Okavango River Basin Transboundary Diagnostic Analysis Technical Report

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Okavango River Basin Trans-Boundary Diagnostic Assessment (TDA): Botswana Component Partial Report Key Public Health Issues

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OKAVANGO RIVER BASIN TRANS-BOUNDARY DIAGNOSTIC ASSESSMENT (TDA): BOTSWANA COMPONENT

Partial Report
KEY PUBLIC HEALTH ISSUES IN THE OKAVANGO BASIN, BOTSWANA

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EXECUTIVE SUMMARY

This report addresses key health issues in the Okavango Delta and its riparian areas as part of the Botswana component of the Okavango River Basin Trans-boundary Diagnostic Assessment (TDA). The analysis identified potential health risks and hazards, initially screened them and analysed those considered to be important on the basis of the initial screening. The analysis used a combination of TDA and Health Impact Assessment (HIA) methodologies.

In the initial screening schistosomiasis, malaria, trypanosomiasis, filariasis, cholera, diarrheal diseases, chemical poisoning, malnutrition and injuries were identified as potential health hazards. Of these potential hazards only schistosomiasis and malaria were subjected to detailed analysis as their risk in the context of TDA and their associations with water were classified as very high.

Previous publications indicated that transmission was once very high in Ngami district particularly in Maun but was controlled to a point where its public health importance became insignificant in 1993. Since then no other studies were conducted and notification of the disease became so relaxed resulting in possible underreporting of cases. However, snail surveys conducted as late as 2009 show that the intermediate host snails for both Schistosomiasis haematobium and Schistosomiasis mansoni are present within the Delta and the Boro and Thamalakane rivers. This suggests that transmission could be going on unnoticed. The study also noted that transmission of schistosomiasis was dependent on the flood regimes as snail abundance snails and intensity of water contact activities in the Boro and Thamalakane rivers depended on that. Furthermore the study predicted that the problem of schistosomiasis would increase due to the current (2009) floods and that expansion of irrigation activities planned for Shakawe would increase transmission of schistosomiasis. The current capacity to diagnose schistosomiasis within the district is considered to be weak and health posts in areas within the Delta face serious challenges in health service delivery.

Previous studies and analysis of data obtained from the Ngami District Council showed that malaria is a major problem for at least 6 months in a year with sporadic cases throughout the year. Transmission of malaria was shown to follow the rainfall pattern with a lag period of 3 months and some association with water discharge at Mahembo was established. Temperature was not considered to be a major limiting factor as average temperatures do not drop below the critical temperature (for malaria parasite development in the mosquito) of 180C for prolonged periods. Although the high clinical cases of malaria in comparison to confirmed cases indicated poor clinical diagnosis there was a close association between the confirmed and unconfirmed cases of malaria. There is a functional malaria control programme in the district but there are problems of health facilities accessibility during the rainy season and during times of high floods. Furthermore the need to strengthen capacity of the health posts was identified. The plans to expand irrigation activities in the Shakawe area are expected to exacerbate the malaria problem in that area if preventive and mitigation measures are not incorporated into the irrigation designs.

The study concluded that although there are several potential health hazards associated with water inflows into the Okavango Delta and rainfall, the hazards that need to be monitored closely are malaria and schistosomiasis. Monitoring of malaria was considered to be easier if done in the context of the ongoing control programmes but monitoring of schistosomiasis was considered to be difficult since there is no operation control programme. Emphasis to monitor

malnutrition, cholera and diarrheal diseases during periods of unusually high rainfall and high floods was made.
In view the uncertainty regarding climate change with regards rainfall it is recommended that studies that determine the possible impacts of the wet and
dry scenarios of the Okavango Basin on diseases, particularly malaria and
schistosomiasis be carried out.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1. BACKGROUND AND SCOPE

This chapter contributes to the Botswana component of the Okavango Basin Trans-boundary Diagnostic Assessment (TDA). The chapter focuses on public health aspects that are directly influenced by water resources and limited to the Okavango Delta and its immediate surroundings. HIV/AIDS issues, though critical in determining use and management of water resources management, are not dealt with in this chapter as there is a chapter focusing on that. Thus, this chapter mainly deals with diseases transmitted by intermediate hosts based in water (water based diseases), diseases transmitted by insect vectors that breed in or near water (water related diseases), diseases contracted by drinking contaminated water (water-borne diseases) and diseases caused by lack of hygiene (water washed diseases).

2. METHODOLOGY

The general methodology for TDA constituting five steps was adopted for this chapter. The steps followed are i) identification and initial prioritization of public health problems, ii) analysis of impacts and consequences of the identified problems, iii) final prioritization of the public health problems and iv) causal chain analysis and governance analysis. The production of a full TDA (v; step 5) is not covered in this chapter as that will be done for the overall component. The analyses for the various steps was done in accordance with the 3 standard components of Health Impact Assessment (HIA); community vulnerability (extent to which a community is exposed to a risk), environmental receptivity (extent to which environmental factors provide conducive conditions for disease transmission) and capacity of health services and other protection agencies (extent to which health services or protection agencies are able to deal with a given risk or hazard) (Birley, 1991). In doing that, studies that have been conducted in the Okavango Delta were reviewed and trend analysis of health statistics from the health facilities in the Delta was done.

3. RESULTS

3.1 Identification and initial prioritization of health problems

Using regional diseases distribution maps, Botswana national health information system and published material, potential water related public health problems for the Okavango Delta were classified into 4 groups; communicable diseases, non-communicable diseases, malnutrition and injury.

3.1.1 *Communicable diseases*

Schistosomiasis was considered a major problem in Ngamiland in the 1980s with prevalences of up to 80% for Maun. A recent study (Appleton et al. 2008) predicted that another epidemic is likely to occur in Maun in 2020. Both intermediate host snails for *Schistosoma haematobium* and *Schistosoma mansoni* are present within the Delta and in channels flowing out of the Delta. Thus, schistosomiasis was considered to be a problem needing further investigation.

Malaria is endemic in Botswana and is ranked as one of the major public health problems that must be reported routinely by the Ministry of Health. The available records for the years 1998 to 2003 showed that amongst the five notifiablle diseases (diarrhea, confirmed malaria, viral hepatitis, measles and rabies exposure) in Botswana, malaria was second to diarrhoea in terms of cases and deaths recorded in all the years. Analysis of 2007 health statistics for Maun showed that cases of malaria were reported throughout the year. The malaria vector is present within the Delta and generally in Ngamiland. In view of this malaria was considered to be a problem needing further investigation.

In Botswana ***African trypanosomiasis*** was only a problem in the Okavango Delta. Many years of control efforts backed by a strong political will and financial support have yielded very good results. This zoonotic disease is currently not of public health importance but there is need for continued surveillance.

Filariasis has not been reported in Botswana, South Africa, Namibia, Swaziland and Lesotho. It is therefore not considered to be a potential important problem in the Delta.

Cholera cases were in 2008 detected in Francis town which is close to the Zimbabwean border but it did not spread in the country. The Delta is prone to flooding and cholera is a potential problem if pit latrines are flooded and drinking water is contaminated. For this reason cholera has been considered as a problem that may need to be monitored.

Diarrheal diseases

Outbreaks of diarrheal diseases are often associated with unusually high rainfall and poor water and sanitation facilities. In 2006 Botswana (mostly east and south eastern areas) experienced an outbreak of diarrhea caused by *Cryptosporidium spp.* The parasite is found in water, soil and food and is transmitted through ingestion. Cryptosporidium infections result in high case fatalities due to poor diagnostic capacity and complications due to malnutrition and HIV. Although there is a potential risk of contamination of drinking water from waste disposal systems in the Delta, McCarthy et al. 2004 demonstrated that transpiration by island vegetation salinized ground water and reduced movement of pollutants while the sandy soils were found to exhibit

significant filtration effects on bacteria. In view of the 2009 floods in the upper Delta resulting in flooding of water purification and some sanitary facilities it is important to monitor the situation of diarrhea in these areas.

3.1.2 *Non-communicable diseases*

Chemical poisoning is the only non-communicable condition that is considered to be potentially important particularly if irrigation activities expand resulting in increased use of agro-chemicals. Water quality monitoring done in the delta has not shown significant amounts of harmful contaminants.

3.1.3 Malnutrition

The Okavango Delta currently supports riparian communities with a reliable source of protein. Any changes that may affect fish abundance may also affect the nutritional status of communities that rely on fish as a source of protein. Furthermore any outbreaks of diarrhea due to *Cryptosporidium spp* that may result from flooding may increase fatalities among malnourished and HIV positive children. On another positive note expansion of irrigation development may improve the nutritional status of riparian communities by increasing their incomes and introducing more protein sources for their diets. The 2006/07 Ngami Annual Report reported an increase of severe malnutrition among children from 0.2% in 2006 to 0.3% in 2007 and also an increase of total malnutrition from 1.3% in 2006 to 1.4% in 2007.

3.1.4 Injury

Injury is likely to occur during periods of floods and occasionally from attacks by animals like crocodiles and hippos.

3.2 Analysis of impacts and consequences of the identified problems

Importance of each public health problem identified during step 1 was ranked by assessing community vulnerability, environmental receptivity and capacity of health services and other protection agencies. Table 1 shows the analysis resulting in the prioritization.

Table 1. Initial prioritization of public healt problems identified in the Okavango Delta

Disease	Community vulnerability	Environmental factors	Health service capability	Prioritization of diseases
Schistosomiasis	• Fishers have occupational vulnerability • Children and women living close to water courses are vulnerable	• Intermediate host snails have been observed at sites in the delta • Cases of schistosomiasis are reported at health posts	• Access to health posts sometimes difficult • Drugs may run out • No diagnostic facilities	Very high risk
Malaria	• Lodge workers and other communities living close to water are vulnerable	• Mosquito vector for malaria is present within the delta • Malaria cases reported at health posts	• Access to health posts sometimes difficult • Drugs may run out • No diagnostic facilities	Very high risk
Cholera	• Communities relying on fish may be vulnerable	• processing of fish may lead to contamination	No outbreaks have been reported	Low risk as no outbreaks have been reported
Diarrheal Diseases	• Communities within the Delta and on the outskirts of the delta that have no safe water are vulnerable	• Diarrheal disease cases reported at health posts	Access to health posts sometimes difficult	Medium risk
Filariasis	• The geographical distribution of the disease does not extend to Botswana	• The potential vector for the disease is present	• Health system has no capacity to deal with the problem at local level	Low risk as disease is rare or absent in Botswana
African trypanosomiasis	• Communities living in or near the Delta are exposed to the disease	• The vector (tsetse fly) responsible for transmission of the disease is present	• Protection agencies responsible for control of the disease have done very well in controlling the vectors • Control programme has been well funded	Although cases have only been reported in th past the level of risk is medium and the situation needs to be monitored.

			and given sustained political support.	
Chemical poisoning	• Communities drinking raw water may be vulnerable to chemical poisoning (arsenic, lead, flouride, etc.)	• Water quality is dependent on developments that may take place in Namibia and on the agricultural expansion programme proposed by Botswana government • Ongoing monitoring has not shown significant quantities of contaminants	• Currently capacity to deal with cases of poisoning is weak	Low risk as water quality analysis has not shown presents of significant contaminants.
Malnutrition	• Fish abundance in the Delta is good for the nutrition of the riparian communities	• Reduction in fish stocks due to pollution or over-fishing can seriously affect the community's nutritional status	• Plans to expand irrigation activities will provide source of income and alternative sources of protein • Legislation to regulate fishing in order to sustain the resource is in place	Low risk as fish stocks are not likely to seriously decline because of measures put in place and plans to diversify livelihoods of riparian communities will provide other sources of protein
Injury	• Communities are largely involved in water related occupations that place them at risk of being attacked by wild animals and drowning	• Delta waters are infested with crocodiles and hippos and there are many dangerous terrestrial animals that live within the delta	• There is limited capacity to deal with serious injuries	Accidents do not happen often but when they happen there is little capacity to deal with the situation thus making the risk medium.

3.3 Final prioritization of the public health problems

Based on the screening and scoping done in steps 1 and 2, respectively a decision was made to further assess the problems of schistosomiasis, malaria and diarrheal diseases.

3.3.1 Schistosomiasis

Schistosomiasis has been reported as an important public health problem in the Ngamiland /Chobe regions of Botswana. In a survey conducted between October 1976 and October 1978 the prevalence of *S. mansoni* in Ngamiland/Chobe regions was reported to be 24 % (Rudo, 1979). Areas where *S. mansoni* was present included Sepopa, Seronga, Gomare, Nokaneng, Tsau, Maun and Shorobe while no schistosomiasis was detected in Sehitwa and Toteng. Several authors have indicated that in Maun there has been a gradual increase in prevalence of schistosomiasis that reached a peak of 80.5% in 1986 (Friis and Byskov, 1987), a period that coincided with the period just after high inflows of floods in the Thamalakane river and the rapid population increase in Maun village. A control programme based on treatment of infected people was successfully carried out from 1985 to 1993. S*. mansoni* prevalence dropped from 28.7% 1985 to 6.7% in 1993. Consequently, the cases reported at the hospital were reduced to about 1 case/month with the result that notification of the disease was relaxed. The current situation of schistosomiasis in Maun is not known as there have been no other active surveys and the notification of the disease has remained relaxed. Figure 1 shows trends of schistosomiasis prevalence in Maun as reported by Appleton et. al. (2008).

TABLE 1. *Prevalences of* Schistosoma mansoni *infection recorded amongst primary schoolchildren in the vicinity of Maun*

Year of survey	Prevalence (%)	Locality	Reference
1949	0	Maun	De Meillon (1956)
1953	<1	Maun	C. F. Hansford (unpubl. obs.)
1956	0	Maun	Pitchford (1958)
1965	13.0*	Maun	Geldenhuys *et al.* (1967)
1976	12.9–69.7	Maun	Sibiya *et al.* (1976)
1976	60–70†	Maun	Pitchford and Wolstenholme (1977)
1976–1978	24.4	Maun	Rudo (1979)
1983	80.3	Maun	Andersen *et al.* (1985)
1985–1986	80.5	Matlapaneng	Friis and Byskov (1987)
1986	45.0	Matlapana	Anon. (1986)
1997	2.2	Matlapana	S. S. Mokgweetsinyana (unpubl. obs.)
2001	0	Matlapana	S. S. Mokgweetsinyana (unpubl. obs.)

Figure 1. Prevalence of *Schistosoma mansoni* infection recorded amongst primary school children in the vicinity

As part of the Rapid Biological Assessment of the Aquatic Ecosystems of the Okavango Delta (AquaRAP 2000), a survey of freshwater invertebrates of the Okavango Delta was conducted. The survey was conducted in four focal areas within the Okavango Delta: Upper Panhandle (UPH), Lower Panhandle and Guma Lagoon (LPH), Moremi Game Reserve (MGH), and Chief's Island (CHI). Both *Bulinus globosus* and *Biomphalaria pfeifferi* snails, intermediate hosts for transmission of *Schistosoma haematobium* (urinary schistosomiasis) and *Schistosoma mansoni* (intestinal schistosomiasis) respectively, were found in all the focal areas with *B.pfeifferi* being more widespread. Although the survey was not extended to the Thamalakane river that passes through Maun Village, the report concluded on the basis of literature available that transmission of schistosomiasis was dependent on the floods regimes of the Delta suggesting that transmission in Maun increased during years when annual inflow of floodwater into the Thamalakane River was high. This is illustrated in Figure 1 published by Appleton et al. (2008).

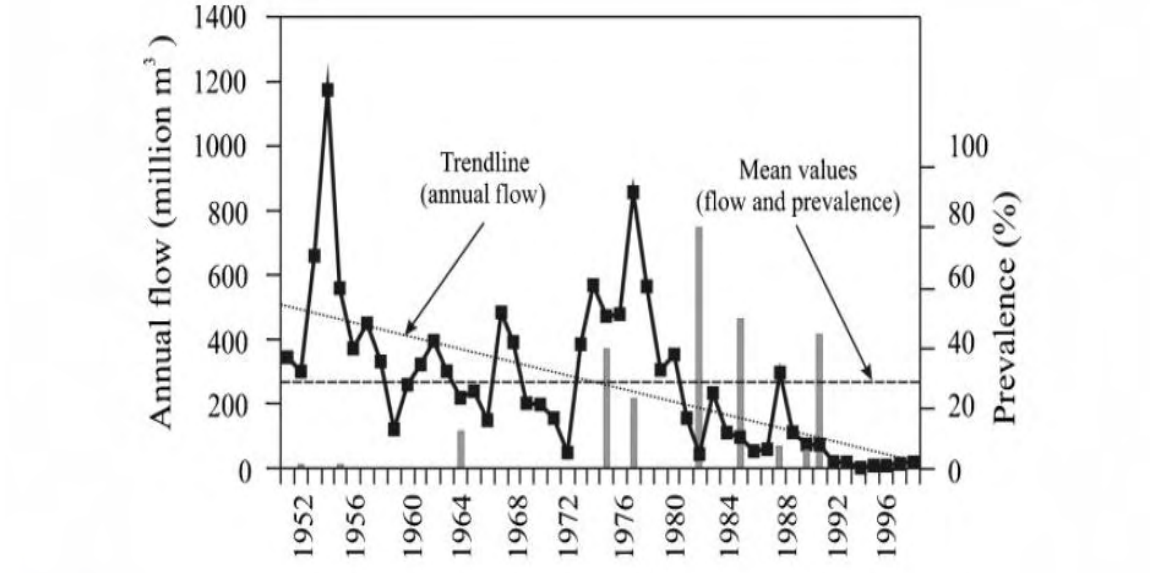


Figure 2. Annual flow of the Thamalakane River (line) and prevalence of S. mansoni (bars) in the Maun area from 1952 to 1999

Given that in 2007 and 2008 Thamalakane river maintained a steady flow, there is a possibility that schistosomiasis prevalence levels may rise to levels comparable to those experienced between 1976 and 1980. Appleton et. al. (2008) projected that a schistosomiasis epidemic similar to the one of the 1980s will recur in 2020. Chimbari (personal communication) is currently assessing the situation of schistosomiasis in Maun through parasitology and snail surveys. The study, which has already identified intermediate host snails at sites along the Boro river which feeds into the Thamalakane river, will also determine the association between schistosomiasis prevalence, snail abundance and the delta flooding regimes. At present there is no schistosomiasis control programme being implemented in Ngamiland. If plans to expand irrigation activities in the Shakawe area proceed the implications on transmission of schistosomiasis will be increased snail habitats and direct human water contact which will increase the transmission rate. Possible increased floods during the Delta flooding increased flooding cycle may increase Molapo farming (flood-recession farming) practice as floods extend to areas that have not been flooded for many years. This will increase human water contact thereby increasing the risk of people to contracting schistosomiasis.

3.3.2 Malaria

3.3.2.1 *Country overview*

Almost 2/3 of Botswana is malaria free. The remaining 1/3 which is mainly the northern part of the country experiences a 4-6 months period of malaria transmission. According to WHO (2002) the number of deaths due to malaria recorded nationwide were 141, 23, 49, 30, 29 and 14 in 1997, 1998, 1999, 2000, 2001 and 2002, respectively. As indicated in Figure 2 the Okavango Delta lies in a belt where transmission takes place for 4-6 months (MARA/ARMA, 2001). In much of the malaria endemic area transmission follows the rainy season with a lag of about 2-3 months as indicated in Figure 3.

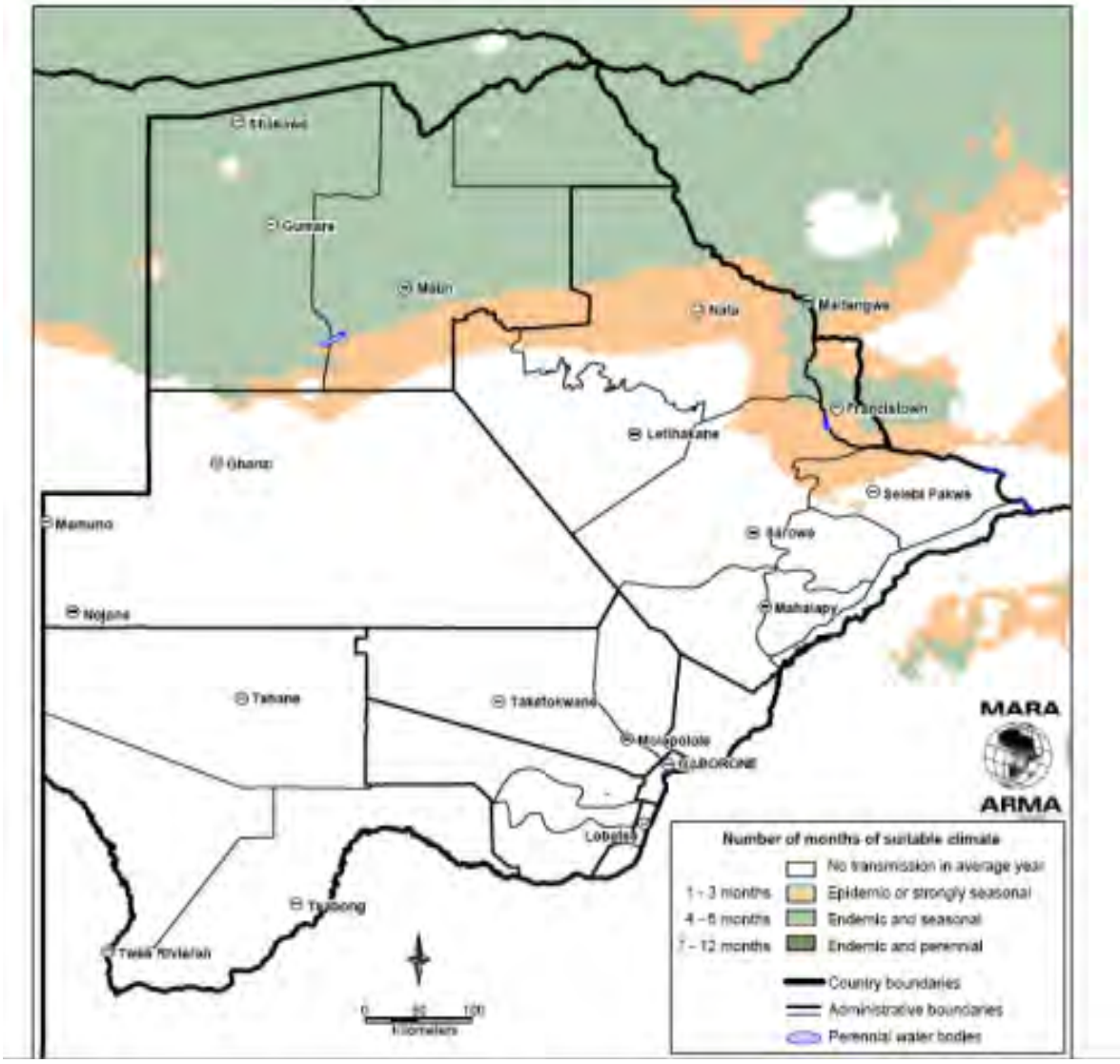


Figure 3. Malaria transmission zones in Botswana

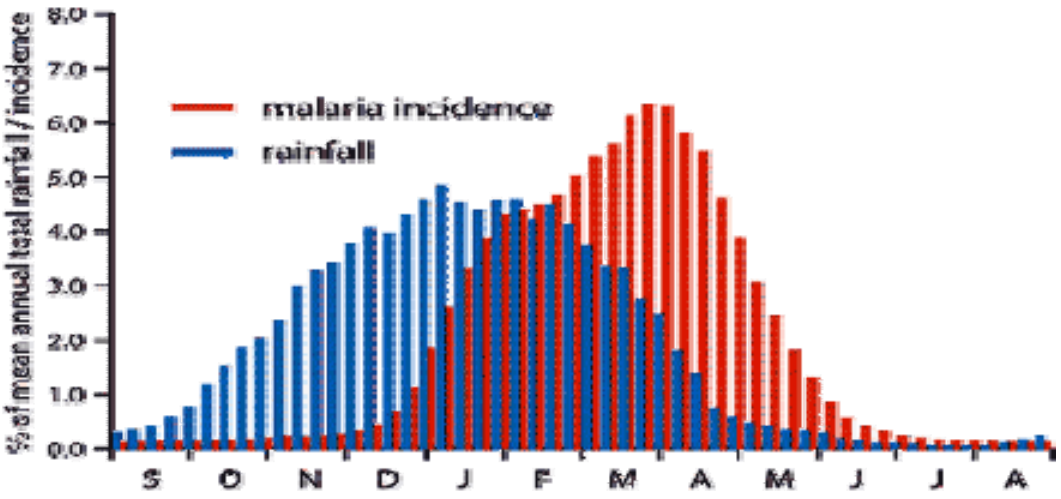


Figure 4. Influence of rainfall on malaria incidence (www.rollbackmalaria.org/countryaction/Botswana.html)

3.3.2.2 *Situation in Ngamiland*

Analysis of cases recorded in 2004 and from 2006 to 2009 in health posts in Ngamiland, where the Delta is situated, shows that both clinical and confirmed cases of malaria were recorded throughout the year (Figure 4). Consistent with the MARA predictions, most of the clinical cases were between December and April. As expected, confirmed cases were fewer but also spread throughout the year with most of the cases in the December to April period. The highest number of recorded deaths were in 2009 (12 cases) followed by 2006 (5 cases). There were 2 deaths recorded in 2008 and none in 2007. For both confirmed and unconfirmed cases children under the age of 5 years had fewer cases than those 5 years and older (Figures 5a and 5b). However, the total number of deaths for children under 5 years old were higher (18 deaths) than for those 5 years and above (1 death).

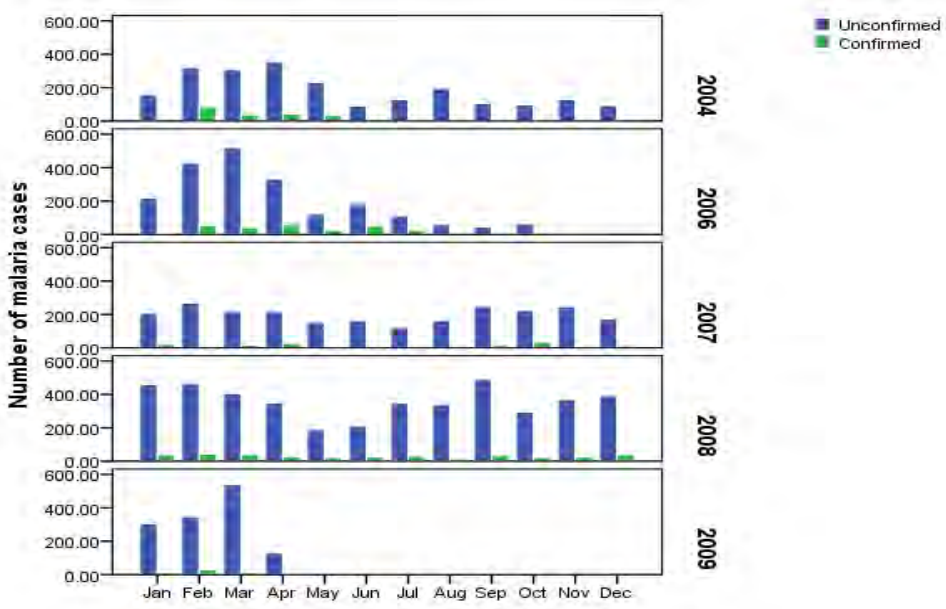
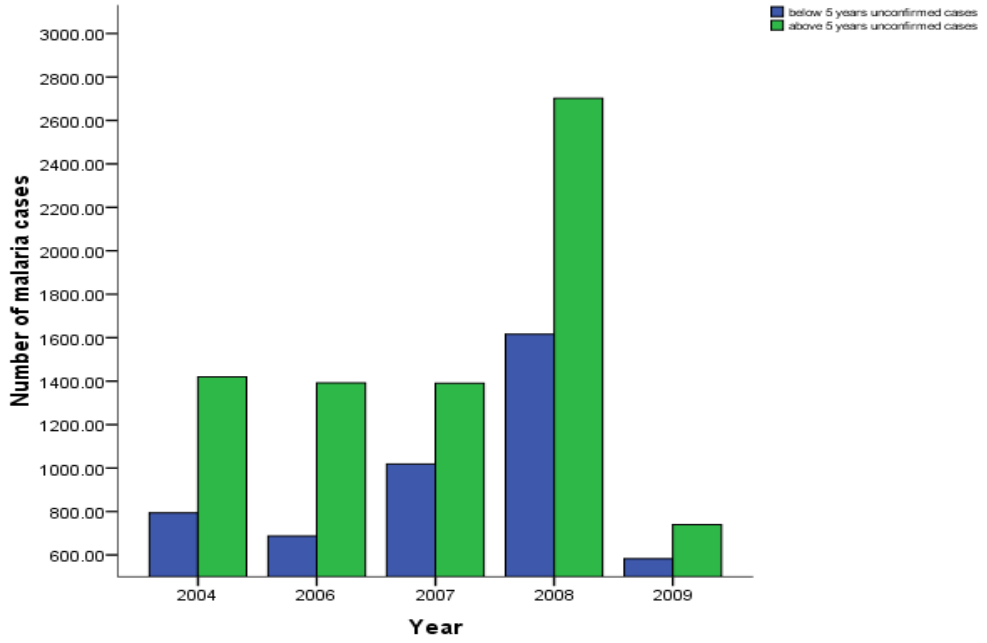


Figure 5. Unconfirmed and confirmed malaria cases in Ngamiland

a)



b)

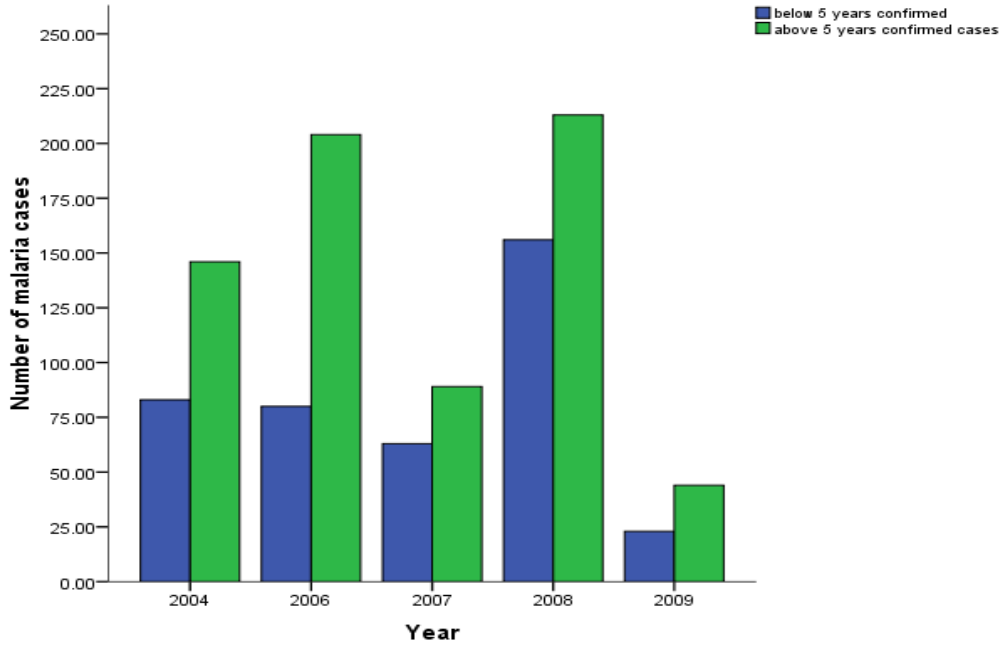


Figure 6. Number of unconfirmed (a) and confirmed (b) cases of malaria among children below 5 years and those 5 years and older

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The monthly distribution of cases in the period January 2006 to April 2009 seems to have been determined by both rainfall and discharge of water at Mahembo (Figure 6a and 6b). The rainy season usually starts in November and ends in March, a

period during which most of the malaria cases were recorded. Thomson et al. 2005 demonstrated the use of rainfall monitoring for malaria early warning in Botswana. In the period 2006 to 2009 the peak discharge of water at Mahembo was in May for 2006 and in April for the rest of the years. In 2007 and 2008 cases of malaria were recorded in October, November and December while very few or no cases were recorded in the same period for 2006, a year that was characterized with much less water discharge at Mahembo. Data for 2009 is only up to April. It should be noted that the discharge of water largely has influence in lower areas of the delta and further downstream where some areas are without water in some months of the year than in the panhandle and middle of the Delta where there is water throughout the year.

a)

b)

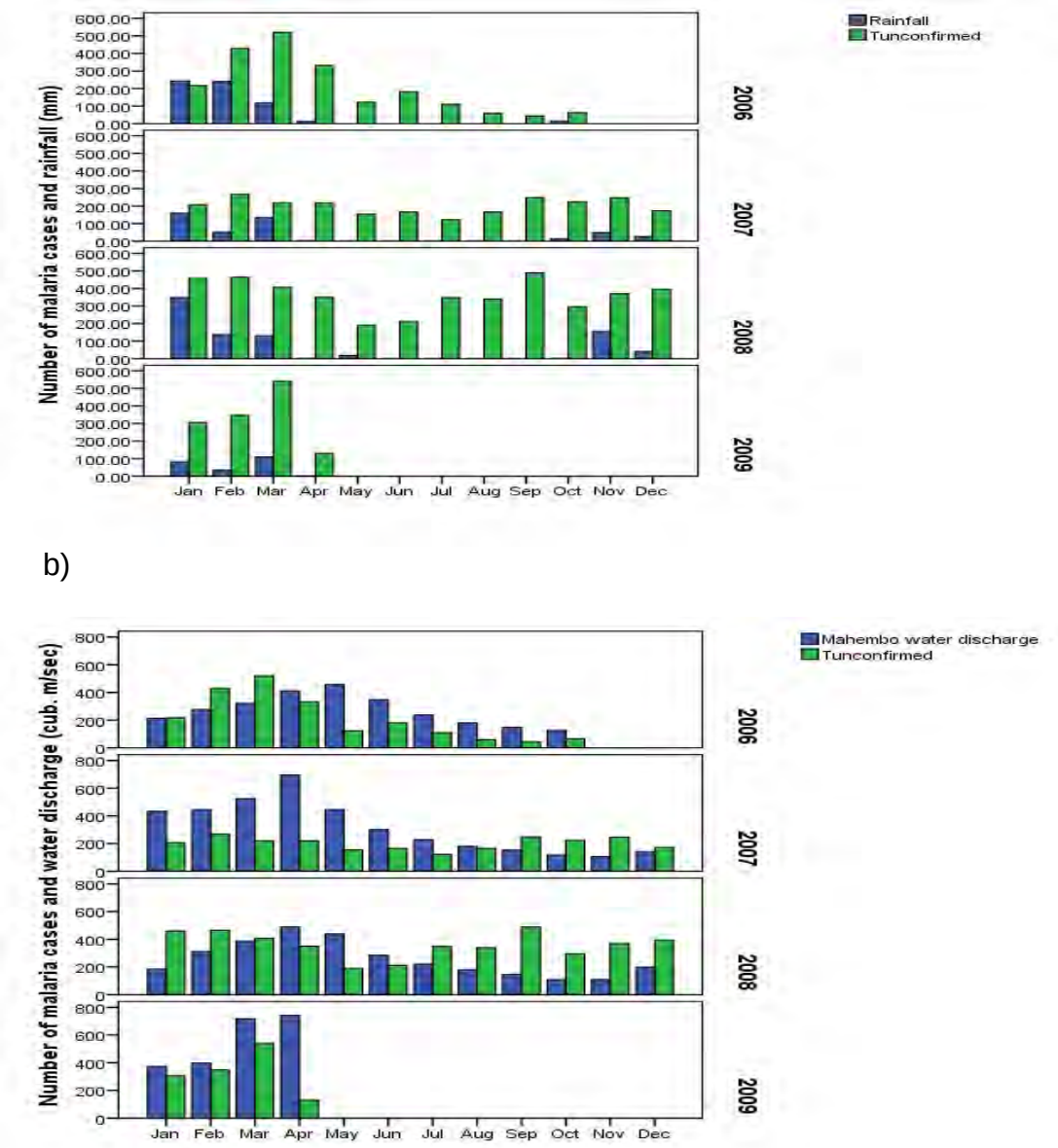

Figure 7. Cases of unconfirmed malaria plotted together with monthly rainfall recorded at Shakawe (a) and water discharge at Mahembo

Temperature is a key determinant of malaria transmission. If temperature falls below 18^{o}C for extended periods parasite development in the mosquito stops and therefore transmission is significantly reduced. Figure 7 shows the minimum, maximum and average (of minimum and maximum) temperatures recorded from January 2006 to April 2009. The minimum temperatures were far below 18^{o}C from May to August, a period during which very few clinical cases of malaria were recorded. It should however be noted that the average temperature was close to 20^{o}C suggesting that transmission may not have been completely stopped because of low temperatures.

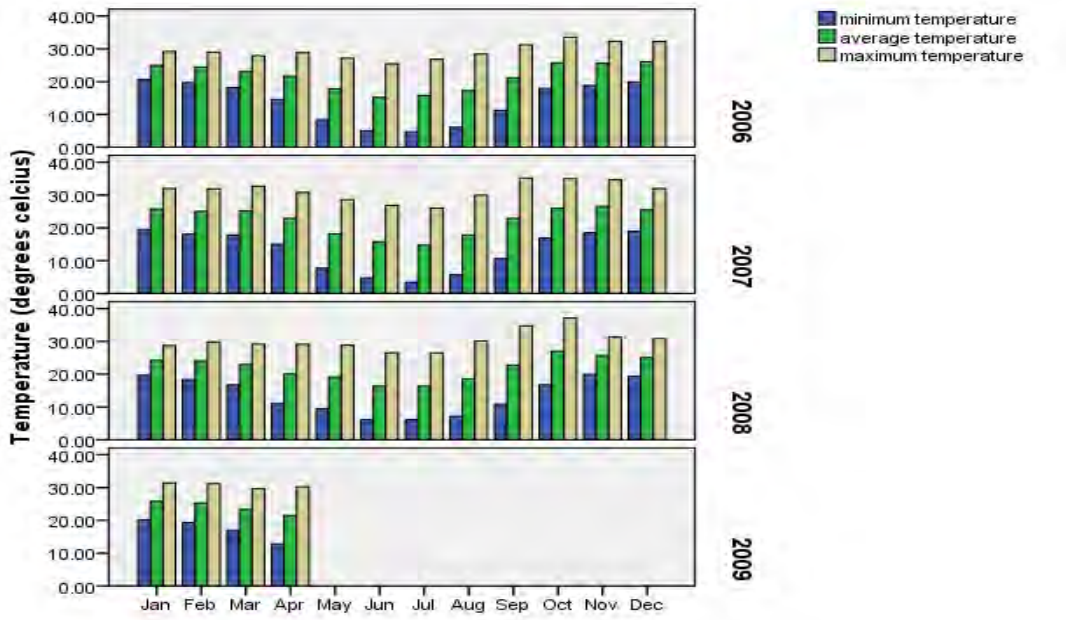

Figure 8. Minimum, maximum and average (of minimum and maximum) temperatures recorded at Shakawe

The Ngamiland local authority and Ministry of Health prioritize malaria and therefore have an operational control programme consistent with the national control programme. In 2007/2008 the annual coverage of house spraying using deltamethrine was 80%. The chemical currently used is DDT. The control programme also includes supply of Insecticide treated nets (ITN) at a cost of P20 per net and awareness campaigns. According to the Ngami Annual Report of 2006/07 the district maintains an all year round malaria vigilance. As argued for schistosomiasis if plans to expand irrigation activities go ahead more breeding sites for the anopheline mosquito will be created thereby increasing the force of malaria transmission. Furthermore, possible increased Molapo farming (flood-recession farming) due to extended flooded areas may result in increased malaria transmission as more mosquito breeding sites will be created as the floods recede. The potential areas where Molapo farming may occur have been mapped.

4. CHAIN AND GOVERNANCE ANALYSIS

The situation analysis of health aspects in the Okavango Delta identified 9 potential health risks. At the initial prioritization stage cholera and diarrheal diseases were classified as currently low risk hazards but need to be monitored particularly when unusually high discharges of water at Mahembo or an unusually good rainy season is expected. Despite the great successes registered in containing the African trypanosomiasis in Botswana, the need to monitor this zoonotic disease classified as a low risk hazard was highlighted. Chemical poisoning and malnutrition were rated low in view of the encouraging results being obtained through the water quality monitoring and the nutritional monitoring programmes. Injuries were classified as medium risk needing constant monitoring. The risk was considered to be mainly associated with interactions between animals and people. In view of the fact that filariasis has not been detected in southern African countries it was considered to be a very low risk that should not be monitored.

Schistosomiasis and malaria were rated highly as potential hazards determined by both rainfall and water inflows from the upper Okavango River. For schistosomiasis to be transmitted the appropriate intermediate host snail must be present, there must be human water contact activities and the parasite must be present in the locality. All these conditions are met. Studies conducted in the past clearly indicate the association between water inflows into the delta and abundance of intermediate host as well as prevalence of the disease. *S. mansoni* seems to be the dominant schistosome species mainly because *Biomphalaria pfeifferi*, the intermediate host of that schistosome is more widespread in the delta. There is a wide range of groups of people that are vulnerable to schistosomiasis including children who swim in the river, particularly downstream of the Delta, fishers, tourists, women harvesting reeds and the workers in tour operator lodges. The capacity of health institutions and other protection agencies with regards to schistosomiasis diagnosis and control is weak. There is no control programme in place and very few or no cases of schistosomiasis are being recorded at health posts indicating poor diagnostic capacity or low prioritization of the disease. The study that has just been initiated in Maun may show the current situation of the disease leading to reprioritization of the disease. The heavy floods experienced in 2009 may result in several years of maintained flows in the Thamalakane and lower river systems thereby increasing the risk schistosomiasis to riparian communities.The proposed expansion of irrigation activities in Shakawe will need to be accompanied by a Health Impact Assessment (HIA) in order to incorporate disease preventive and mitigation measures in the designs and operations of the irrigation scheme.

The anopheles mosquito responsible for malaria transmission is present in the Okavango Delta and surrounding areas. This mosquito breeds in clear shallow water. The hoof prints left by animals on the edges of water channels are perfect breeding sites for the anopheles mosquito. This therefore creates good breeding sites for mosquitoes outside the rain season. During the rainy season the number of breeding sites is increased and as shown by the analysis of health centre data for Ngamiland and national data the trend of malaria transmission is largely influenced by rainfall. Temperature was shown to be not a limiting factor in the transmission of malaria in the Delta and surrounding areas as the average temperatures do not fall below 18^0C for extended periods there by having little effect on malaria parasite development. Communities in tour operators' lodges

and tourists are vulnerable to malaria. However, tourists usually take prophylaxis for malaria and therefore rarely contract malaria. The large discrepancy between clinical cases and confirmed cases suggest poor clinical diagnosis for malaria due to lack of facilities and expertise (microscopes and technical staff). However, it should be noted that the trend of confirmed cases usually closely follows that of clinical cases (Chirebvu et. al. 1998). Thus, the observation, largely based on clinical cases, that there are cases of malaria throughout the year suggests that transmission of malaria is not restricted to the 4 months that other studies specify. During heavy rains and during high floods most of the health posts are difficult to reach and therefore delivery of hospital supplies and access to the health facilities are made difficult. This results in late treatment and the consequent fatalities. Despite these difficulties there is a malaria control programme implemented by the Ministry of Health. As indicated above there will be need to have an HIA if the Shakawe irrigation expansion plans proceed. The heavy floods experienced in 2009 may result in the *Molapo* farming (flood-recession farming) practice being extended to areas which have not received floods in many years. Thus, malaria transmission may increase as people get exposed to more mosquito bites due to increased numbers of mosquitoes arising from the cultivated areas.

5. CONCLUSIONS

This analysis shows that although there are many potential health hazards associated with water inflows into the Okavango Delta and rainfall, the hazards that need to be monitored closely are malaria and schistosomiasis. Monitoring the malaria situation is likely to be much easier as that can be done in the context of the existing malaria control programme but monitoring the schistosomiasis situation is difficult since there is no operational control programme. However, malnutrition, cholera and diarrheal diseases need to be monitored during periods of extreme weather events (too much water and too little water) as they interact with devastating effects. For instance, a malnourished child who ingests a diarrhea causative agent like Cryptosporidium is likely to die if they do not receive attention in good time.

6. RECOMMENDATIONS

Based on the analysis done by reviewing existing literature and use of secondary data obtained from the Ngamiland Council the following recommendations are made.

6.1 There is need to strengthen the capacity of health institutions and other protection agencies in the Delta and riparian areas to deal with malaria. This can be done by building capacity for diagnosis of malaria through staff refresher courses and routinely confirming cases either on site or at higher level.

6.2 Training of staff in health posts on schistosomiasis and advocacy is needed as there seems to be a lack of attention on the disease.

6.3 There is need to carry out a Delta wide survey (both parasitology and snail aspects) to determine the current situation of schistosomiasis. This can be done as an extension of the work currently being done in Maun.

6.4 There is need to improve the water and sanitation facilities in Delta riparian areas to prevent and/or control diarrheal disease.

6.5 In view of the uncertainty regarding climate change with regards rainfall there is need to carry out studies that determine the possible impacts of the wet and dry scenarios of the Okavango Basin on diseases, particularly malaria and schistosomiasis

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The Okavango River Basin Transboundary Diagnostic Analysis Technical Reports

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

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

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

Final Study Reports	***Reports integrating findings from all country and background reports, and covering the entire basin.***		
		Aylward, B.	*Economic Valuation of Basin Resources: Final Report to EPSMO Project of the UN Food & Agriculture Organization as an Input to the Okavango River Basin Transboundary Diagnostic Analysis*
		Barnes, J. et al.	*Okavango River Basin Transboundary Diagnostic Analysis: Socio-Economic Assessment Final Report*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Project Initiation Report (Report No: 01/2009)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment EFA Process Report (Report No: 02/2009)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Guidelines for Data Collection, Analysis and Scenario Creation (Report No: 03/2009)*
		Bethune, S. Mazvimavi, D. and Quintino, M.	*Okavango River Basin Environmental Flow Assessment Delineation Report (Report No: 04/2009)*
		Beuster, H.	*Okavango River Basin Environmental Flow Assessment Hydrology Report: Data And Models(Report No: 05/2009)*
		Beuster, H.	*Okavango River Basin Environmental Flow Assessment Scenario Report : Hydrology (Report No: 06/2009)*
		Jones, M.J.	*The Groundwater Hydrology of The Okavango Basin (FAO Internal Report, April 2010)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions (Volume 1 of 4)(Report No. 07/2009)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions (Volume 2 of 4: Indicator results) (Report No. 07/2009)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions: Climate Change Scenarios (Volume 3 of 4) (Report No. 07/2009)*
		King, J., Brown, C.A., Joubert, A.R. and Barnes, J.	*Okavango River Basin Environmental Flow Assessment Scenario Report: Biophysical Predictions (Volume 4 of 4: Climate Change Indicator Results) (Report No: 07/2009)*
		King, J., Brown, C.A. and Barnes, J.	*Okavango River Basin Environmental Flow Assessment Project Final Report (Report No: 08/2009)*
		Malzbender, D.	*Environmental Protection And Sustainable Management Of The Okavango River Basin (EPSMO): Governance Review*
		Vanderpost, C. and Dhliwayo, M.	*Database and GIS design for an expanded Okavango Basin Information System (OBIS)*
		Veríssimo, Luis	*GIS Database for the Environment Protection and Sustainable Management of the Okavango River Basin Project*
		Wolski, P.	*Assessment of hydrological effects of climate change in the Okavango Basin*
Country Reports Biophysical Series	***Angola***	*Andrade e Sousa, Helder André de*	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Sedimentologia &*

			Geomorfologia
		Gomes, Amândio	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Vegetação*
		Gomes, Amândio	*Análise Técnica, Biofísica e Socio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final:Vegetação da Parte Angolana da Bacia Hidrográfica Do Rio Cubango*
		Livramento, Filomena	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina:Macroinvertebrados*
		Miguel, Gabriel Luís	*Análise Técnica, Biofísica E Sócio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Subsídio Para o Conhecimento Hidrogeológico Relatório de Hidrogeologia*
		Morais, Miguel	*Análise Diagnóstica Transfronteiriça da Bacia do Análise Rio Cubango (Okavango): Módulo da Avaliação do Caudal Ambiental: Relatório do Especialista País: Angola Disciplina: Ictiofauna*
		Morais, Miguel	*Análise Técnica, Biófisica e Sócio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final: Peixes e Pesca Fluvial da Bacia do Okavango em Angola*
		Pereira, Maria João	*Qualidade da Água, no Lado Angolano da Bacia Hidrográfica do Rio Cubango*
		Santos, Carmen Ivelize Van-Dúnem S. N.	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório de Especialidade: Angola: Vida Selvagem*
		Santos, Carmen Ivelize Van-Dúnem S.N.	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango:Módulo Avaliação do Caudal Ambiental: Relatório de Especialidade: Angola: Aves*
	Botswana	*Bonyongo, M.C.*	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Wildlife*
		Hancock, P.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module : Specialist Report: Country: Botswana: Discipline: Birds*
		Mosepele, K.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Fish*
		Mosepele, B. and Dallas, Helen	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Aquatic Macro Invertebrates*
	Namibia	*Collin Christian & Associates CC*	*Okavango River Basin: Transboundary Diagnostic Analysis Project: Environmental Flow Assessment Module: Geomorphology*
		Curtis, B.A.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report Country: Namibia Discipline: Vegetation*
		Bethune, S.	*Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO): Transboundary Diagnostic Analysis: Basin Ecosystems Report*
		Nakanwe, S.N.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Aquatic Macro Invertebrates*
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		Roberts, K.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Wildlife*
		Waal, B.V.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia:Discipline: Fish Life*
Country Reports Socioeconomic Series	***Angola***	*Gomes, Joaquim Duarte*	*Análise Técnica dos Aspectos Relacionados com o Potencial de Irrigação no Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final*
		Mendelsohn, .J.	*Land use in Kavango: Past, Present and Future*
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		Saraiva, Rute et al.	*Diagnóstico Transfronteiriço Bacia do Okavango: Análise Socioeconómica Angola*

	Botswana	*Chimbari, M. and Magole, Lapologang*	*Okavango River Basin Trans-Boundary Diagnostic Assessment (TDA): Botswana Component: Partial Report: Key Public Health Issues in the Okavango Basin, Botswana*
		Magole, Lapologang	*Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin: Land Use Planning*
		Magole, Lapologang	*Transboundary Diagnostic Analysis (TDA) of the Botswana p Portion of the Okavango River Basin: Stakeholder Involvement in the ODMP and its Relevance to the TDA Process*
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		Ngwenya, B.N.	*Final Report: A Socio-Economic Profile of River Resources and HIV and AIDS in the Okavango Basin: Botswana*
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		Paxton, C.	*Transboundary Diagnostic Analysis: Specialist Report: Discipline: Water Quality Requirements For Human Health in the Okavango River Basin: Country: Namibia*

Environmental protection and sustainable management of the Okavango River Basin

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