underlaying rock which made it necessary to construct an anti-seepage grout curtain. The dam also includes construction of a 30 m (98 ft) intake tower, intake main and a 600 m (1 967 ft) long spillway. Since work on the dam commenced as far back as 1977 and was interrupted in 1987, considerable erosion damage occurred to the structure. This made it necessary to scratch off the damaged layers prior to excavation and fill-work. After 26 months of construction, the dam was completed (Julius Berger Nigeria Plc n.d.).

After completion, the Hadejia river system—one of the major water sources for the Hadejia-Nguru Wetlands located in the Lake Chad basin—became more than 80 per cent controlled by the Tiga and Challawa Gorge dams. These two dams feed the Kano River Irrigation Project, the Hadejia Valley Irrigation Project and the Kano City Water Supply (KCWS). Earlier agreements to guarantee certain amounts of flow from the Hadejia river system for the downstream communities living in the floodplains, who are dependent on flood recession agriculture, have so far not been implemented (IUCN 2004).

In this arid region, the fast-growing population and its economic activities demand a large share of the water resources. Demand is approximately 2.5 times higher than available water. Decreasing rainfalls, possibly due to climate change have already reduced flows in the basin.

The result is growing tension between water users and regions. This is already leading to conflicts. Illustrations include the dogged opposition of the downstream states of Yobe and Borno to the construction of Kafin Zaki Dam, and the incessant conflicts between farmers and pastoralists over access to water.

Action is being taken to address these issues. The Nigerian National Council on Water Resources established a Hadejia-Jama'are-Komadugu-Yobe Coordination Committee in 1999. Also, the Lake Chad Basin Commission (LCBC) is implementing a GEF-supported programme for the integrated management of Lake Chad and associated river systems (FAO 1997).

Hadejia-Jama'are River Basin, Northern Nigeria

In Northern Nigeria, an extensive floodplain exists where the Hadejia and Jama'are Rivers converge. The floodplain provides essential income and nutrition benefits in the form of agriculture, grazing resources, non-timber forest products, fuelwood and fishing for local populations. It also helps to recharge the regional aquifer which serves as an essential groundwater source. However, in recent decades the floodplain has come under increasing pressure from the construction of the Tiga and Challawa Gorge dams upstream. The maximum extent of flooding has declined from 300 000 ha in the 1960s to around 70 000 to 100 000 ha more recently and there are plans for a new dam at Kafin Zaki.

Economic analysis of the Kano River Project, a major irrigation scheme benefiting from the upstream dams and traditional use of the floodplain, showed that the net economic benefits of the floodplain (agriculture, fishing, fuelwood) were at least US$ 32 per 1000 m^3 of water (at 1989 prices). However, the returns per crops grown in the Kano River Project were at most only US$ 1.73 per 1000 m^3 and when the operational costs are included, the net benefits of the Project are reduced to US$ 0.04 per 1000 m^3.

The Kadawa River Project in the northern state of Kano includes a short-range scheme for safeguards against further drought. Here farmers are being taught new irrigation techniques

B. Imevbore/UNEP/FAO

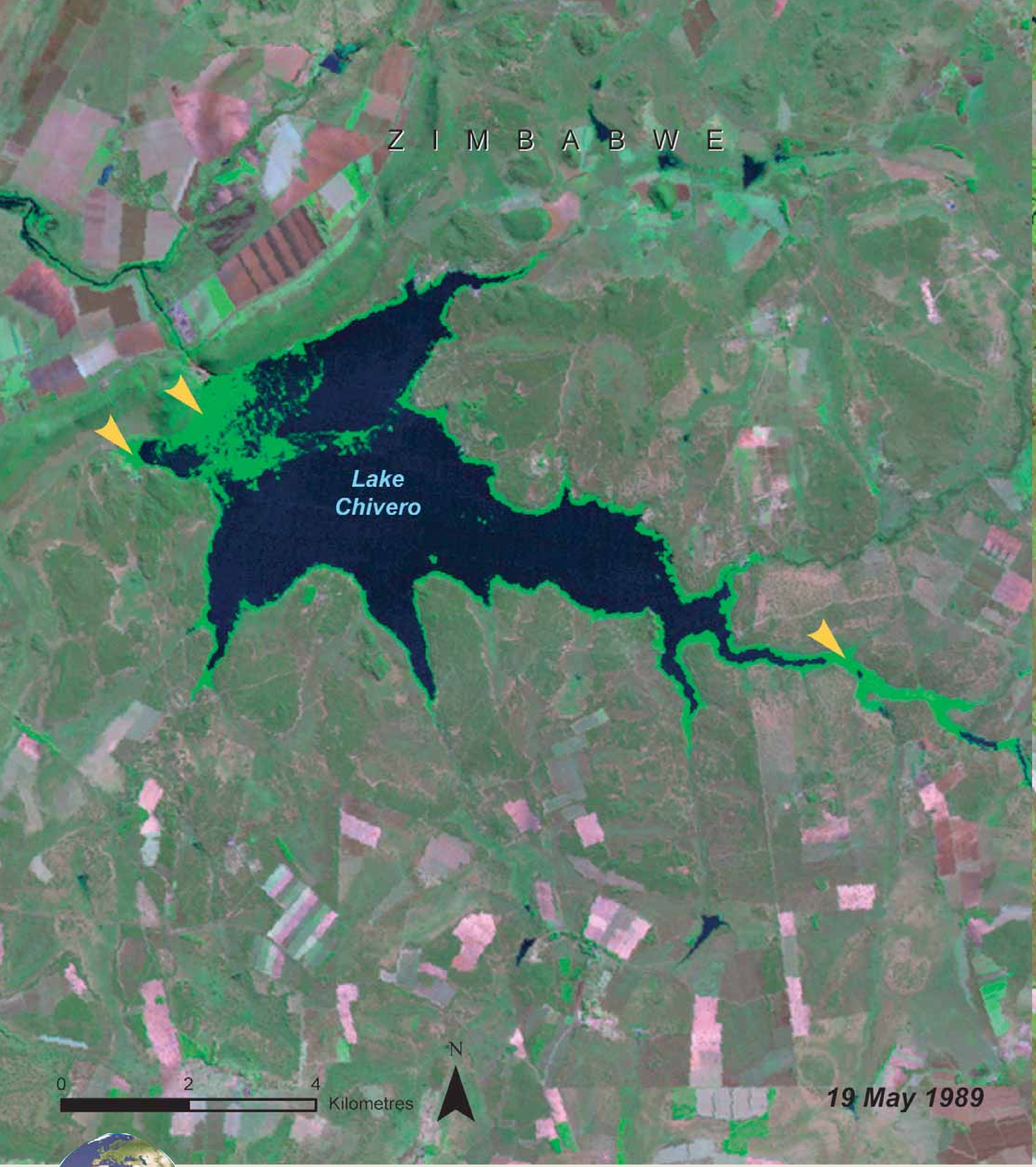
A combined economic and hydrological analysis was conducted to simulate the impacts of these upstream projects on the flood extent that determines the downstream floodplain area. The economic gains of the upstream water projects were then compared to the resulting economic losses to downstream agricultural, fuelwood and fishing benefits. Given the high productivity of the floodplain, the losses in economic benefits due to changes in flood extent for all scenarios are large, ranging from US$2.6-4.2 million to US$23.4-24.0 million. As expected, there is a direct trade-off between increasing irrigation upstream and impacts on the floodplain downstream. Full implementation of all the upstream dams and large-scale irrigation schemes would produce the greatest overall net losses, around US$20.2-20.9 million.

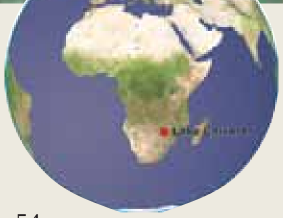
These results suggest that the expansion of the existing irrigation schemes within the river basin is effectively "uneconomic." The introduction of a regulated flooding regime would substantially reduce the scale of this negative balance, to US$15.4-16.5 million. The overall combined value of production from irrigation and the floodplain would, however, still fall well below the levels experienced if the additional upstream schemes were not constructed (UNEP n.d.a).

CHALLAWA DAM
NIGERIA

The Challawa Gorge Dam, completed in 1993, is the second largest of the 23 dams along the rivers in Nigeria's Hadejia-Jama'are River Basin. Although the dam has improved the water supply for irrigation,

it has also ruptured the fragile natural balance along this stretch of water. When it rains heavily, the river can break its banks and flood farms and land upstream from the dam. Areas downstream, meanwhile, do not receive enough water to maintain the wetlands bordering the river. Under these conditions, the soil dries out and overgrazing occurs, which in turn leads to wind erosion of the topsoil. These satellite images provide a comparison of the area before and after the dam's construction. The 1999 image shows the degree to which flooding upstream impacts the landscape, and how the lack of water downstream negatively affects riverine wetlands and cropland. The colour of the water in the flooded area is also indicative of high-sediment content.





LAKE CHIVERO
ZIMBABWE

Lake Chivero holds about 250 000 million litres (264 000 million quarts) of water and is approximately 26 km² (10 square miles) or 2 632 ha. Beginning in the mid 1980s, the

lake became progressively eutrophic, after a recovery period from a previous eutrophication phase in the mid 1960s. While these two images suggest an overall reduction of the presence of invasive water weeds in Lake Chivero between 1989 and 2000, there is evidence that this remains a persistent problem. The weeds show up as green strands along the edges of the lake. Like most of Zimbabwe's freshwater bodies, freeing Lake Chivero from the weed menace will require long-term eradication strategies, continuous monitoring, and a comprehensive integrated water basin management programme.

Lake Chivero

In recent years, Zimbabwe has instituted major control programmes to tackle the negative effects of aquatic weed infestations in its rivers, wetlands and other freshwater bodies. The problems have proved hard to solve. Three free-floating weeds—Water Lettuce (*Pistiastratiotes*), the Water Carpet, Azolla (*Azolla azolla*), and Water Hyacinth (*Eichhornia crassipes*)—are the major culprits, with the latter creating by far the biggest problem. Aquatic weeds disrupt domestic and industrial water supplies, as well as fishing activities, irrigation schemes, hydroelectric power generation, and water-borne recreational activities. Eradication strategies can also cause additional problems, with the use of herbicides such as 2,4-D linked to serious health risks, including cancer, and the use of some non-endemic biological predators disrupting fragile ecological balances.

Further investigations are required to identify the most effective control strategies for combating Zimbabwe's water hyacinth infestations. This robust, fast-growing weed has a large number of fibrous roots, which are highly adapted to absorb nutrients in eutrophic waters. Either free-floating or rooted in shallow waters, it forms dense mats, which can weigh as much as 25 kg/m^2 (55 lbs/m^2)or 2500 t/ha. The hyacinth thrives in nutrient-rich waters, particularly those adjoining agricultural lands, such as Lake Chivero. In such waters, the plant's growth rates can reach a staggering five per cent per day. Water hyacinth propagates itself through vegetative means and through seeds, which can remain viable for up to 15 years (Gurure 2000). This means that, even if the weed is totally removed, possibilities for regeneration still exist through its seeds. Therefore, long-term eradication strategies need to include continuous monitoring programmes.

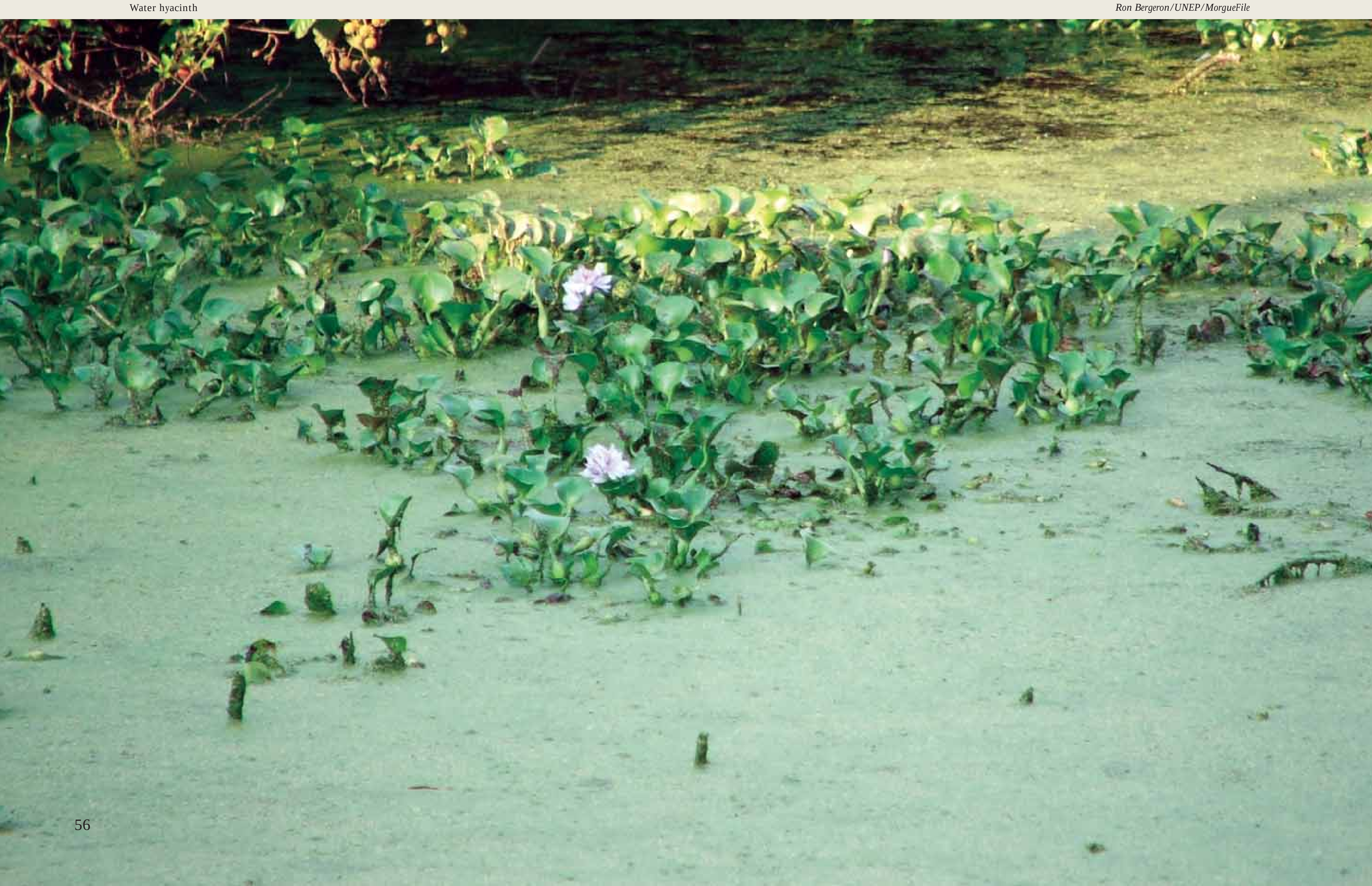
Table 3.3: Historical trends in phosphorus loading to Lake Chivero

Parameter	*1967*	*1978*	*1996*
P- load, tons yr^{-1}	288	39.6	350
Mean P concentration in inflow mg l^{-1}	2.25	0.13	1840
Conductivity mS cm^{-1}	160	120	800

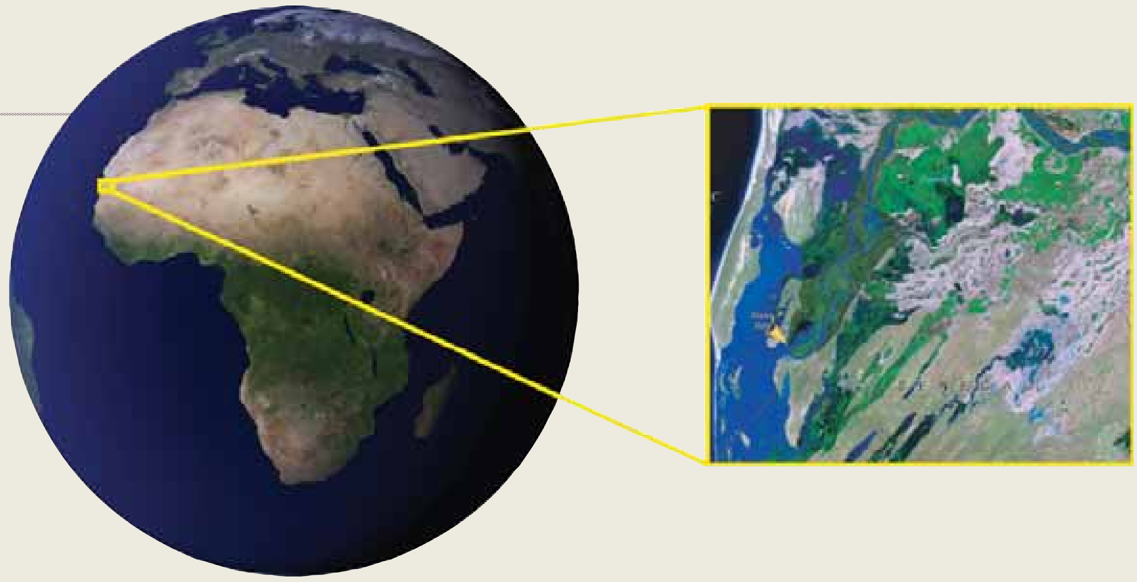
UNEP (n.d.b)

Water hyacinth

Ron Bergeron/UNEP/MorgueFile



Lake Djoudj



Lake Djoudj is about 60 km (37 miles) from Senegal's regional capital of St. Louis, close to its northwestern border with Mauritania. The lake is part of the Djoudj Sanctuary, a 16 000-hectare wetland in the Senegal River delta. The sanctuary is composed of lakes surrounded by streams, ponds and backwaters. The lakes are large, open expanses of brackish water with no vegetation, whereas the creeks and ponds are relatively enclosed and bordered by fairly thick vegetation. In 1977, the sanctuary was added to the Ramsar Convention's list of Wetlands of International Importance. Since 1981, UNESCO has also listed it as a World Heritage Site.

Nature tourism is the predominant activity within the lake's vicinity. The local people also gather cattails (*Typha australis*) and grass (*Sporobolus robustus*) to make mats. Stray domestic animals pose a threat to the wildlife in the area. Navigable waterways have become overgrown and choked because of the commissioning of the Diama Salt Dam on the Senegal River 20 km (12 miles) downstream (23 km or 14 miles upstream from the river's mouth) in 1986. The dam's primary function is to prevent saltwater intrusion from the Atlantic Ocean; it is closed during the dry season from November to June, and gradually opened during the rainy season, generally around July. The Diama Dam has improved river navigation, and a series of dikes were also built to protect the banks along the river downstream from the dam.

The Djoudj Sanctuary forms a living but fragile reserve for an estimated 1.5 million resident waterbirds, including the Purple Heron, the African Spoonbill, the Great Egret, the Cormorant, and the Great White Pelican (*Pelecanus onocrotalus*), which has a large breeding colony numbering 15 000 birds. The Arabian Bustard (*Ardeotis arabs*), a highly endangered species, is starting to make occasional appearances. Almost 3 million birds from more than 350 species visit the sanctuary each year.

Over the past 30 years, however, agricultural activities have taken a heavy toll on this vital wetland. Before 1965, flood-based agriculture was dominant in the Djoudj basin. Then, as a result of a hydro-agricultural improvement programme instituted by the state-run Delta Improvement and Exploitation Society (SAED), irrigation-based agriculture took over. Since the SAED's withdrawal and the introduction of an agricultural loans system, individual farmers' development groups have overseen the expansion of small-scale irrigation schemes—and increasing freshwater extraction from the Senegal River.

Giant Salvinia

Giant salvinia (*Salvinia molesta*) is considered to be one of the world's worst aquatic pests. It is an aggressive, competitive species that can impact aquatic environments, local economies, and human health. In favorable environments plants can be expected to double within about a week and excessive growth of giant salvinia can result in complete coverage of water surfaces. This degrades natural habitats in several ways by competing with and shading desirable native vegetation. Mats of floating plants prevent atmospheric oxygen from entering the water while decaying salvinia drops to the bottom, consuming dissolved oxygen needed by fish and other aquatic life. Animal habitat is most noticeably altered by the loss of open water. Migrating birds may not recognize or stop at waterbodies covered with giant salvinia. Giant salvinia clogs water intakes, interfering with agricultural irrigation and electrical generation, and the floating mats provide excellent habitat for disease carrying mosquitoes. Salvinia reproduces so rapidly that infestations rapidly become impossible to eradicate. The mats have been reported to be up to 91 cm (3 ft) thick which hinders management by chemical control (WAPMS, 2006).

Salvinia molesta

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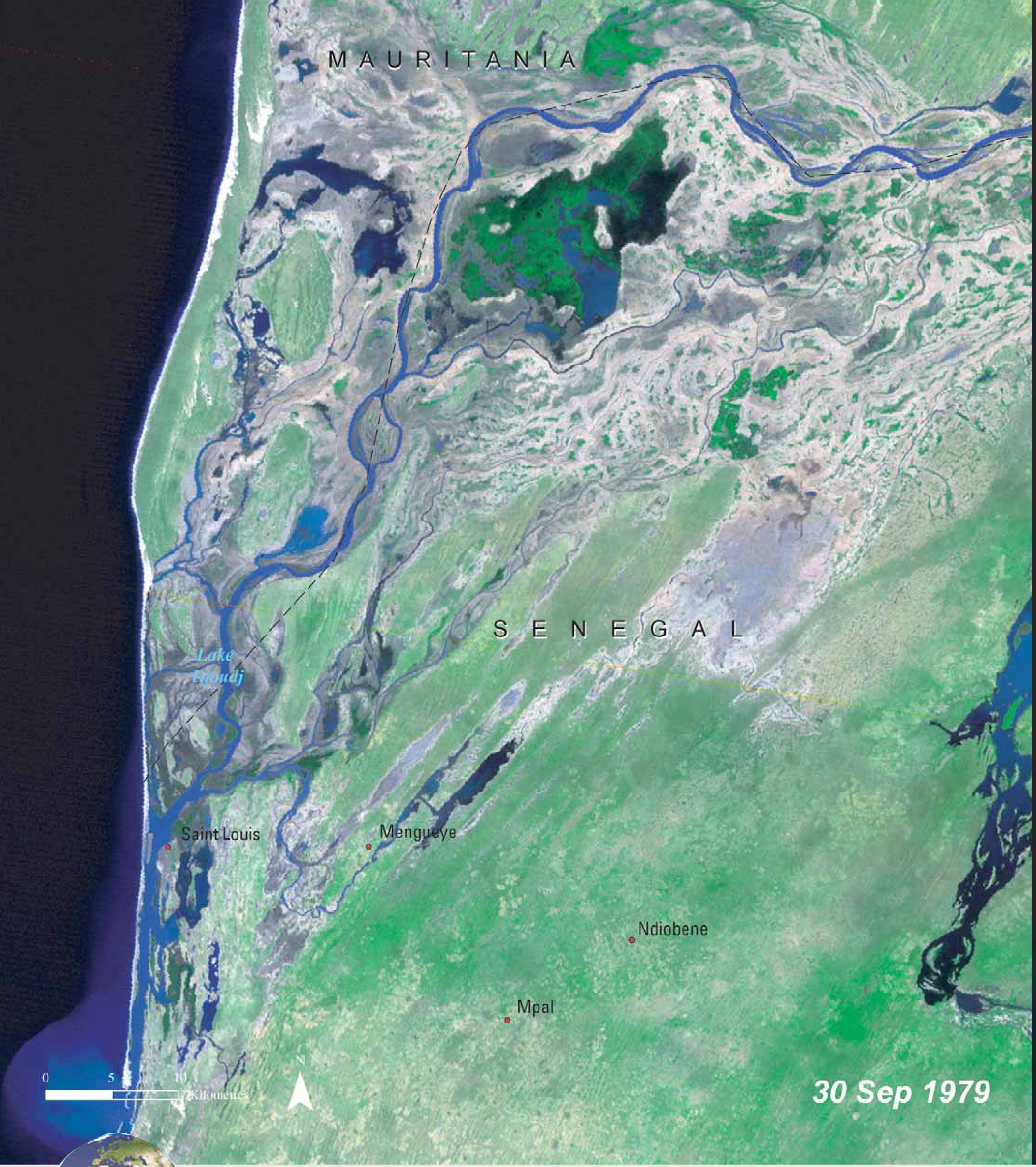
Giant Salvinia first appeared in the Senegal River delta in September 1999 and has since spread to many bodies of water and water basins, disturbing the existing biological equilibrium and threatening human health as well as the overall ecological and economic characteristics of the delta. This invasive species directly threatens the Parc National des Oiseaux du Djoudj (Djoudj Sanctuary), included in the Montreux Record in 1993 and formerly placed on the list of endangered UNESCO World Heritage sites in 1984, and the Parc National du Diawling in Mauritania (UNESCO, 2006).



LAKE DJOUDJ
SENEGAL

Situated in the Senegal river delta, the Djoudj Sanctuary is a wetland of 16 000 ha, comprising a large lake, referred to as Lake Djoudj in this publication, surrounded by streams, ponds and backwaters. These two

images show the Djoudj Sanctuary before and after the construction of the Diama Dam. The image from September 1979 shows the impact of drought on the Djoudj Sanctuary, while the image from November 1999 shows rejuvenation of the sanctuary wetlands due to the significant floods of that year. The two images vividly depict the impact of climate variability on the Djoudj Sanctuary—and demonstrate the broader need for close monitoring of the impacts of climate variability and climate change on lake environments.