Okavango River Basin Transboundary Diagnostic Analysis Technical Report

OKACOM

The Permanent Okavango River Basin Water Commission

Technical Report on Irrigation Development in the Namibia Section of the Okavango River Basin

P.J. Liebenberg

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Environmental protection and sustainable management of the Okavango River Basin

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SOCIOECONOMIC SERIES

TECHNICAL REPORT ON IRRIGATION DEVELOPMENT IN THE NAMIBIA SECTION OF THE OKAVANGO RIVER BASIN

REPORT COMPILED BY

P.J. LIEBENBERG

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PREAMBLE

The easiest way to represent all the data available / needed for this report is in table format. Great effort was done to ensure that it is comprehensible to the widest forum possible.

1. INTRODUCTION:

Overall Namibia is a dry country and water is very scarce. Therefore it is of the utmost importance for the country that the limited resources it possesses are utilised as effectively and sustainably as possible. The country is surrounded by perennial rivers bordering it (of which the Okavango river is one), but none flow through the country. Thus, the Government of Namibia must seek to build good relationships with its' neighbouring countries in an effort to utilise these shared resources in a sustainable way and to mutual benefit.

2. CURRENT AND FUTURE IRRIGATION SITUATION:

Currently there are only a few irrigation projects in existence, but the Government of the Republic of Namibia (GRN) has embarked on a course to utilise most of the potentially irrigable land within Namibia by the year 2030 to reach its Vision 2030. To reach this, the Government will endeavour to develop an additional 27 000 ha over the next 16 years with the biggest emphasis on the Kavango Region.
Potentially unlimited land is available for this in the Kavango Region, if distance from the river were not a factor, but development is restricted to the volume of water available. A further restriction (and the most severe) is the seasonal flow pattern of the Okavango River, in that the flow upstream of the Cuito is highly seasonal, whereas the downstream flow is more uniform due to the smoother inflow from the Cuito.

During deliberations between the Department of Agriculture and the Department of Water Affairs (Policy Document No. 7/2/10/3), a decision was reached that limited the abstraction rate out of the Okavango River upstream of the confluence with the Cuito to 5.5 m /s, anddownstream to 27 m /s, for use by Namibia. Taking that into account, a development scenario was developed by the Green Scheme Agency which allowed for the equal and fair distribution of this water allocation between the different Tribal Areas.

Much more water is available downstream of the confluence with the Cuito than upstream, thus more development can take place downstream of the Cuito. To calculate the area that can be developed, a figure of 125 m /day/ha (ETO = 12.5 mm per day) was used to ensure a safe margin. However, to be on the safe side and to be more realistic about the volume that would actually be likely to be abstracted during peak demand periods, a figure of 100 m /day/ha was used. The current and future irrigation development together with the abstraction rate each represents, is shown in Tables 1 & 2. A map showing the present irrigation water demands, is attached as Appendix A.

The current area under irrigation is 2,197 ha and future possible area is 13,462 ha, totalling 15,659 ha.

Table 1: Water Demand Upstream of the Cuito

No	Tribal Area	Place (If Known)	Existing Area under irrigation (ha)	Future Planned Irrigation (ha)	Abstraction Rate m /s 3	Flow Balance m /s 3
Maximum Abstraction Rate						5.50
1	**Kwangali**	**a. Musese & Maguni**	300	200	0.58	4.92
		b. Simanya	0	200	0.23	4.69
		c. Sihete	0	200	0.23	4.46
		d. Other	0	200	0.23	4.23
	Total		1,100		1.27	
2	**Mbunza**	**a. Sikondo**	0	800	0.93	3.30
		b. Other	0	300	0.35	2.95
	Total		1,100		1.27	
3	**Sambyu**	**a. Rundu**	60	0	0.07	2.88
		b. Kaisosi	36	0	0.04	2.84
		c. Vungu-Vungu	285	0	0.33	2.51
		d. Mashare Irrigation	60	0	0.07	2.44
		Training Centre				
		e. Mashare CFU	80	30	0.13	2.32
		f. Mashare	0	574	0.66	1.65
	Total		1,125		1.30	
4	**Gciriku**	**a. Ndonga Linena**	400	400	0.93	0.73
		b. Shankara	20	0	0.02	0.70
		c. Shitemo	400	0	0.46	0.24
	Total		1,220		3.38	
			1,641	2,904		
Total Development Upstream from Cuito			4,545			

Table 2: Water Demand Downstream of the Cuito

No	Tribal Area	Place (If Known)	Existing Area under irrigation (ha)	Future Planned Irrigation (ha)	Abstraction Rate m /s $_3$	Flow Balance m/s$_3$
			Maximum Abstraction Rate			21.50
4	Gciriku	a. Other	0	3,500	4.05	17.45
	Total		3,500		4.05	
5	Mbukushu	a. Shadikongoro	400	0	0.46	16.99
		b. Bagani Gardens	40	0	0.05	16.94
		c. Divundu Prisons	116	40	0.18	16.76
		d. Katondo	0	4,000	4.63	12.13
		e. New Projects	0	3,018	3.49	8.64
	Total		7,614		8.81	
			556	10,558		
Total Development Downstream from Cuito			11,114			

3. ESTIMATED DEMAND

To calculate the estimated demand for low, medium and high irrigation development scenarios, two different crop mixes were used, to present a worse case scenario and an average scenario. The peak water demand and the average water use per hectare per year are calculated for both crop mixes. Table 3 shows the peak daily demand and average volume of water used per hectare per year whilst Table 4 shows the area for different scenarios on either side of the Cuito confluence.

Table 3: Peak daily demand and Volume of water used per hectare annually

	Peak Demand (mm/day)	Volume of Water needed per hectare per year
Crop mix 1:		
Full area planted with Maize & Wheat	10.0	15,000
Crop mix 2:		
1/3 of area with Maize & Wheat	10.0	15,000
1/3 of Area with Fruit Trees	6.7	12,000
1/3 of Area with Vegetables & Aromatic Oils	6.7	12,000
Average	7.8	13,000

The following development were accepted for the different irrigation development scenarios: Low development scenario Y 2 x Current Situation = 4,394 ha Medium development scenario Y 9,000 ha High development scenario Y 15,659 ha

Table 4: Different Development Scenarios

Scenario		**Irrigation Development in hectare**			
	Upstream		Downstream		Total
Low	2,461		1,933		4,394
Medium	3,600		5,400		9,000
High	4,545		11,114		15,659

To calculate the percentages of the different scenarios against low flow conditions and average flow the flow rates given in Table 5 were used:

Table 5: Characteristics of Okavango River flow 2

Site	**Min Daily Flow**		**Annual Flow in Mm /a^3**	
	in m /s ^{3}	in Mm /a ^{3}	Average	Minimum
Rundu	11	345	5,200	2,260
Mukwe	80	2,520	9,350	5,635

Table 6 gives projected water volumes and flow rates needed for each crop mix for each development scenario and calculates the percentages that this is of total average flow, minimum flow and minimum daily flow rates.

Table 6: Water Demand for different Scenarios

Scenario	Crop Mix 1	Crop Mix 2
UPSTREAM OF Cuito		
LOW DEVELOPMENT - 2,461 ha		
Volume of Water Needed per year (Mm^3)	36.92	32.00
As % of Total Average Flow Volume	0.71%	0.62%
As % of Minimum Flow Volume	1.63%	1.42%
Peak Abstraction Rate (m^3/s)	2.85	2.22
As % of Minimum Daily Flow	25.91%	20.20%
MEDIUM DEVELOPMENT - 3,600 ha		
Volume of Water Needed per year (Mm^3)	54	46.8
As % of Total Average Flow Volume	1.04%	0.90%
As % of Minimum Flow Volume	2.39%	2.07%
Peak Abstraction Rate (m^3/s)	4.17	3.25
As % of Minimum Daily Flow	37.91	29.55
HIGH DEVELOPMENT - 4,545 ha		
Volume of Water Needed per year (Mm^3)	68.18	59.09
As % of Total Average Flow Volume	1.31%	1.14%
As % of Minimum Flow Volume	3.02%	2.61%
Peak Abstraction Rate (m^3/s)	5.26	4.10
As % of Minimum Daily Flow	47.82	37.27
DOWNSTREAM OF Cuito		
LOW DEVELOPMENT - 4,394 ha		
Volume of Water Needed per year (Mm^3)	65.91	57.12
As % of Total Average Flow Volume	0.71%	0.61%
As % of Minimum Flow Volume	1.17%	1.01%
Peak Abstraction Rate (m^3/s)	5.09	3.97
As % of Minimum Daily Flow	6.36%	4.96%
MEDIUM DEVELOPMENT - 9,000 ha		
Volume of Water Needed per year (Mm^3)	135	117
As % of Total Average Flow Volume	1.44%	1.25%
As % of Minimum Flow Volume	2.40%	2.08%
Peak Abstraction Rate (m^3/s)	10.42	8.13
As % of Minimum Daily Flow	13.03%	10.16%
HIGH DEVELOPMENT - 15,659 ha		
Volume of Water Needed per year (Mm^3)	234.89	203.57
As % of Total Average Flow Volume	2.51%	**2.18%**
As % of Minimum Flow Volume	4.17%	3.61%
Peak Abstraction Rate (m^3/s)	18.12	14.14
As % of Minimum Daily Flow	22.65%	17.68%

From Table 6 it is clear that even under the High Development Scenario, the total volume of water abstracted is relatively little of the available water in the system. For the most likely situation, that of the Crop Mix 2, it will only amount to 2.18% of the total average flow per year.

4. IRRIGATION AND SOIL

4.1. SOILS:

Geologically most of the Kavango soils comprise Cenozoic deposits of the Kalahari Group that overlay extensive basalt sheets of the Stormberg Series. The deposits of the Kalahari Group consist mostly of light coloured sands, chalcedonic limestones, silicified sandstones and ochreous sands. The last mentioned forming the Kalahari Sandveld in Namibia. 3

The Okavango River area consists out of two distinguishable landforms namely, the inland sand plateau and, the river terrace system. The riverine landform consists out of a floodplain that is partially under water during the rainy season and therefore not considered suitable for intensive irrigation purposes. The terrace is situated ± 6 to 7 metres above the riverbed. The parent material of the inland sand plateau is composed predominantly of infertile aeleon sands of the Kalahari Group with a low organic matter content. Along the terraces the sandy soil is enriched with clay and silt deposits by seasonal floods.

Due to the sandy nature of the soils and low clay and organic matter content, the soils are well drained, have a high infiltration rate and a low water retention capability. This can be mitigated by incorporating a good deal of compost and other organic material into the soil. Typically, this soil has a useful water retention capability of ± 30mm which is just enough water for three to four days during the peak demand periods. The farmer and irrigation designer therefore has to take this into account when designing the irrigation systems and irrigation scheduling. On the other hand, this also makes it a very easy soil to manage because drainage is not a problem and the right amount of water and fertilizer can be applied when needed. A good deal of initial fertilizer however is needed to bring the soil fertility a good level after which only regular maintenance fertilizer application is needed.

4.2. DRAINAGE:

Due to the high drainage capacity of the sandy soils, the farmer must take care that no over-irrigation takes place, because he will leach his expensive fertilizers out of the soil. In seasons with abnormal rainfall, this will happen naturally in the sandy soils and therefore, the essential application of organic matter cannot be over emphasised. To manage the scheduling of his irrigation correctly, he is advised to gauge soil moisture regularly to indicate when and how much to irrigate. Continued over-irrigation will also lead to contamination of groundwater and high return-flows to the river. The danger for this can however be reduced dramatically if the farmer applies only the right amount of water when it is needed.

The relatively high rainfall, coupled to the high drainage capacity of the soils, has also led to natural leaching of most of the calcium in the soils. This also needs to be rectified before cultivation of the land can begin.

At certain sites, an impermeable layer of calcium or other hard rock may underlay the topsoil and will prevent the drainage of irrigation water as well as rain water. Such soils are clearly not suitable for irrigation purposes as it will clearly pose a problem with drainage and drowned conditions will occur. To avoid this, proper site investigations must be executed before any development starts. Despite this, if such an impermeable layer is encountered, it can be rectified with sub-surface drainage or surface drainage but at a high cost to the project. Subsurface drainage water must be treated before it is allowed to flow back into the river. This can be done by directing it into a settling dam where the excess water can evaporate and the salt can be collected and removed or by diverting the water through a reed bed, which will take care of the nutrients in the water.

4.3. EROSION:

In such a flat area, it is not foreseen that irrigation will pose a problem regarding erosion as such, but the fact that an irrigation project is at a certain place, may attract more people to the surrounding area. Their land-use practices can lead to erosion during heavy rainfall or even wind-erosion because of over-grazing and deforestation. This can be mitigated by good Agricultural Extension work and awareness campaigns, to show farmers the results of such unsustainable land-uses practices and to teach ways to prevent it. It will also be good practice to prevent any land clearing within 150m from the river bank for cultivation purposes. This will ensure that if erosion does start, soil and nutrients will not wash into the river with subsequent detrimental results to the ecology downstream.

Another good practice will be to teach farmers to incorporate all organic material harvested on the land back into the soil, instead of burning it or using it as fodder for their livestock. (This also applies to the initial land clearing operation). In this way, they will enhance the water holding capacity of the soil and the soil will not be prone to wind or water-erosion. A better practice still will be to manufacture compost from this material and the manure from cattle. This will also lead to higher crop yields due to the higher nutrient content and better water holding capacity of the soils which will be an added benefit for subsistence farmers.

5. FINANCIAL VIABILITY AND SUSTAINABILITY

The first irrigation projects in the Kavango were started during the 1960's - 70's. These schemes had their ups and downs as far as financial sustainability was concern. One of the main reasons for this was the approach followed to manage the projects. All of them were managed by a salaried manager from the Development Corporation. The staff/labourers were all under a typical Government organizational structure which resulted in a very expensive labour force for the projects after a few years. Furthermore, the Corporations overheads were pushed down onto the projects, which overburden the projects. Another constraint was that the managers worked under instruction from the Head Office and could not respond to an emergency as quickly as they should have. Further, the managers worked for fixed salaries and had no incentive to do more (or anything other than grain production) on the project because of no direct benefits.

It was only during the late nineties that the projects were leased out to private entrepreneurs or managers that received no salary, but only shared in the profit, that this has changed. Even so, the projects did not necessarily immediately turn into success stories.

One of the reasons for this is that the managerial skills of the manager on the ground, must be of the highest quality and he must have a free hand as to the day to day decisions and purchases to be made. The success of any irrigation project/farm depends mostly on these skills, more than on technical knowledge and skills. A manager should have a sound understanding of financial matters or the right staff in service to cater for that. A further prerequisite is a clear understanding of the market systems into which the farm is producing. This is especially true for entering into some niche market opportunities.

One such project’s audited income statements showed a turnover of N$ 60 million over 10 years, while the operational profit was N$ 14 million during the same period. This means a gross margin of N$ 1.16 mil per year or N$ 3,800 per hectare. This can be increased by utilising the equipment available to cultivate additional land under rain-fed (dryland) conditions or to supply services to the surrounding communities.

Although it is commonly known that it is not really viable to produce any staple food under irrigation, it is still done, because it has some strategic value for the Government to have producers irrigate staple food crops. Two reasons for this are:

A.

To have food readily at hand and not be dependent on imports (Strategic importance);

B.

The variety of downstream benefits derived from the production of food.

To demonstrate the financial viability/or non-viability of irrigation in the region, a pre-feasibility study was carried out with maize and wheat as main crops and as an alternative crop, aromatic oils (essential oils). The production of vegetables, fruits, nuts and many other crops can also prove to be profitable, some more than others, but to execute this exercise, more than the available time would be needed. Some of these crops will fetch a higher price on the international markets if it is organically produced. This study indicated that it is possible to produce a crop under irrigation and make a profit from it, and again proved that production of staple foods under irrigation is not viable, although the gross margin is positive.

In each case a 100 ha unit was taken and all development costs calculated. All operational costs were estimated and a profit/loss balance sheet created for a 20-year period. As a departure point it was assumed that all capital for the development, as well as all operational cost were borrowed at a 10% interest rate. Any positive balance was also invested at an interest rate of 5%.

This exercise showed that for a higher value crop, like aromatic oils, the project can recover all of its capital costs at market related prices within 13-years, while staple foods like maize and wheat are not capable of recovering their capital development costs. (Although, if a person develops such a project with his own capital, it will also be viable, but the return on investment will be very low.) (Appendix B & C).

6. COST BENEFIT ANALYSIS:

An interesting point to discuss is the multiplier effect of any development in a region. This means that for every dollar that is created in a development project, whether it is agriculture, industry or tourism, additional value is created in the surrounding area and the country as a whole. In case studies all over the world, different multiplier coefficients have been calculated but they differ widely.

In a study in Oklahoma, United States of America, the following statements were made:

Multiplier analysis is useful to determine the total impact on an economy of some change caused by an external force or decision, such as location of a new business or government facility. The total impact of any basic industry on an economy consists of direct, indirect, and induced impacts. Direct impacts are the immediate effects of the impacting industry; for example, the jobs created to fill certain positions within the firm and the payroll to pay those new employees. Indirect impacts are the effects that occur in the sectors as a result of the input purchases made by the impacting industry. Induced effects are the changes in other sectors brought about by the increased consumer spending, due to the initial direct and the following indirect effects. In brief, the initial jobs are created and income is spent in ways that tend to create further employment and income in other sectors of the local economy.

In this study a coefficient of 2.51 were calculated for Agriculture Crop Production. This means that for every dollar created, an additional 1.51 dollars is created in the direct, indirect and induced effects around such development. This however does not mean that this figure will be accurate for the Kavango Region or Namibia, but in the absence of a proven local figure, it can be used to illustrate this example.

In Table 7 the multiplier factor is applied to the information obtained from the feasibility studies in Appendixes B & C.

Tables 8 & 9 show, Cost/Benefits matrixes created to show the more obvious benefits derived from Irrigation Development, but there are many benefits that can not be predicted, because opportunities in further processing to be done or services that can be delivered down the line, are not always seen and maximized by each entrepreneur.

These matrixes are developed for grain production on the one hand and for high value crops on the other, using the figures from the aromatic oils as basis. Please take note that although the transport cost for aromatic oils is almost non-existent, it is a huge factor with vegetables and some fruits because their volume of produce far outstrips that of grains. Tomatoes for instance have a yield of between 100 to 200 tons per hectare. Couple this to the fact that they need special transport to prevent spoilage, it is clear that this will also have huge costs associated with it as well as downstream benefits for other people.

The downstream benefit to the Government form sales of fuel to transport the products, fertilizer and fuel alone is given in Appendix D.

Table 7: Total Cost Benefit from Irrigation comparing irrigation of aromatic oils to grain production.

Description:	Aromatic Oils 5	Grain Production
Development Cost in N$ per ha	230882	131740
Operational cost in N$ per ha	37097	40792
Income per ha (N$)	74629	45850
After multiplier effect	187319	115084
Years to break even	13	-
Job opportunities per ha (permanent)1	0.28	0.07
No of Casual working days per Year per ha	24	1
Benefit for the region/Country per 100 ha unit per year (N$)	18731900	11508400
Benefit for the region/Country for 15,659 ha development per year(N$)	2,933 mil	1,802 mil
Possible Permanent Job opportunities with 15,659 ha of development	4384	1096
Possible Casual work days per year with 15,659 ha of development	375816	15659

7. CONCLUSION:

It is clear from this report, that such water use from the Okavango River could have huge benefits, not only for the irrigation farmers, but for the region and country as well. However, development of any irrigation project should be undertake with caution and only after a detailed feasibility study that includes an environmental impact assessment is done to ensure that all relevant options are fully addressed. This should include detailed sustainable management and environmental management plans. Evaluation and monitoring of these plans should be done at regular intervals to ensure that the projects is managed on sound and sustainable principles. It is advisable that only high value crops like aromatic oils, vegetables, nuts, fruits, pineapples, etc., be irrigated to ensure that the water is used as efficiently as possible.

This is for large commercial farming with aromatic oils. For small scale farmers, where they will do the harvesting by hand, a much higher figure of ± 1 job per hectare could be reached.

The total area that can be irrigated with minimal effect on the river in low flow conditions, is ± 16,000 hectares. Of this, only 4,545 ha may be upstream of the confluence with the Cuito. The rest must be downstream of the confluence. This will result in an abstraction of ± 2.17 % of the average flow per year and a maximum low flow abstraction rate upstream of the Cuito confluence of of 37.27 % (i.e. more than a third of the water flowing in the river at low flow.)

The most likely development scenario that will happen is a scenario where different crop mixes are cultivated with grain production as an integral part of it. For the best use of the water however, it is not recommended that grain be irrigated. If only high value crops are planted, the return on investment will be highest and the water used the most beneficially.

Erosion and drainage should pose no problems, but it is recommended that a detailed soil investigation be carried out, before an area is selected for a project. It is furthermore important that effective irrigation scheduling be implemented to ensure that no leaching of nutrients take place and that these do not wash down into the river as back flows that could let to future enrichment or even eutrophication of these nutrient poor waters.

8. REFERENCES

Information as compiled by the Green Scheme Agency.

1. Information from the Department of Water Affairs - File 11/5/3/1.

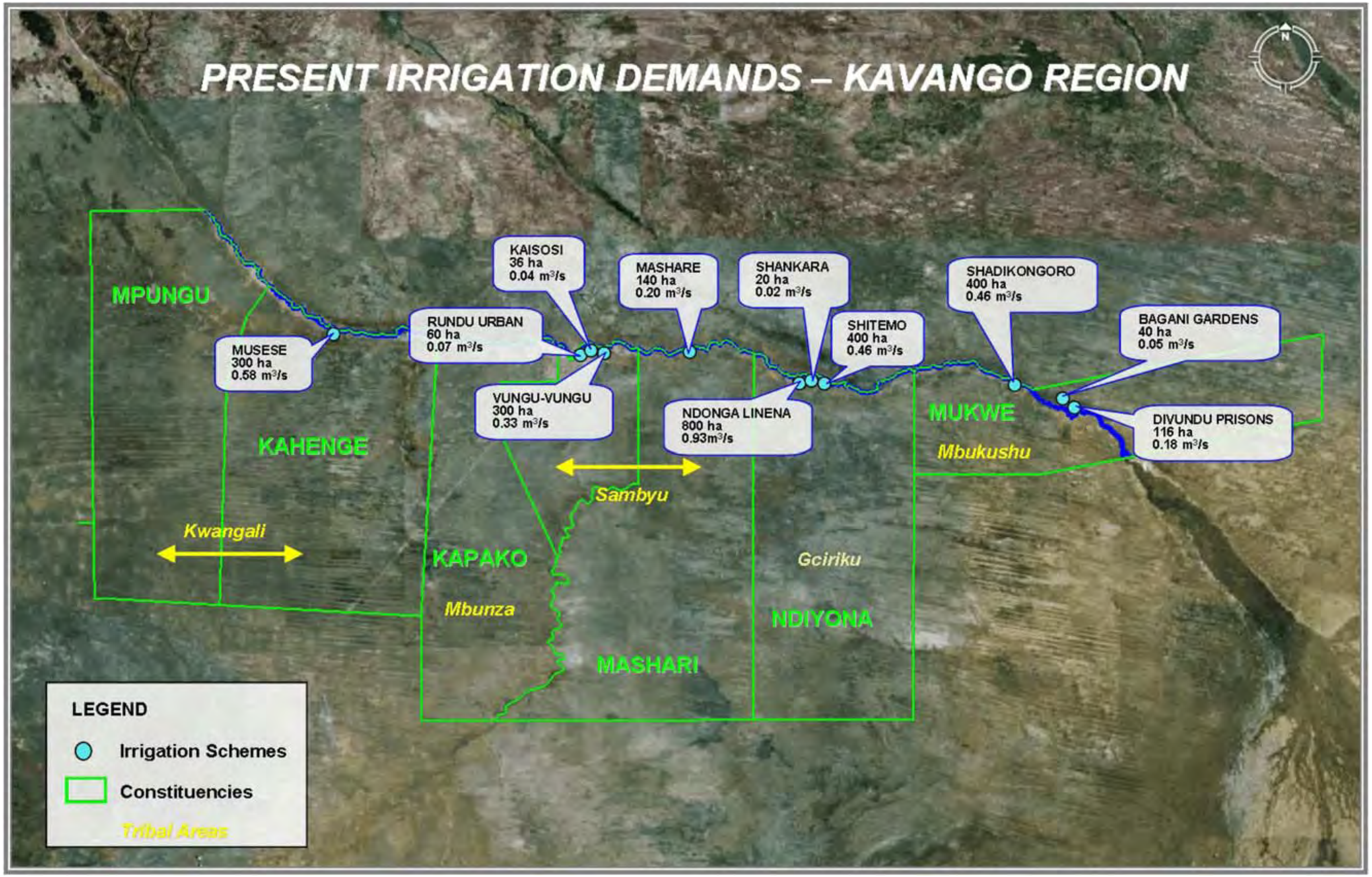
2. Project to support the Agro-Ecological Zoning Programme (AEZ) in Namibia, The Ministry of Agriculture, Water and Rural Development and the Spanish Agency for International Cooperation.

3. Song, B., Woods, M.D., Doeksen, G.A., Schreiner, D., Multiplier Analysis for Agriculture and other Services, Oklahoma Cooperative Extension Services, USA.

4. Market News Service (MNS), Division of Market Development, International Trade Center. The Joint Agency of the World Trade Organization and The United Nations.

Appendix A

APPENDIX 1: Appendix A


PRESENT IRRIGATION DEMANDS – KAVANGO REGION
N
MPUNGU
KAHENGE
KAPAKO
MASHARI
NDIYONA
MUKWE
Kwangali
Mbunza
Sambyu
Gciriku
Mbukushu
MUSESE 300 ha 0.58 m³/s
RUNDU URBAN 60 ha 0.07 m³/s
KAISOSI 36 ha 0.04 m³/s
VUNGU-VUNGU 300 ha 0.33 m³/s
MASHARE 140 ha 0.20 m³/s
SHANKARA 20 ha 0.02 m³/s
NDONGA LINENA 800 ha 0.93m³/s
SHITEMO 400 ha 0.46 m³/s
SHADIKONGORO 400 ha 0.46 m³/s
BAGANI GARDENS 40 ha 0.05 m³/s
DIVUNDU PRISONS 116 ha 0.18 m³/s
LEGEND
Irrigation Schemes
Constituencies
Tribal Areas

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APPENDIX B

APPENDIX 2: Appendix B

CAPITAL DEVELOPMENT - MAIZE & WHEAT AS MAIN CROP					
ITEM	UNIT	QTY		RATE	TOTAL (N$)
1	De-bush & Ripping	ha	100	7,000.00	700,000.00
2	Initial Soil Preparation	ha	100	3,000.00	300,000.00
4	Pump Station	sum	1	2,000,000.00	2,000,000.00
5	Main Pipelines	sum	1	820,000.00	820,000.00
7	Power Connection - 1x200kVA	sum	1	800,000.00	800,000.00
8	Irrigation System 25ha Centre Pivots	ea	4	418,500.00	1,674,000.00
9	Roads	sum	1	300,000.00	300,000.00
10	Fencing	km	5	20,000.00	100,000.00
11	Houses	ea	1	500,000.00	500,000.00
12	Office Block	sum	1	350,000.00	350,000.00
13	Sheds	ea	3	300,000.00	900,000.00
15	Tractor - 82 kW	ea	1	621,000.00	621,000.00
16	Tractor - 58 kW	ea	1	418,000.00	418,000.00
18	Trailer - 5Ton	ea	2	95,000.00	190,000.00
20	Disc - 2.3m	ea	1	125,000.00	125,000.00
21	Ripper - 2 tines	ea	1	21,000.00	21,000.00
22	Chisel Plough - 7 tines	ea	1	60,000.00	60,000.00
23	Boom Sprayer - 12m	ea	1	60,000.00	60,000.00
24	Workshop Equipment	ea	1	100,000.00	100,000.00
25	Light Delivery Vehicle - 1 ton	ea	1	180,000.00	180,000.00
27	Combine Harvester	ea	1	2,400,000.00	2,400,000.00
28	Meaze Planter	ea	1	230,000.00	230,000.00
29	Wheat Planter	ea	1	325,000.00	325,000.00
TOTAL					13,174,000.00
SALARIES & WAGES					
1	Manager	ea	1	300,000.00	300,000.00
2	Section Manager	ea	0	150,000.00	0.00
3	Team Leader	ea	1	30,000.00	30,000.00
4	Labourers	ea	5	24,000.00	120,000.00
5	Admin Officer	ea	0	75,000.00	0.00
6	Casuals - days	ea	100	50.00	5,000.00
Total					455,000.00
RECURRENT COST					
Seed - Maize		ha	100	1,033.85	103,385.00
Seed - Wheat		ha	100	288.00	28,800.00
1	Fertilizer - Maize	ha	100	8,498.68	849,868.00
2	Fertilizer - Wheat	ha	100	9,153.66	915,366.00
Micro Elements - Maize		ha	100	119.58	11,958.00
Micro Elements - Wheat		ha	100	358.74	35,874.00
3	Pesticides - Maize	ha	100	2,063.83	206,383.00

	Pesticides - Wheat	ha	100	488.81	48,881.00
	Herbisides - Maize	ha	100	352.00	35,200.00
	Herbicides - Wheat	ha	100	447.87	44,787.00
	Marketing - Maize	ha	100	3,830.00	383,000.00
	Marketing - Wheat	ha	100	2,500.00	250,000.00
4	Water & Electricity	ha	100	2,637.08	263,708.00
5	Transport - LDV's	km	36,000	1.63	58,680.00
6	Diesel	R	10,000	7.50	75,000.00
8	Maintenance- Pump S tation - 2%	sum	1	40,000.00	40,000.00
9	- Main pipe line - 2%	sum	1	16,400.00	16,400.00
10	Irrigation System - 3% -	sum	1	50,220.00	50,220.00
11	Buildings - 1% -	sum	1	17,500.00	17,500.00
12	Trac tors & Equipment - 4% -	sum	1	189,200.00	189,200.00
Total					3,624,210.00

INCOME		Unit	Qty	Yield - Ton/ha	Tons	Price per ton	Total
1	Maize	ha	100	10.00	1,000	2,500.00	2,500,000.00
2	Wheat	ha	100	6.00	600	3,475.00	2,085,000.00
Total			200		1,600		4,585,000.00

APPENDIX C

APPENDIX 3: Appendix C

						BALANCING SHEET - MAIZE AND WHEAT YEAR															
ITEM	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
INCOME																					
Product Sold		4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000	4,585,000
OPERATIONAL COST																					
1 Capital Cost	13,174,000																				
2 Recurrent Cost		3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210	3,624,210
3 Salaries		455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000	455,000
5 Replacement of						360,000					860,000				500,000	2,400,000					540,000
Equipment																					
TOTAL	13,174,000	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210	4,079,210
INTEREST		1,317,400	1,398,561	1,487,838	1,586,043	1,694,068	1,848,896	1,983,207	2,130,948	2,293,464	2,472,232	2,754,876	2,979,784	3,227,184	3,499,323	3,148,812	3,023,352	2,670,437	2,352,815	2,066,954	1,809,680

Own Capital	0																				
BALANCE	-13,174,000	-13,985,610	-14,878,381	-15,860,429	-16,940,682	-18,488,960	-19,832,066	-21,309,483	-22,934,641	-24,722,315	-27,548,757	-29,797,842	-32,271,837	-34,993,230	-31,488,117	-30,233,516	-26,704,374	-23,528,147	-20,669,542	-18,096,798	-16,321,328

Appendix D

APPENDIX 4: Appendix D

					Down Stream benefit to the Transport Industry per annum								
Product	**Yield/ha**	**Ha Planted**	**Total tons**	**No of 30 ton trucks loads**	**Freight km driven per trip**	**Price per km N$**	**Total Cost**	**Km Inside Namibia per trip**	**Litre/km**	**Liters of diesel used**	**Price per Litre**	**Total Cost N$**	**Tax N$ on Fuel alone**
Maize	10	15,659	156,590	5,220	700	30	109,613,000.00	700	0.5	3,653,767	7.50	27,403,250.00	13,701,625.00
Wheat	6	15,659	93,954	3,132	700	30	65,767,800.00	700	0.5	2,192,260	7.50	16,441,950.00	8,220,975.00
Fertilizer	1.3	15,659	20,357	679	700	30	14,249,690.00	700	0.5	474,990	7.50	3,562,422.50	1,781,211.25
Fuel (R/ha)	100	15,659	1,566	52	700	30	1,096,130.00	700	0.5	36,538	7.50	274,032.50	137,016.25
Total			270,901	9,030	2,100		190,726,620.00			6,357,554		47,681,655.00	23,840,827.50

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 Transboundary 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*
		Paxton, M.	*Okavango River Basin Transboundary Diagnostic Analysis: Environmental Flow Module: Specialist Report:Country:Namibia: Discipline: Birds (Avifauna)*
		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*
		Pereira, Maria João	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Qualidade da Água*
		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*
		Masamba, W.R.	*Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin: Output 4: Water Supply and Sanitation*
		Masamba,W.R.	*Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin: Irrigation Development*
		Mbaiwa.J.E.	*Transboundary Diagnostic Analysis of the Okavango River Basin: the Status of Tourism Development in the Okavango Delta: Botswana*
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		Mmopelwa, G.	*Okavango River Basin Trans-boundary Diagnostic Assessment: Botswana Component: Output 5: Socio-Economic Profile*
		Ngwenya, B.N.	*Final Report: A Socio-Economic Profile of River Resources and HIV and AIDS in the Okavango Basin: Botswana*
		Vanderpost, C.	*Assessment of Existing Social Services and Projected Growth in the Context of the Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin*
	Namibia	*Barnes, J and Wamunyima, D*	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Socio-economics*
		Collin Christian & Associates CC	*Technical Report on Hydro-electric Power Development in the Namibian Section of the Okavango River Basin*
		Liebenberg, J.P.	*Technical Report on Irrigation Development in the Namibia Section of the Okavango River Basin*
		Ortmann, Cynthia L.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module : Specialist Report Country: Namibia: discipline: Water Quality*
		Nashipili, Ndinomwaameni	*Okavango River Basin Technical Diagnostic Analysis: Specialist Report: Country: Namibia: Discipline: Water Supply and Sanitation*
		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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