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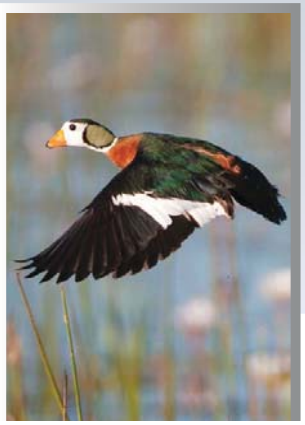
Floods for the future

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.[1] 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.[2] 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 in 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* 56). 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.[3]

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.[4] 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

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 stramonium*), *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.[5] 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.[6]

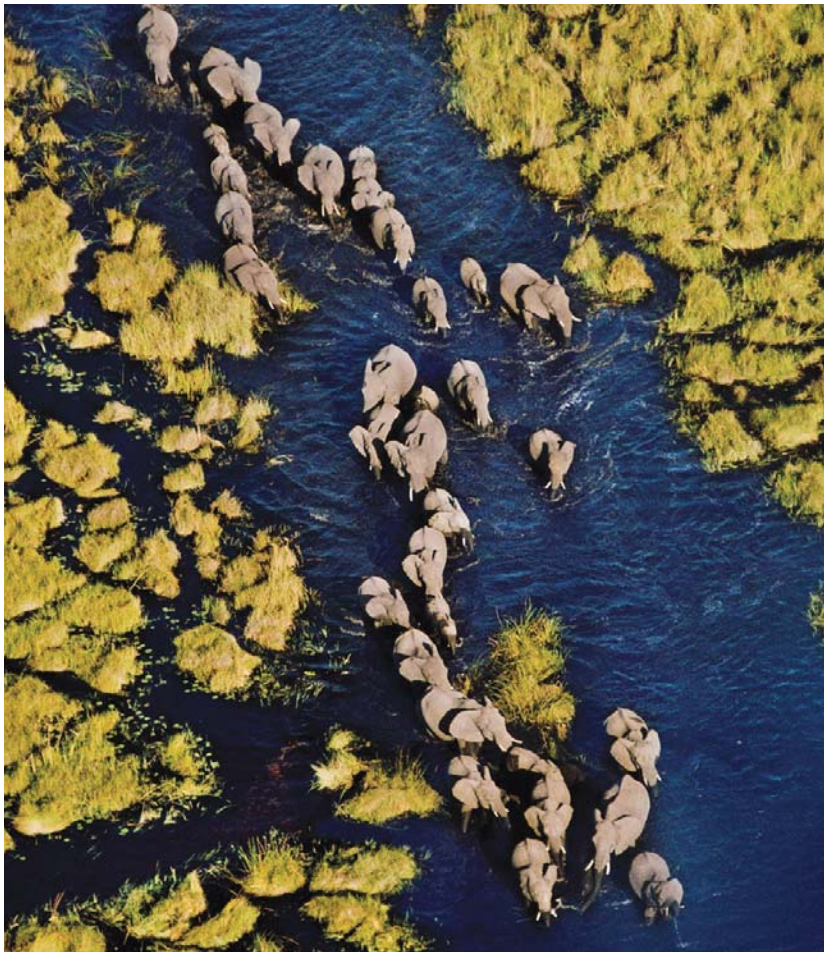
External challenges in the catchment and elsewhere

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 35*).

It is possible that we may one day understand how to manage water flows and flooding patterns to maintain production, but this will require major improvements in our understanding of nutrient cycling and other aspects of the Delta's physiology. Until then, centres of production need to carry on wandering across the floodplains as they do now, unhindered and unmanaged.

Most conservation programmes focus on rare, charismatic or iconic species. But plants (*Chapter 5*) and animals (*Chapter 6*) should look after themselves as long as the functioning (*Chapter 4*) of this wetland is not altered. It is the system functioning of the Delta that is so special, and what we all marvel at is simply the manifestation a big, healthy ecosystem working in an unimpaired way.



The paradox of the Delta is that its productive value lies not in the water, but in the nutrients that the same river system, animals and aerosols have deposited here over at least the last 120,000 years (*see page 24*). Yet, the water and nutrients cannot be separated. Water is needed to release the productive potential of nutrients, but without the nutrients the water would be rather lifeless.

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.[7] 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 hydropower 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 offtake of several farms – together with those in Namibia[8] – 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.[9]

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 bedfellows 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 founded 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. The 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 there 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 technical 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.[10]

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).[11]

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 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.[12]

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 Ngamiland. 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.[13] During its first 10 years, the commission concentrated largely on the concept of water allocations between the countries, and on over-seeing 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 see sovereign interest, state responsibility and good neighbourliness as rival themes.[14] 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.[15]

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 people 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.[16]

Seeing beyond Mohembo

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 catchment being put to degrading use.

Spreading the fame and brand name is one thing. Another is to extend the vested interests and experience that now lie in the Delta upstream into the Angola. Tourism companies from Botswana, in conjunction with the Botswana government, could give value and protection to the catchment by investing in tourism and wildlife in Angola. Jobs and infrastructure would be created there, and new perspectives on the use of water and natural landscapes would be developed 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

Much has been learnt about the Delta over the years. Further study will expand our knowledge so that humanity will be better placed to care for the health of this wetland and the value of its wealth.

purpose. 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).[17] 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.

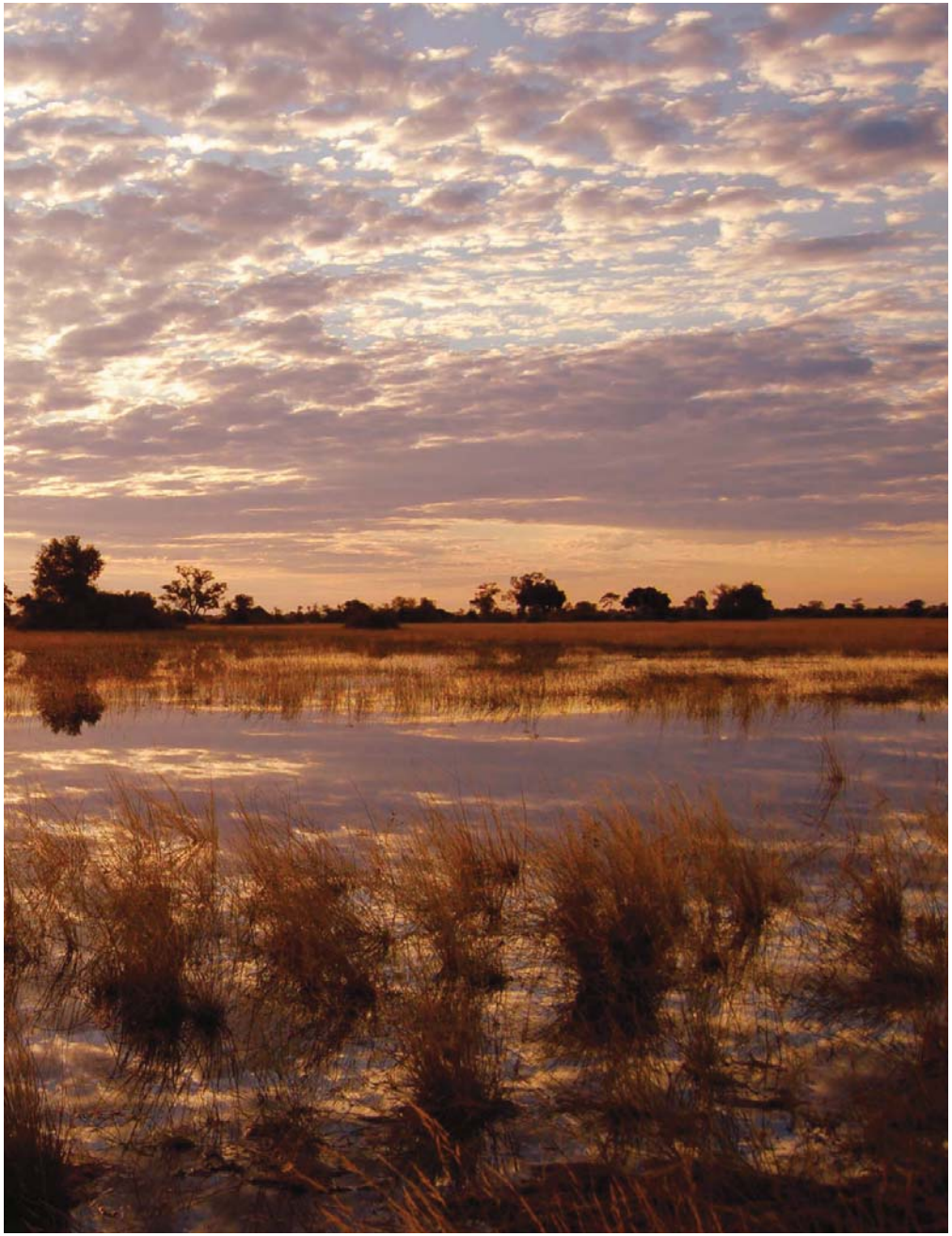
Implementation of the ideas suggested above would also have the private and public sectors of one country invest in another country, and they would focus on development of the Okavango River Basin as a hydrological and ecological entity. Amongst other measures, the current Ramsar site could be extended 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 Tchicala Tcholohanga to Menongue, Calai, Andara, Jao 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.
4. Global forces, such as climate change, food and energy prices, and demands for tourism will directly and indirectly influence the future of the Delta.
5. Uncontrolled pulses and shifts in the supply of water across the Delta are crucial for the maintenance of its biological wealth and health.
6. Measures to improve the use of information and the implementation of plans are required to enhance the management of the Delta.
7. 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.
8. 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.
9. Investments in the catchment by the Botswana tourism industry and government would help protect the Delta's future.
10. 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.



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3. Based on the total estimated population in the Basin area of each country as a percentage of the national population. The map is based on Morebodi BBH. 2001. *Botswana National Atlas*. Department of Surveys and Mapping, Gaborone; Mendelsohn JM, Jarvis AM, Roberts CS & Robertson T. 2002. *Atlas of Namibia*. David Philip, Cape Town; and the UNEP database of population density in Angola (grid2.cd.usgs.gov/globalpop/Africa).
4. Ramberg L & Wolski P. 2008. Growing islands and sinking solutes: processes maintaining the endorheic Okavango Delta as a freshwater system. *Plant Ecology* 196: 215–231.
5. *Diagnóstico Transfronteiriço Bacia do Okavango – Análise Socioeconómica Angola*. Report for Transboundary Diagnostic Assessment, EPSMO/OKACOM project; and Mendelsohn JM. 2006. *Farming systems in Namibia*. RAISON, Windhoek.
6. Swatuk LA. 2005. Whose values matter most? Water and resource governance in the Okavango River Basin. *Mechanisms of Economic Regulation* 35: 521–529.
7. Mendelsohn JM. 2009. *Land use in Kavango: past, present and future*. Report for Transboundary Diagnostic Assessment, EPSMO/OKACOM project.

Chapter 4: The functioning Delta

1. Gumbricht T & McCarthy TS. 2002. Hierarchical processes and patterns sustaining the Okavango: an integrated perspective for policy and management. In Bernard T, Mosepele K & Ramberg L, (eds). *Environmental Monitoring of Tropical and Subtropical Wetlands*. Harry Oppenheimer Okavango Research Center. Okavango Report Series No. 1.
2. Much of the information on water flow was provided by Piotr Wolski, HOORC.
3. Calculated from data collected by the Department of Water Affairs at Mohembo.
4. Wolski P, Savenije HHG, Murray-Hudson M & Gumbricht T. 2006. Modelling of the flooding in the Okavango Delta, Botswana, using a hybrid reservoir-GIS model. *Journal of Hydrology*. 331: 58–72.
5. Gumbricht T, Wolski P, Frost P & McCarthy TS. 2004. Forecasting the spatial extent of the annual flood in the Okavango delta, Botswana. *Journal of Hydrology* 290: 178–191.
6. McCarthy TS, Ellery WN & Stanistreet LG. 1993. Lakes of the north eastern region of the Okavango Swamps, Botswana. *Zeitschrift für Geomorphologie* 37: 273–294.
7. MODIS images provided by NASA/GSFC, MODIS Rapid Response (http://rapidfire.sci.gsfc.nasa.gov).
8. McCarthy TS, Cooper GRJ, Tyson PD, Ellery WN. 2000. Seasonal flooding in the Okavango Delta, Botswana – recent history and future prospects. *South African Journal of Science* 96: 25–33; Mazvimavi D & P Wolski. 2006. Long-term variations of annual flows of the Okavango and Zambezi Rivers. *Physics and Chemistry of the Earth*, 31: 15–16, 944–951; Wolski P, Gumbricht T & TS McCarthy. 2002. Assessing future change in the Okavango Delta: the use of a regression model of the maximum annual flood in a Monte Carlo simulation. In Bernard T, Mosepele K & Ramberg L, (eds). *Environmental Monitoring of Tropical and Subtropical Wetlands*. Harry Oppenheimer Okavango Research Center. Okavango Report Series No. 1; Tyson PD, Cooper GRJ & McCarthy TS. 2002. Millennial to multi-decadal variability in the climate of southern Africa. *International Journal of Climatology* 22: 1105–1117.
9. Same as 5 above.
10. From a two-way analysis of variance by Piotr Wolski. Another 25% of variance is not explained and interaction between the three variables accounts for a further 3%.
11. From analyses of MODIS images by Piotr Wolski, HOORC.
12. Wolski P, Savenije HHG, Murray-Hudson M & Gumbricht T. 2006. Modelling of the flooding in the Okavango Delta, Botswana, using a hybrid reservoir-GIS model. *Journal of Hydrology* 331: 58–72.
13. From data analysed by Piotr Wolski, who used a long series of LandSat images to determine the frequency of inundation. The procedure for identifying water is described in Wolski P & Murray-Hudson MH. 2006. *Reconstruction of 1989–2005 inundation history in the Okavango Delta, Bostwana from archival Landsat imagery*, Globwetland Symposium, ESA-ESRIN, Frascati, Italy, 19–20 October 2006 (available from http://www.globwetland.org/news_links/links/433855kj.pdf).
14. Wolski P & Gumbricht T. 2003. *Mapping hydrological units in the Okavango Delta*. Report for Water and Ecosystem Resources for Regional Development (WERRD) project. Maun, Botswana.
15. Wilson BH. 1974. Some natural and man-made changes in the channels of the Okavango Delta. *Botswana Notes and Records* 5, 132–153; Shaw PA. 1983. Fluctuations in the level of Lake Ngami: the historical evidence. *Botswana Notes and Records* 5: 132–84.
16. Wolski P & Murray-Hudson M. 2006. Recent changes in flooding in the Xudum distributary of the Okavango Delta and Lake Ngami, Botswana. *South African Journal of Science* 102: 173–176.
17. This was adapted from a Quickbird image used by Google Earth, while the extent of flooding in other years was mapped from MODIS images provided by NASA/GSFC, MODIS Rapid Response (http://rapidfire.sci.gsfc.nasa.gov).
18. Ellery WN, Ellery K, Rogers KH, McCarthy TS & Walker BH. 1993. Vegetation, hydrology and sedimentation processes as determinants of channel form and dynamics in the northeastern Okavango Delta, Botswana. *African Journal of Ecology* 31: 10–25.
19. Wolski P & M Murray-Hudson. 2008. An investigation of permanent and transient changes in flood distribution and outflows in the Okavango Delta, Botswana. *Physics and Chemistry of the Earth* 33: 157–164.
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23. Ramberg L, Wolski P & Krah M. 2006. Water balance and infiltration in a seasonal floodplain in the Okavango Delta, Botswana. *Wetlands*, 26: 3, 677-690.
24. Ramberg L & Wolski P. 2008. Growing islands and sinking solutes: processes maintaining the endorheic Okavango Delta as a freshwater system. *Plant Ecology* 196: 215–231.
25. Gumbricht T, McCarthy J & McCarthy TS. 2004. Channels, wetlands and islands in the Okavango Delta, Botswana, and their relation to hydrological and sedimentological processes. *Earth Surf Proc Land* 29:15–29.
26. Adapted from Ramberg L & Wolski P. 2008. Growing islands and sinking solutes: processes maintaining the endorheic Okavango Delta as a freshwater system. *Plant Ecology* 196: 215–231
27. Bauer-Gottwein P, Langer T, Prommer H, Wolski P & Kinzelbach W. 2007. Okavango Delta Islands: interaction between density-driven flow and geochemical reactions under evapo-concentration. *Journal of Hydrology* 335: 389–405; and Zimmermann S, Bauer P, Held R, Kinzelbach W & JH Walther. 2006. Salt transport on islands in the Okavango Delta: Numerical investigations. *Advances in Water Resources* 29: 11–29.
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30. Adapted from Krah M, McCarthy TS, Huntsman-Mapila P, Wolski P & Sethebe K. 2006. Nutrient budget in the seasonal wetland of the Okavango Delta, Botswana. *Wetlands Ecology and Management* 14: 253–267.
31. Garstang M, Ellery WN, McCarthy TS, Scholes MC, Scholes RJ, Swap RJ & Tyson PD. 1998. The contribution of aerosol- and water-borne nutrients to the functioning of the Okavango Delta ecosystem, Botswana. *South African Journal of Science* 94: 223–229.
32. Krah M, McCarthy TS, Huntsman-Mapila P, Wolski P & Sethebe K. 2006. Nutrient budget in the seasonal wetland of the Okavango Delta, Botswana. *Wetlands Ecology and Management* 14: 253–267.
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34. Same as 29.
35. Hogberg P, Lindholm M, Ramberg L & Hessen DO. 2002. Aquatic food web dynamics on a floodplain in the Okavango Delta, Botswana. *Hydrobiologia* 470: 23–30. Lindholm M, Hessen DO, Mosepele K & Wolski P. 2007. Food webs and energy fluxes on a seasonal floodplain: The influence of flood size. *Wetlands* 27: 775–784.
36. Hancock P, Oake K, Tyler SJ & Brewster C. 2005. *Monitoring waterbirds at Lake Ngami – an Important Bird Area: June 2004 to January 2007*. Reports to Wetlands International and Wilderness Wildlife Trust.

Chapter 5: Plants: producers, filters and distributors

1. From data provided by Mike Murray-Hudson HOORC.
2. A great deal of the information available on the Delta's plants was compiled by the pioneering work of Pete Smith and Fred and Karen Ellery.
3. Ramberg L, Hancock P, Lindholm M, Meyer T, Ringrose S, Sliva J, Van As J & Vanderpost C. 2006. Species diversity of the Okavango Delta, Botswana. *Aquatic Sciences* 68: 310–337.
4. Ellery WN & Tacheba B. 2003. Floristic Diversity of the Okavango Delta, Botswana. In Alonso, L.E. and L-A. Nordin (eds.) A Rapid Biological Assessment of the Aquatic Ecosystems of the Okavango Delta, Botswana: High Water Survey. *RAP-Bulletin of Biological Assessment* 25: 69–96.

5. Junk W, Brown M, Campbell I, Finlayson M, Gopal B, Ramberg L & Warner B. 2006. The comparative biodiversity of seven globally important wetlands: a synthesis. *Aquatic Sciences* 68: 400–414.
6. Adapted from Meyer T. 1999. *Ecological mappings in the research area of the Harry Oppenheimer Okavango Research Centre, Okavango Delta, Botswana*. MSc thesis, Hochschule Anhalt, Bernburg, Germany.
7. From Smith P. 1989. In Snowy Mountains Engineering Corporation (SMEC) Cooma NSW Australia. *Ecological Zoning Okavango Delta. Final report, Volume 1*. Main report to the Ministry of Local Government and Lands, Government of Botswana.
8. Sliva J, Murray-Hudson M & Heinl M. 2004. Vegetation species diversity inventory in the Okavango Delta, Botswana. In Mosepele K. & Mosepele B (eds.) *AquaRap II: A Rapid Assessment of the Aquatic Ecosystems of the Okavango Delta, Botswana: Low Water Survey*. Draft Final Report, Conservation International, Washington DC, USA, pp. 69–83.
9. The orchid *Habenaria pasmithii* may be the Delta's only endemic plant.
10. Same as above.
11. For the first time in years, waters of the Okavango and Kwando met on the Selinda on the 18th of August 2009 at 18.52052 South, 23.45602 East (Alison and Roger Heath, personal communication).
12. Smith P. 1989. In Snowy Mountains Engineering Corporation (SMEC) Cooma NSW Australia. *Ecological Zoning Okavango Delta. Final report, Volume 1*. Main report to the Ministry of Local Government and Lands, Government of Botswana; Ellery WN & Tacheba B. 2003. Floristic Diversity of the Okavango Delta, Botswana. In Alonso, LE & Nordin L-A (eds.) A Rapid Biological Assessment of the Aquatic Ecosystems of the Okavango Delta, Botswana: High Water Survey. *RAP-Bulletin of Biological Assessment* 25: 69–96; Sliva J, Murray-Hudson M & Heinl M. 2004. Vegetation species diversity inventory in the Okavango Delta, Botswana. In: Mosepele K & Mosepele B (eds.) AquaRap II: *A Rapid Assessment of the Aquatic Ecosystems of the Okavango Delta, Botswana: Low Water Survey. Draft Final Report*. Conservation International, Washington DC, USA, pp. 69–83; Murray-Hudson M. 2009. *Floodplain vegetation responses to flood regime in the seasonal Okavango Delta, Botswana*. Ph D thesis University of Florida.
13. Mendelsohn JM & el Obeid S. 2004. *Okavango River: the flow of a lifeline*. Struik, Cape Town. Based on NDVI data collected over 16 seasons between 1985/1986 and 2002/2003.
14. Iron is reduced to Fe^{2+}; nitrogen changes from nitrate (NO_3^{2-}) to NH_3 (via many intermediates) and may be lost to the atmosphere, as also happens after the reduction of sulphur to H_2S and carbon to CH_4 (methane).
15. Same as above.
16. As a slight diversionary hypothesis, the north-eastern area of mopane woodlands may have experienced greater clay sedimentation from waters of the Zambezi River when it flowed into this area of Botswana (see page 24). By contrast, inflows to the western areas may have carried less clay because they largely came from areas of Kalahari Sand.
17. Burrough SL, Thomas DSG, Shaw PA & Bailey RM. 2007. Multiphase Quaternary highstands at Lake Ngami, Kalahari, northern Botswana. *Palaeogeography, Palaeoclimatology, Palaeoecology* 253: 280–299; Burrough SL, Thomas DSG. 2008. Late Quaternary lake-level fluctuations in the Mababe Depression: middle Kalahari palaeolakes and the role of Zambezi inflows. *Quaternary Research* 69: 388–403.
18. Cholnoky BJ. 1966. Die Diatomeen im Unterlaufe des Okawango-Flusses. *Beihefte Nova Hedwigia* 21: 1–102.
19. Mackay AW, Todd M & Wolski P. 2009. *Monitoring and simulating threats to aquatic biodiversity in the Okavango Delta*. Project report for the Darwin Initiative, University College of London.
20. Heinl M, Neuenschwander A, Sliva J & VanderPost C. 2006. Interactions between fire and flooding in a southern African floodplain system (Okavango Delta, Botswana). *Landscape Ecology* 21: 699–709; and Heinl M, Sliva J, Murray-Hudson M & Tacheba B. 2007. Post-fire succession on savanna habitats in the Okavango Delta wetland Botswana. *Journal of Tropical Ecology* 23: 705–713.
21. Cassidy L. 2003. *Anthropogenic Burning in the Okavango Panhandle of Botswana: Livelihoods and Spatial Dimensions*. MSc Thesis, University of Florida, Gainsville, FL, U.S.A; and Heinl M. 2005. Fire Regime and Vegetation Response in the Okavango Delta, Botswana. PhD thesis, *Lehrstuhl fur Vegetaionsökologie, Department für Ökologie, Technische Universität München*, Munich, Germany.
22. Tacheba B, Segosebe E, VanderPost C & Sebego R. 2009. Assessing the impacts of fire on the vegetation resources that are available to the local communities of the seasonal wetlands of the Okavango, Botswana, in the context of different land uses and key government policies. *African Journal of Ecology* 47: 71–77.
23. Frost PGH, Plavsic M & Rogow T. 2004. Observations on the occurrence, impacts and effects of fire in the Okavango Delta In: Mosepele K, & Mosepele B. (eds.) *AquaRap II: A Rapid Assessment of the Aquatic Ecosystems of the Okavango Delta, Botswana: Low Water Survey. Draft Final Report*. Conservation International, Washington DC, USA, pp. 98–111.
24. Ramberg L, Lindholm M, Bonyongo C, Hessen DO, Heinl M, Masamba W, Murray-Hudson M, VanderPost C & Wolski P. In press. Aquatic ecosystem responses to fire and flood size in the Okavango Delta – Natural experiments on seasonal floodplains. *Wetland Ecology and Management*.

Chapter 6: Animals: shifting consumers

1. The species are allocated to their preferred habitats but, of course, some species occur in more than one habitat. Adapted from Ramberg L, Hancock P, Lindholm M, Meyer T, Ringrose S, Sliva J, Van As J & VanderPost C. 2006. Species diversity of the Okavango Delta, Botswana. *Aquatic Sciences* 68: 310–337.
2. The title of Frans Lanting's book: *Okavango: Africa's Last Eden*, published in 1993 by Chronicle Books, San Francisco.
3. Darwall WRT, Smith KG, Tweddle D & Skelton P (eds) (2009). *The Status and Distribution of Freshwater Biodiversity in Southern Africa*. Gland, Switzerland: IUCN and Grahamstown, South Africa: SAIAB.
4. Much of this information was supplied by Jens Kipping. His research follows that of the pioneering work of Eliot Pinhey.
5. Ramberg L, Hancock P, Lindholm M, Meyer T, Ringrose S, Sliva J, Van As J. & VanderPost C. 2006. Species diversity of the Okavango Delta, Botswana. *Aquatic Sciences* 68: 310–337.
6. Okavango Crocodile Research Group. 2008. *A Management Plan for the Conservation of the Nile crocodile (*Crocodylus niloticus*) in the Okavango Delta, Botswana*. University of Stellenbosch, South Africa.
7. Pete Hancock (personal communication) and Hancock P, Mpofu Z, Tyler SJ & Meyer T. 2005. *A baseline survey of the slaty egret in the Okavango Delta Ramsar site, Botswana*. Report by BirdLife Botswana for Okavango Delta Management Plan.
8. Hancock P, Oake K, Tyler SJ & Brewster C. 2005. *Monitoring waterbirds at Lake Ngami – an Important Bird Area: June 2004 to January 2007*. Reports to Wetlands International and Wilderness Wildlife Trust.
9. Lindholm M & Hessen DO. 2007. Competition and niche partitioning in a floodplain ecosystem: a cladoceran community squeezed between fish and invertebrate predation. *African Zoology* 42: 158–164; and Lindholm M, Hessen DO & L Ramberg. 2009. Diversity, dispersal and disturbance: Cladoceran species composition in the Okavango Delta. *African Zoology* 44:24–35.
10. Mosepele K, Moyle PB, Merron GS, Purkey DR & Mosepele B. 2009. Fish, Floods, and Ecosystem Engineers: Aquatic Conservation in the Okavango Delta, Botswana. *BioScience* 59: 53–64.
11. Welcomme, R.L., 2001. *Inland fisheries; ecology and management*. Blackwell Science, Oxford.
12. Mosepele K, Mmopelwa TG, Mosepele B. 2003. Characterization and monitoring of the Okavango Delta artisanal fishery. In Bernard T, Mosepele K & Ramberg L. (eds). Environmental *Monitoring of Tropical and Subtropical Wetlands*. Harry Oppenheimer Okavango Research Center. Okavango Report Series No. 1: 391–413.
13. Mosepele K & Kolding J. 2003. Fish stock assessment in the Okavango Delta: Preliminary results from a length-based analysis. In Bernard T, Mosepele K & Ramberg L (eds). *Environmental Monitoring of Tropical and Subtropical Wetlands*. Harry Oppenheimer Okavango Research Center. Okavango Report Series No. 1: 363–390; and Bayley PB. 1988. Accounting for effort when comparing tropical fisheries in lakes, river-floodplains, and lagoons. *Limnology and Oceanography* 33: 963–972.
14. Mosepele K. 2003. *Trends in Fisheries Development and Fish Utilization in the Okavango Delta*. Report for Water and Ecosystem Resources for Regional Development (WERRD) project. Maun, Botswana.
15. Caspar Bonyongo (personal communication) and Bonyongo MC. 2004. *The ecology of large herbivores in the Okavango Delta, Botswana*. University of Bristol, Bristol, UK.

Chapter 7: People: predators and protectors

1. VanderPost C. 2004. Human Sprawl and the African Wilderness of the Okavango. *South African Geographical Journ*al 86: 65–73
2. From information in Lane P, Reid A & Segobye A. (eds). 1998. *Ditswa Mmung: The archaeology of Botswana*. Pula Press and The Botswana Society, Gaborone.
3. Tlou T. 1985. *A history of Ngamiland, 1750 to 1906. The formation of an African state*. Gaborone: MacMillan; Bock J. 1998. Economic development and cultural change among the Okavango Delta peoples of Botswana. *Botswana Notes and Records* 30: 27–44
4. Tlou T & Campbell AC. 1984. *History of Botswana*. Macmillan Botswana.
5. Kgathi DL, Ngwenya BN & Wilk J. 2007. Shocks and rural livelihoods in the Okavango Delta, Botswana. *Development Southern Africa*. 24: 289–308
6. IUCN. 1992. *The IUCN Review of the Southern Okavango Integrated Water Development Project*, Final Report, Gaborone
7. Recent figures come from the Central Statistics Office, Botswana. The last full census was in 2001 when a total of 124,700 people were counted in Ngamiland. The 2006 Inter-censal sample survey showed that the population to be 138,600. At an annual growth rate of 2.1%, Ngamiland's population should amount to 156,000 in 2010 and 185,000 in 2020.
8. VanderPost C. 2007. Protected areas in Ngamiland, Botswana: investigating options for conservation-development through human footprint mapping. *International Journal of Environmental Studies* 64: 555–570.
9. Results supplied by the Central Statistics Office based on the 1991 population census and 2006 inter-censal survey.
10. Central Statistics Office. 2004. *Botswana AIDS Impact Survey II: Preliminary Results*. Ministry of Finance and Development Planning, Gaborone.
11. http://www.avert.org/aids-botswana.htm.
12. Officially, these are designated as villages but they are really small towns.
13. Hannelore B & Meyer T. 2004. The dynamics of the land use systems in Ngamiland, Botswana: changing livelihood options and strategies. Hierarchical processes and patterns sustaining the Okavango: an integrated perspective for policy and management. In Bernard T, Mosepele K & Ramberg L (eds). Environmental *Monitoring of Tropical and Subtropical Wetlands*. Harry Oppenheimer Okavango Research Center. Okavango Report Series No. 1:
14. Department of Environmental Affairs. 2008. *Okavango Delta Management Plan*. Dept. of Environmental Affairs, Gaborone, Botswana.
15. Pastoralists rely on livestock for both their revenue streams and capital savings or security, whereas people with mixed economies (such as crops and livestock, or wages and livestock) usually keep their animals as security and use other income sources to meet day-to-day revenue needs. This is particularly true in societies living on communal land where people are prohibited from having capital assets and security in land.
16. Same as 13 above.
17. Kgathi DL, Bendsen H, Blaikie PEMJ, Ngwenya B & Wilk J. 2003. *Rural Livelihoods, Indigenous Knowledge Systems and the Political Economy of Access to Natural Resources in the Okavango Delta*. Water and Ecosystem Resources for Regional Development (WERRD) project; Kgathi DL, Ngwenya BN & Wilk J. 2007. Shocks and rural livelihoods in the Okavango Delta, Botswana. *Development Southern Africa* 24: 289–308
18. The outbreak of CBPP was so threatening to the whole beef industry that the Botswana government culled all cattle. An estimated 320,000 cattle were thus killed in Ngamiland.
19. Ministry of Finance and Development Planning. 1997. *Study of poverty and poverty alleviation in Botswana*. Gaborone.
20. Anon. 2006. *Agricultural Support Schemes*. Ministry of Agriculture, Gaborone.
21. Central Statistics Office. 2008. *Poverty Datum Line for Botswana 2003*. Government of Botswana, Gaborone.
22. Of the 15 WMAs leased to commercial operators, 11 are mainly for hunting and four are for tourism. Most of the 13 WMAs allocated to communities have private sector partners, eight being used largely for hunting and five for tourism. One WMA has not been designated.
23. Mbaiwa JE. 2009. Tourism development, rural livelihoods and biodiversity conservation in the Okavango Delta, Botswana. In Hottola P. (ed). *Tourism strategies and local responses in southern Africa*. CAB International 2009.
24. The Ramsar List was established in response to Article 2.1 of the Convention on Wetlands (which was signed and agreed at Ramsar, Iran in 1971).
25. Magole L & Magole LI. 2009. The Okavango: Whose Delta is it? *Physics and Chemistry of the Earth* 34: 874–880.
26. Turpie J, Barnes J, Arntzen J , Nherera B, Lange G-M & Buzwani B. 2006. *Economic value of the Okavango Delta, Botswana, and implications for management*. Okavango Delta Management Plan. Dept. of Environmental Affairs, Gaborone, Botswana.
27. Tawana Land Board and Northwest District Land Use Planning Unit. 2008. *Okavango Delta Ramsar site land use and land management plan (2005–2029)*. Published by Okavango Delta Management Plan Project Secretariat, Department of Environmental Affairs; and Department of Lands, Ministry of Lands and Housing. 2009. *Ngamiland Integrated Land Use Plan*. Gaborone, Botswana.
28. Darkoh MBK & Mbaiwa JE. 2009. Land-use and resource conflicts in the Okavango Delta, Botswana. *African Journal of Ecology* 47: 161–165.

Chapter 8: Floods for the future

1. Darwall WRT, Smith KG, Tweddle D & Skelton P. (eds). 2009. *The Status and Distribution of Freshwater Biodiversity in Southern Africa*. Gland, Switzerland: IUCN and Grahamstown, South Africa: SAIAB.

2. Biodiversity monitoring studies in the Delta are reviewed by Dallas HF. 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 IP. 1981. *Report on the effects of a deltamethrin and endosulfan mixture on the non-target arthropods during the 1981 tsetse spraying program*. Maun, Botswana Department of Veterinary Services and Tsetse Fly Control; Fox, P.J. & Matthiessen, P. 1982. Acute toxicity to fish of low-dose aerosol applications of endosulfan to control tsetse fly in the Okavango Delta, Botswana. *Environmental Pollution Series A* 27: 129–142.
4. Perkins JS & Ramberg L (eds). 2004. *Environmental monitoring of Tsetse fly sprayingimpacts of the Okavango Delta – 2002*. Okavango Report Series, No. 2. Final Report prepared by the Harry Oppenheimer Okavango Research Centre, University of Botswana.
5. Junk W, Brown M, Campbell I, Finlayson M, Gopal B, Ramberg L & Warner B. 2006. The comparative biodiversity of seven globally important wetlands: a synthesis. *Aquatic Sciences* 68: 400–414.
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 River Basin (EPSMO) of the Global Enviornmental Facility (GEF) project.
8. Liebenberg PJ. 2009. *Technical report on irrigation development in the Namibia section of the Okavango River Basin*. Ministry of Agriculture, Water & Forestry, Windhoek, Namibia.
9. Mmualefe LC, Torto N, Huntsman-Mapila & Mbongwe B. 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.
10. Wolski P, Ramberg L, Magole L & Mazvimavi D. 2009. Evolution of river basin management in the Okavango system, Southern Africa. In Ferrier R & Jenkins A (eds). *Handbook of Catchment Management*. Wiley-Blackwell.
11. Ross K. 1999. *Okavango: jewel of the Kalahari*. Struik, Cape Town; and Lanting F. 1993. *Okavango: Africa's Last Eden*. Chronicle Books, San Francisco.
12. 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.
13. http://www.okacom.org
14. Ashton PJ, & Neal M. 2003. An overview of key strategic issues in the Okavango Basin. In Turton AR, Ashton PJ & Cloete TE. (eds). *Transboundary rivers, sovereignty and development: hydropolitical drivers in the Okavango River basin*. AWIRU, Pretoria, South Africa, Green Cross International, Geneva, Switzerland. Other papers in this volume are also relevant to these issues.
15. Same as 10 above.
16. Swatuk LA. .2005. Whose values matter most? Water and resource governance in the Okavango River Basin. *Mechanisms of Economic Regulation* 35: 521–529.
17. http://www.kazapark.com.

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