Okavango River Basin Transboundary Diagnostic Analysis Technical Report

OKACOM
The Permanent Okavango River Basin Water Commission

Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin

Output 3: Irrigation Development

Wellington R.L. Masamba
Harry Oppenheimer Okavango Research Centre

July 2009

Environmental protection and sustainable management of the Okavango River Basin
EPSMO

SOCIOECONOMIC SERIES

TRANSBOUNDARY DIAGNOSTIC ANALYSIS OF THE BOTSWANA PORTION OF THE OKAVANGO RIVER BASIN

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ACRONYMS AND ABBREVIATIONS

DWA	Department of Water Affairs
EPSMO	Environmental Protection and Sustainable Management of the Okavango River Basin
GDP	Gross Domestic Product
GEF	Global Environment Facility
MoA	Ministry of Agriculture
MPWWS	Master Plan for Waste Water and Sanitation
NAMPAADD	National Agricultural Master Plan for Arable Agriculture and Dairy Development
Ml/year	Million litres per year
NDP	National Development Plan
NMPWWS	National Master Plan for Wastewater and sanitation
NWMPR	National Water Master Plan Review
OKAKOM	Permanent Okavango River Basin Water Commission
ORB	Okavango River Basin
SAP	Strategic Action Program
TDA	Trans-boundary Diagnostic Analysis
WDS	Water Development Sector
WWTP	Wastewater Treatment Plant
ZAMCOM	Zambezi Watercourse Commission

EXECUTIVE SUMMARY

This report covers the irrigation component of the Trans-boundary Diagnostic Assessment (TDA) whose term of reference was to review the current irrigation planning and development initiatives in Botswana as they related to the Okavango Basin. The findings of this work are as follows:

1. The main irrigation planning and development initiative for Botswana is under the National Agricultural Master Plan for Arable Agriculture and Dairy Development (NAMPADD)
2. Only 1,800 ha are currently under irrigation in Botswana. This is to increase to 5,400 ha by 2012 under NAMPADD. Depending on successful negotiations within ZAMCOM (Zambezi Watercourse Commission), there are future plans to irrigate up to 40,000 ha in the Pandamatenga area
3. The water requirements for the 5,400 ha planned by the year 2012 are 53,000 Ml/year
4. The Central District has the highest irrigation. These are mostly commercial farms located along the Limpopo in the Tuli Block
5. Groundwater constitutes the main source of water for irrigation. The registry at DWA records a total of over 11,000 permits issued for groundwater abstraction, which corresponds to an estimated 11,500 Ml/year
6. Surface water supplies for irrigation are limited to abstraction from rivers and streams when they have flow, small and medium livestock dams and recycled wastewater. Availability of river water flows is limited as Botswana has only two perennial rivers, the Okavango and the Chobe, but international agreements for large –scale use of these rivers have not been concluded.
7. Reclaimed wastewater offers an excellent source of water for irrigation in Botswana but only 10 % of the return flows from wastewater treatment plants are reused, the rest being lost to seepage and evaporation.
8. Only 31.35 ha of land is being irrigated around the Okavango Delta out of an allocated area of 188.15 ha.
9. Around the Okavango Delta, 520,000 m^3/year is used for current irrigation and 3,000,000 m^3/year would be used if all the allocated land were irrigated.
10. Currently, there are no plans for major irrigation using waters of the Okavango
11. There is very little, unquantified use of fertilisers and pesticides around the Okavango Delta
12. Upstream activities that would result in reduced quantity and poor quality water would affect future irrigation projects.

1. INTRODUCTION

The Ministry of Agriculture has emphasized the need for irrigation if the agricultural sector is to be developed further in Botswana. Irrigation is required in most areas as a result of poor performance of rain fed agriculture attributed to, among other reasons, inadequate and unreliable rainfall. Annual rainfall ranges from 250 mm in the extreme south-west to 650 mm in the extreme north-east. Most of the rainfall comes in summer when moisture loss to the atmosphere is high and tends to limit the amount of moisture available for crops to grow and mature.

Irrigation development in the country focuses mainly on expanding horticultural production to meet a larger percentage of domestic demand and to generate employment. With the implementation of the National Agricultural Master Plan for Arable Agriculture and Dairy Development (NAMPAADD), a total of 5,200 ha – 5,400 ha is planned for irrigation by the year 2012 (from a total of 1,800 ha in 2004); with 3,600 ha proposed to be irrigated by treated wastewater. The total amount of irrigation water to meet these goals is estimated at 51,000 Ml/year to 53,000 Ml/year.

The impact of the agricultural sector, in general, on the economy of Botswana in terms of the Gross Domestic Product (GDP) is quite small compared to other sectors like mining, manufacturing, trade and tourism. The sector's contribution to GDP has been declining from 42.7% at independence in 1966 to 1.7% in 2008 (Table 1). The Government of Botswana continues to promote this sector for food security and employment, especially for people in rural areas.

The Ministry of Agriculture (MoA) engaged TAHAL consultants in 1998 to prepare NAMPAADD. The objective of this Master Plan was "to improve the performance of the agricultural sector and ensure sustainable use of the country's resources". NAMPAADD's planning horizon was 10 years from 2002-2012. NAMPAADD considered two scenarios for agricultural development; a socially oriented scenario where rural employment and household food security take precedence over economic efficiency; and an economically oriented scenario where competitiveness and the most economically efficient of resources assume precedence. The potential for employment was envisaged at 50% under the NAMPAADD socially oriented scenario (NAMPAADD 2000).

The Okavango River Basin (ORB) remains one of the least human impacted basins on the African continent. Mounting socio-economic pressures in the riparian countries; Angola, Botswana and Namibia, threaten to change its present character. The Permanent Okavango River Basin Water Commission OKAKOM) therefore solicited funds from the three governments and the Global Environment Facility (GEF) and

Table 1. GDP by Economic Activity-Selected years (constant 1993/94 prices) million Pula. Data from National Development Plan 9, 2003, except for 2005-2008 which is from National Accounts Statistics, March 2009)

Economic activity	1966		1975/76		1985/86		2000/01		2005		2007		2008	
	Value	Share (%)	Value	Share (%)	Value	Share (%)	Value	Share (%)	Value	Share (%)	Value	Share (%)	Value	Share (%)
Agriculture	387.6	42.7	431.1	20.7	318.9	5.6	434.0	2.6	401.1	1.8	432.8	1.8	435.0	1.7
Mining and quarrying	-	-	565.3	17.5	2790.8	48.9	6027.2	36.5	9,134.2	40.7	9,661.7	39.2	9,293.7	36.6
Manufacturing	51.4	5.7	159.2	7.6	224.9	3.9	681.3	4.1	785.4	3.5	952.8	3.9	972.3	3.8
Water and electricity	5.2	0.6	48.4	2.3	113.1	2.0	391.3	2.4	490.5	2.2	544.9	2.2	574.3	2.3
Construction	71.2	7.8	267.1	12.8	260.7	4.6	954.8	5.8	1,009.4	4.5	1,183.0	4.8	1,208.7	4.8
Trade, hotels, restaurants	81.4	7.8	267.1	12.8	260.7	4.6	954.8	5.8	2,051.7	9.1	2,245.1	10.1	2,653.0	10.4
Transport	39.4	4.3	23.5	1.1	141.5	2.5	623.7	3.8	720.7	3.2	881.8	3.6	1,013.2	4.0
Banks, insurances, Business Services	183.0	20.1	97.5	4.7	367.4	6.4	1794.7	10.9	2,238.5	10.0	2,606.3	10.6	2,996.8	11.8
General Government	89.2	9.8	305.0	14.6	730.5	12.8	2640.6	16.0	3,740.0	16.6	3,847.6	15.6	4,146.6	16.3
Social and personal services	-	-	57.8	2.8	145.4	2.5	663.2	4.0	909.9	4.0	973.8	3.9	1,040.0	4.1

initiated the Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO) Project.

The long-term objective of the EPSMO Project is to achieve global environmental benefits through concerted management of the naturally integrated land and water resources of the Okavango River Basin. The specific objectives of the project are to:

a. Enhance the depth, accuracy, and accessibility of the existing knowledge base of basin characteristics and conditions and identify the principal threats to the trans-boundary water resources of the Okavango River Basin through a Trans-boundary Diagnostic Analysis (TDA);
b. Develop and implement, through a structured process, a sustainable and cost-effective program of policy, legal and institutional reforms and investments to mitigate the identified threats to the basin's linked land and water systems through the Strategic Action Program (SAP); and,
c. Assist the three riparian nations (Angola, Botswana and Namibia) in their efforts to improve their capacity to collectively manage the basin.

The SAP will include baseline and additional actions to address priority trans-boundary issues and provide a monitoring and evaluation tool for implementation. It will also recommend the development and testing of a set of institutional mechanisms and implementation methodologies, including pilot demonstrations that explicitly link regional, national and local initiatives in land and water management. Additionally, it will involve preparation of a basin-wide framework in which trans-boundary priorities can be addressed and project interventions monitored.

The TDA will inform and guide the development of the SAP and will be a platform where trans-boundary externalities can be examined and resolved. The TDA will underpin the SAP design and indicate monitoring and reporting criteria for SAP implementation. Most importantly, the process of completing the TDA will inform policies and initiatives to be launched in preparation for SAP implementation. This report is part of the TDA with focus on irrigation.
The term of reference for this work was to review the current irrigation planning and development initiatives in Botswana as they related to the Okavango Basin

2 METHODOLOGY

Information was collected from a knowledge gathering workshop, discussions with Government Officers and the literature.

2.1 Knowledge gathering workshop

A knowledge gathering workshop was conducted on 24th – 25th February 2009. The participants had been asked before hand to prepare information on irrigation (and the other TDA areas). Preliminary information was therefore obtained during the workshop. In addition to the information, participants also provided input as to what they expected to be included in this report. A feedback workshop was conducted from 15 to 16 July 2009 where additional input was provided by the workshop participants.

2.2 Discussions with Government Officers

Additional information was obtained by visits to offices (Agricultural Research, Maun, Regional Agricultural Office, Maun, NAMPPAARD offices in Gaborone)

2.3 Literature

Secondary data was sourced from the offices or libraries. Most of the information in this report is derived from SMEC (2006)-the National Water Master Plan Review Volume (NWMPR) Volume 8-Agriculture.

3.0 IRRIGATION IN BOTSWANA

Irrigation in Botswana is mainly for high value horticultural production and citrus. Whereas small – scale farmers dominate other forms of agriculture; large-scale farmers dominate irrigated horticultural production. Irrigation is predominantly carried out in the Tuli Block area which has high yielding wells and good soils along the Limpopo River. The farmers in this area also have standby pumps to abstract water from the river during the months when there are flows. Small-scale farmers comprise many farmers, most of whom have one hectare or less, mainly because of low borehole yields. This denies the growers the economies of scale. The potential for commercial horticultural production is largely underutilized, even within the limitations of water supply. In regards to irrigated agriculture, especially horticultural production, the objective of the Government is to increase domestic production to meet 70% of the domestic horticultural demand. This is motivated by the need for some level of food security and employment generation (NAMPAADD Government White Paper No. 1 of 2002).

The history of planed water usage in the Okavango delta has been reviewed by several workers (Randall 1957; Scudder et al 1993). The proposals in Randall (1957) focused on draining the Okavango delta for crop production. Pike (1970) evaluated the Okavango as a primary water resource, and irrigation zoning around the Nhabe River in Ngamiland was carried out where approximately 1,100 ha were zoned for irrigation (van der Sluis 1990). Prior to this, the Southern Okavango Development project proposed the potential development of 10,000 ha for irrigated agriculture along the Delta's southern fringe (SMEC 1987). This project was later abandoned by Botswana Government. Currently no major irrigation is planned for the Okavango Delta region until international agreements for the use of the waters of the Okavango are signed.

3.1 Present Irrigation and Plans for Expansion

The majority of farms using irrigation grow horticultural products whereas a few small-scale farms grow field and fodder crops. Estimates show that a total of 1,800 ha is cultivated under irrigation to produce vegetables and fruits (Regional Project inventories 2004 quoted in SMEC (2006). Table 2 provides a summary of the irrigated areas in 2004 by region. The Central District has the highest irrigation. These are farms mostly commercial farms located along the Limpopo in the Tuli Block. Small-scale irrigation projects have been developed in other parts of the country, including along the Tati River in the vicinity of Francistown and in Gaborone and the Southern Regions.

Table 2. Total area developed for irrigation as of December 2004.

Region	Area (ha)
Western	25.36
Southern	240.85
Gaborone	288.36
Central	593.90
Francistown	273.53
Northwest	339.00
TOTAL	1760.97

(Source: Regional project inventories 2004 quoted SMEC 2006)

3.2 Water Demand

The extent of irrigation development in Botswana is constrained by the seasonal availability of water. In the absence of storage and relocation facilities, the maximum area that can be cultivated is the area that can be adequately supplied with water during the period of highest demand. Reservoirs can provide the necessary storage but it is unlikely to be cost effective to construct on-farm storage areas on the majority of the scattered farms in Botswana. For boreholes, treated wastewater, river and sand river withdrawals, the highest daily yield will constrain the irrigable area. Monthly water requirements for various NAMPAADD scenarios are given in Figure 2. Generally the scenarios give similar water demand.

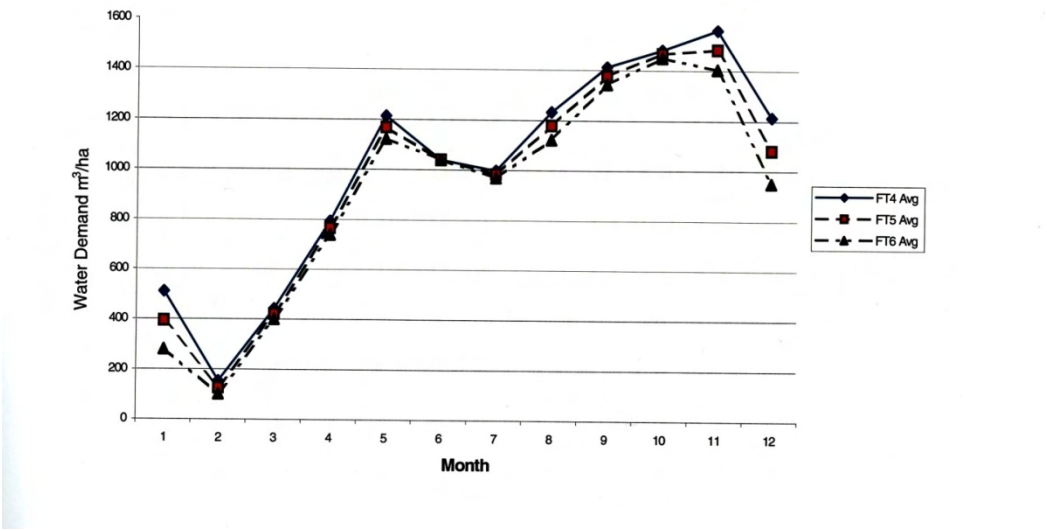

Figure 1. Average monthly water requirements for NAMPAADD Scenarios. FT4-Irrigation developing, FT5-irrigation established and FT6-irrigation advanced.

The total planned irrigated area under horticultural and field crops in NAMPAADD under the economic and social scenario is 5,200 and 5,400 ha, respectively. Of this 1,600 ha in the economic scenario and 1,900 ha in the social scenario is planned for irrigation with mainly groundwater and complimented by some river extractions. The remaining area will be irrigated

by treated wastewater. Table 3 presents the summary of potential production and planned utilization for irrigation for the two NAMPAADD scenarios

Table 3. The potential production and planned irrigation for NAMPAADD scenarios in Ml/year. Source: NAMPADD quoted in SMEC 2006.

	Existing boreholes	Existing dams	Existing streamflow	Potential groundwater	Potential wastewater	Total
Potential production	19622	1694	5102	22840	47500	96758
Planned utilization by 2010 (socially oriented)	8210	2482	3496	1453	35047	50688
Planned utilization by 2010 (Econ. Oriented)	6134	2058	3445	1042	35047	47726

3.3 Sources of Water for Irrigation

Groundwater (including sand river water extractions), river withdrawals, wastewater and small dams comprise the main source of water for irrigation. Monitoring of these sources is not conducted systematically and therefore there is lack of reliable data on quantity and quality of water used.

3.3.1 Groundwater

Groundwater constitutes the main source of water for irrigation. The registry at DWA records a total of over 11,000 permits issued for groundwater abstraction, which corresponds to an estimated 11,500 Ml/year. The actual quantity abstracted may be higher than this figure as there are no controls of policing of abstractions.

3.3.2 Surface water

Surface water supplies for irrigation are limited to abstraction from rivers and streams when they have flow, small and medium livestock dams and recycled wastewater. Availability of river water flows is limited as Botswana has only two perennial rivers, the Okavango and the Chobe. Both rivers are subject to international protocols that have not been finalized. Other rivers are ephemeral, with the majority having no flows at all.

Although the permits to pump water specifies the maximum amount of water that can be abstracted, it is not adhered to due to lack of monitoring and therefore data on surface water usage is scarce (SMEC 2006). NAMPAADD projects that by 2010, the potential availability of water for irrigation in rivers will be 7,118Ml/year. The Water Development Sector (WDS) of the Ministry of Agriculture (MoA) builds operates and maintains a large number of small and medium livestock dams (currently approximately 800) throughout the country. The primary function of these dams is to provide storage for livestock watering but surplus water may be available for irrigation. The WSD initially identifies 15 or so dams with some potential for irrigation but presently there are only seven dams with some potential for irrigation (Table 3).

Table 4. Small dams currently used for irrigation (Source: Data from MoA quoted by SMEC 2006).

Dam	Location	Approximate area that can be irrigated (ha)
Mmamokhasi	Kanye	20
Kubung	Kubung	8
Somanka	Malotswane	5
Dikabeya	Palapye	60
Mmakgodumo	Kanye	8
Semarule	Molopolole	18
TOTAL		119

3.3.3 Reclaimed Wastewater

Reclaimed wastewater offers an excellent source of water for irrigation in Botswana. The Botswana National Master Plan for Waste Water and Sanitation (NMPWWS) (2003) states that only 10 % of the return flow from wastewater treatment plants (WWTP) are reused, the rest being lost to seepage and evaporation. The NMPWWS (2003) estimated that 12,000 Ml/year of treated waste water is available in Botswana. Of these 80% is from the five major urban centres of Gaborone, Francistown, Selibe-Phikwe, Lobatse and Orapa.

4. CURRENT IRRIGATION IN THE OKAVANGO DELTA AREA

There is little irrigation being undertaken around the Okavango Delta area (Figure 2). The following data was obtained from the Regional Agriculture Office and Department of Agricultural Research in Maun. Out of 188.15 ha allocated for irrigation, only 31.35 ha (17%) is being utilised. Most of the irrigation is for vegetables. All the irrigation farms are owned by citizens except for the 81.25 ha commercial farm which is being run by a non citizen. It must also be noted that only 1.25 of this area is currently under utilization.

4.1 Ngamiland East District (Maun)

The allocated land for irrigation is 48.8 ha. Only 15.2 ha of these (31%) are under irrigation (Table 4). The mean and mode for the irrigated land is 0.46 ha and 0 ha, indicating that many of the allocated plots are not being irrigated. All the irrigation is for vegetables except for two farms. The percent area under each vegetable grown is given in Figure 2. Rape and tomatoes are the most grown, covering 28% and 26% of the area under vegetables, respectively. Squash (12%), cucumber (9%) and spinach (6%) are next in importance in terms of the percent area under their cultivation. The rest (Figure 2) are grown on a much smaller area.

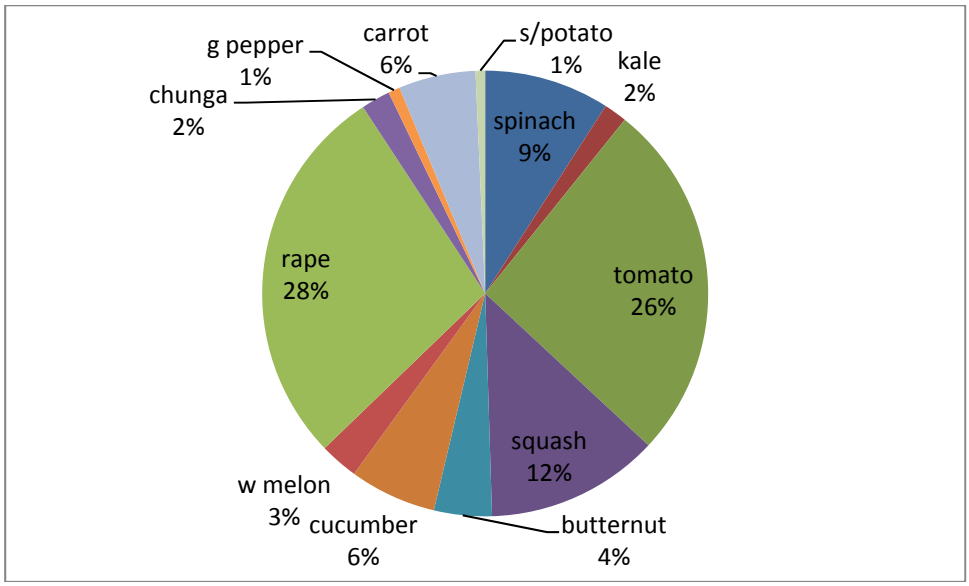

Figure 2. Proportion of area under each vegetable in Ngamiland East.

4.2 Ngamiland West (Gumare)

Only 20 ha are allocated for irrigation in Ngamiland West, and of these, 8.5 Ha (43%) are being utilised (Table 5). The mean and maximum area utilised per farmer are 0.6 ha and 1.5 ha, respectively. Six out of the 15 farms in this area use open wells and the rest use river water. The breakdown of area under different vegetables was not available.

4.2 Okavango District

A total of 119.35 Ha have been allocated for irrigation in the Okavango District. Out of these one is a commercial farm that was allocated 81.25 ha. Only 6% of the allocated land (7.65 ha) is being utilised (Table 6). Except for one farm that uses a borehole all the others use river water. Figure 3. Shows the proportion of the area under each vegetable. Rape (34%), cabbage (16%), spinach (11%) and tomato (11%) are the vegetables grown the most. Unlike Ngamiland East, cabbages are more significant in the Okavango District.

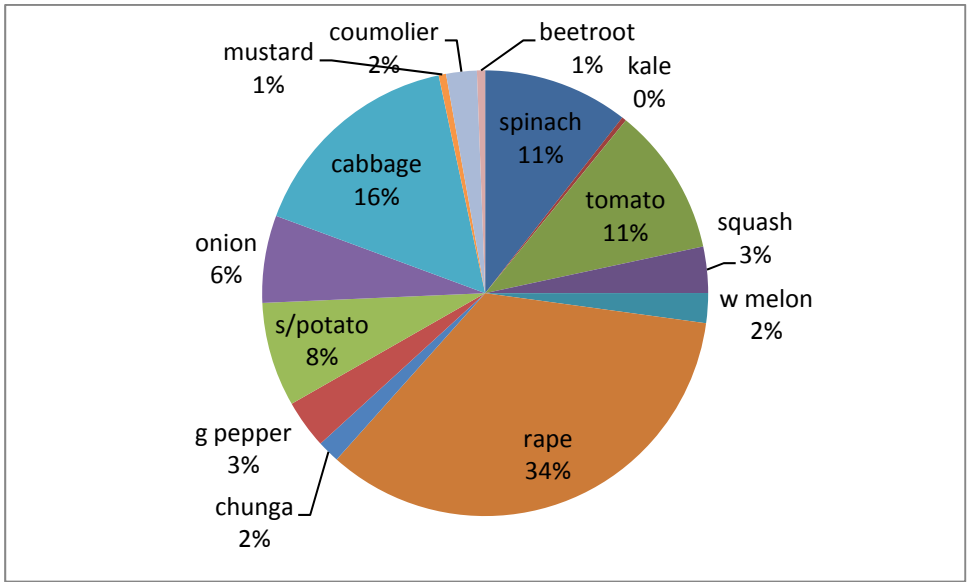

Figure 3. Proportion of area under each vegetable in the Okavango district.

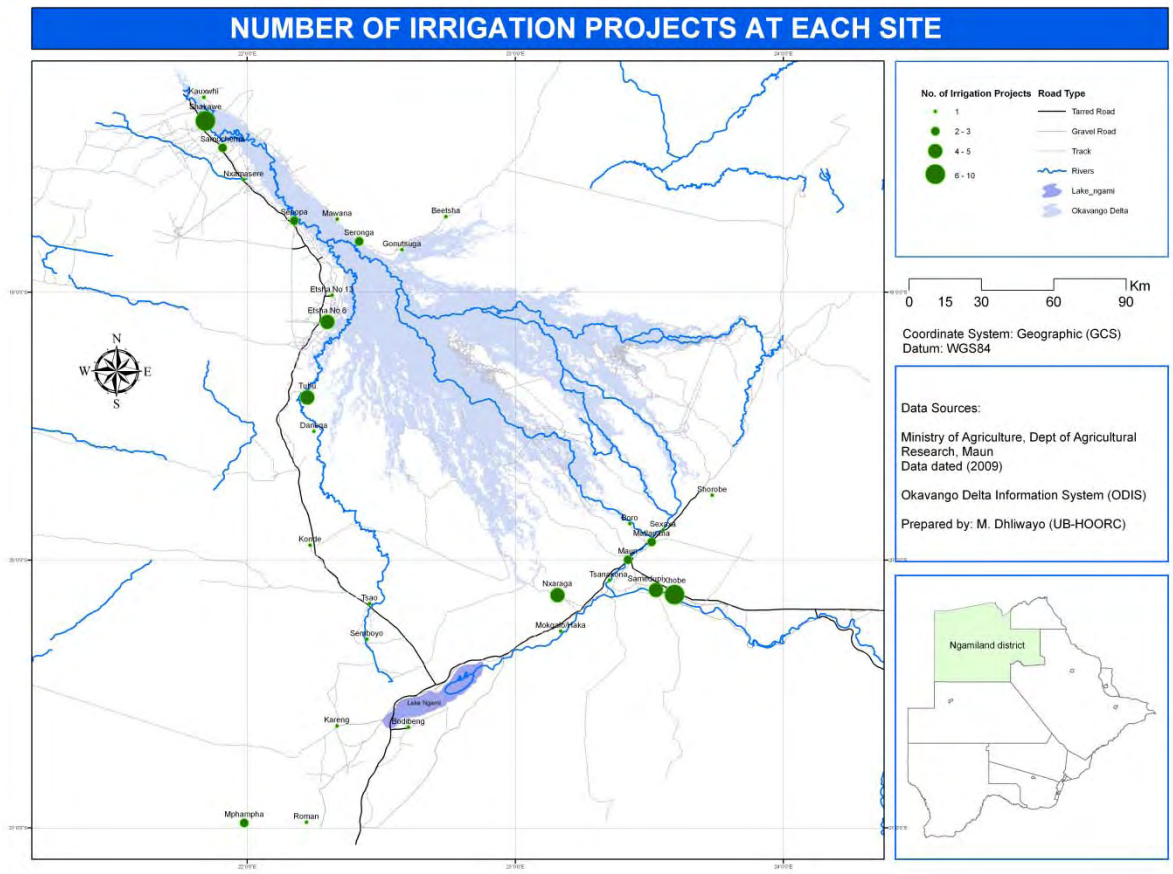

Figure 4. Location of irrigation projects in the Okavango Delta region.

Table 5. Irrigation projects in Ngamiland East District (Maun). Source: Ministry of Agriculture, Crop Production section, Maun.

	LOCATION	SOURCE OF OF WATER	PROJECT SIZE (Ha)	IRRIGATION SYSTEM	IRRIGATED AREA	CROPS GROWN
1	Bodibeng	River	1	Stand pipe	0	Vegetables
2	Boro	Borehole	1	Microjets	0	
3	Kareng	Borehole	1	Stand pipe	0	
4	Makgalong	Open well, borehole	1	Sprinkler	1	Vegetables
5	Matlapana	River well point	1.5	Sprinkler	0	Vegetables
6	Matlapana	River	1			Vegetables
7	Matlapana	River	2		0.03	Vegetables
8	Maun	Borehole	1	Sprinkler	0	Vegetables
9	Maun	River	2	Sprinkler	1	Vegetables
10	Maun	River	3.8	Tunnels, drip, sprinkler	0.45	Tomatoes
11	Mawana	Borehole	1	Sprinkler	0	
12	Mphampha	Borehole	1.5	Microjets	1.5	Citrus
13	Mphampha	Borehole	1		1	Citrus
14	Nxaraga	Borehole	1	Stand pipe	0	
15	Nxaraga	River	1	Drag hose	1	Vegetables
16	Nxaraga	Borehole	1	Sprinkler, microjet	1	Veg. Orhard
17	Nxaraga	Borehole	1	Sprinkler, microjet	1	Vegetables
18	Roman	Borehole	1	Hose		
19	Samedupi	River	1	Sprinkler	1	Vegetables
20	Samedupi	River	1.5		0.32	Vegetables
21	Samedupi	River	2	Microjets	2	Vegetables
22	Samedupi	River	0.5		0.03	Vegetables
23	Samedupi	River	1.5		0.07	Vegetables
24	Semboyo	Borehole	1	Sprinkler	0	Vegetables
25	Sexaxa	River	1	Sprinkler	0.5	Vegetables
26	Shorobe	Borehole	1	Stand pipe	1	Vegetables
27	Tsanekona	River	1	Sprinkler	0.5	Vegetables
28	Tsao	Borehole	1	Sprinkler	0	Vegetables
29	Xhobe	River	7	Sprinkler	1	Vegetables
30	Xhobe	River	1	Sprinkler	0.05	Vegetables
31	Xhobe	River	1	Microjets	0	Vegetables
32	Xhobe	River	1.5	Sprinkler	0.04	Vegetables
33	Xhobe	River	1	Sprinkler	0.1	Vegetables
34	Xhobe	River	1		0.56	Vegetables
35	Xhobe	River	1		0.05	Vegetables
TOTAL			48.8		15.2	

Table 6. Irrigation projects in Ngamiland West District (Gumare). Source: Ministry of Agriculture, Crop Production section, Maun.

	LOCATION	SOURCE OF OF WATER	PROJECT SIZE (Ha)	IRRIGATION SYSTEM	IRRIGATED AREA	CROPS GROWN
1	Tubu	Open well	1	Stand pipe	1	Vegetables
2	Tubu	River	1	Hose	0.75	Vegetables
3	Sepopa	River	1	Stand pipe	0.5	Vegetables
4	Tubu	Open well	1	Stand pipe	0.5	Vegetables
5	Danega	Open well	1	Stand pipe	0	Vegetables
6	Sepopa	River	1.5	Sprinkler	1.5	Vegetables
7	Etsha 6	River	5	Sprinkler	1	Vegetables
8	Tubu	Open well	1	Bucket	0.25	Vegetables
9	Tubu	Open well	1	Bucket	0.25	Vegetables
10	Etsha 6	River	1	Hose	0.25	Vegetables
11	Sepopa	River	1		0	Vegetables
12	Etsha 13	River	1	Bucket	0.5	Vegetables
13	Etsha 6	River	1	Hose	0.25	Vegetables
14	Etsha 6	River	1	Bucket	0.25	Vegetables
15	Konde	Open well	1.5	Hose	1.5	Vegetables
	TOTAL		20		8.5	

Table 7. Irrigation projects in Okavango District. Source: Ministry of Agriculture, Crop Production section, Maun.

	LOCATION	SOURCE OF OF WATER	PROJECT SIZE (Ha)	IRRIGATION SYSTEM	IRRIGATED AREA	CROPS GROWN
1	Samochima	River	1	Sprinkler	0.5	Vegetables
2	Shakawe	River	3.5	Sprinkler	2	Vegetables
3	Shakawe	River	0.6	Basin	0.5	Vegetables
4	Seronga	River	1	Sprinkler	1	Vegetables
5	Nxamasere	River	0.75	Sprinkler	0.25	Vegetables
6	Samochima	River	4	Microjets	0	Citrus
7	Shakawe	River	1.5	Basin	0.5	Vegetables
8	Shakawe	River	81.25	Centre pivot	1.25	Vegetables
9	Shakawe	River	3	Sprinkler		Vegetables
10	Shakawe	River	2.5	Sprinkler	0.45	Vegetables
11	Beetsha	Borehole	1	Hose	0	Vegetables
12	Mohembo	River	3	Hose	0	Vegetables
13	Kautwe	Stand pipe	0.2	Hose	0.2	Vegetables
14	Shakawe	River	2	Hose	0	Vegetables
15	Shakawe	River	1	Sprinkler	1	Vegetables
16	Shakawe	River	0.75			Veg. Orhard
17	Mohembo	River	4			Vegetables
18	Seronga	River	3.4			Vegetables
19	Gunotsoga	River	3.5			Vegetables
20	Shakawe	River	1.4			Vegetables
	TOTAL		119.35		7.65	

4.4 Water Usage

4.4.1 Current and short-term future water usage

Based on the allocated and actual area under irrigation, the current and future short-term water usage was estimated using the pan evaporation values of Maun and Shakawe/Gumare (Table 7). Irrigation is mostly carried out during the dry months of April to October, hence the current annual water usage in Ngamiland East is about 264,000 m^3. If all the land currently allocated were used, the future short-term annual water usage would be 837,000 m^3.

A similar estimate for Ngamilang West and Okavango combined shows that the current annual water used in irrigation is 256,000 m^3 and the short term future requirements will be 2,206,000 m^3 (Table 8). The current and short term use of the water is therefore small.

Table 8. Current and future water for irrigation in Ngamiland East. The column marked 15.2 Ha corresponds to current water usage and that marked 48.3 Ha corresponds to future short term estimated water usage in irrigation.

Month	Evaporation	m^3/ha/month	Total (m^3) for 15.2 Ha	Total (m^3) for 48.3 Ha
April	199	2274	35,000	110,000
May	189	2160	33,000	104,000
June	158	1806	27,000	87,000
July	183	2091	32,000	101,000
August	218	2491	38,000	120,000
September	263	3006	46,000	145,000
October	307	3509	53,000	169,000
Total (m^3/yr)			264,000	837,000

Table 9. Current and future water for irrigation in Ngamiland West and Okavango. The column marked 16.15 Ha corresponds to current water usage and that marked 139.39 Ha corresponds to future short term estimated water usage in irrigation.

Month	Evaporation	m^3/ha/mth	Total 16.15	Total 139.35
April	192	2194	35,000	306,000
May	178	2034	33,000	283,000
June	146	1669	27,000	233,000
July	161	1840	30,000	256,000
August	190	2171	35,000	302,000
September	241	2754	44,000	384,000
October	277	3166	51,000	441,000
Total (m^3/yr)			256,000	2,206,000

4.4.2 Long Term Water Usage

So far, Botswana has not planned any major irrigation activities along the Delta, waiting for international protocols to be finalised. However, based on the land suitability map (Figure 3), all the area around the Okavango Delta can result in moderate to moderately high yields in rain-fed agriculture. The yields would improve if irrigation were used. Most of the unoccupied area in Ngamiland has, therefore, potential for irrigated agriculture. When Ngamiland land suitability is considered, 48% of the area (53,000 km^2) falls between moderately high and moderate, showing that a huge area has potential for irrigation if water resources were available. An irrigation zonation would indicate which of these areas are actually suitable for irrigation.

5. Use of Fertilisers and Pesticides

Based on the information from the Department of Crop Production, there is very little use of fertilizers and pesticides in the area around the Okavango Delta. In some cases, livestock manure is used, but, like fertilizers, the amounts used are not documented. Table 8 lists the pesticides and fungicides that have been recommended by the Department of Agricultural research for application to protect vegetables. Since the amounts that are applied are little, no further discussion of these will be made except to recommend that manure, fertilizer and pesticide usage in the Okavango Delta region be monitored.

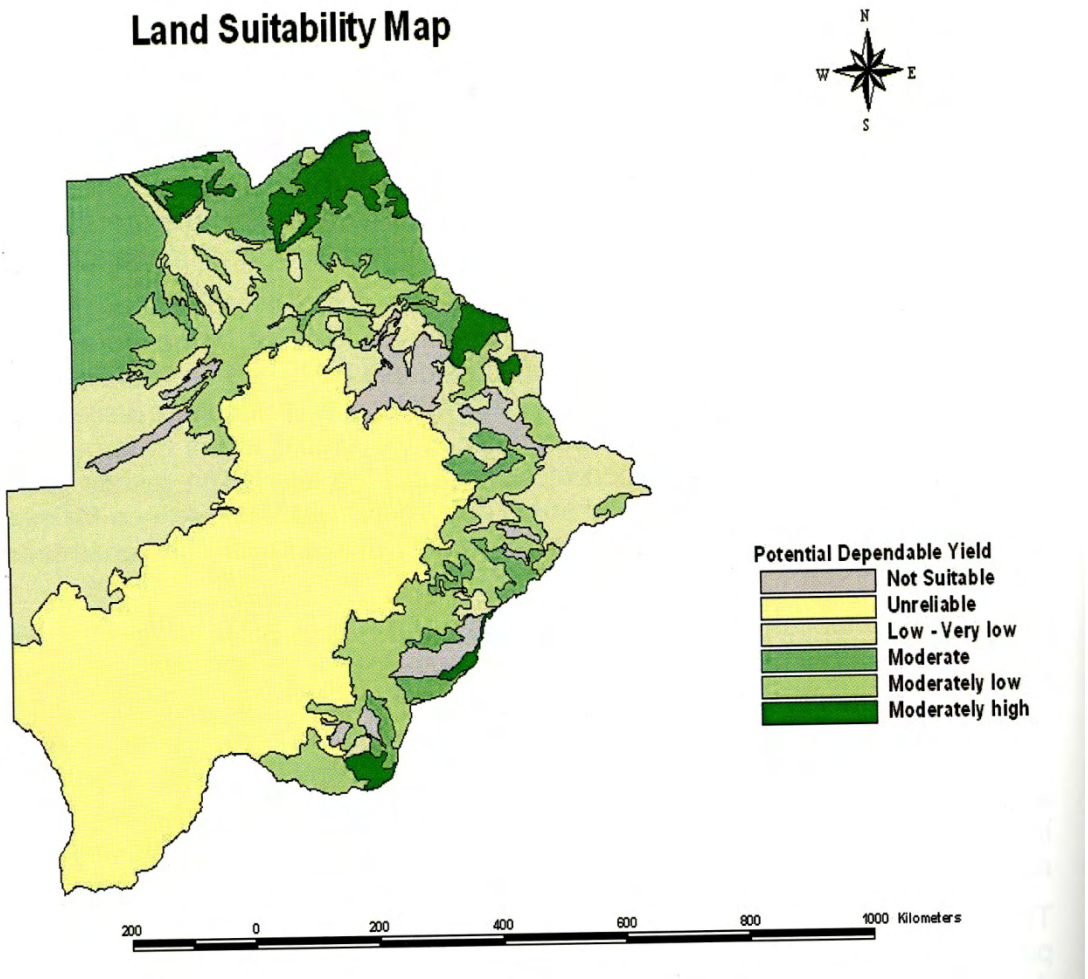

Figure 5. Land suitability map of Botswana. The area around the Okavango Delta has soils that would provide moderate to moderately high crop yields (From SMEC 2006).

Table 10. Pesticides and fungicides recommended for vegetables by the Department of Agricultural Research.

Pesticide/fungicide	Pesticide/fungicide	Pesticide/fungicide
Mancozeb	Permethrin	cypermethrin,
Copper oxychloride	Apron C	Deltamethrin
Funginex	Ridomil	Gamma-BHC
Ridomil	Bravo 50	Nemacur
Apron C	Dithane M45	thiram
Dichlorvos		
Carbofuron		

6. ISSUES OF TRANSBOUNDARY IMPORTANCE

Since Botswana is downstream of the Okavango River Basin, most of the issues of trans-boundary significance with regard to irrigation will be those that upstream users would impact on the downstream users. These include:

6.1 Water abstraction

Extensive abstraction of water upstream would result in low flows into Botswana. The availability of water for irrigation would therefore be affected, especially when considering that irrigation would be competing with other uses of water e.g. domestic, environment for the Okavango delta etc. This is also true for water abstraction in the northern part of the Delta affecting the downstream areas. The environmental flow requirement of 390m^3/s (vol 6) needs to be evaluated to check whether it could be adopted for determining abstractions upstream.

6.2 Pollution

Whereas water for irrigation may not necessarily have to have high quality, certain water quality parameters may reduce the usefulness of the water for irrigation if present in high concentrations. Examples of such pollutants include:

6.2.1 Pollution resulting in high salinity

A salinity problem exists if salts accumulate in the crop zone to a concentration that causes a loss in yield. These salts may originate from salts in the applied water. Currently the main-channel water of the Okavango is of low salt content; but high salt levels are observed in some pools. Any process that increases the salt content of the water has the potential to contribute to the salinity problem. Such processes include discharge of wastewater from a reverse osmosis plant, or discharge of sewage effluent into the water.

6.2.2 Pollution resulting in low water infiltration rates

An infiltration problem related to water quality occurs when the normal infiltration rate for the applied water or rainfall is appreciably reduced and water remains on the soil surface too long or infiltrates too slowly to supply the crop with sufficient water to maintain acceptable yields. Although the infiltration rate of water into soil varies widely and can be greatly influenced by the quality of the irrigation water, soil factors such as structure, degree of compaction, organic matter content and chemical make-up can also greatly influence the intake rate. The two most common water quality factors which influence the normal infiltration rate are the salinity of the water and its sodium content relative to the calcium and magnesium content. A high salinity water will increase infiltration. A low salinity water or a water with a high sodium to calcium ratio will decrease infiltration.

6.2.3 Pollution resulting in toxicity

Toxicity problems occur if certain constituents in the water are taken up by the plant and accumulate to concentrations high enough to cause crop damage. Ions of primary concern are chloride, sodium and boron. Introduction of high concentrations of these into the water upstream of Botswana will negatively impact on its irrigation.

6.2.3 Other factors

Any factor that would impact on water quantity and quality will affect irrigation. This could range from climate change to deforestation.

7. CONCLUSION

Agricultural activities contribute less than 2% to the Botswana's GDP and 80% of this 2% is from the beef industry. Only 1,800 ha are currently under irrigation in Botswana, with plans to increase this to 5,400 ha in the short term and up to 40,000 in the long term. The long term irrigation is planned for the Panandamatenga-Chobe area with water drawn from the Chobe/Zambezi. Implementation of this long term plan is subject to international agreements which are currently not in place. Currently, only 31.38 ha out of an allocation of 118.15 ha near the Okavango Delta are under irrigation. There are no plans for extensive irrigation using waters from the Okavango Delta until international agreements on the use of the water from the Okavango are reached.

8. RECOMMENDATIONS

The following recommendations can be made:

- For planning purposes, an environmental flow requirement (EFR) with an accompanying definition of the acceptable ecological level of the Okavango Delta beyond which Botswana is not prepared to go should be undertaken as a matter of urgency. The EFR is currently being undertaken but there is need to define the acceptable ecological integrity that balances environmental and developmental needs. This would then provide a measure of how much water can be drawn from the Okavango for irrigation
- There is need to have irrigation plans for the Okavango Delta as these can then be used to test adequacy of water.
- There is need to monitor the use of fertilisers, manure and pesticides in the Okavango Delta area even though application rates are low

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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)*
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