The Delta has been protected from the kinds of development that often lead to the loss of natural resources. What can be done to secure its good health in the foreseeable future?
Okavango Delta: Floods of Life had its origins in a programme led by the International Union for the Conservation of Nature. A major goal of this IUCN programme was to promote the use of information to monitor the abundance and composition of life in the Delta. What are known as *freshwater biodiversity monitoring* programmes have been implemented elsewhere in the world, particularly along rivers where the deterioration of water quality upstream is likely to cause populations of plants and animals to decline downstream. Such changes are used to flag the possibility that upstream polluters, for example, have added additional or new poisons to their effluent. That information is then passed to people responsible for managing the quality of river water so that the sources of pollution can be tracked down and eliminated.

Many projects to do similar monitoring in the Delta have been implemented. As a first step, baseline information was collected to determine what populations of animals and plants were present. In such a diverse environment, samples had to be taken in different places, and samples had to be collected at various times to account for seasonal changes. Quantitative indices as measures of both the abundance and diversity of organisms were then developed so that future samples could be compared against the baseline indices. Changes in the indices should thus provide warnings that all is not well, either as a result of water being altered locally or as it flows out of Angola and Namibia.

This book was intended to synthesise the baseline monitoring information and experience, and thus to demonstrate the value of monitoring freshwater biodiversity in the Delta. However, it was found that more work was needed to develop appropriate monitoring measures before a synthesis could be attempted. An alternative approach was then taken, which was to summarise what is known about the Delta, in a format that would interest people who should care for the Delta. In other words, since an adequate supply of information on freshwater biodiversity monitoring was not yet available, we hoped that this book would create greater demand for monitoring and responsive management in the future. Likewise, we hope that the thoughts offered here will raise awareness about the challenges to be faced.

**Threats: internal and external**

These first few paragraphs touched on the intentions of IUCN and other people to keep an eye on the Delta. For what, however, should the monitoring be? Thoughts on that question are split into two categories: internal risks that originate within and immediately around the wetland, and external factors that potentially affect the Okavango River in its Angolan catchment and its passage through Namibia to Mohembo. We begin with potential internal hazards.

**Chemical pollution**

Thus far this has not been a major problem in the Delta, perhaps because contamination has not been significant and because wetlands filter out organic compounds so effectively. However, there are concerns about effluent from villages and towns, lodges, camps and boats for tourists. Measures have recently been implemented to require tourism facilities to process sewage water and to bury the remaining concentrates beneath saline sediments in the centres of islands (see page 95). Some lodge and camp owners have also implemented their own monitoring programmes to check the quality of water around their facilities.

The use of pesticides to kill tsetse flies has caused considerable alarm. There have been two major recent applications of deltamethrin, in 2001 and 2002, when the entire alluvial fan was sprayed several times from aeroplanes. Deltamethrin was used because it targets invertebrates and degrades rapidly, unlike such persistent and infamous poisons as DDT and dieldrin that further accumulate in deadly concentrations in animals at the top of the food web. The use of deltamethrin is also an improvement over the use of endosulphan (which is toxic to fish) during the 1980s for tsetse fly control in the Delta.

After the deltamethrin spraying, the abundance of aquatic and terrestrial invertebrates was found to have dropped by between 25 and 65%, depending on the family of invertebrate family. Dragonflies (see page 95) and beetles were particularly hard hit, while others were less affected. By 2003, many groups had recovered to pre-spraying abundances; and while some species had not recovered, others were more abundant than before the spraying. It is not known if this was due to natural population changes or if the ‘new’ species occupied niches left vacant by those that were killed. Fish and birds were apparently not harmed by the spraying.

Although contamination by pesticides applied within Botswana has perhaps not been too problematic, this potential hazard needs to be monitored continuously since the impacts of inadvertent poisoning can be utterly devastating, and because residues can remain toxic for so long. Contaminants applied locally could also increase toxic burdens introduced from upstream and atmospheric sources of chemical poisoning.

**Alien species**

Invasive, exotic plants and animals are another potential threat to the Delta. Like chemical pollution, they may be introduced unwittingly and remain inconspicuous, at least in the beginning. And as with pollutants, there are some problems already.

Foremost of these is the water weed *Salvinia molesta*, which first appeared in the Delta in the mid 1980s. Experiments by Namibians along the Kwando River showed that the weed could largely be contained by *Cyrtobagous salviniae*, a small beetle introduced from Brazil. The Botswana Department of Water Affairs accordingly implemented an on-going programme to pre-spray abundances; and while some species had not recovered, others were more abundant than before the spraying. It is not known if this was due to natural population changes or if the ‘new’ species occupied niches left vacant by those that were killed. Fish and birds were apparently not harmed by the spraying.

The most serious invasive alien is the water weed *Salvinia*, mats of which can cover large areas of open water. The weed was first recorded in the Delta in July 1986 at Xini Lake. Adult beetles (above) destroy leaf buds of *Salvinia* and their larvae tunnel into the rhizomes causing the plants to disintegrate and sink.
introduce the insect, as well as using manual labour to remove mats of Salvinia. So far, these efforts have limited the spread of the weed in the Delta, but the control measures have to be applied repeatedly wherever Salvinia reappears. A good deal of vigilance is thus needed to detect outbreaks and to respond to them in good time. One difficulty arises from the growth of beetle populations apparently lagging behind that of Salvinia, which allows mats of the weed to develop. Fortunately, the low nutrient content of Delta water (see page 53) appears to limit the growth and spread of the weed.

A variety of other alien plants occur in the Delta, such as thorn apples or jimson weeds (Datura ferox and D. stramonium), the burweed (Xanthium strumarium), Mimosa pigra, Sesbania species, syringa (Melia azederach) and exotic food plants, such as guavas, pawpaws and cassava. Thorn apples and burweed sometimes cover large areas of disturbed ground in the Delta (see page 82), and all these species may be invasive at the expense of natural vegetation. Unlike most large wetlands elsewhere in the world, no invasive species of fish yet occur in the Delta. However, there are risks of the unwanted introduction of such species as the Nile tilapia (Oreochromis nilotica), which might hybridise with several of the tilapia species that are native to the Delta. The possibility of Nile tilapia reaching the Delta from the Zambezi River (through the Chobe River, Linyanti Swamps and Selinda Spillway) appears slight, but the route down the Okavango River is direct and easy to follow should people in Angola or Namibia start to farm with these fish.

Clearing of channels

Development in most societies strives towards stability and predictability, which in the case of the Okavango Delta is in direct conflict with its inherently unstable, shifting nature. Channelling of water and clearing waterways has been done frequently in the past, and is still often proposed to facilitate boat traffic and to provide villages with permanent water supply. However, the removal of blockages will make the channels more permanent which, in turn, will create stable flooding patterns. This is likely to reduce the size of the Delta in the long term, as well as lowering the productivity of floodplains for livestock, wildlife, fish and other populations. Bush encroachment may increase, and biological diversity could be reduced.

Moreover, and perhaps fortunately, clearing activities are usually doomed to fail because they attempt to reverse natural changes. The failure of every historically recorded channel clearing effort over the last century in the Delta bears this out.

Elephants

Populations of these giants have been booming in northern Botswana for the past 20 years. Large swathes of mature riverine forest along the Kwando and Okavango Rivers (in Namibia’s Bwabwata National Park) have been entirely decimated, and elephants have done the same to mopane woodlands in some areas of the Delta (see page 87). If similar significant damage happens to woodlands on islands there is the risk of transpiration and the concentration of salts being reduced (see page 55), and that could lead to the Delta becoming saline.

Although almost everyone condemns the loss of woodland and agrees that there are too many elephants, no one appears willing to take measures to control the problem. Any significant culling programme would elicit howls of protest from animal rights groups, and this could damage Botswana’s reputation and tourism industry.

External challenges in the catchment and elsewhere

Large areas of land and natural resources in the Delta have essentially been set aside for conservation. This is economically valuable to the country as a whole and financially beneficial to many local residents. At the same time, this approach does much to safeguard environmental health.

Quite different perspectives and values hold in the Okavango River catchment in Angola and Namibia. Here, little land is allocated for environmental conservation, few people benefit financially from tourism, and more important economic interests elsewhere in the two countries carry much greater weight (see page 55).
In recent years, several studies and projects have explored development options in the catchment area in Angola and for the flow of Okavango River water as it passes through Namibia. With few exceptions, the postulated development scenarios have focused on (a) options for water use, (b) government policies and programmes for the use of water and (c) water allocations for the three countries. These are all extremely important aspects.

Yet little or no attention has been paid to (a) the financial benefits of tourism and wildlife in Angola and Namibia, (b) the growing use (and likely abuse) of the catchment’s resources by private people and companies, (c) the promotion of the Okavango River Basin as a valuable ecological entity, and (d) the sharing of benefits between Botswana, Namibia and Angola. These, too, are important matters, to which we later return.

Namibia

Official perspectives on the Okavango in Namibia concentrate on the use of river water for agricultural, domestic and industrial use and fish farming. Although several non-government organisation (NGO) programmes have promoted non-consumptive uses of the Okavango in Namibia and entrepreneurs have established a number of lodges and camps, the value of the river in attracting tourism revenue is seldom mentioned in government circles.

For the future, we can expect more water to be extracted from the river, both by government projects and private use. Usage will increase gradually for much of the time, but it will also escalate sharply when Namibia next experiences conditions as dry as those in the early 1990s. Plans to pipe limited volumes of water to the central areas of the country were then developed, but were suddenly shelved after good rains fell.

The plans also attracted harsh criticism from many environmental groups who were concerned about the impacts of reduced flow into the Delta. Similar criticism was voiced when Namibia investigated the construction of a hydro-power facility at Popa Falls (see page 21).

An important point, however, is that the Namibian population, economy, and demands for water have all grown considerably since the 1990s. Thus, when very dry conditions next occur Namibia is certain to make much greater demands on the river for its water.

Angola

Much of the Angolan catchment remains the terras do fim do mundo; the land at the end of the earth, unknown and unseen by most members of the public. The servants of the public in government will probably place emphasis on the development of water resources and more fertile soils elsewhere, which are closer to the more populous regions of the country. Potential for hydro-power development has been identified at several sites along tributaries of the Okavango, but serious plans to develop these have yet to be made. It is possible that ‘run-of-the-river’ designs could be used to minimize the impacts of hydro-power schemes on water flow.

Since rainfall is usually higher and less variable, and evaporation lower in Angola than in Namibia, abnormally dry conditions in the catchment are unlikely to be that demanding of river resources. However, as in Namibia and Botswana, the relatively small population in the catchment will continue to grow steadily, expanding its footprint on the catchment. And as in the other countries, much of the footprint will be from low input, low output traditional farming.

While common sense dictates that the relatively infertile soils and remoteness from markets should make most of the Angolan catchment unsuited to commercial crop production, entrepreneurs may see the broad floodplains of rivers as suitable for large-scale irrigation, perhaps for sugar cane, maize, rice or jatropha, for example. Such developments will doubtless have to be subsidised with public money, thus copying the unprofitable irrigation schemes in Namibia (see page 35). Foreign investments and influences may be involved, as is happening elsewhere in several African countries, where large tracts of land are leased to feed foreign consumers and to meet growing demands for biofuels.

The amounts of water used for each irrigation scheme should be relatively small. However, the cumulative off-take of several farms – together with those in Namibia – could be significant, especially if large volumes are removed at the start of the growing season in September and October when river levels are lowest (see page 41).

Of greater concern is what might run off all these irrigation schemes. Since the soils are low in nutrients, substantial applications of fertilizers will be required and a good deal of these nutrients could be washed into the adjacent rivers. Insecticides and herbicides...
will be needed, and if applied on a large scale, significant residues will find their way into the river water and Delta. A recent study of residues of DDT, aldrin and HCB (hexachlorobenzene) found significant concentrations in sediments in the Delta.

The available evidence indicates that these poisons were washed down the Okavango River into the Delta. Interestingly, progressively higher concentrations were found downstream, so the lowest residues were in the Panhandle and the highest were in Lake Ngami and other distal parts of the alluvial fan.

Erosion off the large irrigation schemes, together with the clearing of land for small-scale cropping could lead to increased loads of suspended clay in the river water. These are unlikely to have an immediate impact on the Delta since much of the clay would be filtered out before reaching the sandy, permeable substrate of the alluvial fan. Over the longer term, however, increasing clay inputs would reduce the chances of the Delta remaining a freshwater system (see page 53).

Finally, global forces are likely to shape the Delta in ways that are both unforeseen and less manageable. Climate change is an obvious example. The bedfellow of economics and politics will influence food and energy prices (and therefore motives for irrigation schemes) and the fickle tourism industry, for example, by raising safety concerns and eroding savings for holidays. And tectonic movements inside the Delta may shift the distribution of water in ways that surprise its residents.

Challenges for management

A host of factors can thus compromise the health of the Delta. Some are global in scale, others are found hundreds of kilometres upstream in the Okavango River catchment. Yet others are local in origin. How should people with responsibilities for managing the Delta respond, and what should be done by those with direct economic and financial interests in the Delta? Likewise, what can the international community do to maintain the wealth and health of this apparent organism (see page 39)?

Keeping the overall system dynamic

The biological wealth of the Delta, along with the goods, services and capital it provides is very largely a product of water supply being able to vary across two dimensions: time and space. The pulsing of inflows between seasons and years results in parts of the Delta being inundated and then dried. Similarly, the spatial redistribution of water allows some areas to dry up and others to be flooded afresh. These changes continually shift the interface between water and nutrients, enabling the former to mobilise the latter. These changes also allow desiccation, grazing, fire and decomposition to recycle nutrients into forms available for new bouts of biological production.

Little of this would happen if the changes in time and space were to stop. If the water remains in one place, nutrients will be locked up in plants, while dormant nutrients elsewhere will lie quietly, their potential locked away by the absence of water. A key measure for the future is therefore to allow the interplay between water and accumulated nutrients to continue moving.

Building demand for information and response

The chapter began by describing how information to monitor the Delta was being developed. The complexity and challenges in doing this for such a dynamic wetland are enormous. A further challenge lies in the use of monitoring information. Without special measures to develop procedures for its use (including accountability), all that we can hope for is that: managers will get the information, will understand its importance, and will respond accordingly.

The same is true for planning. For instance, the recently completed Okavango Delta Management Plan (ODMP) has been hailed as a good example of how planning processes should be done. It also makes excellent recommendations, which everyone hopes will be implemented. But hoping is not enough. Neither is it enough to have lots of information and plans in our shop window if there are no customers. There are no simple methods of developing demand for monitoring (or any other objective) information and implementation. A multitude of approaches are required, many of which will have to be repeated and tuned to different audiences. Accountability and incentives are perhaps the most important facets, as are public awareness, lobbying and political interests.

Enlarging the identity and security of the Delta

In combination, no other wetland in Africa is (a) as large, (b) well protected, (c) so pristine, (d) of such high economic value and (e) as well-known internationally. These attributes probably set the Delta apart from all other African wetlands by an order of magnitude. Indeed, the combination of values could be unique worldwide.

The Okavango Delta is thus a big deal, and it deserves a reputation larger than the one it now enjoys. It also requires an identity that goes beyond its present borders. Its ownership should surpass national pride since this is an international asset, which has been called the Jewel of the Kalahari (which covers a large area of Africa) and the Eden of Africa (which is a significant part of the world). We close by exploring three aspects that are crucial to a better, more secure future for this very significant wetland.

Going beyond food

Generalised assumptions that agriculture in Africa is Africa’s salvation are unfortunate, particularly when they are applied to low input, low output farming in areas that are poorly suited to food production and its commercialization. Along with these broad assumptions go a variety of notions, for example that rural Africa is best suited to traditional economies, that nothing better can be done with communal land, that secure tenure is unnecessary or too complicated in communal areas, and that alternative livelihoods are just too remote and challenging. As a result and for example, development programmes vigorously promote food self-sufficiency. Yet virtually every young person in Africa wants food security and cash security, and thus makes the one-way journey from a rural to an urban environment.

Much of the debate about the pros and cons of financial and economic benefits of conservation and tourism are bedeviled by assumptions that low input, low output, traditional farming is a good thing. We are not against farming, and appreciate its value in providing food security for the many poor families in Namibland. But surely the development and expansion of farming should be done in places where it is productive, where farmers and families can make a decent living from their harvests, and where the environmental costs of land clearing and grazing are worth bearing?

As discussed previously (see page 124), this debate is not easy to resolve. But we do suggest that the debate be tackled earnestly (and honestly, on the basis of economic and environmental arguments) when the use of the Delta’s natural resources are considered. Exactly the same objective approach is needed when people ponder over land uses in the Angolan catchment and along the Okavango River in Namibia.

Broadening OKACOM

OKACOM is the river basin commission established between Angola, Namibia and Botswana in September 1994. During its first 10 years, the commission concentrated largely on the concept of water allocations between the countries, and on overseeing various donor-funded projects. As senior public servants, mostly in departments of water based in Luanda, Windhoek and Gaborone, its commissioners had limited opportunity to engage in day-to-day matters of concern to the Okavango River and its Delta.

More recently, OKACOM has done much more to strengthen and broaden its mandate in the complicated playing field that may include sovereign interest, state responsibility and good neighbourliness as rival themes. Some of these developments were stimulated by Botswana’s initiative in having the Delta declared as a Ramsar site, and in formulating the Okavango Delta Management Plan (ODMP).

Other progress has been made through a range of projects conducted under the auspices of OKACOM. These include work to develop (1) support among local communities for the environmental health of the River Basin; (2) approaches to integrated water resource management; (3) trans-boundary diagnostic assessments (TDAs); (4) a strategic action programme (SAP); (5) studies of environmental flows (E-flows). In addition, an OKACOM secretariat has been established in Maun, which is alongside a newly created office for the Botswana Directorate of Environmental Affairs. Such broadening of scope from one purely based on water supply, to one in which water is seen as an ecological driver, is to be commended and supported.
In our view, OKACOM could further enhance its role by obtaining greater representation of local and environmental interests. A broadening of its debating field would also be valuable, especially if greater emphasis were placed on such issues as pesticide contamination, the enrichment of river water by nutrients from farming, private uses of the Okavango’s resources, and the creeping expansion of the human footprint on the Okavango River Basin. It would be useful for OKACOM to ensure that environmental impact assessments precede all major developments in the Basin. Regular environmental audits commissioned by OKACOM would provide useful measures to assess the use of water and all other natural resources. The same audits should take stock of benefits of these resources, reporting on which are useful, which require promotion, and how the benefits are used. To reiterate, the human footprint around the Delta and the source of water on which it depends is expanding. The expansion and its implications must be monitored, and OKACOM is the only organisation with the mandate to do the monitoring. By taking on these kinds of responsibilities, OKACOM could evolve from its present advisory capacity into one where it becomes a river basin authority.

In essence, discussions about the interests of Angola, Namibia and Botswana have largely focused on what the three governments do, relationships between them, and on the sharing of water. There has been less discussion on what local communities and private enterprises in the River Basin might think. Likewise, focus has been placed on the value of water, rather than on the environmental value of the Basin. For the future, expanded perspectives that reach across national boundaries to recognize the unitary value and integrity of the Okavango River Basin are desirable. In the longer term, each of the three countries stands to gain a great deal from such trans-national perspectives.

Seeing beyond Mokhomo

Much of the debate within Botswana about the management of the Delta concentrates on issues in and around the Delta. This is rightly so. But the debates sometimes include the implication that Botswana alone controls the destiny of the Delta. That is misguided, however. For example, the economy of the Delta depends largely on the willingness of foreigners to pay for tourism, and how well the Delta can compete with other foreign holiday attractions. More importantly, the quality and quantity of water inflow is controlled entirely by Namibia and Angola. The Delta is thus surrounded by external influences, with which Botswana should engage.

Broadening the identity of the Delta is necessary for such engagement. Most people now see the Okavango and Delta as the same thing or place, as if only the ‘Okavango Delta’ matters. The word Okavango has virtually been unwittingly commandeered for exclusive use in Botswana, as if the Delta is independent of its Angolan catchment. But the broader area of the Okavango River Basin is actually what counts, both in its own right as a basin covering 192,500 square kilometres, and as the Delta’s source of water. And unintended implications that the Delta equals the Okavango diminish value of its catchment. But there is a grand opportunity here, which is to capitalize on the international fame of the Delta and to spread that reputation (and its associated values) across the whole river basin. In essence, use the ‘big deal’ name of the Delta to give the Okavango River Basin ‘big deal’ status. Doing so would give greater security to the Delta’s water sources by reducing the possibility of the Delta, only part of the Cuito River and its tributaries is included in Angola.

Food security for residents of the catchment could come from wildlife, tourism and its associated industries, rather than from slash-and-burn farming that produces low yields.

Having the Botswana government as a partner would give security and credibility to the private sector. Angola’s reputation would be enhanced by giving the land at the end of the earth renown and benefit. Botswana would be the first African country to invest in the protection of a foreign environmental resource. Benevolent organizations and people elsewhere in the world who believe in the value of the Okavango could contribute to these developments. In doing so, they would swell the international community of people who would be vigilant over the entire Okavango.

Elements of these recommendations are to be found in the proposed Kavango Zambezi Trans-Frontier Conservation Area (KAZA). This initiative involves Angola, Botswana, Namibia, Zambia and Zimbabwe, and aims to broaden and connect conservation areas over some 300,000 square kilometres. Tourism is to be promoted, in part to boost the livelihoods of residents of KAZA. While the KAZA area encompasses the Delta, only part of the Cuito River and its tributaries is included in Angola.

Implementation of the ideas suggested above would also have the private and public sectors of one country invest in another country, and they would focus on development of the Okavango River Basin as a hydrological and ecological entity. Amongst other measures, the current Ramsar site could be extended across the whole Basin.

The whole Okavango River Basin should also be developed into a tourism destination. In addition to visiting individual attractions in the catchment, tourists could also follow the flow of water by boat, road and air from Tschicala Tchololanga to Menongue, Cala, Andara, Iao and Lake Ngami, for example. How many other places in the world offer journeys and holidays across an entire river basin, much of which is pristine, wild and scenic? The Delta would of course gain by having much greater security over the quantity and quality of water on which it depends. The national economy of Botswana would have greater confidence in counting on future revenues from tourism and conservation.

It is our hope that vision and innovation prevails to expand the concept of the Delta and the resources that are central to its health. This will be to the benefit of the diatoms (see page 82), cladocerans (page 100), people (page 109) and all others who use the Delta's nutrients and waters. It can be done!

KEY POINTS

1. While the Delta is in relatively pristine condition, it faces local threats from chemical contamination, invasive aliens, the clearing of channels, and a burgeoning population of elephants.
2. Since the Delta depends on water from the Okavango’s Angolan catchment that passes through Namibia, it may suffer from increasing water extraction for irrigation, and the addition of pesticides, nutrients and clay to water that enters Botswana.
3. Global forces, such as climate change, food and energy prices, and demands for tourism will directly and indirectly influence the future of the Delta.
4. Uncontrolled pulses and shifts in the supply of water across the Delta are crucial for the maintenance of its biological wealth and health.
5. Measures to improve the use of information and the implementation of plans are required to enhance the management of the Delta.
6. Expanding the identity of the Okavango upstream of the Delta would add security to its future, as well as enhancing the value of natural resources and livelihoods in the catchment.
7. Trans-boundary discussions on management of the Okavango should be broadened to include, for example, local interests, environmental impact assessments and audits, and the sharing of benefits from the Okavango.
8. Investments in the catchment by the Botswana tourism industry and government would help protect the Delta’s future.
9. Bold, innovative management of the Delta and its catchment will allow those who come after us to benefit from this eden and jewel of the world.
Chapter 1: Introducing the Okavango Delta
3. Adapted from definitions proposed by the American Geological Institute, http://www.agi.org.
4. The Ramur last was established in response to Article 2.1 of the Convention on Wetlands (which was signed and agreed to at Ramsar, Iran in 1971).

Chapter 2: Shaping the Delta
2. Based on a map compiled by the Council for Geoscience, South Africa and provided by Spike McCarthy, and data provided by USGS National Earthquake Information Center, http://neic.usgs.gov/ftp/eqc/jc.html.
3. From NASA LandSat and Modis images.
5. Substantial layers of material formed from the decomposing boulders have been found in north-western Ngamiland, suggesting that alluvial and aeolian sedimentation may be less significant than usually assumed (see McFarlane MJ, Coetzee SH, Kuhn JR, Vanderpost CHM & Eckardt FD. 2007. In situ rounding of quartz in southern Africa. South African Journal of Geology 104: 47-48.).

Chapter 3: The Okavango River: a flow of a lifetime
1. Based on an interpolation of average seasonal totals calculated from weekly records obtained from the Global Historical Climate- Network database, and the Botswana and Namibia Meteorological Services.

Notes and Sources

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Chapter 7: People, predators and protectors


Chapter 8: Animals: shifting consumers

1. The species are allocated to their preferred habitats but, of course, some species occur in more than one habitat. Adopted from Ranberg L, Hanscom P, Lindhald M, O. Meyer T, Ringrose S, Sliva J, Van De & Vanderpost C. 2006. Species diversity of the Okavango Delta, Botswana. Aquatic Sciences 60: 310–337.

2. The title of Fan Lantting S book Okavango: Africa’s Last Eden published in 1993 is quoted in a number of the botanists and biologists.


4. Much of this information was supplied by Jenny Kipping in her research work at UNCTC that the Journal of the Okavango Delta Ramatste Botswana: Report by Rebus Life Botswana for Okavango Delta Management Plan.


14. Iron is reduced to Fe(II) and Fe(III) and Fe(III) is oxidized to Fe(II) and Fe(II) interacts with HS(2-) from vegetation to create a metal-HS chelate which may precipitate. Limnologica 13: 43–61; and Buzwani T. 2006. Species diversity of the Okavango Delta, Botswana: Development Southern Africa: 24: 269–308.

15. The outlook of CRBC was so threatening to the whole bowhead whaling that the Botswana government called all cattles. An estimated 320,000 cattles were killed in Nijgnland.

16. As a slight diversionary hypothesis, the north-eastern area of mopane woodland may have experienced greater clay sedimentation from the river when it flowed into this area of Botswana (see page 24). By contrast, inflows to the western area may have carried less clay because they largely came from areas of Kalahari Sand.
Biodiversity monitoring studies in the Delta are reviewed by Dallas (2008). Supercritical fluid extraction of pesticides in sediment from the Okavango Delta, Botswana, and determination by gas chromatography with electron capture detection (GC-ECD) and mass spectrometry (GC-MS). Water SA 34: 405–41.

Okavango Delta: Floods of Life

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2. Biodiversity monitoring studies in the Delta are reviewed by Dallas HE. 2009. Wetland monitoring using aquatic macroinvertebrates. Technical report for Biokavango Project, Harry Oppenheimer Okavango Research Centre, University of Botswana. The Freshwater Consulting Group, University of Cape Town, Cape Town, South Africa. The main difficulty with biodiversity monitoring stems from the dynamic condition of the Delta, particularly in its alluvial fan. As a result, we do not expect, nor desire indices of biodiversity to be constant. The interpretation of any changes would also be hard since they could reflect changing natural processes or man-made degradation.

3. Games FP. 1981. Report on the effects of a deltamethrin and endosulfan mixture on the non-target arthropods during the 1981 tsetse spraying program. Ministry of Agriculture, Water & Forestry, Windhoek, Namibia. The Freshwater Consulting Group, University of Cape Town, Cape Town, South Africa. The main difficulty with biodiversity monitoring stems from the dynamic condition of the Delta, particularly in its alluvial fan. As a result, we do not expect, nor desire indices of biodiversity to be constant. The interpretation of any changes would also be hard since they could reflect changing natural processes or man-made degradation.


6. One option that has been considered is the transfer of elephants to south-eastern Angola, where almost all were wiped out during the civil war. Significant numbers of elephants have indeed recently moved on their own into south-eastern Angola (Mike Chase personal communication).

7. The most comprehensive of these are the trans-boundary diagnostic assessments and environmental flow studies recently commissioned by the Environmental Protection and Sustainable Management of the Okavango Basin (EPSMO) of the Global Environmental Facility (GEF) project.


11. Food self-sufficiency aims for people to produce enough food to feed themselves, while food security implies that people can feed themselves adequately, irrespective of whether they grow or buy their food.

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