

**Environmental- Economic Accounting for Water in  
Botswana:**

**Detailed accounts for 2010-11 and 2011-12 and General  
Trends 1993-2010**

**October 2013**



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## bbreviations

BA	Business Area
BEAC	Botswana Economic Advisory Council
BWP	Botswana Pula
CAR	Centre for Applied Research
DC	District Council
DWA	Department of Water Affairs
GDP	Gross Domestic Product
GoB	Government of Botswana
IWRM	Integrated Water Resources Management
MC	Management Centre
MCM	Million Cubic Metre
MDG	Millennium Development Goals
MMEWR	Ministry of Mineral, Energy and Water Resources
MoA	Ministry of Agriculture
NDP	National Development Plan
NSC	North South Carrier
NSO	National Strategy Office
NWMP(R)	National Water Master Plan Review
SB	Statistics Botswana
SEEA	System of Environmental -Economic Accounting
UN(SD)	United Nations (Statistics Department)
VA	Value Added
WA	Water Accounts
WAVES	Wealth Accounting and Valuation of Ecosystem Services (WAVES)
WB	World Bank
WUC	Water Utilities Corporation
WSSD	World Summit on Sustainable Development

## Executive summary

In March 2012 the Botswana Government entered into a partnership with the World Bank to develop accounts for natural resources and to value ecosystem services under the Wealth Accounting and Valuation of Ecosystem Services (WAVES) programme; ([www.wavespartnership.org](http://www.wavespartnership.org)). At its May 2012 meeting, the Botswana Economic Advisory Council BEAC prioritised the up-dating and elaboration of water accounts for the first year of the Botswana WAVES programme. Government also committed itself to natural capital accounting in May 2012 in the Gaborone Declaration on Sustainability in Africa. Therefore the WAVES initiative can be viewed as an implementation activity of the national road map towards sustainability.

The Botswana water accounts for 2010-12 are based on the United Nation's System of Environmental –Economic Accounting for Water (SEEA-water). The framework considers water-economic interactions, which is important for addressing cross sectoral and broader issues related to water resources management. SEEA- Water directly links water data to the system of National Accounts. The SEEA WA system captures information on the water stocks, flows from the environment and within the economy in physical and monetary terms and water quality issues. Current water accounting efforts in Botswana focus on physical water resources stock accounts (reservoirs) and physical flow accounts (use and supply). Monetary aspects have focused on review of revenues and costs of water supply as well as value added produced by m<sup>3</sup>.

### Stock accounts

The stock accounts in Botswana are of three types, namely surface water stocks (reservoirs and rivers) groundwater stocks, and waste water stocks. The stock accounts exercise concentrated on stock accounts for five water supply reservoirs, namely Nnywane, Gaborone, Bokaa, Letsibogo and Shashe dam. Groundwater and wastewater accounts were postponed to future work as the current available data is not sufficient for their development.

The accounts gave a general picture of the annual availability of water in the five dams. The accounts also indicated that dams in the north are generally more reliable as they have receive sufficient inflow on an annual basis to replace the losses to abstraction and evaporation. This is an important finding as it informs how the dams can be operated to give a more reliable yield from the resources.

### Flow accounts

*The use accounts* show that annual water abstraction is around 195 Mm<sup>3</sup>. Abstraction declined slightly in 2011-12 to 194.6 Mm<sup>3</sup>. Abstraction for own use and for distribution is almost equal for self-providers (51.8%) and service providers (48.2%). With regards to *water supply accounts*, service-providers (WUC and DWA) distribute water to various economic sectors and households in settlements (cities, towns and villages). The bulk of this water is supplied to households (56% in 2011/12). Water abstraction is just over 170 Mm<sup>3</sup>. The consumption is highest for the agricultural sector (44% in 2011/12) followed by households and mines. Given the large share of self-providers, their water abstraction and consumption require greater attention for water resources management. There is need to monitor return flows (e.g. inflows and outflows of waste water treatment works). In terms of sector water consumption (figure 6), agriculture consumes a large amount of water but contributes little to GDP and formal employment. The mining sector makes a large contribution to GDP and consumes a significant amount of water. Its contribution to direct formal employment is limited due to the capital intensive nature of mining. The service sectors make a large contribution to GDP and employment and use a modest amount of water. Two conclusions emerge:

- a. The opportunity costs of agricultural water consumption need to be carefully considered in development planning. These are generally low for the livestock sector but could be high for irrigation; and
- b. Water consumption and requirements should be considered as part of the economic diversification drive and trade policies; from an IWRM perspective, diversification should favour the service sectors and trade policies must recognise Botswana's comparative disadvantage in water resources.

#### Irrigation sector

The exploration of water use in the irrigation sector showed that water abstraction, use and consumption are not measured and cannot be reliably estimated at present due to lack of data. More work is needed on water abstraction for irrigation, especially if new irrigation projects are developed. The ~~previously used~~ estimate of 18 Mm<sup>3</sup> is probably an over estimate as it is based on the serviced irrigable land, and only around a third to just over half of the land was used in the period 2011-13. In terms of water provision, over two thirds of the farmers use their own water supply; over a quarter use village water supplies, and a few (3.2%) use government irrigation schemes. Irrigation heavily relies on groundwater (60.2%); 34% of the farmers use water from rivers, while 5.8% uses dams.

Data collection and analysis need to be improved significantly in order to assess the sector's performance and productivity. Priority should also be given to fully utilise serviced irrigation land and increase its productivity.

#### Water management areas

The study currently used the WUC management centres as the water management areas. Water consumption is highest in the Gaborone MC (26.2 Mm<sup>3</sup>) followed by Letlhakane (19.3 Mm<sup>3</sup> with the Orapa/ Letlhakane mines), Francistown (16 Mm<sup>3</sup>) and Kanye (15 Mm<sup>3</sup> with the Jwaneng mine), Selebi-Phikwe (14.3 Mm<sup>3</sup> with the BCL mine) and Lobatse (12.4 Mm<sup>3</sup>).

The bulk of the water transfers between MCs originate from the NSC (Gaborone MC receives more than 50% of this water) and a limited amount through imports from Molatedi Dam (for Gaborone and Mochudi MCs).

#### Trend analysis

Botswana's water accounting efforts date back to the 1990s. The combination of earlier work with the current water accounting offers opportunities to identify long term water trends. The trend analysis is meant to link the earlier water accounts (1994 - 2003) and the new SEEA Water accounts (2010/11 and 2011/2). The main findings of the trend analysis are:

- a. Water use has increased from under 50 Mm<sup>3</sup> in 1993 to just under 200 Mm<sup>3</sup> per annum in 2010/11 (Figure 10). The increase has lagged behind the population and economic growth due to water efficiency increases;
- b. The value added per m<sup>3</sup> has increased in time from just over BWP0.20/ m<sup>3</sup> over BWP 0.30/m<sup>3</sup>; Water is most productively used (in terms of value added and formal employment) in the transport, trade, tourism and other service sectors (Figure 12). From a water resource perspective, the economic diversification drive needs to target service industries, transport and tourism;
- c. WUC has been successful in recovering operating costs over the last decade largely due to low supply costs compared to revenues. Since 2009 however, operating costs have rapidly grown and exceeded revenues in 2011/2. This situation is not sustainable, and cost control (e.g. greater O & M efficiency) and revenue boosting measures (e.g. tariff adjustment) need to be considered once more recent financial data indicate the same shortfall.

In terms of employment creation, an average of 2.7 jobs are associated with 1000 m<sup>3</sup> of water use (2007). Job generation in the agricultural sector is low as compared to economic sectors, other than mining (even if one includes informal employment).

### Institutionalisation of water accounting

#### Indicators

The water accounts generate a number of indicators for water resources management. For water resources availability, these indicate that:

- ✓ Safe yields of reservoirs are well below per capita water use;
- ✓ Expansion of reservoir safe yields is urgent and can be achieved by completion of new dams and interconnection of reservoirs and well fields;
- ✓ Heavy reliance on external renewable surface water resources, showing the need for active participation in shared water management.

For water abstraction and use, the indicators show that:

- ✓ Groundwater is the largest source of water country wide; mines and livestock and rural settlements depend on groundwater;
- ✓ Abstraction for own use exceeds the abstraction for distribution by WUC;
- ✓ Agriculture is the largest water using sector followed at a considerable distance by domestic use and mining;
- ✓ Per capita total water use is 267 L/person/day, compared with safe yields from reservoirs of 96 L/person/day

For water use efficiency, the indicators show that:

- ✓ Per 1000 m<sup>3</sup>, BWP0.37 value added is created and 2.3 jobs in the formal sector and another 1.2 jobs in the informal and traditional agricultural sector;
- ✓ Value added efficiency has increased in time.

For technical and financial performance of water service providers, the indicators show that:

- ✓ In 2010-12, water losses are just over 25%;
- ✓ In 2010/11, WUC did not recover O&M costs from water sales.

#### Policy implications

It is encouraging to note that water use increases are partly delinked from population and economic growth. Had this not been the case, water scarcity would have been more pressing and water infrastructure would have had to increase faster.

Water abstraction and use figures for small settlements are now becoming available through WUC. These figures are important to better account for water in rural areas, and will facilitate better planning and management of rural water infrastructure.

WUC revenue and expenditure balance has been deteriorating during the water sector reform transition period. The causes of the growing imbalance between costs and revenues need to be analysed and addressed. The possible solutions include raising tariffs (e.g. adding a wastewater treatment fee to the water tariff), costs reductions and/or increased subsidies. Efficient service delivery needs to contribute to cost control, and reduce the level of future tariff increases.



Records on the amounts of waste water (inflows and outflows) do not exist. This data gap hampers the re-use and recycling of wastewater as targeted by the 2003 NMPWWS, which has the target of 96% re use of the outflows. It is essential that WUC starts measuring wastewater inflows and outflows as soon as possible, and that the re-use of wastewater is metered and recorded. New wastewater treatment plants should be constructed with a re-use component included.

The review of the irrigation sector showed that data on water abstraction and use for irrigation are fragmented and need validation before new figures can be included in the water accounts. Better insight is needed in the current water abstraction and use of the sector as well as its performance in terms of food production and value added/m<sup>3</sup>.

Self-providers account for half of the water consumption and yet they are often overlooked in discussions about water resource management. The water supply and use of self-providers deserves much more attention in future water resource management.

The water sector reform programme has important potential advantages for water accounts and IWRM. These include: accounting of water consumption in all settlements, accounting for wastewater inflows and outflows, greater simplicity and transparency of supply (i.e. only one water service provider) a dedicated water resources management institution (DWA).

This study has shown, however, that the reforms pose short term problems such as data gaps, incompatibilities and discrepancies and renewed focus on supplying water ('keep it flowing'). Moreover, the risk exists that water supply is solely prioritised at the expense of IWRM and water demand management. This would take the country a step back from the recommendations of the 2006 Review of the BNWMP and the IWRM-WE Plan, and have significant long term costs.

Water accounting results need to be fully integrated in the NDP 11 preparation process. This means that:

- a. Future water allocation should be based on social and economic merits and should compare the merits of alternative sector water uses. During the plan preparation, government needs to discuss the best use of its Chobe-Zambezi allocation.
- b. NDP 11 should contain a detailed wastewater re-use strategy in order to achieve the NMPWWS re-use target. Re-use efforts need to be accelerated by the Ministry of Agriculture and WUC;
- c. The costs of water management should be fully assessed and the financial burden should be fairly and evenly distributed between government, households and the private sector; the current level of subsidies is probably unsustainable and rising costs will lead to higher water tariffs across the board.
- d. Water scarcity should become one of the considerations in the economic diversification drive. It should:
  - Discourage economic diversification towards water intensive sectors; and
  - Encourage the development of a water conservation industry for the local and export markets.

### Recommendations

For water resource management:

- ✓ Include water resources availability in economic diversification and trade policies;
- ✓ Prioritise water demand management for MC shortage areas;

- ✓ Further increase water efficiency gains;
- ✓ Regular data collection & analysis;
- ✓ Re-use of treated wastewater and saline water for suitable sectors;
- ✓ Increase safe yields from water infrastructure system;
- ✓ Improve monitoring of self providers;
- ✓ Implement user-pays-principle and polluter-pays-principles;
- ✓ Expand water accounts with a. stock accounts for major aquifers/ well fields, b. flow accounts for treated wastewater and c. with monetary accounts; and
- ✓ Regular policy analysis of water accounting findings.

For water service providers:

- WUC should include the economic sector classification in its client details data base;
- Adopt an agreed regional classification for the water accounts (in consultation with DWA, WUC, Ministry of Agriculture MoA and Statistics Botswana SB);
- DWA needs to establish a Water Accounting Unit and other stakeholders (WUC, SB, MoA and Department of Mines) need to have support staff to regularly up-date water accounts. Partnerships between the stakeholders should be formed to support the water accounting process.
- The policy implications of the results should be regularly assessed and discussed with stakeholders to ensure their future cooperation and the actual implementation of the recommendations.
- Significant efforts should be directed towards reducing losses in areas with high loss rates.

For irrigation:

- Improve data collection; the data could be a section of the annual Agricultural Statistics;
- The use of serviced irrigation land should be increased;
- There is need for close and effective collaboration between the Irrigation and Horticulture Divisions of the Ministry of Agriculture;
- Government irrigation schemes and NAMPAAAD farms should be privatised to make them more productive.
- Use of treated effluent should be encouraged, accompanied by water quality monitoring;
- For bigger schemes and irrigation farms, metering should be introduced to allow more accurate water use estimates.

For self providers:

- Self providers should annually report their water abstraction, consumption and losses to DWA and the WRB;
- DWA should monitor and oversee water abstraction and consumption of self providers.

## Chapter 1 Introduction

During the 1970's and 1980's Botswana made enormous progress with regard to water supply. With the rural water supply programme ground water investigation programs were carried out countrywide to identify and develop sources for village water supply reticulation schemes. This was further enhanced in the 1990's by the construction of the North South Carrier (NSC) Scheme, which transferred water from the north to the south of the country. However these later developments have come at a high cost to the country.

In the 2006 Review of the National Water Master Plan (NWMP), it was observed that future supply of water would be increasingly challenging and costly, requiring a switch from supply orientation to water demand management. In terms of water supplies, the main option after the completion of the dams currently under construction is to access water from the Chobe-Zambezi river basin. Government has since acquired annual abstraction rights of 495 Mm<sup>3</sup> from this river basin. The question of paramount importance to the country's long term development planning is how these water resources can be best used? How much water should each sector get? Is it for households, mining, irrigation, manufacturing and/or the service industry? How much food should be domestically produced; is there enough water to do so and what are the opportunity costs (e.g. non-development of other sectors)? As will be shown later in this report, water accounting provides data and findings to make informed decisions for development planning.

In March 2012 the Botswana Government entered into a partnership with the World Bank to develop accounts for natural resources and to value ecosystem services under the Wealth Accounting and Valuation of Ecosystem Services (WAVES) programme; ([www.wavespartnership.org](http://www.wavespartnership.org)). Botswana is one of the partner countries<sup>1</sup> in this global programme, which was endorsed at the Rio + 20 Summit in 2012. The Botswana WAVES programme is anchored within the Ministry of Finance and Development Planning; it is led by a programme coordinator and a high level Project Steering Committee (Deputy Permanent Secretaries).

At its May 2012 meeting, the Botswana Economic Advisory Council BEAC prioritised the up-dating and elaboration of water accounts for the first year of the Botswana WAVES programme. Government also committed itself to natural capital accounting in May 2012 in the Gaborone Declaration on Sustainability in Africa. Therefore the WAVES initiative can be viewed as an implementation activity of the national road map towards sustainability.

The preparation of water accounts started in September 2012 and phase 2 was completed in June 2012. Preliminary results of phase 1 were presented at the November 2012 BEAC meeting. The Water Accounting (WA) activities of WAVES-Botswana have been split into several phases:

- ✓ Phase 1 (September – November 2012): preliminary account construction and analysis;
- ✓ Phase 2 (December 2012 – June 2013): elaboration of the water accounts and development of a road map towards full institutionalisation of water accounts at DWA, support institutions (e.g. Statistics Botswana, Ministry of Agriculture and Water Utilities Corporation); and
- ✓ Phase 3: (July 2013 – 2015): full institutionalisation, up-dating and expansion of water accounts and ensuring full integration of results in National Development Plan (NDP) 11.

This report covers the activities and findings of phase 1 and 2 and indicates the roadmap for institutionalisation in phase 3 (July 2013 – 2015). It is an "interim" report as water accounting will continue and soon be institutionalised at DWA (phase 3).

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<sup>1</sup> Other developing countries include Colombia, Costa Rica, Madagascar, Philippines.

The structure of the report is as follows. The changing water resources context in Botswana is discussed in chapter 2. This shows the institutional and policy support for water accounting as well as the growing need to use and allocate water efficiently. Chapter 3 outlines the adopted approach linking the current water accounting efforts with past ones and with the internationally adopted System of Environment-Economic Accounting (SEEA). Chapter 4 deals with the stock accounts for the major water supply reservoirs. Chapter 5 shows the flow (Tables 2 and 3) accounts for two years, which will become the baseline for future water accounts (2010-11 and 2011-12). The accounts are linked with the overall water balance for the country (Figure 2). During phase 2, special attention was paid to irrigation water abstraction and use as well as examining spatial variations in water abstraction and use. The results of this on-going work are reported in chapter 5 (section 5.1 and 5.2 respectively). The chapter also briefly examines costs and revenues of water abstraction and distribution (section 5.3). Chapter 6 connects the 2010-11 and 2011-12 results with earlier WA results to assess general trends. The analysis is restricted to overall trend in water use and water productivity. Chapter 7 outlines the road map for full institutionalisation of WA within the country and government structures. DWA will be the lead agency but needs to be supported by key government departments, parastatals and the private sector. Chapter 8 contains a set of indicators related to the accounts (section 8.1) followed by policy analysis of the main results (section 8.2).

## Chapter 2 The changing context of water resources and their management

Botswana's water sector is evolving and it has now taken the direction of integrated water resources management (IWRM) in line with internationally accepted practice. Among others, this implies that water resources should be treated as economic goods. Water resources management remains one of the most critical issues for future economic development and growth of the country. Botswana, like many other countries, is facing a range of interrelated challenges, including: persistent poverty, growing water scarcity, water pollution, insufficient sanitation facilities, droughts and climate change. In light of these issues, the country is striving to ensure that water is available in both sufficient volumes and acceptable quality, and that water is used efficiently generating economic benefits and meeting basic needs. Water issues are addressed in an integrated manner where the different stakeholders are engaged and participate to ensure sound planning, development and sustainable management of the available water resources. The National Water Master Plan Review of 2006 (NWMPR) took cognizance of the need to arrange existing water legislation, policies and institutional arrangements in the sector so as to meet the needs of the growing population overall economy. Additionally, an integrated water resources management and water efficiency (IWRM-WE) plan was recently developed and is awaiting approval by government. This section summarises the activities and milestones pertinent to the growth of Botswana's water sector as well as the challenges therein.

### 2.1 Water sector reforms

Botswana continues to experience increasing water demand amidst limited water resources. The challenge has been to ensure sufficient and good quality supply to all users, increase efficiency in water allocation and use and to strengthen the policies, laws and organisational structures in the water sector. In-terms of service provision, water and sanitation services were provided by a variety of agencies (Water Utilities Corporation-WUC in urban areas; Department of Water Affairs-DWA in large villages and District Councils –DCs in small villages). DWA was also responsible for water resources management while DCs managed wastewater. This division of responsibility resulted in an uneven level of services, a lack of transparency for government subsidies, and a lack of accountability (World Bank, 2009). This requires clear separation of responsibility between water supply and water resources management. Additionally, the water sector needs to be financially sustainable to reduce high reliability on government hence the need to enhance efficiency, implement targeted subsidies and adopt a modern and effective system for regulating tariffs. In light of these challenges in the water sector, the NWMPR recommended a reform of the water sector; a process that is currently being implemented (2008 to 2014). For technical assistance in the implementation of the reform process, Government engaged the World Bank between 2008 and 2010 for support and advice on effective implementation of Botswana's preferred reform option.

The reform will result in WUC having overall responsibility for water service provision as well as waste water treatment and management throughout the country. DWA is now responsible for overall planning, development and management of water resources. The reform also seeks to set up an independent Water Resources Board with an overall responsibility of overseeing and allocating water resources, as well as a Water and Energy Regulator, who will be responsible service standards. Policies and legal instruments are also being reviewed under the reform. Briefly the main outputs of the WSR process are indicated in Table 1.

**Table 1: Main outputs of Botswana's WSR process**

Category	Outputs	Progress
Water system reform	Water supply systems taken over by WUC. The process started in 2009 and should be completed in 2013.	WUC has taken over about 533 villages. The remaining activities include customer data collection, cleaning, testing and verification, and importing the customer and technical data into WUCs SAP system. Currently Ngamiland is the only district lagging behind in-terms of data migration.
Wastewater reform	Establishment of capacity within WUC to enable sound wastewater supply and management in the country Wastewater systems and treatment works operated and managed by WUC	Capacity building is an on-going activity. All the wastewater treatment facilities are currently under WUC operations.
Legal and institutional frameworks	National Water Policy Water Tariffs Policy Water Resources Board Water and Energy Regulator DWA assuming overall water planning, development and management	<ul style="list-style-type: none"> <li>• The National Water Policy has been approved by Cabinet and now needs to be approved by Parliament for it to come into force.</li> <li>• Establishment of the board and regulator depend on approval of the Policy</li> <li>• DWA restructuring process is being implemented</li> </ul>
Communication and participation	Communication strategy Consultation of stakeholders on the process and mainly Water Policy	The strategy is available and consultation reports have been prepared.

Source: based on DWA, 2013.

## 2.2 Policies and plans for water resources management

There is renewed impetus for integrated, holistic water resources management in Botswana. The national development planning frameworks recognise the importance and needs of the water sector and progress has been made in fulfilling international obligations such as the 2002 World Summit on Sustainable Development. The major planning and policy documents are discussed in this section.

### National Development Plan 10 (NDP 10)

The plan supports sustainable water use and management. It mentions the implementation of the water sector reforms programme. DWA will become responsible for construction of strategic water infrastructure as well as overall water resources management, while WUC has assumed nation-wide responsibility for water delivery in settlements and for wastewater treatment and management. In terms of infrastructural developments, the plan refers to the completion of Dikgatlhong, Lotsane, Thune and Mosetse dams, which will increase the total dam capacity from 393 Mm<sup>3</sup> to 948 Mm<sup>3</sup>, while combined sustainable yield will increase from 68 Mm<sup>3</sup> to 147.9 Mm<sup>3</sup> per annum. More groundwater investigations are also planned during NDP 10 so as to increase groundwater abstraction. Government plans to establish an independent quality monitoring and evaluation division, under the new Regulator as well as water quality testing laboratories.

### National Water Master Plan Review NWMPR (2006)

The report identifies the outstanding recommendations from the 1991 NWMP such as review of the Water Act, development of a water pricing policy as well as establishment of the Water Resources

Board. The NWMPR calls for implementation of IWRM and water demand management (WDM) with emphasis on the need to reform the sector as well as incorporating environmental issues in the management of water resources. With regards to WDM, the review calls for water monitoring, the establishment of a water user forum, review of NSC to determine major leakages, review of national metering, assessment of water usage among major users, incorporation of water efficiency in building codes and standards as well as development of water management plans for all suppliers and areas with piped water. The plan encourages the use of treated effluent to enhance water resources management. The main objective for use of treated effluent is to supply activities that do not require potable water quality, for example, irrigation and landscaping, dust suppression, road construction and water for mining. The advantage of treated effluent is that as the national demand for water increases, the volume of effluent also increases which makes re-use more attractive, among others because treatment plants are close to population centres.

The plan refers to water accounting and its importance for water management and calls for intensified efforts in developing the accounts for Botswana. It also considers the need to reform the policy and institutional environment to ensure sustainability of the water sector and provide an enabling environment for recommended changes.

#### Draft National Water Policy (2012)

Premised on the core principles of sustainable development and IWRM, the draft policy aims to provide a framework that will foster access to good quality water by all users and also advocates for sustainable development of water resources in support of economic growth, diversification and poverty eradication. The policy adopts a decentralised catchment area approach and uses the precautionary principle. These guiding principles include equity, efficiency and environmental sustainability.

The Policy seeks to establish a Water Resources Board (WRB) which has the responsibility for equitable and sustainable allocation of water resources and development of water related policies as well as the efficient implementation of the IWRM plan. In addition, a Water Regulator will also be established and it will be mainly responsible for ensuring financial sustainability in the water sector, guiding and monitoring development and implementation of water tariff structures as well as ensuring that service providers comply with service standards. The policy distinguishes eleven focus areas that address IWRM at the local, national and international<sup>2</sup> levels. The policy is yet to be approved by parliament.

#### National IWRM-WE Plan (2013)

In the quest to fulfil her obligation to the 2002 Johannesburg Summit for Sustainable Development (WSSD), Botswana has developed the national IWRM-WE plan parallel to the WSR process. Development of the plan followed a consultative process and stakeholders were made aware of the process and the need for IWRM. Premised on sustainable development and the GWP-IWRM toolbox, the plan distinguishes ten strategic areas with specific objectives and fifty-five activities to be implemented as per the implementation strategy. Efficient water allocation, water demand management and benefits from shared water resources are among the plan's priorities given rising and competing demands and scarce water resources. The institutional setup for implementation of the plan is fully aligned to the WSR. The WRB and DWA are expected to drive and coordinate implementation of this plan. The objective is to integrate the activities of the plan into existing planning frameworks and budgets and encourage private sector and community participation in implementing the plan. The seventeen year plan (2013-2030) is currently awaiting approval and will strengthen the enabling environment for implementation of IWRM in the country.

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<sup>2</sup>This refers to transboundary management issues as well as the catchment management approach.



## Chapter 3 The adopted approach towards water accounting

The Botswana water accounts for 2010-12 are based on the United Nation's System of Environmental–Economic Accounting for Water (SEEA-water; for a detailed discussion see section 3.1). To-date, the work involved small working groups from DWA, WUC, and MoA, which mainly focussed on three areas:

- a. Stock accounts – assessing the quantity of water resources in the country at the beginning and end of the year and the changes that occur during this period;
- b. Flow accounts – this category was divided into two groups:
  - Regionalisation of water accounts – to determine the volumes of water used by different sectors in the different management areas as well as the costs incurred by service providers and the revenues attained.
  - Irrigation water use- to determine use of water for irrigation in Botswana primarily focussing on large government irrigation schemes and major private farms.

Detailed information about the working groups and their activities are given in Chapter 5. An important feature of the working groups is the interaction between the different institutions: Ministry of Agriculture, DWA, Statistics Botswana and WUC as discussions were initiated in addressing among others, data issues, economic benefits of irrigation water use and water distribution in the different management centres.

The approach adopted in the two phases is summarised below:

1. Phase 1 (September – December 2012):
  - a. Develop detailed flow accounts for 2010-11 and 2011-12, and this would serve as the basis for future accounts;
  - b. Trend analysis of up-dated existing accounts. Data were collected from water service providers and self providers for the period 2003-2009 to allow a trend analysis linked to the existing accounts.

For Phase 1, the accounts do not distinguish water use by region and by source due to data limitations. The actual water use in most rural settlements was also not yet available during phase 1 and therefore assumptions were made to estimate their water use.

2. Phase 2 (January – June 2013):
  - a. Determine water abstraction and use in 16 WUC management centres (MC), particularly understanding the distribution and flow of water for each region, water flow by source, water flows between regions, water resources and treatment facilities and other major current and planned infrastructural developments.
  - b. Update the 2010-12 water flow accounts with new proportions for water sources for service providers and self providers<sup>3</sup>; adjust the distribution of livestock water use by MC and update information on settlement water use.
  - c. Transform Botswana's use accounts for 2010-12 into the SEEA-Water framework.

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<sup>3</sup> Self providers are institutions that abstract water for own use.



### 3.1 The international SEEA-Water approach

The UN's SEEA of 2003 led to the establishment of SEEA-Water framework, which provides information on the interactions between the economy and water resources. According to United Nations (2012), SEEA-Water Accounts provide a conceptual framework for organising hydrological and economic information in a sound and consistent manner. It is a satellite system to the UN's System of National Accounts (SNA) that is used for compiling economic statistics and deriving economic indicators such as the gross domestic product (GDP). Therefore, they have similar structures and share common definitions, concepts and classifications. SEEA-Water provides aggregate indicators for economic performance and set of statistics that supports decision making for resource utilisation and management.

Two major features of the framework are distinguished:

- The framework considers important water-economic interactions, which is important for addressing cross sectoral and broader issues related to water resources management such as IWRM. Countries are expected to compile a set of standard tables as per the SEEA-WA using harmonised definitions and classifications (Appendix 1); and
- Unlike other environmental information systems, SEEA- Water directly links water data to the SNA as they share similar set of definitions, concepts and classifications. For instance, both the SNA and SEEA-Water use the International Standard Industrial Classification (ISIC) that gives a breakdown of industrial or sectoral activities. ISIC is regularly updated, with the current set being ISIC rev 4. Currently, Botswana uses ISIC Rev 3 and this has been adopted in the water accounts (Appendix 2).

The SEEA WA system captures information on the water stocks, flows from the environment and within the economy in physical and monetary terms and water quality issues. Figure 1 illustrates the SEEA-Water framework. Current WA efforts in Botswana have focused on physical water resources stock accounts (reservoirs; chapter 4) and physical flow accounts (use and supply; chapter 5). Monetary aspects have focused on review of revenues and costs of water supply as well as value added produced by m<sup>3</sup>.

#### Asset accounts

These provide information on the stocks of water at the beginning and end of the accounting period. They also record the changes that take place in the stocks in the same period. Three types of asset accounts are distinguished: produced assets, water resources and water quality accounts.

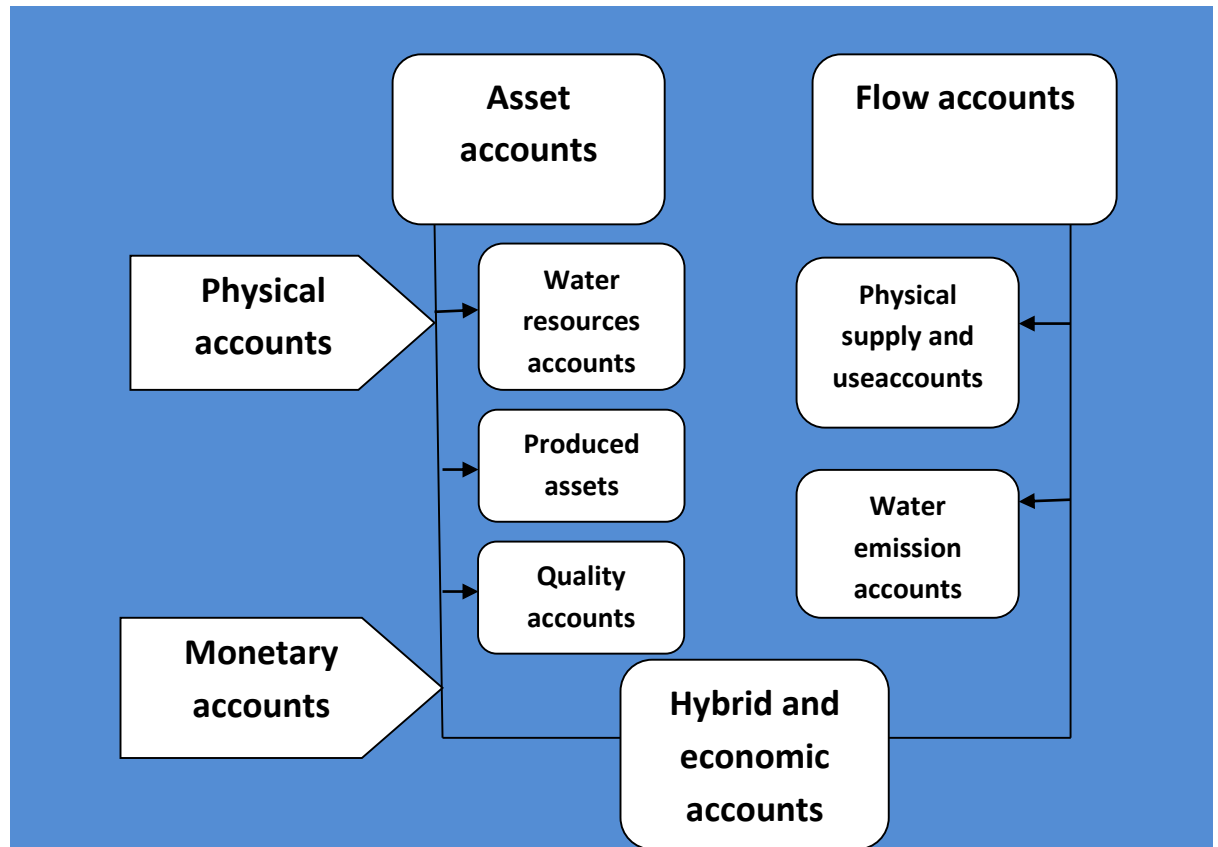
- a. Produced assets – these include infrastructure used for the abstraction, distribution and treatment of water. They are included already in the national accounts as fixed assets. They provide information on the economy's ability to mobilize and treat water such as investment in infrastructure and depreciation of this infrastructure;
- b. Water resources – these form the major part of the assets accounts. They measure the volume of water resources in the country and the changes that occur within a given period (per annum). These changes may be naturally induced (e.g. rainfall, evaporation, run-off) or occur as a result of human activities (abstractions or discharges). The accounts consider all types of water resources; relevant for Botswana are groundwater, reservoir water, river water and wastewater<sup>4</sup>). These are commonly compiled in physical units but could also be compiled in monetary terms;

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<sup>4</sup>Wastewater was not considered for the accounts. WUC has assumed the role of managing this resource and therefore needs to provide information in future to be included in the accounts.

- c. Water quality accounts – asset accounts can be compiled in terms of the quality of water. That is, the stocks of water at the beginning and end of the year according to their quality. In most cases, the accounts only give an indication of changes in the quality of water throughout the accounting period.

**Figure 1: SEEA-Water framework**



Source: United Nations, 2012.

#### Flow accounts

The accounts provide information on the contribution of water to the economy and the pressure exerted by the economy on the environment (abstraction and emissions). Flows are expressed in quantitative, physical terms and there is direct linkage to national accounts thus making it easy to understand for economists and planners. The accounts contain physical supply and use tables that record the flow of water of water between the economy and the environment, including the abstraction, use and returns of water by industries and households. Three types of water flows can be distinguished:

- Flows from the environment to the economy. These largely constitute abstraction for own use and for distribution. For Botswana, water is abstracted for own use by self providers and service providers and is distributed by water service providers (WUC, DWA and DCs in 2010-12);
- Flows within the economy which involves water exchanges between economic actors. They are recorded as use of water received from other economic units (e.g. service providers) or supply of water to other economic units; and
- Flows from the economy back to the environment involves returns to water resources, including losses and treated effluent, returned to the environment.

The results of the physical use and supply tables is “water consumption” which denotes the difference between water use by an economic unit and water supplied to other economic units and the environment.

In addition to the physical use and supply tables, the flow accounts also cover water emission accounts. These provide information by economic activity and households on the quantity of pollutants which have been added or removed from the water during its use. The accounts therefore describe the flows of pollutants added to wastewater. These are important for assessing pollution levels in the water, types and sources of pollution as well as the destination of the emissions (water resources). These accounts have not been developed for Botswana.

#### Hybrid and economic accounts

These describe in monetary terms, the supply and use of water related products and identify:

- a. Costs associated with the production of these products (operations);
- b. Revenues generated by their production;
- c. Investments in water infrastructure;
- d. Maintenance costs; and
- e. Water user fees or tariffs incurred by the users as well as the level of subsidies for water.

The hybrid accounts combine both physical and monetary units in one account while economic accounts expand the hybrid accounts showing the information stipulated above. The accounts rely on information on the value of water resources. Water can be valued as an intermediate input into production; as a final consumer good; or considering the environmental services that water provides such as waste assimilation. A variety of techniques can be used to value water depending on availability of information within the country.

It is noted that hybrid and economic accounts have not been developed for Botswana. Instead, priority has been given to the development of water efficiency indicators such as value added/ m<sup>3</sup> and job creation/ m<sup>3</sup> by economic sector.

### **3.2 Data requirements and challenges**

Water accounts require different types of data from various sources. The main data sources were DWA, WUC, MoA, self providers and Statistics Botswana (SB).

#### WUC

Ideally, the following data are required from WUC:

- a. Water abstraction and use by source and MC;
- b. Water abstraction and use by economic sector;
- c. Water distribution among MCs, including imports and exports;
- d. Water losses by MC; and
- e. Costs and revenues by region.

Water abstraction data was provided for some areas in 2010-12; data was missing for most small settlements as many settlements are hand billed or in some areas, there are no meters. This was addressed by applying the estimated daily per capita water abstraction for small settlements based on available figures for 2012/13. Water abstraction by sources of water at management centre (MC) was only available for 2012/13 and the same proportions of ground and surface water were applied to the previous years (2010-12). Additionally, efforts to determine the distribution of water between MCs were successful, including the amount of water imported from Molatedi Dam in South Africa. It

was complex to disaggregate of annual water use by economic sectors (for 2010/11 and 2011/12). The SAP system does not hold data by economic sector, and therefore, the link between water use and economic sector was made manually. It is recommended that WUC incorporates economic sector classification into its customer information base (SAP system) as this would allow for automatic generation of water use figures by sector.

Water abstraction and sales data were only available for three quarters in 2012. Additionally, there were too many data discrepancies especially the sales information. As a result, the accounts could not be computed for this period as agreed with WUC that these data issues need to be addressed before they could be used. Water losses were available for 2011/12 by MC while in 2012/13 they were available for one quarter.

Data for physical stock accounts obtained from WUC was augmented with data from DWA, and with estimates using the water balance where no measurements are available. Data on opening and closing stocks were available from both WUC and DWA. Abstraction from the various reservoirs was obtained from WUC. Data on opening and closing stocks were obtained from both WUC and DWA. However data on inflow and evaporation were not available for any of the dams.

#### DWA

DWA's mandate of water service provision was phased out in April 2013 when the final village, Maun, was finally taken over by WUC. In 2010/11, nine large villages were still under DWA and in 2011/12, it was only Maun that remained. DWA provided water abstraction and use data for the large villages as well as data on recurrent expenditures and revenues. Two files provided this data but there were inconsistencies in the two data sets and therefore correction factors were applied to bridge the differences. Data for Maun in 2012/13 was not available.

#### Self providers

The main self providers are mines, livestock and irrigation sectors. Most mining companies provided water abstraction data (also assumed to be water use). In estimating the water use by livestock, daily water requirements per head of livestock were multiplied by the annual livestock population from the Agricultural Statistics (2010). The number of livestock is assumed to be constant in the period 2010-2012.

#### MoA

Irrigation data are useful for the flow accounts. Ideally, the following data are required:

- a. Water abstraction and use for irrigation;
- b. Water sources (dams, rivers or groundwater) and institutional set up (provided by service providers or own water abstraction; and
- c. Water returns to the environment or otherwise.

The Irrigation department provided regional irrigation data while other information was sourced from the farmers, especially regarding the large private schemes.

Statistics Botswana has been resourceful in providing economic data on value added and formal employment figures by economic sector. They also provided the adopted ISIC classifications that Botswana uses for the national accounts. This was used for computing the flow accounts.

In the absence of empirical data, several assumptions and correction factors were applied for the study. The assumptions for flow accounts are:

1. In estimating water abstraction for settlements, there was need to assume population figures for 2010. The average intercensal (2001 – 2011) growth rate of 1.9% was applied across all villages to estimate settlement population from the 2011 Population Census;
2. WUC took over villages and settlements in phases between 2009 and 2013. The most common take over dates were February and October 2010 as well as April 2011. Those settlements taken over in October 2010 were assumed to have been under the authority of DCs between April and October. Those taken over in April 2011 were also assumed to have been under DWA or DCs in 2010. This resulted in a distinction between WUC supplied areas, DWA and DC supported areas. The phase 1 2010-12 accounts were updated with this information.
3. For settlements without water abstraction figures, the abstraction was based on the average per capita water abstraction for metered small settlements and DWA villages (72 L and 135 L/ person/ day respectively).
4. For 2010-12 water sources proportions for water use, it is assumed that the proportions for water abstracted are similar to proportions for water used in WUC serviced areas. In other words, water losses are the same irrespective of the source.
5. For water use in settlements without metering, it was assumed that:
  - a. The per capita water abstraction was the same as the average for metered settlements;
  - b. The losses were the same as the average DWA loss rate of 26% (2010-11).
6. For self providers, it is unclear whether the available figures refer to abstraction or use. This needs further investigation. For the time being, it is assumed that abstraction equals use (hence zero losses).
7. To determine livestock water abstraction and use by MC, agricultural districts were super imposed on WUC MCs by assigning proportions of the cattle population in each area based on the total cattle population for 2010. Further overlay work with GIS is needed to estimate the proportion's more accurately.

For stock accounts the following assumptions were made:

1. Long term average monthly evaporation rates were disaggregated to daily rates, and these were used in the water balance equation to estimate daily inflows into the reservoirs; and
2. The difference in the closing stocks as measured and that calculated using the water balance were attributed to seepage losses, which are not monitored.

## Chapter 4 The stock accounts of major water supply reservoirs

The stock accounts in Botswana are of three types, namely surface water stocks (reservoirs and rivers) groundwater stocks, and waste water stocks. Currently data exists only for reservoirs in the form of opening and closing stocks, abstractions, transfers into and from the reservoirs, and evaporation data in the form of average long term monthly evaporation. However inflows into all the major reservoirs are not measured. For groundwater there is some limited data in the form of abstractions, but it is still not possible to determine opening and closing stocks. For wastewater accounts there are no measurements for outflows from water treatment works. Therefore the stock accounts exercise concentrated on stock accounts for five water supply reservoirs, namely Nnywane, Gaborone, Bokaa, Letsibogo and Shashe dams.

Information from the physical flow accounts indicate that groundwater is still by far the largest source of water used. As more wellfields are explored the use of groundwater will increase. On the other hand ground water resources are vulnerable to over-exploitation. Therefore in the future efforts must be directed at constructing groundwater stock accounts to help ensure their sustainable use.

Previous work indicates that there are sufficient waste water resources that can be exploited. This can help reduce pressure on the scarce surface and ground water resources. Therefore there is a need to put in this endeavour as well.

The water supply dams can be characterised according to their size and yield:

Dam	Full Supply Capacity (MCM)	Annual Yield (MCM)
Gaborone	140.5	9.4*
Bokaa	18.5	-
Nnywane	1.75	-
Shashe	87.9	25.3*
Letsibogo	100	60

\*Based on presiltation volumes

Data required for stock accounts include the following:

- Opening volume;
- Inflows;
- Incoming transfers;
- Abstractions;
- Evaporation;
- Outgoing transfers; and
- Closing volume

From the above inflows and evaporation are not measured. However data exists on long term monthly evaporation for the various locations in Botswana. Therefore these were used for the respective months. However since no flow measurements are undertaken inflows were calculated using the water balance equation on a daily basis. Table 2 shows the stock accounts for the above dams.

The data is summarised in Figure 2. Gaborone dam has the greatest annual fluctuation of volumes. Even taking into account inflows from Molatedi dam abstractions from Gaborone dam exceed the safe annual yield of the dam. Shashe Dam has the least annual fluctuations and high safe yields. Future water resource management efforts must be directed at both ground and waste water resources.

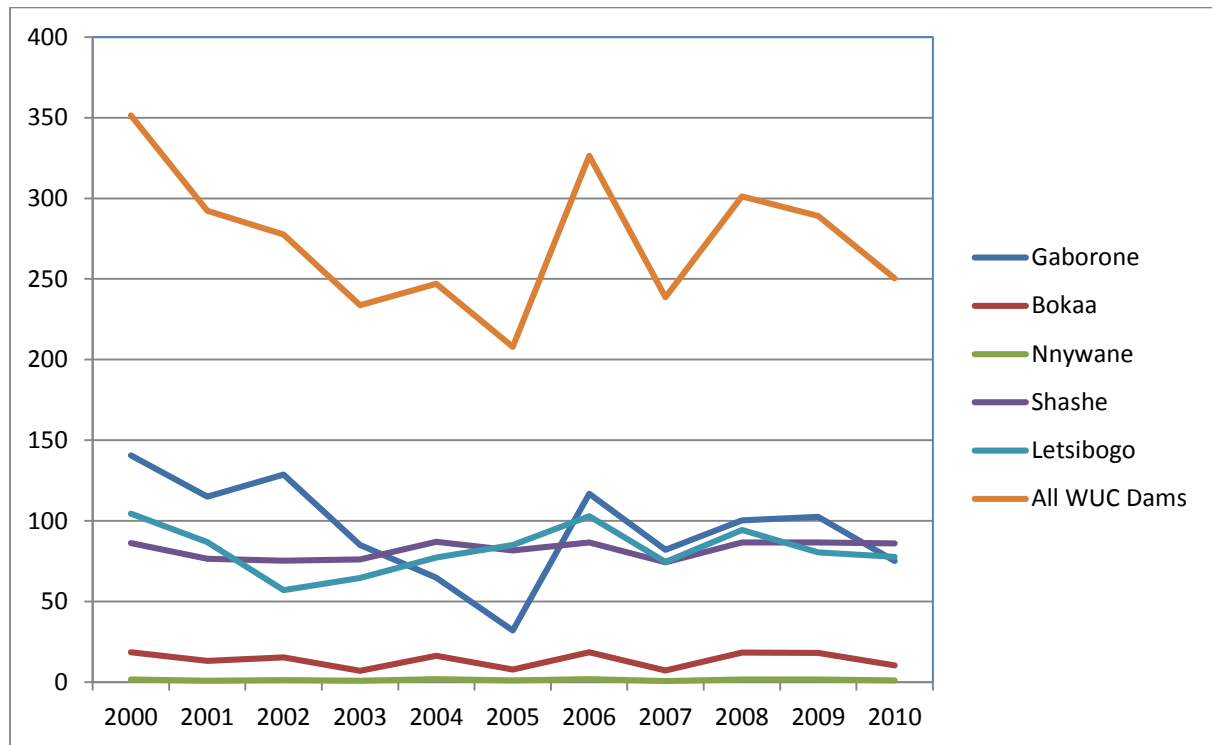
**Table 2: Stock accounts of WUC dams**

<b>1</b>	<b>Gaborone dam</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>
	Opening volume (MCM)	140.591	114.9	128.7	85.06	64.74	32.09	116.77	82.04	100.25	102.44	75.03
	Inflows (MCM)	<b>17.40</b>	<b>57.25</b>	<b>8.39</b>	<b>19.7</b>	<b>8.08</b>	<b>138.88</b>	<b>0.58</b>	<b>72.05</b>	<b>41.18</b>	<b>12.35</b>	<b>87.03</b>
	Incoming transfers Bokaa (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Incoming transfer Molatedi (MCM)	2.9148	5.798	6.314	4.21	5.522	0.00	6.11	4.14	2.70	2.72	7.6
	Abstraction <b>000M<sup>3</sup></b>	13573.4	15862	22372	24842	19605	17800	8000	18700	22300	26350	26400
	Evaporation (MCM)	24.53	23.39	20.52	14.38	9.30	14.29	19.09	17.50	19.46	17.04	19.01
	Outgoing transfers (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Closing volume (MCM)	114.9	128.7	85.06	64.74	32.09	116.77	82.04	100.25	102.44	75.03	122.98
<b>2</b>	<b>Bokaa dam</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>
	Opening volume (MCM)	18.5	13.2	15.3	6.98	16.34	7.8	18.5	7.29	18.38	18.2	10.44
	Inflows (MCM)		18.46		20.11	2.41	21.74	5.55	25.3	13.56	4.86	17.74
	Incoming transfers (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Abstraction <b>000M<sup>3</sup></b>		5409	3068	2800	1900	1200	2400	3800	5300	8100	6900
	Evaporation (MCM)	3.804	3.42	2.674	2.798	2.897	3.156	3.0948	3.0804	4.3896	3.4368	2.544
	Outgoing transfers (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Closing volume (MCM)	13.2	15.3	6.98	16.34	7.8	18.5	7.29	18.38	18.2	10.44	10.76
<b>3</b>	<b>Nnywane dam</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>
	Opening volume (MCM)	1.71	0.802	1.14	0.91	1.74	1.11	1.75	0.62	1.73	1.72	1.11
	Inflows (MCM)	0.38	1.53	0.86	1.86	0.47	1.78	0.19	2.24	1.12	0.54	1.67
	Incoming transfers (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Abstraction <b>000M<sup>3</sup></b>	1014.32	992	700.00	700.00	500.00	700.00	900.00	800.00	290	460	210
	Evaporation (MCM)	0.34666	0.268	0.283	0.366	0.393	0.39468	0.32706	0.3243	0.4761	0.39054	0.37674
	Outgoing transfers (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Closing volume (MCM)	0.802	1.14	0.91	1.74	1.11	1.75	0.62	1.73	1.72	1.11	1.62
<b>4</b>	<b>Shashe dam</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>
	Opening volume (MCM)	94.03	76.5	75.2	75.97	87.9	81.7	86.5	71	86.5	86.5	86.1

		21.4	52	38.9	44.6	48	70.3	25	51	43.3	48.9	29.5
	Inflows (MCM)											
	Incoming transfers (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Abstraction 000M <sup>3</sup>	11635	9082	9200	9100	12900	13400	14600	14400	16290	17310	13530
	Evaporation (MCM)	26.6027	23.67	23.58	25.56	26.46	26.2392	24.57	24.57	26.988	26.9256	26.3484
	Outgoing transfers(MCM)	0	0	0	0	0	0	0	0	0	0	0
	Closing volume (MCM)	76.5	75.2	75.97	87.9	81.7	86.5	71	86.5	86.5	86.1	82.8
<b>5</b>	<b>Letsibogo dam</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	2007	<b>2008</b>	<b>2009</b>	<b>2010</b>
	Opening volume (MCM)	104.4	86.82	57.11	64.58	77.28	85.1	102.96	74.42	94.32	80.46	77.6
	Inflows (MCM)	21.54	13.45	38.42	59.01	66.71	52.95	19.18	53.361	87.883	29.73	47.03
	Incoming transfers (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Abstraction 000M <sup>3</sup>	5170	12642	15650	14555	18623	11100.00	16600.00	13100.00	3200.00	12020	11030
	Evaporation (MCM)	35.6	17.27	14.6	17.02	19.49	22.5672	21.2856	20.2488	20.9736	18.9672	9.312
	Outgoing transfers Gabs-WUC											
	Outgoing transfers DWA-villages											
	Closing volume (MCM)	86.82	57.11	64.58	77.28	85.1	102.96	74.42	94.32	80.46	77.6	
<b>6</b>	<b>All WUC dams</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	2007	<b>2008</b>	<b>2009</b>	<b>2010</b>
	Opening volume (MCM)	351.501	292.2	277.5	233.6	248	207.8	326.48	238.57	301.18	289	250.28
	Inflows (MCM)	55.38	148.07	86.57	141.73	125.67	304.96	55.23	204.32	131.06	132.45	135.94
	Incoming transfers Bokaa (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Incoming transfer Molated i(MCM)	2.9148	5.798	6.314	4.21	5.522	0	6.105091	4.144032	2.696259	2.72	7.6
	Abstraction (000M <sup>3</sup> )	31392.7	43988	50990	51997	53528	44200	42500	50800	47380	64240	58070
	Evaporation (MCM)	90.88	68.01	61.67	60.13	58.53	66.65	68.36	65.72	72.29	66.76	57.59
	Outgoing transfers (MCM)	0	0	0	0	0	0	0	0	0	0	0
	Closing volume (MCM)	292.222	277.5	233.6	248	207.8	326.48	238.57	301.18	289	250.28	218.16



**Figure 2: Water volumes in WUC dams 2001/2 – 2010/11**



## Chapter 5 The 2010/11 and 2011/12 flow accounts

Botswana water flow accounts for 2010-12 follow the SEEA-water framework. They distinguish water supply and use tables indicating water flows from the environment, within the economy and from the economy to the environment.

The use tables capture direct water abstraction from the environment for own use and for distribution to other economic agents. Abstraction for own use is carried out by self providers: mines, livestock and most irrigation farmers, and service providers abstracting small amounts for own use. Abstraction for distribution is carried out by water service providers: WUC, DWA and DCs. However, as stated above, WUC is the sole water service provider in the country since April 2013.

Water is also received from other economic sectors and used for various purposes. Additionally, the economic units can also supply water to other units and this is captured in the supply table of the accounts.

Return flows into the environment also form part of the supply tables. Botswana's economic sector classifications are adopted from UN's ISIC rev 3 (see also Appendix 2).

### 5.1 Physical water use and supply accounts

Tables 2 and 3 are abridged versions of the physical use and supply tables for 2010-12. Detailed tables are provided in the appendices.

A brief explanation of the tables is required before the results are discussed. The top part of each table is the use account which documents water abstraction for own use and for distribution, water abstraction by sources and water distribution (2). The bottom part of each table is the physical supply table, which refers to supply of water within the economy and to returns to the environment. Total supply is the supply within the economy plus the return flows to the environment. Water consumption is the use (from the use table) minus the supply (from the supply table).

The use accounts show that annual water abstraction is around 195 Mm<sup>3</sup>. Abstraction declined slightly in 2011-12 to 194.6 Mm<sup>3</sup>. Abstraction for own use and for distribution is almost equal. Self providers abstract 51.8% of the water in 2011-12 compared to 48.2% for service providers. Imports for distribution, in this case water imported from Molatedi dam in South Africa, are 3.7% of abstractions. There are no exports. By water source, water is mostly abstracted from groundwater contributing just over half of total abstraction in both years. Self providers mostly abstract ground water. Abstraction from rivers (Chobe and Limpopo) was approximately 1% in both years with irrigation accounting for about 66% of the abstraction from rivers. Water use from other economic sectors is water distributed by service providers to different economic units. In 2010, 51% of the water distributed was used by households while 49% of water use is spread among the rest of the economy. Water loss (i.e. difference between abstraction and distribution) is shown to be 25.2% in the period 2010-12.

With regards to water supply accounts, service providers are mostly responsible for distribution of water to various sectors of the economy. As indicated earlier, the bulk of this water is supplied to households (53% and 56% in 2010/11 and 2011/12 respectively). In some cases water supplied to other sectors can be in the form of re-used water or wastewater to sewerage systems transported through the mains. This has not been captured in the Botswana accounts due to limited data. Future accounts should investigate this further, especially for households that produce a significant amount of sewage that ends up at treatment plants. Once WUC records the inflows and outflows of WWTW, this should be possible. Return flows are only known for water service providers, whose losses mostly

seep into the ground water. There are minimal return flows to the environment from the economy. It is assumed that self providers do not incur any losses and as such their abstraction is equal to the water they use.

## 5.2 Overall water abstraction, use and consumption

Tables 3 and 4 show the following overall results:

a. Water abstraction:	197.2 Mm <sup>3</sup> (2010-11)	194.4 Mm <sup>3</sup> (2011-12)
b. Water use (incl. distribution)	270.2 Mm <sup>3</sup> (2010-11)	262.5 Mm <sup>3</sup> (2011-12)
c. Water consumption (use – supply)	172.5 Mm <sup>3</sup> (2010-11)	171.6 Mm <sup>3</sup> (2011-12)

Water abstraction is just under 200 Mm<sup>3</sup> while consumption is just over 170 Mm<sup>3</sup>. Botswana's water consumption has decreased marginally from 173 Mm<sup>3</sup> in 2010/11 to 172 Mm<sup>3</sup> in 2011/12. This slight decrease in water consumption may be due to low abstraction from dams and boreholes; and it may also be due to data inadequacy. The consumption is highest for the agricultural sector (43% in 2010/11 and 44% in 2011/12) followed by households and mines. Given the large share of self providers, their water abstraction and consumption require greater attention for water resources management. Water demand management measures are critical for these sectors and use of non-potable water could be enhanced particularly saline water for mining processes and treated wastewater for irrigation and horticulture production. The amount of treated effluent has increased (about 27 Mm<sup>3</sup> in 2003) and it is likely to have grown further due to expansion of wastewater treatment facilities. Evidence from past studies shows that the resource is valuable and close to major demand centres, e.g. Glen Valley in Gaborone therefore its utilisation should be enhanced in major sectors that do not necessarily require potable water use. Treated wastewater needs to be incorporated in future flow accounts<sup>5</sup>.

Figure 3 shows the share in water abstraction and consumption by economic sector and for households (as reflected in Table 3). Water service providers and self providers account for the abstractions. Water consumption is dominated by the end users such as households and government as well as the large self providers (irrigation, mines and livestock sector).

The WA results can also be put in the broader perspective of a water balance of the country. This is reflected in Figure 4. The figure shows that an estimated 98.5% of the precipitation evaporates (241 860 Mm<sup>3</sup>) and is not available for abstraction and use. The remainder (a mere 1.5% of precipitation) is equally divided between run off into river and reservoirs and groundwater recharge (1 840 Mm<sup>3</sup>). The groundwater recharge refers to recharge country wide, and not only to recharge of well fields. After the completion of Dikgatlong Dam, the reservoir capacity is 440 Mm<sup>3</sup> or around a quarter of total run-off through rivers. The average inflow from water from abroad is 8 440 (period (2000 – 2004), most of which evaporates in the Delta. The outflow refers to run-off through the Limpopo River system (the figure is based on old estimates, which need to be up-dated and improved). The inflows and outflows from the Zambezi-Chobe river system have been left out of the figure, assuming that outflows virtually equal inflows. The human use is minimal (Kasane) and ecosystems use is unknown.

Figure 5 shows the flows of water resources in the economy (2010-11). In essence, it depicts Table 4 in a figure. Question marks for flows in figure 4 indicate the absence of figures. This is the case for most return flows as well as some environmental returns and losses of self providers. Tables 3 and 4 show that this part of the flow accounts still needs to be completed. WUC measurements of inflows and outflows will be important to fill the gap. The alternative is to estimate return flows by using

<sup>5</sup>This should be possible after WUC starts to monitor and record the inflows and outflows of wastewater treatment plants.

percentages of use (e.g. 80% of water use by households is returned). This approach would require validation of the percentages through an empirical study. From an IWRM perspective, it is necessary to get better insight in the 'return' part of the water cycle and identify opportunities for re-use and recycling to reduce abstraction of fresh water resources.

Figure 6 shows the sectoral contributions to Gross Domestic Product (GDP), formal employment and water consumption. The agricultural sector consumes a large amount of water but contributes little to GDP and formal employment. The mining sector makes a large contribution to GDP and consumes a significant amount of water. Its contribution to direct formal employment is limited due to the capital intensive nature of mining. The service sectors make a large contribution to GDP and employment and use a modest amount of water. Two conclusions emerge:

- c. The opportunity costs of agricultural water consumption need to be carefully considered in development planning; and
- d. Water consumption and requirements should be considered as part of the economic diversification drive and trade policies; from an IWRM perspective, diversification should favour the service sectors and trade policies must recognise Botswana's comparative disadvantage in water resources.

**Table 3: Physical use and supply tables of the flow accounts for 2010/11 (000 Mm<sup>3</sup>).**

Physical use table	Agriculture	Mining	Manufacturing	Electricity	Water service providers	Construction	Trade	Hotels	Transport	Finance	Social services	Government	Int. organs	Agric. & industries	HH	Rest of the world	Grand total
Abstraction for own use	74,315	25,167			15									99,498			99,498
Abstraction for distribution					90,410									90,410		7,300	97,710
<b>1. Total abstraction</b>	74,315	25,167	-		90,425	-	-	-	-	-	-	-	-	189,907	-	7,300	197,207
Reservoir water	12,470	-			62,727									75,197		7,300	82,497
Ground water	48,841	25,167			25,317									99,325			99,325
River water	13,004				2,381									15,385			15,385
<b>Abstraction from water resources</b>	74,315	25,167	-		90,425	-	-	-	-	-	-	-	-	189,907		7,300	197,207
<b>2. Water from other economic sectors</b>	264	7,275	2,758	80		369	1,645	786	258	1,329	5,254	15,686	104	35,809	37,218		73,027
																	-
<b>Total use of water (1+2)</b>	74,578	32,442	2,758	80	90,425	369	1,645	786	258	1,329	5,254	15,686	104	225,716	37,218	7,300	270,234
<b>Physical supply table</b>																	
<b>4. Supply of water to other economic units</b>					65,727									65,727		7,300	73,027
																	-
<b>5. Total returns</b>					24,683									24,683			24,683
Groundwater					24,683									24,683			24,683
<b>6.Total supply of water (=4+5)</b>	-	-	-	-	90,410	-	-	-	-	-	-	-	-	90,410	-	7,300	97,710
<b>7. Consumption</b>	74,578	32,442	2,758	80	15	369	1,645	786	258	1,329	5,254	15,686	104	135,306	37,218	-	172,524

Table 4: Physical use and supply tables of the flow accounts for 2011/12 (000 Mm<sup>3</sup>)

Physical use table	Agric	Mining	Manufacturing	Electricity	Water service providers	Construction	Trade	Hotels	Transport	Finance	Social services	Govt	Int. organs	Agric & industries	HH	Rest of the world	Grand total
Abstraction for own use	74,315	29,108			25									103,448			103,448
Abstraction for distribution					83,715									83,715		7,200	90,915
<b>1. Total abstraction</b>	74,315	29,108	-	-	83,740	-	-	-	-	-	-	-	-	187,164	-	7,200	194,364
Reservoir water	12,470	-			55,935									68,405		7,200	75,605
Ground water	48,841	29,033			25,492									103,366			103,366
River water	13,004	75			2,313									15,392			15,392
Abstraction from water resources	74,315	29,108	-	-	83,740	-	-	-	-	-	-	-	-	187,164		7,200	194,364
<b>2. Water from other economic sectors</b>	289	5,467	3,446	103		405	1,259	872	258	2,254	3,983	11,563	156	30,054	38,048		68,103
<b>Total use of water (1+2)</b>	74,604	34,575	3,446	103	83,740	405	1,259	872	258	2,254	3,983	11,563	156	217,218	38,048	7,200	262,466
<b>Physical supply table</b>																	
<b>4. Supply of water to other economic units</b>					60,903									60,903		7,200	68,103
																	-
<b>5. Total returns</b>					22,813									22,813			22,813
5.a.1. Surface water														-			-
5.a.2. Groundwater					22,813									22,813			22,813
<b>6.Total supply of water (=4+5)</b>	-	-	-	-	83,715	-	-	-	-	-	-	-	-	83,715	-	7,200	90,915
<b>7. Consumption</b>	74,604	34,575	3,446	103	25	405	1,259	872	258	2,254	3,983	11,563	156	133,503	38,048	-	171,551

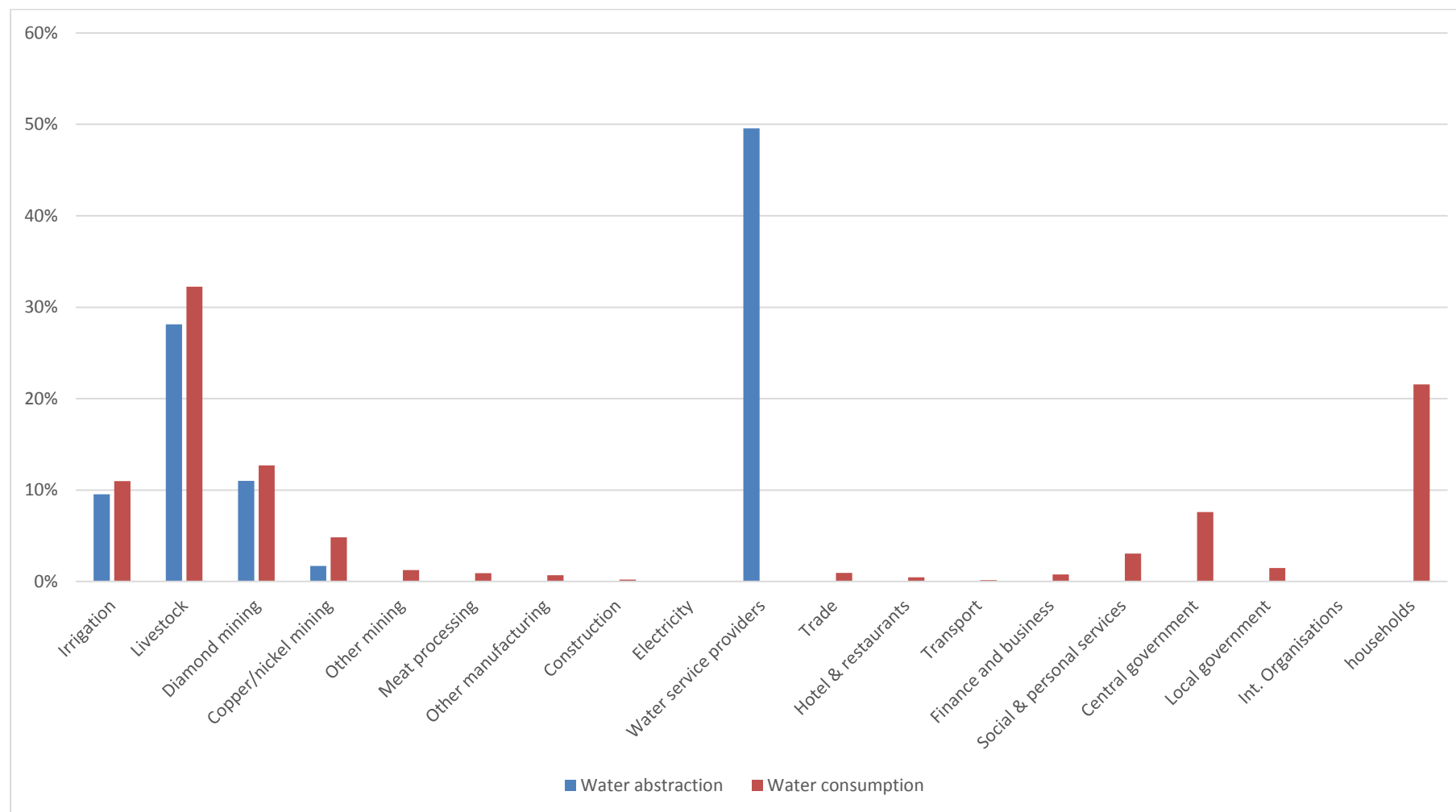
**Figure 3: Shares of economic sectors and households in water abstraction and consumption (2010/11).**

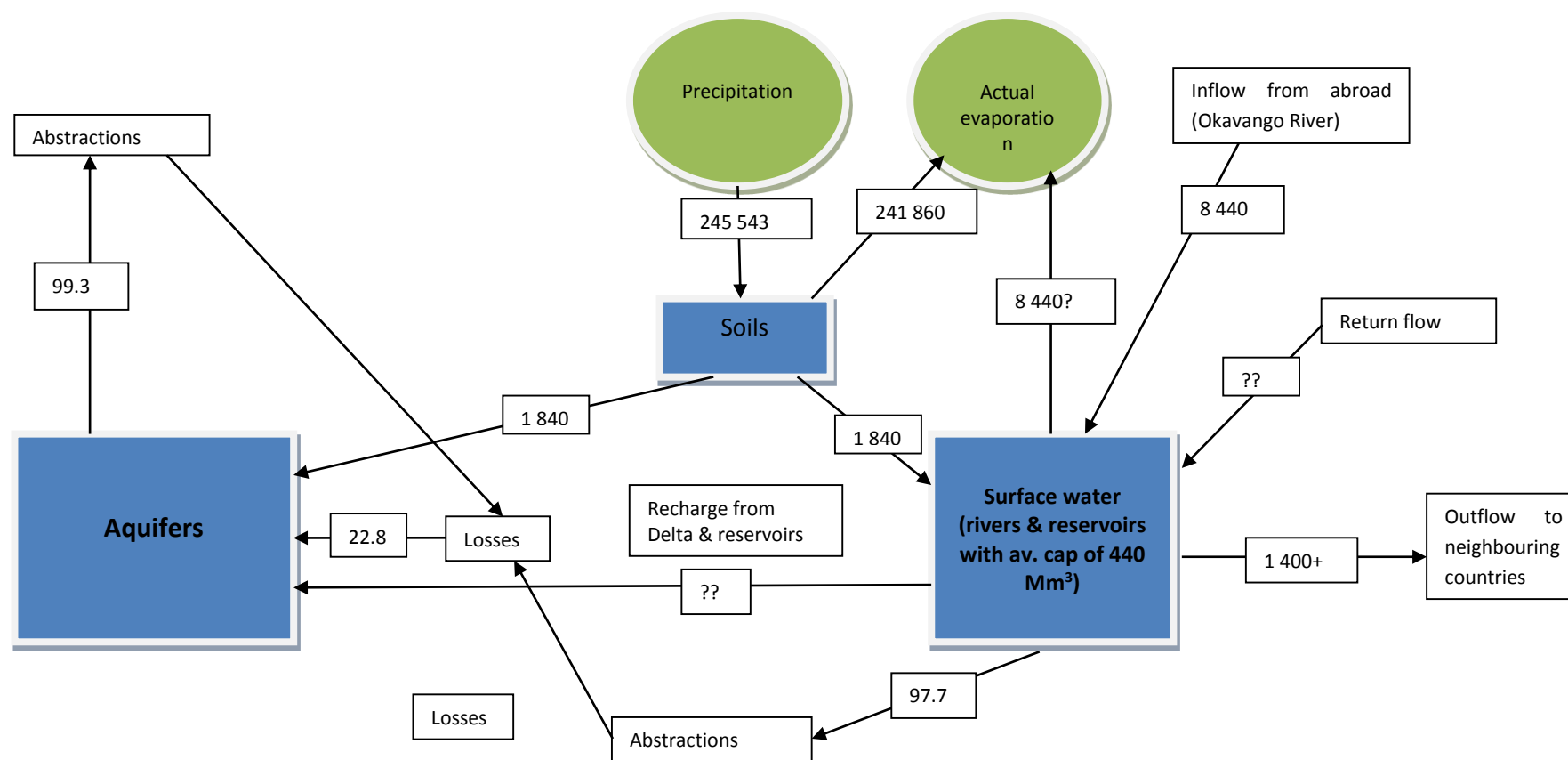
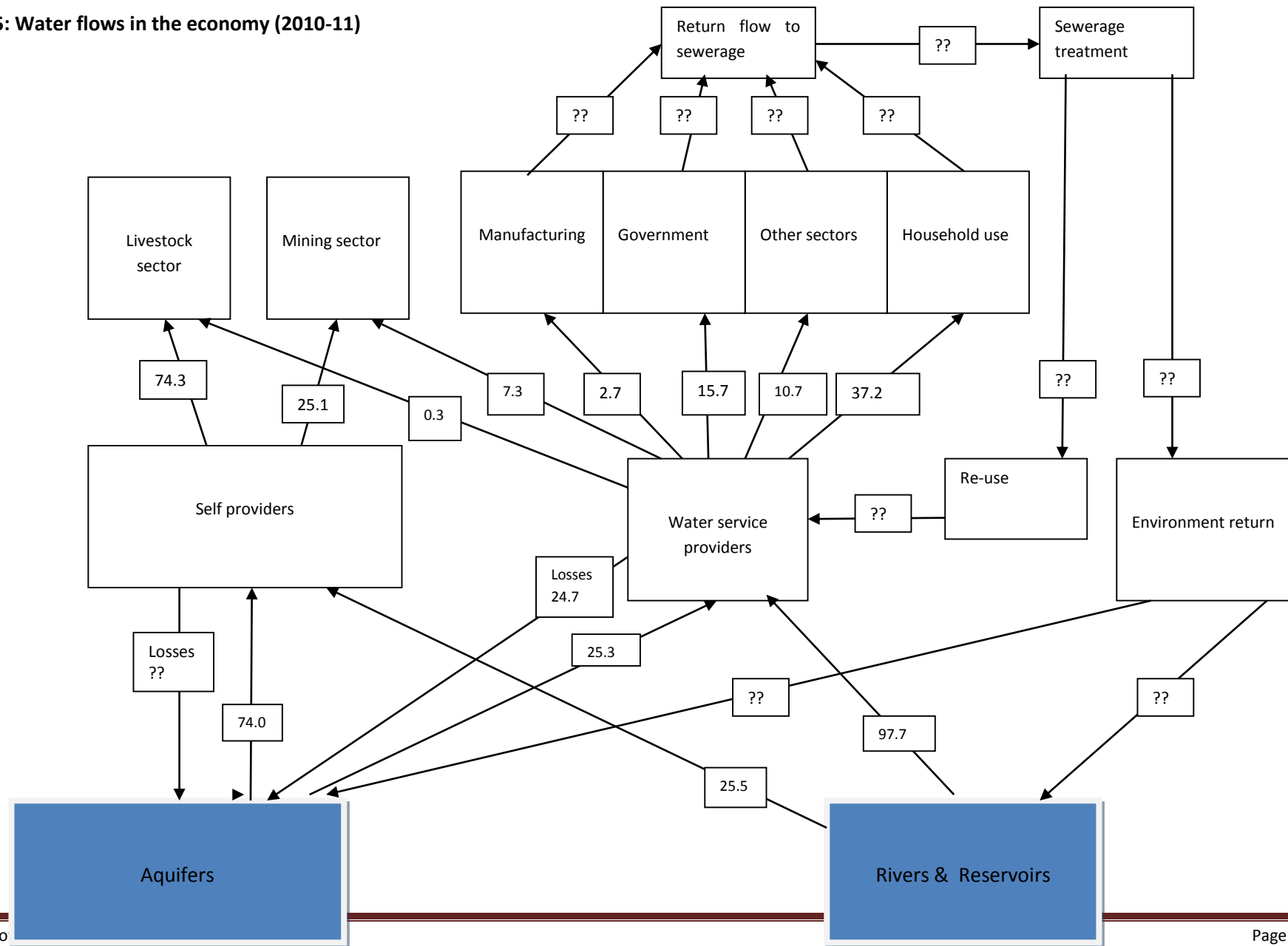
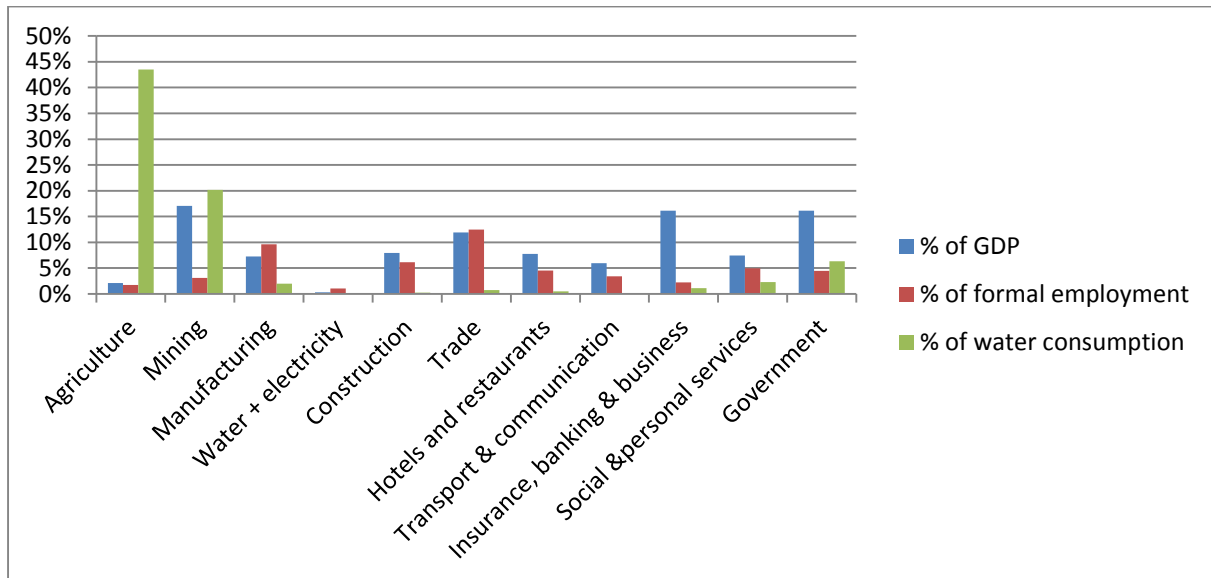
Figure 4: Water flows to and from Botswana inland water resources (Mm<sup>3</sup>)



Figure 5: Water flows in the economy (2010-11)



**Figure 6: Share in GDP, formal employment and water consumption.**



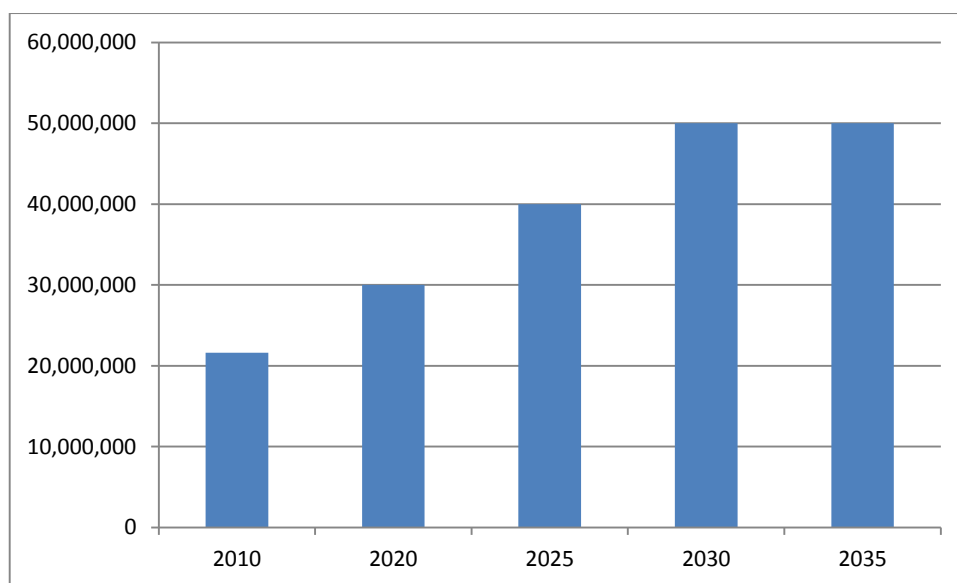
## Chapter 6 Water use in the irrigation sector

### 6.1 Introduction

The irrigation sector is a major water user worldwide. In Botswana however, the irrigation sector is small in size, with estimates ranging from 1 200 ha to 2 500 ha, and abstracts less water than in most countries.

Climate change and variability and the desire to increase domestic food production<sup>6</sup> are expected to boost irrigation in future. The Review of the NWMP (SMEC *et.al.* 2006) envisages significant growth of water use for irrigation from 21.6 Mm<sup>3</sup> in 2010 to 50 Mm<sup>3</sup> in 2030 (Figure 7).

**Figure 7: Forecasted growth of water use for irrigation (in m<sup>3</sup>)**



Source: adapted from SMEC *et.al.*, 2013.

The National Agricultural Master Plan for Arable and Dairy Development (NAMPADD) also envisages significant growth in irrigation using treated effluent, groundwater and surface water. If these plans materialise, the irrigation sector would become a major water using sector in future, and it is therefore essential to properly capture the sector in water accounts. The Ministry of Agriculture is investigating the feasibility of large scale irrigation with water from the Chobe-Zambezi basin (around 35 000 ha). If this happens the irrigation sector would become by far the largest water user in the country.

In previous water accounts (DEA and CAR, 2006), water use by irrigation was kept constant at around 18 800 Mm<sup>3</sup>/annum (1 200 ha at 15 000 m<sup>3</sup>/ha), equally divided over ground water, reservoir water and rivers. The main reason for 'keeping it constant' was the poor documentation of the sector.

A small working group with staff from DWA, WUC, MoA and CAR explored water abstraction and use in the sector. The group collected and analysed irrigation data from agricultural regions and undertook case studies of two government irrigation schemes and an irrigation farm. Through this working group, government institutions started to collaborate in the field of water use and irrigation. Within

<sup>6</sup>Botswana imports most of the cereal requirements.

MoA, horticulture and irrigation departments initiated discussions about the economic benefits of irrigation water use. It also became evident that the Ministry of Lands needs to participate in the group in future as a number of 'farmers' that have been allocated irrigated land leave it undeveloped and idle<sup>7</sup>.

## **6.2 Data requirements and sources**

The following data are ideally needed for the estimation of water abstraction and use for the irrigation sector:

- a. Water abstraction, use and consumption for irrigation;
- b. Water sources (dams, rivers, groundwater or wastewater) and institutional set up (provided by service providers or own water abstraction; and
- c. Water returns to the environment or otherwise.

The water use by irrigation should be linked to the value added of this sector. Unfortunately, the value added of the irrigation sector is not separately recorded in the National Accounts. Moreover, few irrigation schemes are monitored so the annual water use has to be estimated based on agro data such as crops grown, crop cycles and irrigation technology used. Farmers at the visited schemes have three to four crop cycles, and mostly grow cabbage, tomatoes, green peppers, green mealies, butternut, spinach, swiss chard and fruits. Drip irrigation is most common with a few cases of sprinkler irrigation. Water use can be estimated as:

Water use = cultivated area in ha.\* water use/ha.

The estimates are more accurate if the equation is specific for crops and irrigation technology. For example, in the FAO Irrigation Manual (Sava & Frenken, 2002) it is argued that localised irrigation such as drip irrigation uses less than half the amount of water of surface irrigation technologies (e.g. sprinklers). Water use also depends on the crop and soil/ climatic conditions. Because of the high water use of irrigation, its water efficiency is very important for most countries and IWRM. The efficiency is the result of three factors: conveyance efficiency (between water inlet and entry into scheme), field canal efficiency (from entry point scheme to each field hydrant) and field application efficiency (efficiency within the field).

For WA, water return flows need to be estimated in terms of return to the environment through groundwater recharge or surface water flows. In the visited schemes, no surface water ran off, but ground recharge is likely to have occurred when water use exceeded crop requirements/ consumption. Recharge can only be estimated if the water use and water requirements are exactly known. Recharge is then the difference between use and consumption.

## **6.3 Conclusions**

The results of the water abstraction and use for irrigation are summarised in Appendix 4. Below, the main conclusions are summarised.

The water abstraction, use and consumption are not directly measures for irrigation in Botswana. Moreover, no output, costs and revenue data are available to calculate the water productivity in terms of food security, value added or employment creation.

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<sup>7</sup> The MoA does not have the names of these 'farmers'.

The –previously in water accounting used- estimate of 18 Mm<sup>3</sup> is probably an over estimate as it is based on the serviced irrigable land instead of the actual irrigation land under cultivation. The annually irrigated area is around a third to just over half of the serviced in the period 2011-13. The water used by irrigation varies annually and was estimated to be less than 5 Mm<sup>3</sup> and 7.5 Mm<sup>3</sup> in 2011-2 and 2012-3 respectively (excl. Talane farms). With the estimated water use of 5.5 Mm<sup>3</sup> at Talane Farms, the total water use of the irrigation sector would be in the range of 10 – 12.5 Mm<sup>3</sup>. There is no outflow from irrigation farms and schemes. Therefore return flows are zero and water used is either consumed or goes to the environment (groundwater recharge). Recently provided figures on irrigation and production need further investigation.

The irrigation study provided better insight in the water sources used and the water providers. In terms of water provision, over two thirds of the farmers (68.8%) use their own water supply (so-called self providers, i.e. direct water abstractions from the environment by the agricultural sector); over a quarter (28.2%) use village water supplies (backyard gardens; water supplies from ISIC 36 to irrigation sector) and a few 3.2%) use government irrigation schemes (Dikabeya, Glenn Valley and Kubung). In terms of water sources, irrigation heavily relies on groundwater (60.2% of farmers); 34% of the farmers use water from rivers, while 5.8% uses dams<sup>8</sup>. This result differs from the assumption hitherto made: a quarter each for river, dams and groundwater.

Data collection and analysis need to be improved significantly in order to assess the sector's performance and productivity. While there are some productive farmers, the sector as a whole appears to underperform, for example judged by the underutilisation of land. Therefore, priority should be given to fully utilise serviced irrigation land and increase its productivity.

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<sup>8</sup>The actual amount of water use by source was not (yet) established.

## Chapter 7 Water flows and use by region

Decentralised water management is one of the IWRM principles, which is anchored in Botswana in the draft Water Policy and in the 2013 IWRM-WE Plan. However, Botswana has not yet defined and agreed on the water resource management regions. The only functional regional division at the moment is the Management Centres (MC) that WUC distinguishes for the provision of water to all parts of the country. Therefore, a regionalisation of water flows exercise was undertaken to compile water abstraction and use information by WUC Management Centres. DWA is expected to initiate and lead a process of determining water management regions in the near future.

The exercise carried out for the WA involved a working group with staff from DWA, WUC and CAR. The focus was to determine water abstraction, supply and use in the 16 WUC MCs (Map 1), particularly understanding the water abstraction and distribution for each MC by water source. Data were collected and analysed of WUC water abstraction, use, consumption and losses for 2012-13 by MC and source of water; in addition, data on revenues and costs for WUC by each MC were collected and analysed. Emphasis was mainly on water flows by service providers (WUC and DWA). Abstraction for mines and livestock were allocated to MCs based on the location of the particular mine and estimated livestock numbers in each MC. An update of WUC client data for 2012-13 (phase 1 covered 2010-11 and 2011-12) could not be undertaken because of lack of data.

### 7.1 Data requirements and sources

Regionalisation of water abstraction and use requires data on abstraction, use and losses by source of water, MC and by institution. Costs and revenues are also necessary. Water abstraction data was available for three quarters of 2012/13 while losses were available for one quarter (WUC). The abstraction data was comprehensive for most settlements and in the few villages without data, the average daily per capita water abstraction of 72 L/person/day<sup>9</sup> was used multiplied with 2011 Population Census figures. The costs and revenues were also available for three quarters (April – December 2012). However, figures were considered unreliable and it was decided not to use the data from the WUC sales.

DWA could not provide water abstraction and use data for Maun in 2012/13. To fill this gap, Maun water abstraction for 2012/13 was estimated by multiplying the average per capita water abstraction former DWA villages (135 L/person/day)<sup>10</sup> with the 2011 population figures. Costs and revenues data for Maun were also not available for the accounts.

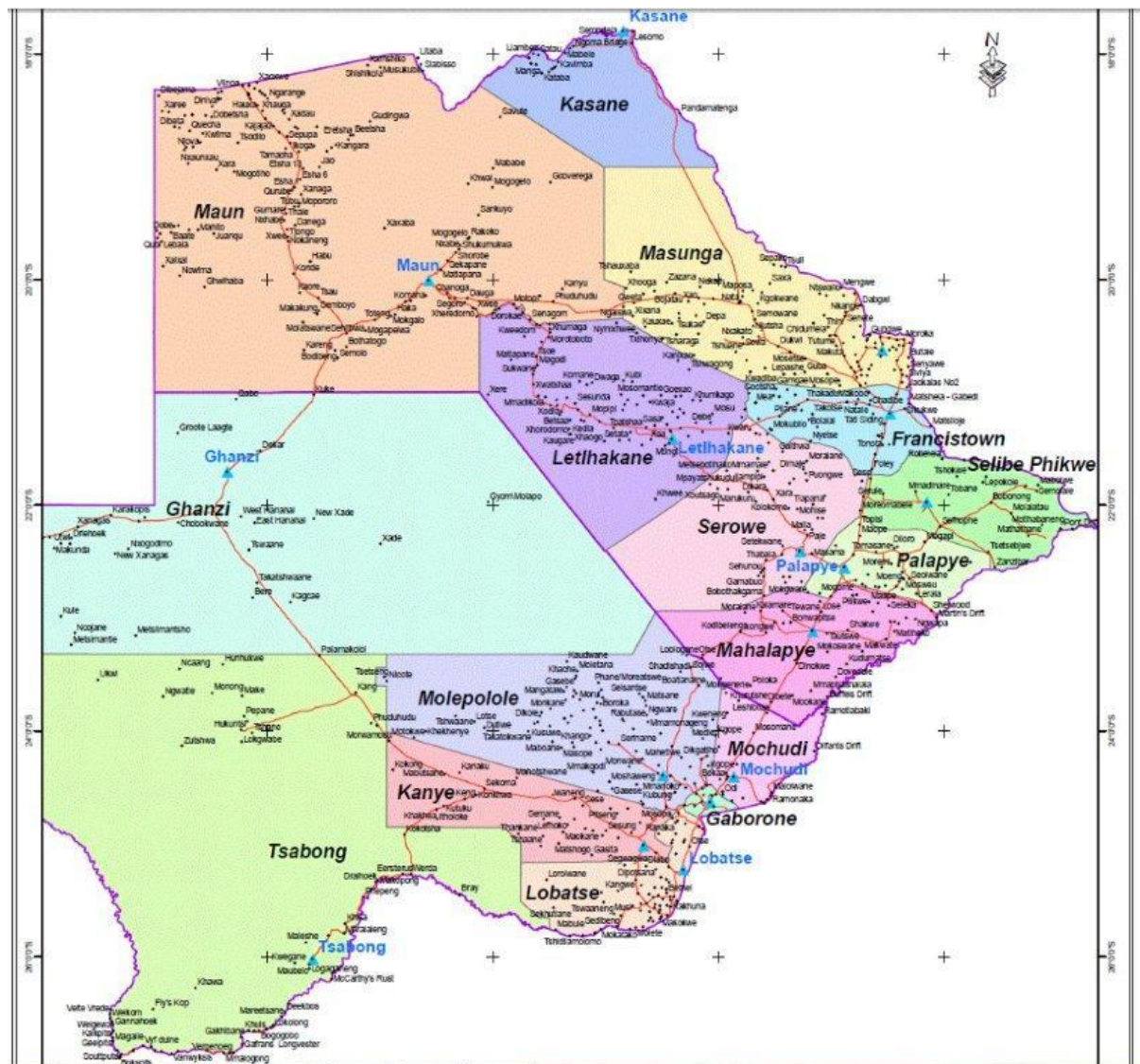
To fill the data gaps, a number of assumptions were used in the study, which are captured in detail in section 3.3 of this report.

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<sup>9</sup>This figure is the average of all metered small villages.

<sup>10</sup>This figure is the average daily water abstraction in all former DWA villages for nine months (period for which data is available).

Map 1: WUC management centres



Source: WUC

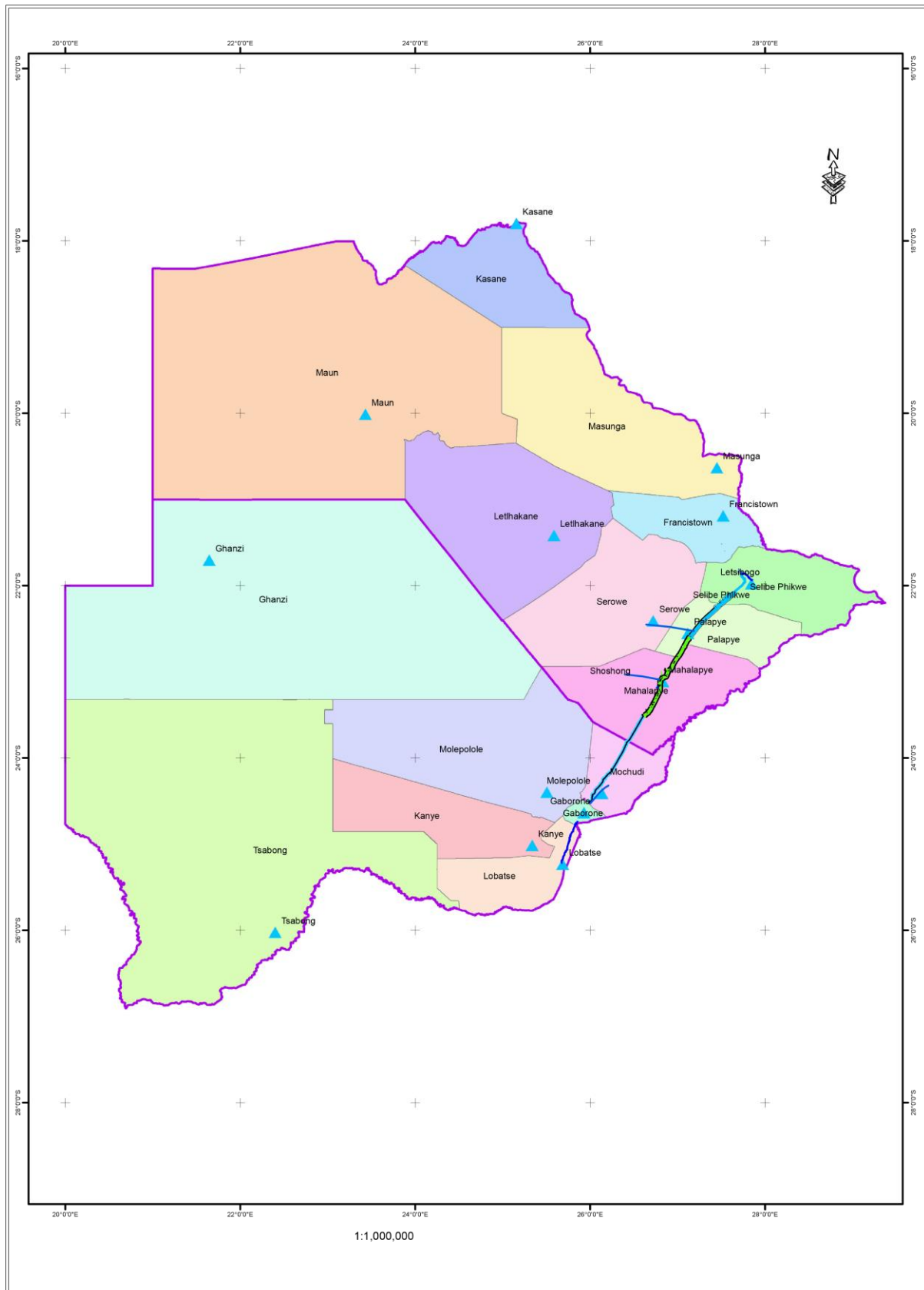
## 7.2 Findings

### 7.2.1 The NSC and water imports

Water resources and supply are unevenly distributed over the country. Some MCs have sufficient water resources (reservoirs) while others depend on limited groundwater that is often saline. Most large reservoirs are found in the north-eastern part of the country. Due to this uneven distribution of water, water is transferred among MCs through the north south carrier (NSC; map 2). The quantity of water abstracted and transferred between April and December through the NSC was about 18.6 Mm<sup>3</sup> between April and December 2012. Most of the water is transferred to Gaborone MC (about 51%; see Map 2 and Figure 8). Selibe Phikwe receives around 28% of water from the NSC while Mahalapye and Palapye account for 12 and 9% respectively. However, the NSC experiences occasional breakdowns, causing water constraints in recipient MCs. WUC continues to encourage water conservation and management measures by the consumers to reduce pressure on the NSC. It is expected that once NSC 2 is in place, it will augment water supply to the southern part of the country.

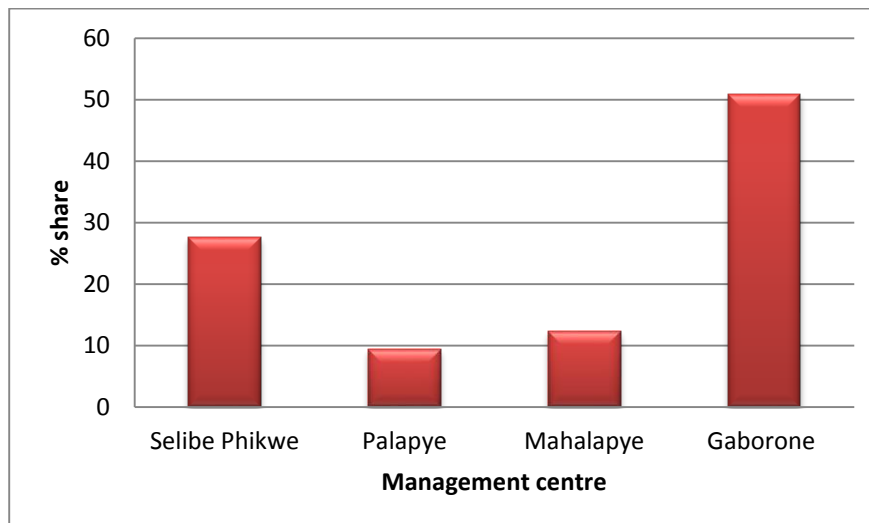


Map 2: The North South Water Carrier



Source: WUC



**Figure 8: Proportion of water transferred from NSC to MCs (April – December 2012)**

Source: based on WUC data.

Additionally, Botswana also has an annual water quota of 7.3 Mm<sup>3</sup> from Molatedi Dam in South Africa (reduced to half when the dam level is below 26%). The imported water (reflected in the SEEA water supply and use tables; Tables 3 and 4) provides water for Gaborone and Mochudi MCs. Other water inflows into the country are restricted to the Okavango and Zambezi/Chobe Rivers. Detailed information on the description of water resources, water abstraction and distribution by MC is given in the appendices and the Regionalisation report.

### 7.2.2 Water abstraction and distribution by MC

Overall, water abstraction is highest for Gaborone MC in 2010/11 and 2011/12 as illustrated in Table 5. Total water abstraction was 197 Mm<sup>3</sup> in 2010/11 and 194 Mm<sup>3</sup> in 2011/12 including abstraction for mines and livestock sectors. District Councils constituted about 15 and 6 Mm<sup>3</sup> in 2010/11 and 2011/12 respectively; the decline in water abstraction is due to the take-over of water provision in most settlements by WUC.

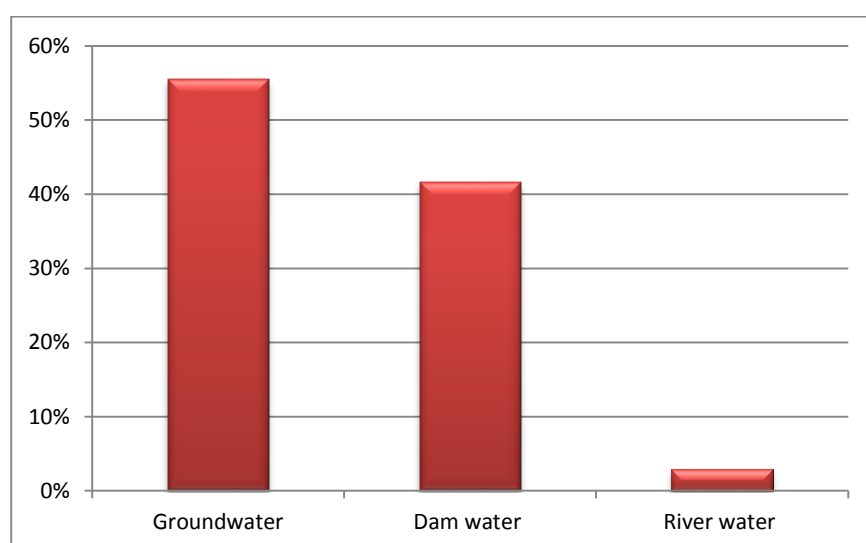
**Table 5: Water abstraction by MC and institution**

	2010/11						2011/12					
	Service providers			Self providers		Total	Service providers			Self providers		Total
MC	WUC	DWA	DCs	Mines	Livestock		WUC	DWA	DCs	Mines	Livestock	
Masunga	3,191.2	-		650.0	5,448.9	9,290.1	5,365.4	-		895.6	5,448.9	11,709.8
Lobatse	10,507.1	-		-	2,793.7	13,300.8	9,617.7	-		-	2,793.7	12,411.4
Mochudi	2,879.7	-		-	1,963.7	4,843.4	3,291.3	-		-	1,963.7	5,255.1
Gaborone	23,851.5	-		-	374.8	24,226.3	25,820.5	-		-	374.8	26,195.3
Palapye	852.2	-		77.5	3,507.1	4,436.8	2,172.6	-		69.5	3,507.1	5,749.3
Mahalapye	1,902.6	-		-	7,269.2	9,171.9	4,727.1	-		-	7,269.2	11,996.3
Kasane	606.6	-		-	698.3	1,304.9	1,147.3	-		-	151.1	1,298.4
Francistown	13,117.1	-		-	3,498.7	16,615.8	12,538.6	-		-	3,498.7	16,037.3
Selibe Phikwe	1,829.8	-		2,740.0	3,368.4	7,938.3	7,743.3	-		3,152.4	3,368.4	14,264.1
Tsabong	-	230.5		-	1,219.3	1,449.9	403.0	-		-	1,283.5	1,686.5
Molepolole	188.2	3,098.3		-	6,983.7	10,270.2	4,357.9	-		-	7,351.2	11,709.1
Kanye	70.2	3,817.8		7,961.9	4,062.9	15,912.8	3,570.3	-		7,106.5	4,276.8	14,953.6
Serowe	-	1,960.8		-	2,143.8	4,104.6	2,629.7	-		-	2,143.8	4,773.6
Letlhakane	-	655.3		13,738.3	2,365.7	16,759.3	681.4	-		16,209.1	2,365.7	19,256.2
Ghanzi	-	644.0		-	4,761.7	5,405.7	865.2	-		-	5,012.3	5,877.5

<b>Maun</b>	-	1,957.1		-	5,015.0	6,972.1	-	1,738.1		1,675.0	4,665.8	8,078.9
<b>Total</b>	<b>70,559</b>	<b>14,787</b>	<b>15,414</b>	<b>30,100</b>	<b>66,348</b>	<b>197,207</b>	<b>93,188</b>	<b>1,907</b>	<b>6,463</b>	<b>31,938</b>	<b>60,868</b>	<b>194,364</b>

Water is mostly supplied from ground water followed by reservoirs and river water. Figure 9 illustrates water abstraction by source of water for 2011/12, including abstraction by self providers and abstraction for Maun MC. The share of groundwater between 2010/11 and 2011/12 has decreased by 1% while surface water use is increasing but not by a large margin (also 1% between 2010/11 and 2011/12). Growth of surface water is likely to increase further in the future with new dam developments and more connections to the NSC. The results indicate that groundwater was mostly abstracted by DWA, DCs and self providers while the share of reservoirs was highest for WUC particularly in 2010/11. During that year, seven large villages (Tsabong, Ghanzi, Molepolole, Kanye, Maun, Thamaga, Serowe, Letlhakane and Moshopa) were still under DWA and a significant number of small villages were also under the DCs where the common source of water is groundwater.

**Figure 9: Water production by source (2011/12)**



### 7.3.3 Conclusions

Water abstraction was estimated for each MC based on WUC data and data/ estimates from self providers. Water abstraction is highest in urban areas (Gaborone and Francistown) and in MCs with large mines and livestock concentrations such as Letlhakane and Kanye MCs. WUC has now abstraction estimates for many small villages with an average daily per capita water abstraction figure 72 L/d/p (water abstraction figures from WUC divided by population size).

In terms of water sources, water abstraction from groundwater is higher than abstraction from reservoirs. There is a slight increase in the use of dam water. There is greater abstraction of dam water by service providers while groundwater is mostly used by self providers. Dam water abstraction has increased from only 41 to 42% between 2010/11 and 2011/12 while groundwater abstraction has declined by 1% from 56% in 2010/11.

The bulk of the water transfers between MCs originate from the NSC (Gaborone MC receives more than 50% of this water) and a limited amount through imports from Molatedi Dam (for Gaborone and Mochudi MCs). There is need to augment water supply with more non-conventional water sources such as treated waste water.

## Chapter 8 Trend analysis

### 8.1 Introduction

Botswana's water accounting efforts date back to the 1990s. The combination of earlier work with the current WAVES WA offer opportunities to identify long term water trends. Earlier reports include DEA, 1999 (covering the period 1990- 1998), CAR, 2002 (focusing on groundwater resources), CAR 2003 (adding wastewater to the accounts) and DEA and CAR, 2006 (up-dating the DEA, 1999 report data to 2003). Therefore, time series existed for the period 1990 – 2003 prior to the WAVES water accounting.

While the trust of the WAVES Water accounting efforts has been on establishing new baseline years 2010-11 and 2011-12, reported in chapter 4 and 5, this chapter presents the findings of a quick up-date of the earlier water accounting results, leading to a 20-year time series in water use<sup>11</sup>. The trend analysis is meant to link the earlier water accounts (1994 - 2003) and the new SEEA modelled water accounts (2010/11 and 2011/2). The main overall findings of this analysis are:

- d. Water use has increased from under 50 Mm<sup>3</sup> in 1993 to just less than 200 Mm<sup>3</sup> per annum in 2010/11. The increase has lagged behind the population and economic growth due to water efficiency increases;
- e. Water is most productively used (in terms of value added and formal employment) in the transport, trade, tourism and other service sectors. From a water resource perspective, the economic diversification drive needs to target service industries, transport and tourism;
- f. WUC has been successful in recovering operating costs over the last decade largely due to low supply costs compared to revenues. Since 2009 however, operating costs have rapidly grown and exceed revenues in 2011/2. This situation cannot continue on the long run and cost control (e.g. greater O & M efficiency) and revenue boosting measures (e.g. tariff adjustment) need to be considered after more recent financial data have become available.

Below, each main trend is further elaborated.

### 8.2 Trend in national water use

The analysis was meant to update and extend the trend in water abstraction and use. The method and assumptions are consistent with the earlier used methods and differ somewhat from the method for the 'new' water accounts 2010-11 and 2011-12. As a result, the abstraction figures slightly differ. The following assumptions were used for the trend analysis:

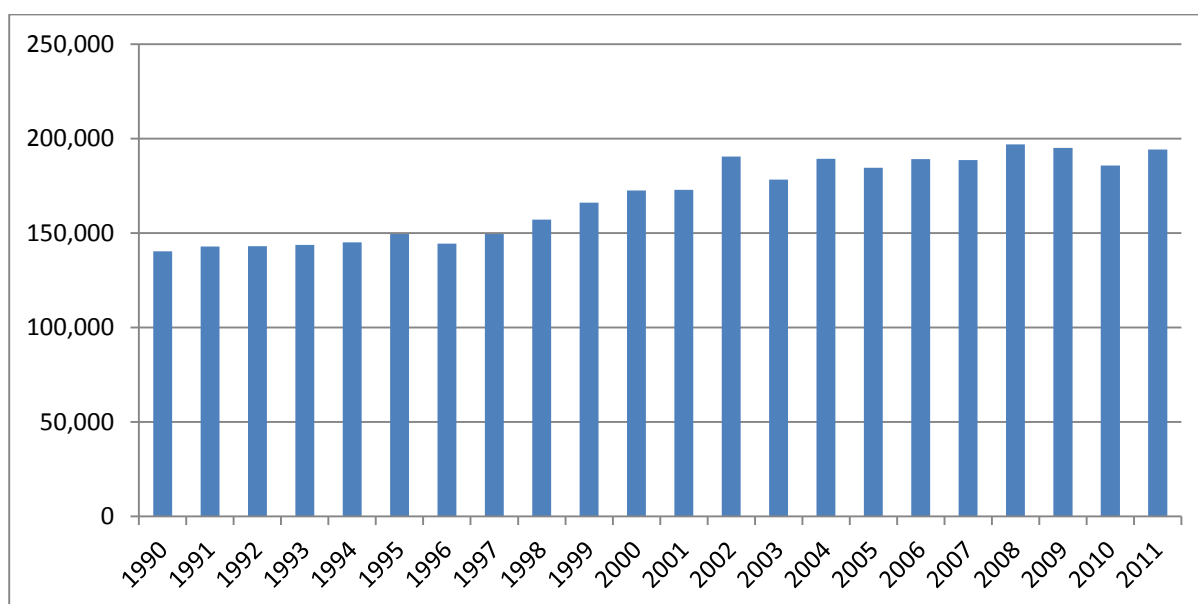
- i. For small villages the water use is assumed to increase annually by 1.9% (this is the annual population growth in the period 2001 – 2011). Water use and abstraction in small villages was never been recorded by the District Councils and therefore had to be estimated. The water use of small villages was earlier estimated based on a per capita use multiplied by the population size. This figure was considered to be too old to be used for the up-date;
- ii. DWA supplied all large villages until 2009/ 10. Tlokweng and Mogoditshane were transferred to WUC in May 2009 and other large villages followed over the period 2010 – 2013; Maun was the last to be transferred in April 2013). The updated sectoral water use (2004-2009) figures were taken from latest DWA file with a sectoral break down and a correction factor (0.49) was applied to be consistent with the overall DWA Production and Consumption file (this procedure was used earlier too).

<sup>11</sup>Due to methodological differences, the results for individual years (2010-11 and 2011-12) are not fully comparable.

No attempt was made to estimate water use by economic sector and sources (as it was too time demanding for a quick trend analysis) and the emphasis on economic sector water use and water sources in the new accounts (chapter 6).

The trend in water use is shown in Figure 10. Botswana's water use has increased by a third from under 150 Mm<sup>3</sup> in 1991/2 to almost 194.3 Mm<sup>3</sup> in 2011/12. Driven by the mining sector, the growth in water use was rapid in the second half of the 1990s, but stabilised in the first decade of the 21<sup>st</sup> century (with annual fluctuations). This can be attributed to agricultural stagnation and lower and economic population growth.

**Figure 10: Long term trend in fresh water use in Botswana (000 m<sup>3</sup>)**



During the same period, GDP more than doubled and the population increased by half. Obviously, water is used more productively and per capita consumption has decreased. Figure 5 implies a decrease in average per capita water use (calculated as the national water use/ national population size) from 107.7 m<sup>3</sup>/person in 1991, to 102.8 m<sup>3</sup>/person in 2001 and to 95.3 m<sup>3</sup>/person in 2011. As during the same period, access to safe water has increased to almost 100%, we conclude that water is used more efficiently. If water use per person would have remained at the 1991 level, the annual water use would have been 215.4 Mm<sup>3</sup> instead of 194.3 Mm<sup>3</sup>. This water efficiency finding forms a good foundation for future IWRM efforts.

### 8.3 Trend in water use productivity

Productivity changes have been measured in terms of value added and employment creation. The value added per m<sup>3</sup> was estimated for the period 1994 – 2010 using rebased value added figures provided by Statistics Botswana (constant BWP2006 in thousands) and the annual water use from the water accounts. The results are shown in Figure 11. The value added increased by 50% from BWP0.21/m<sup>3</sup> in 1994 to BWP0.32/m<sup>3</sup> in 2010. This may be attributed to changes in the economic structure of the country towards less water intensive sectors and/ or achieving greater water efficiency in existing use sectors.

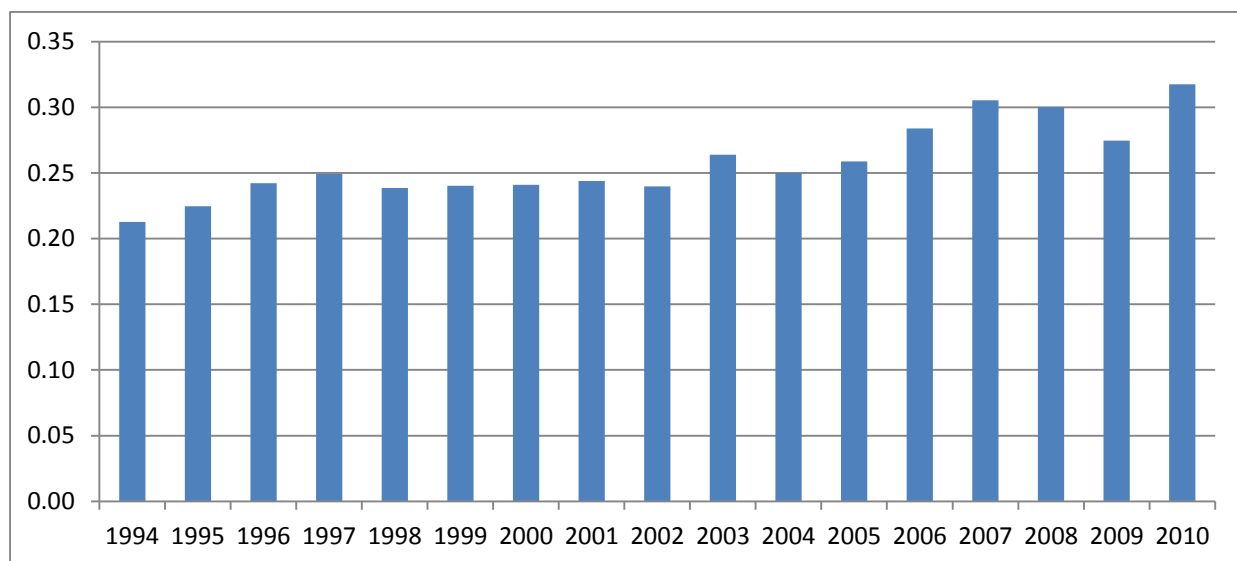
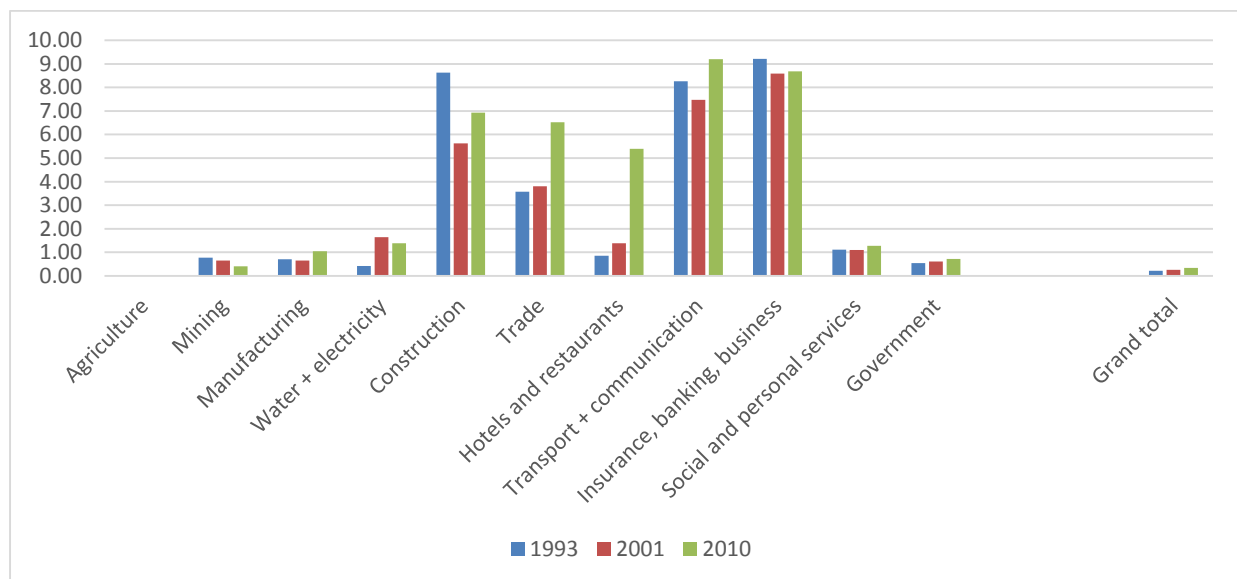
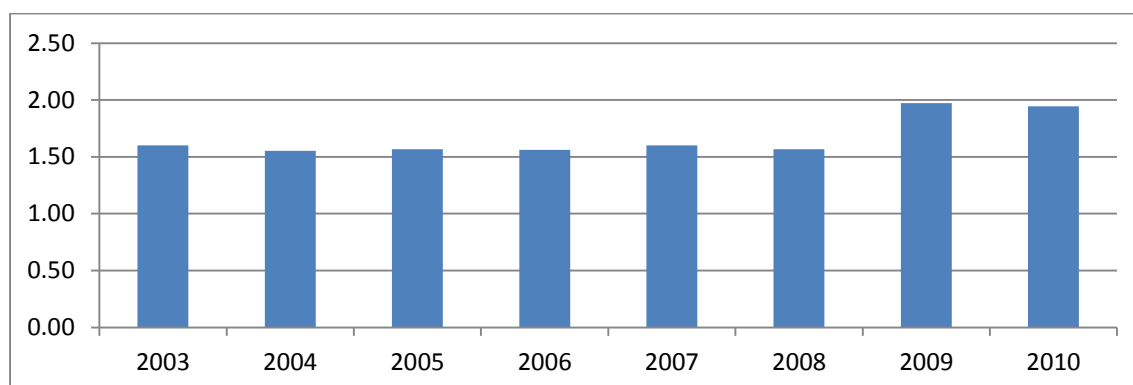
**Figure 11: Trend in value added per m<sup>3</sup> (in constant 2006 BWP)**

Figure 12 shows the value added by sector for three years. The value added/ m<sup>3</sup> has increased in the trade and hotel/restaurant sectors as well in social & personal services and government. Value added/ m<sup>3</sup> has decreased in the mining sector.

**Figure 12: A comparison of sectoral value added/ m<sup>3</sup> in 1994, 2001 and 2010.**

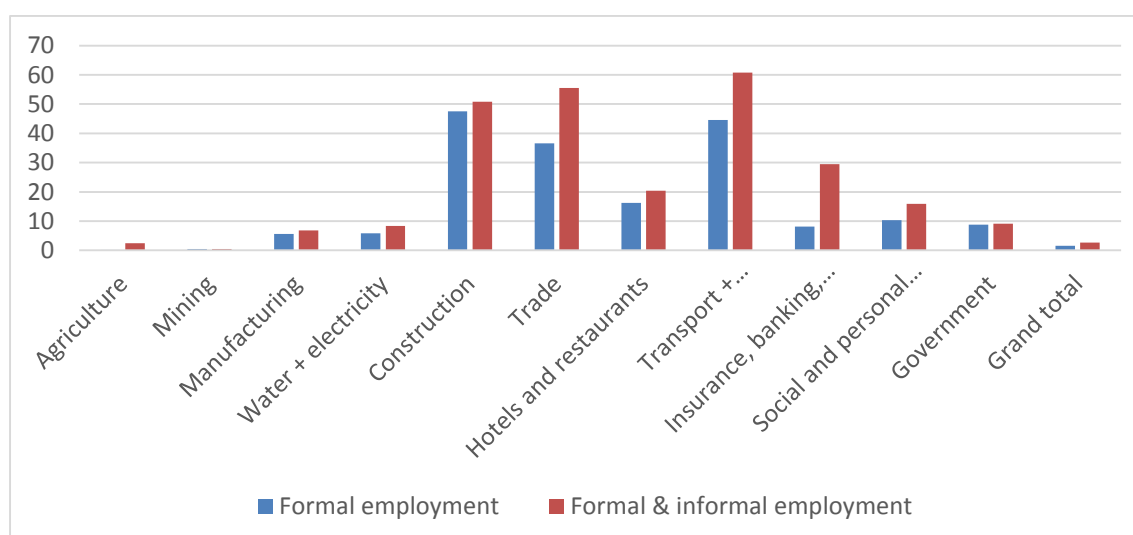
The trend in water use per formal job was assessed for the period 2003 – 2010. Figure 13 shows that formal employment associated with water increased from 1.6 jobs/ 000m<sup>3</sup> in 2003 to 1.9 jobs/ 000m<sup>3</sup>. The relationship between water use and formal employment is fairly stable. The increase in 2009 and 2010 is due to the Ipelegeng programme that has boosted formal employment without using much water.

**Figure 13: Trend in formal jobs per 000m<sup>3</sup>.**

Note: the surge in formal employment from 2009 onwards is due to the Ipelegeng programme.

Informal employment is important for livelihoods and its inclusion in the indicator gives a better perspective on the employment creation/ m<sup>3</sup>. Formal and informal employment data are available for the year 2007 and the employment generation/ 000 m<sup>3</sup> was calculated for that particular year (Figure 12). Informal employment figures are taken from the Informal Sector Survey. In addition, data from the Agricultural Statistics were used to estimate informal employment in the agricultural sector, assuming that all agricultural holdings have 1 informal job, i.e. self-employment of the farmer (110 810). Moreover, agricultural workers data were used from the same statistics (23 056).

Inclusion of the informal employment as described shows in Figure 14 that on average 2.7 jobs are associated with 1000 m<sup>3</sup> of water use (2007). This is almost double that of the formal sector employment (1.5 jobs). Job generation in the agricultural sector more than doubles but the employment/ 000m<sup>3</sup> remains low as compared to economic sectors, other than mining.

**Figure 14: Formal and informal employment by sector (2007; jobs/ 000 m<sup>3</sup>)**

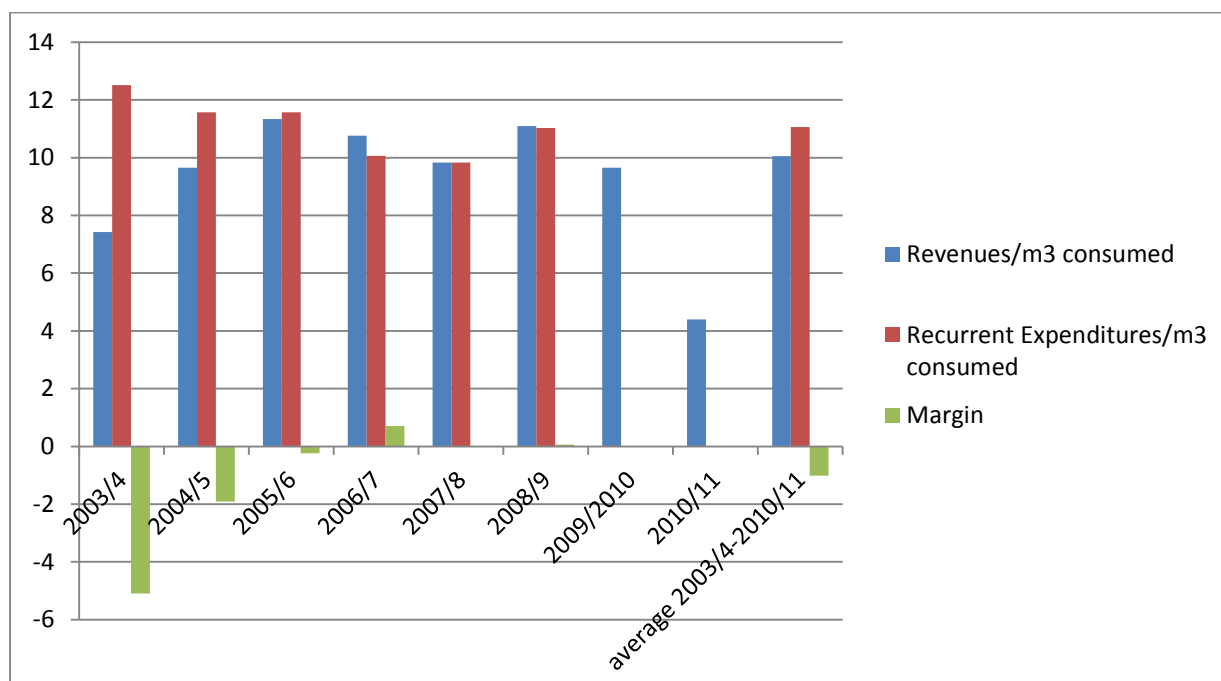
Sources: Employment figures derived from the 2007 Informal Sector Survey and annual employment statistics.



#### 8.4 Trend in revenues & costs

No data exist for District Councils, but DWA and WUC have documented their annual recurrent revenues and costs. Figure 15 shows the trend over the last decade of annual average annual revenues and recurrent costs per m<sup>3</sup> as well as the margin (i.e. revenues – recurrent costs). Over this period 2003/4 to 2010/11, DWA did not recover its recurrent expenditures. The average revenues/m<sup>3</sup> used was BWP 10.05 compared to recurrent expenditures of BWP11.06, leading to a 10% shortfall.

**Figure 15: Trends in DWA unit revenues and recurrent expenditures (2003/4 – 2010/11; BWP/m<sup>3</sup>).**

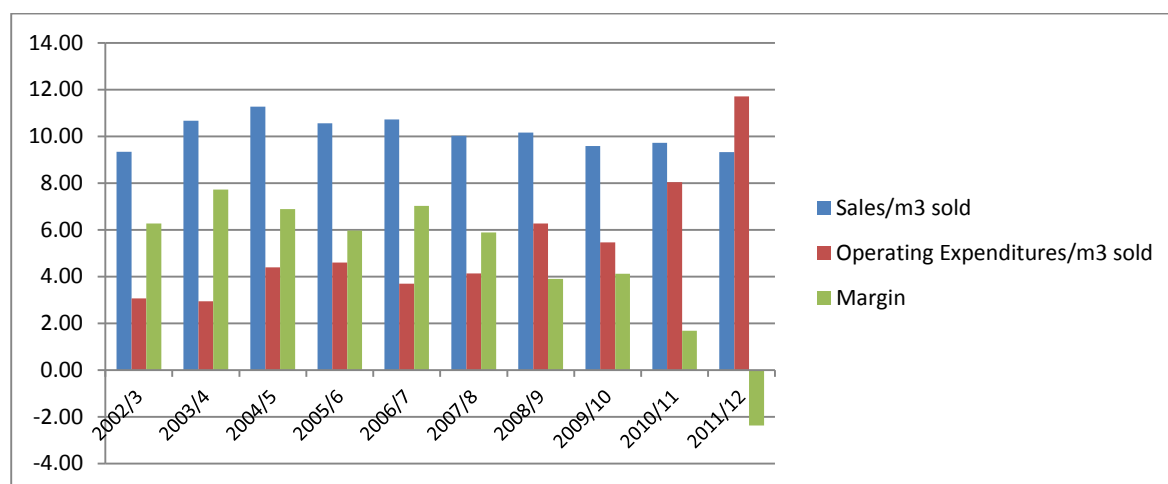


Note: no recurrent expenditure figures available for 2009/10 and 2010/11.

Source: DWA P & C data large villages

In contrast and as required by law, WUC has recovered its operating expenditures over the period 2002/3 to 2011/2 (Figure 16). The average revenues/ m<sup>3</sup> sold BWP 10.14 compared to recurrent expenditures of BWP5.43. The revenues were similar to those of DWA, but the operating expenditures were less than half of those of DWA. However, the positive margin has quickly reduced after the introduction of the water sector reforms and the margin became negative in 2011/12, mostly due to a rapid rise in operating costs to levels similar to DWA. This is unsustainable on the longer term and requires further analysis<sup>12</sup> and action.

<sup>12</sup>One cause of the cost increase is that WUC expenditures now include wastewater treatment, making a direct comparison with earlier figures difficult. It has not yet been possible to separate the cost of wastewater treatment.

**Figure 16: Trend on WUC unit revenues and operating expenditures (2003/4 – 2011/2; BWP/m<sup>3</sup>)**

Source: WUC data on revenues and operating expenditures

## Chapter 9 Road map for institutionalisation of water accounting

### 9.1 Introduction

Proper institutionalisation of water accounting is arguably the most important component of sustainable water accounts. History has made this clear in Botswana as earlier water accounting efforts remained 'projects' without a sustainable institutional base and did not find their roots. As a result, they were one-off exercises that were not maintained.

Botswana is now in a better position to institutionalise the WA due to several recent developments. Firstly, the water sector reforms (2009 – 2014) mandated the Department of Water Affairs to assume responsibility for (integrated) water resource management. WA are an important WRM tool. Reference to the need to establish water accounts is made in policy documents such as the 2006 Review of the NWMP, the draft Water Policy and the 2013 IWRM-WE Plan, indicating that WA are needed and should be housed at DWA. Secondly, NCA has high level policy support in Botswana through the Presidential signing of the May 2012 Gaborone Declaration on Sustainability in Africa and through two 2012 meetings of the Botswana Economic Advisory Council (BEAC), which prioritised the development of water accounts as the first activity of the WAVES Botswana programme (CAR and Econsult, 2012). These developments offer a favourable environment for successful institutionalisation of the WA.

Below, the proposed data collection structure is outlined (section 9.2) followed by the organisational structure (9.3). While DWA is the lead agency, it needs to rely on inputs, data and cooperation from other stakeholders and sectors. Integrated resources planning cannot be achieved by a single institution.

### 9.2 Data collection structure

The main sources of data for the water accounts are the water service provider (WUC), water self providers (mines, farmers and construction and tourist companies operating outside settlements), Statistics Botswana and line ministries/ departments (Ministry of Agriculture, Crop Production, and Ministry of Mineral, Energy and water Resources, dep. of Mines). Data should be annually collected by DWA based on an agreed template with the data providers. It is important that WUC will incorporate an economic classification in its client's base. This will increase the accuracy and consistency of the economic classification, and reduced the work load significantly<sup>13</sup>. DWA will verify the data and enter them into the accounting framework and Excel spread sheets. The next step is to annually analyse the findings and policy implications thereof with the water sectors and development planning stakeholders. The last step is critical in order to ensure that WA will impact on IWRM and development planning. The compilation and analysis process is summarised in Figure 17.

The link between water accounts and the national development planning process is shown in Figure 16. It shows that the policy analysis from water accounting needs to contribute to the review of past NDP and the development of the new NDP (11) as well as to the Mid-term Review, which leads to adjustments in the NDP when necessary. Moreover, findings can be used for the annual budget speeches to briefly describe the water resources situation, for example using some of the indicators.

<sup>13</sup>The annual WUC water use data provision would become a fast, fully computerised exercise. For the current work, a team of up to 9 persons worked for over two weeks on assigning economic classification codes to WUC customers.

Figure 17: Proposed WA compilation and analysis process.

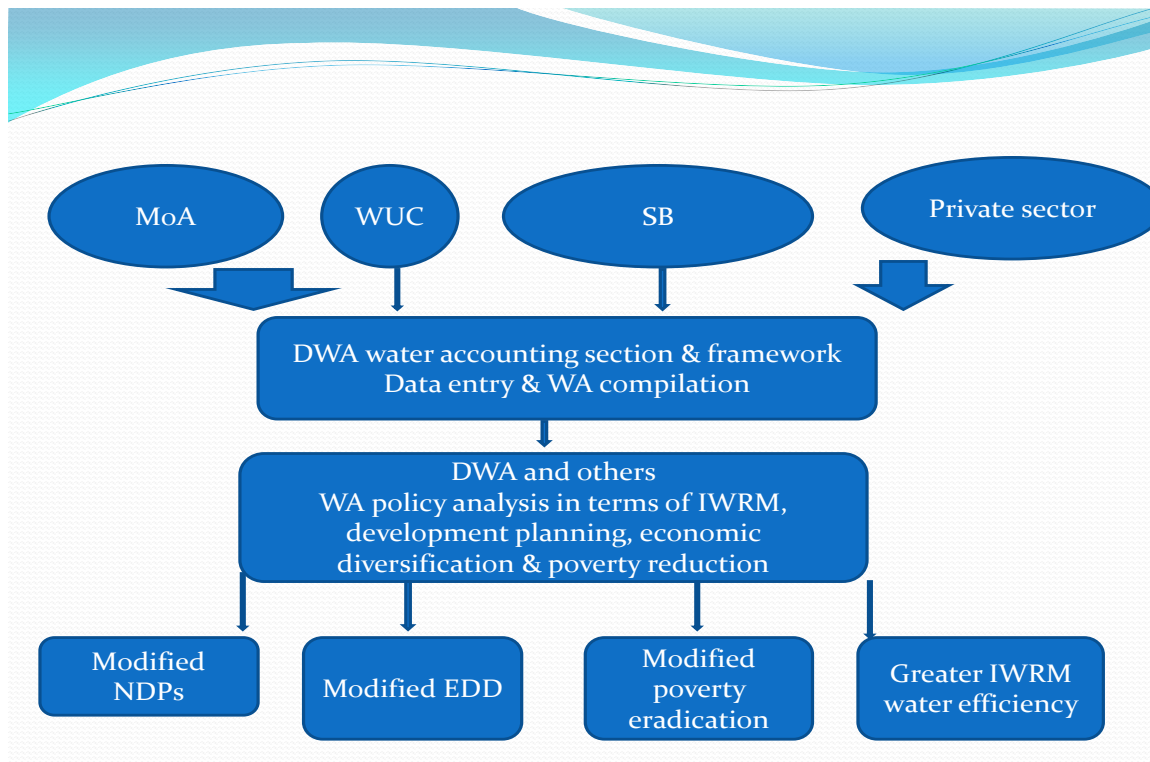
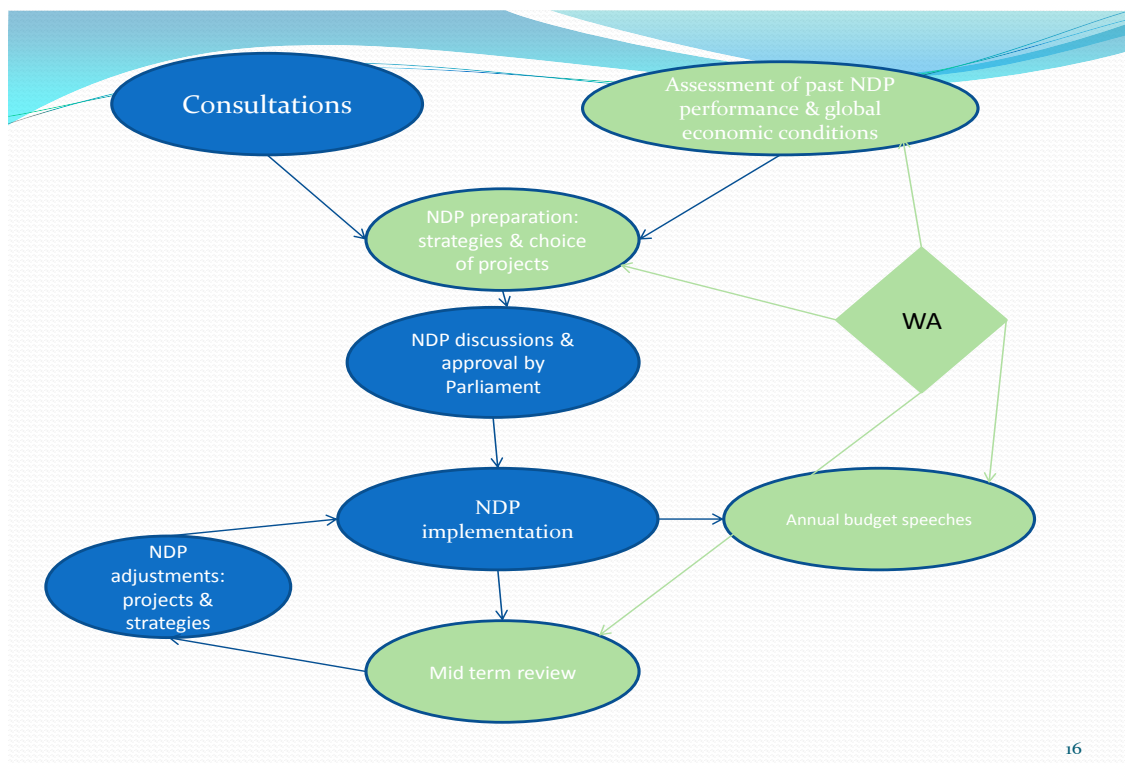


Figure 18: Water accounting and the national development planning process



### 9.3 Organisational structure

With its water management mandate, DWA needs to be the lead and coordinating institution for water accounting. This is consistent with the draft Water Policy and the IWRM-WE Plan 2013 - 2030. DWA plans to establish a water accounting unit with four staff (2 juniors, 1 senior and a supervisor). This unit will have administrative support to ensure its efficient operation. It is important that the water accounting staff have technical water supply/ engineering and (socio-) economic expertise, and a good understanding of IWRM. In other words, a multidisciplinary team needs to be formed.

The Water Accounting Unit needs to be closely linked to and supported by inter-ministerial and interdepartmental working groups, which are responsible for the regular supply of data, expansion of the WA and the policy analysis of the results. The unit also needs to maintain regular contacts with the private sector and civil society. The following working groups (WG) are currently envisaged:

- i. *Water management regions.* Currently, WUC MCs have been used; however, a discussion needs to be initiated as to which regional classification is most appropriate in view of the need to work at water catchment area level and bring in data from agricultural regions and administrative districts. This WG deals mostly with regional data on water abstraction, consumption, losses, costs and revenues from WUC and self providers. The WG should have members from DW, WUC, SB, Ministry of Agriculture and mines as well as from major self providers;
- ii. *Irrigation sector.* This WG will deal with water abstraction, use and consumption for irrigation. While water use is modest at present, it is expected to grow in future. The WG members consist of DWA, WUC, MoA (irrigation & horticulture), SB, Ministry of Lands and WAB/WRB;
- iii. *Mining sector.* This WG will deal with water abstraction and use by the mining sector (mostly self providers). The WG members will be DWA, WUC, Dep. of Mines, mining companies, SB, WAB/WRB and Ministry of Lands;
- iv. *Water stock accounts.* This WG mostly deals with stock accounts, initially of dams later also of aquifers. The WG members consist of DWA, WUC, SB & DGS; and
- v. *Policy analysis of WA findings.* This WG aims specifically to regularly review the results of WA and their implications for development planning, IWRM and land use planning. The members include government (e.g. DWA, WUC, MFDP, Ministry of Lands, MoA, dep. of Mines), private sector and civil society.

Working groups 1, 2 and 4 are already operational; working groups 3 and 5 need to be soon formed.

Regular meetings need to be held by the MMEWR with the main stakeholders to ensure that data are provided to DWA, review progress and resolve any challenges that emerge. The DPS- MMEWR and the WAVES coordinator will discuss progress in the WAVES Steering Committee that is established and chaired by MFDP. The Steering Committee guides the overall WAVES activities in Botswana, ensures institutionalisation of water accounts and other accounts that will be developed and ensures that policy discussions and recommendations emanating from the NCA findings are incorporated in development planning, in particular the preparation of NDP11 and the work of the four thematic working groups formed by NSO.

### 9.4 Road map for institutionalisation of water accounting

The proposed road map for water accounting in WAVES phase 3 is presented in Table 6. There will be regular DWA seminars and training workshop for all major stakeholders, including MFDP to ensure that natural capital accounting will be fully incorporated in the next development planning cycle

(NDP11). It is envisaged that at the end (or earlier) of the WAVES programme the WA are fully institutionalised and maintained by DWA.

#### Key land marks

November 2013:	Establishment of Water Accounting Unit within DWA Introduction of WA at second day of Water Pitso
December 2013:	Formation of mining sector and policy analysis working groups Finalisation of water accounting support structure and responsibilities at MoA, SB, Mines,
2014:	Up-dated 2012-13 water accounts & Policy analysis Up-dated 2013-14 water accounts; Water regionalisation & GIS; Policy analysis & initial inputs into NDP 11 preparation
2015:	WA results fully integrated in NDP11

**Table 6: Road towards institutionalisation of water accounting (2013 – 2014)**

	Activity	July 13- June 14	July 14 – June 15	July 15 – June 16	Lead agent	Technical support
1	Annual up-dating of the WA (starting with 2012-13)	2012 – 2013 2013- 2014	2014 - 2015	2015 - 2016	DWA	Only in 2013-14
2	Capacity building and institutionalisation	Establishment of WA unit in DWA (August 13) Establishment of support capacity in key stakeholders (WUC, MoA, SB. Mines) and WA working groups (Oct. 13) 1 technical training workshop (Nov 13) Quarterly WA seminars at DWA	1 technical training workshop (Sept. 14) Quarterly WA DWA seminars	1 technical training workshop (Sept. 15) Quarterly WA DWA seminars		TA for training workshops, WA unit & WA working groups
3a	WA sub regions and GIS: Agreement about use of and links between MC, catchment areas, agricultural areas and adm districts	Design of most appropriate regionalisation for WA	GIS work and WA on regionalisation		DWA with contributions WUC & MoA	TA
3b	Design of a relevant uniform economic classification for SB, WUC and other accounts	Establishment of working group to identify relevant economic sector classification & uniform corporate classification (Oct. 13) Incorporation of sector classification in WUC client base (March 14)			SB & WUC	TA
4	Policy analysis and recommendations	Policy analysis at 2 <sup>nd</sup> day of 2013 Water Pitso: development planning and implementation of IWRM-WE and Water Policy	Policy brief and policy analysis workshop Position paper WA for NDP11 (June 15?)	Policy brief and policy analysis workshop	DWA & MFDP	TA
5	Monetary aspects of WA	Analysis of WUC revenues and costs as well as tariffs			WUC & DWA	TA
6	Technical expansion of WA	Agricultural dam accounts Irrigation water abstraction and use Water losses	Wastewater subject to metering Groundwater stock accounts Mining sector		DWA	TA

## Chapter 10 Resource indicators and policy analysis

Prudent water resource management should be informed by key resource indicators and by policy analysis of the results of water accounting. This chapter first summarises key indicators developed in conjunction with the water accounts (section 10.1) and proceeds to analyse the results of water accounting for policy and resource management (section 10.2).

### 10.1 Water resources indicators

The current water accounts generate several indicators that are indicative of the use of water as natural capital:

- ✓ Water resources availability indicators such as:
  - Water storage capacity and safe yields
  - Per capita internal (and total) renewable water resources, including the dependency ratio (dependency on external renewable resources);
  - Per capita reservoir water storage capacity and annual reservoir resources available;
- ✓ Water abstraction and use indicators;
- ✓ Water use efficiency indicators: value added per m<sup>3</sup> and employment per m<sup>3</sup>;
- ✓ Technical and financial performance of water service providers:
  - O&M unit costs and revenues, financial sustainability of water service providers.
  - Water losses in distribution networks.

Details for each category of indicators are given below.

#### Water resources availability:

##### *Main features:*

- ✓ Safe yields of reservoirs are well below per capita water use;
- ✓ Expansion of reservoir safe yields is urgent and can be achieved by completion of new dams and interconnection of reservoirs and well fields;
- ✓ Heavy reliance on external renewable surface water resources

##### *Indicator values:*

Internal renewable water resources IRWR (av. Period 2000 – 2010):	3 683 Mm <sup>3</sup>
Total renewable water resources TRWR (av. Period 2000 – 2010):	12 123 Mm <sup>3</sup>
Dependency ratio (1 – IRWR/TRWR):	70%
Per capita IRWR:	4 983 L/p/d
Water storage capacity in reservoirs (2010/11 & 2011/2):	422 Mm <sup>3</sup>
Safe yields from reservoirs (2010/11 and 2011/12):	73.5 Mm <sup>3</sup>
Safe yields as % of storage capacity:	17.4%
Water storage capacity per capita (2011/12):	522 L/p/d
Safe yield storage capacity per capita (2011/12):	96 L/p/d
Storage capacity as % of internal run off:	24%

#### Water abstraction and use:



*Main features:*

- ✓ Groundwater is the largest source of water country wide; mines and livestock and rural settlements depend on groundwater;
- ✓ Abstraction for own use exceeds the abstraction for distribution by WUC;
- ✓ Agriculture is the largest water using sector followed at a considerable distance by domestic use and mining;
- ✓ Per capita total water use is 267 L/d/person, compared with safe yields from reservoirs of 96 L/person

*Indicator values:*

## Total water abstraction p.a.

- |                                       |                      |                       |
|---------------------------------------|----------------------|-----------------------|
| • 2010/11                             |                      | 197.7 Mm <sup>3</sup> |
| • 2011/12                             |                      | 194.4 Mm <sup>3</sup> |
| • Abstraction from groundwater        |                      | 103.4 Mm <sup>3</sup> |
| • Abstraction from surface water      |                      | 91.0 Mm <sup>3</sup>  |
| ✓ Reservoirs                          | 75.6 Mm <sup>3</sup> |                       |
| ✓ Rivers                              | 15.4 Mm <sup>3</sup> |                       |
| • Abstracted for own use              |                      |                       |
| ✓ 2010/11                             |                      | 99.5 Mm <sup>3</sup>  |
| ✓ 2011/12                             |                      | 103.4 Mm <sup>3</sup> |
| • Abstraction for distribution;       |                      |                       |
| ✓ 2010/11                             |                      | 97.7 Mm <sup>3</sup>  |
| ✓ 2011/12                             |                      | 90.9 Mm <sup>3</sup>  |
| • Water use by households (2011/12):  |                      | 38.0 Mm <sup>3</sup>  |
| • Water use by government (2011/12):  |                      | 11.6 Mm <sup>3</sup>  |
| • Water use by agriculture (2011/12): |                      | 74.6 Mm <sup>3</sup>  |
| • Water use by mining (2011/12):      |                      | 34.6 Mm <sup>3</sup>  |
| • Other productive use (2011/12):     |                      | 28.1 Mm <sup>3</sup>  |

## Domestic water use p.c.:

- |           |                   |
|-----------|-------------------|
| • 2010/11 |                   |
| • 2011/12 | 50.4 L/day/person |

## Total water use p.c.:

- |            |                    |
|------------|--------------------|
| • 2010/11: |                    |
| • 2011/12: | 266.6 L/day/person |

## Return flows:

- Currently not included in the accounts. A significant and growing resource.

Water use efficiency:*Main features:*

- ✓ Economic benefits: per 1000 m<sup>3</sup>, BWP 367 value added is created and 2.3 jobs in the formal sector and another 1.2 jobs in the informal and traditional agricultural sector.

*Indicator values:*

- Value added/ m<sup>3</sup> (constant 2006 BWP)
  - ✓ 2010/11: 0.34
  - ✓ 2011/12: 0.37
- Formal employment (jobs/000 m<sup>3</sup>)
  - ✓ 2010/11: 2.3
  - ✓ 2011/12: 2.3
- Formal & traditional agricultural employment (jobs/ 000 m<sup>3</sup>)
  - ✓ 2010/11: 3.5
  - ✓ 2011/12: not available

Technical and financial performance of water service providers

Main features:

- ✓ Water losses are just over 25%: 1 L out of 4 L is lost.
- ✓ WUC did not recover O&M costs from water sales.

*Indicator values:*

Water losses service providers

- 2010/11: 24.7 or 25.3%
- 2011/12: 22.8 Mm<sup>3</sup> or 25.2%

Financial performance water service provider

- ✓ For DWA, the average revenues/m<sup>3</sup> used was BWP 10.05 compared to recurrent expenditures of BWP11.06, leading to a shortfall of 10% (period 2002/3- 2010/11).
- ✓ For WUC, the average revenues/ m<sup>3</sup> sold BWP 10.14 compared to recurrent expenditures of BWP5.43 (period 2002/3 – 2010/11), leading to a considerable surplus of 87%.

## 10.2 Analysis and policy implications

As shown above, the water accounts generate a range of indicators for water resource management and development planning.

As a first step, the renewable water resources have been calculated as the product of rainfall minus evaporation multiplied by the country's size (internal) and the inflows from outside (i.e. Okavango River). The inflow from the Okavango is more than three times the internal renewable water resource (IRWR), leading to a very high dependency ratio (70%). The annual IRWR is estimated to be less than 5000 L/day/person.

The water accounts show that Botswana abstracts 194.4 Mm<sup>3</sup> from groundwater (103.4 Mm<sup>3</sup>), reservoirs (73.5 Mm<sup>3</sup>) and rivers (15.4 Mm<sup>3</sup>). The abstraction from reservoirs (75.6 Mm<sup>3</sup>) marginally

exceed the safe yields of the reservoirs ( $73.5 \text{ Mm}^3$ )<sup>14</sup>. This is risky and explains why several reservoirs drying up during drought periods. The construction of the new reservoirs need to be completed as soon as possible and the reservoirs need to be connected to the water distribution network. A similar concern may exist for ground water: if the abstraction ( $103.4 \text{ Mm}^3$ ) exceeds the recharge (not known for the country), groundwater abstraction is unsustainable and needs to be reduced or new well fields need to be developed. This situation is likely to occur in several well fields (see Water Statistics 2004).

Water abstraction appears to have gone down marginally between 2010/11 and 2011/12. One cannot attach much value to this until more years become available. The drop may be due to improved data sources (in 2010/11) but can also indicate water distribution constraints<sup>15</sup>. In terms of water use, total daily water use is estimated to be 267 L/d/p. This is well below the safe yields of reservoirs (96 L/d/p) and shows the country's continued reliance on groundwater. Households use on average 50 L/d/p while the remainder (217 L/d/p) goes to agriculture, mining, government and other productive uses.

Water losses are only documented for service providers, but are also likely to occur among self providers. Losses are estimated to be 25.2 % in 2011/12 for water service providers (mostly WUC). Reaching the water loss target of 15% losses would save  $6.3 \text{ Mm}^3$  of water or close to 5% of the country's water use. The current accounts do not record return flow. In earlier work, these were estimated to be 20 to  $30 \text{ Mm}^3$ , offering also a significant source for fresh water savings (10 to 15%). Both measures together could thus generate 15 to 20% more water resources for development!

The WA findings to-date have some important policy implications. It is encouraging<sup>16</sup> to note that water use increases slower than the population and economy at large (Figure 5 and section 4.2.3). In other words, water use is partly delinked from population and economic growth. Had this not been the case, water scarcity would have been more pressing and water infrastructure would have had to increase faster.

Water abstraction and use figures for small settlements are now becoming available through WUC. These figures are important to better understand and account for water in rural areas, and will facilitate better planning and management of rural water infrastructure.

WUC revenue and expenditure balance has been deteriorating during the water sector reform transition period. The causes of the growing imbalance between costs and revenues need to be analysed and addressed to ensure long term sustainability and efficient water and wastewater delivery and treatment. The causes may include: extra costs of wastewater treatment without additional revenues, delayed billing, high water supply costs during transition period of the water sector reforms. The possible solutions include raising tariffs (e.g. adding a wastewater treatment fee to the water tariff), costs reductions and/or increased subsidies. Efficient service delivery needs to contribute to cost control, and reduce the level of future tariff increases.

Records on the amounts of waste water (inflows and outflows) do not exist. This data gap hampers the re-use and recycling of wastewater as targeted by the 2003 NMPWWS, which has the target of 96% re use of the outflows. It is essential that WUC starts measuring wastewater inflows and outflows as soon as possible, and that the re-use of wastewater is metered and recorded. The amount of wastewater has rapidly increased (estimated at  $27.1 \text{ Mm}^3$  in 2003; DEA and CAR, 2006). It is a valuable resource (close to population centres) for irrigation and other potential users of non-potable water.

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<sup>14</sup> This excluded the new dams Dikgatlong, Thune and Lotsane. The safe yields have increased to  $139.7 \text{ Mm}^3$  in 2013.

<sup>15</sup> The decrease only occurs for abstraction for distribution.

<sup>16</sup> This assumes that water consumption is not structurally held back by lack of access to water. Monitoring of water consumption in settlement is necessary to answer this question.

Flow accounts of wastewater need to be included in further development of the Botswana Water Accounts.

The review of the irrigation sector showed that data on water abstraction and use for irrigation are fragmented and need validation before new figures can be included in the water accounts. Better insight is needed in the current water abstraction and use of the sector as well as its performance in terms of food production and value added/m<sup>3</sup>. Moreover, over half of the current irrigation schemes are not under cultivation, and there is need to fully utilise serviced irrigation land. This should inform new large irrigation projects sector (e.g. from Chobe-Zambezi). All new wastewater treatment works need to be constructed with adjacent facilities for re use of treated water.

Self-providers account for half of the water consumption and yet they are often overlooked in discussions about water resource management. The water supply and use of self-providers deserves much more attention in future water resource management. Unlike with water-service providers no separate abstraction and use figures are available. Competition for potable fresh water should be eased in future by increasing use of saline water in mining operations (as some mines have started to do or explore). This needs to be a priority for the Water Resources Board, and is included in the IWRM-WE Plan 2013-2030.

The water sector reform programme has important potential advantages for WA and IWRM. These include:

- a. Accounting of water consumption in all settlements
- b. Accounting for wastewater inflows and outflows;
- c. Greater simplicity and transparency of supply (i.e. only one water service provider);
- d. Explicit water resources management mandate for DWA.

This study has shown, however, that the reforms pose short term problems such as data gaps, incompatibilities and discrepancies and renewed focus on supplying water ('keep it flowing'). Moreover, the risk exists that water supply is solely prioritised at the expense of IWRM and water demand management. This would take the country a step back from the recommendations of the 2006 Review of the BNWMP and the IWRM-WE Plan, and have significant long term costs. DWA should already use its existing capacity to urgently monitor the situation and to start compiling a comprehensive data and monitoring base. It is important that the inflow into dams and the in- and out-flows of wastewater treatment works are monitored; this is not the case at the moment.

Competition for water resources has grown and will continue to grow in future. This is of limited concern to the livestock sector. Although its overall water use is large, it is spread over the entire country, and in many instances, there are no more productive alternative uses. This is not the case for irrigation. The use of the country's allocation of 495 Mm<sup>3</sup> of water from the Chobe-Zambezi system needs to be carefully planned and justified. Irrigation expansion must be evaluated together with growing demands of the mining sector and settlements. Promotion of the use of saline water for mining needs to be considered to reduce competition with agriculture and settlements.

It is essential the water accounting results are fully integrated in the NDP 11 preparation process. The main points include:

- e. Future water allocation should be based on social and economic merits and should compare the merits of alternative sector water uses. During the plan preparation, government needs to discuss the best use of its Chobe-Zambezi allocation.

- f. NDP 11 should contain a detailed wastewater re-use strategy in order to achieve the NMPWWS re-use target. Re-use efforts need to be accelerated by the Ministry of Agriculture and WUC;
- g. The costs of water management should be fully assessed and the financial burden should be fairly and evenly distributed between government, households and the private sector; the current level of subsidies is probably unsustainable and rising costs will lead to higher water tariffs across the board.
- h. Water scarcity should become one of the considerations in the economic diversification drive. It should:
  - i. Discourage economic diversification towards water intensive sectors; and
  - ii. Encourage the development of a water conservation industry for the local and export markets.

### 10.3 Recommendations

#### Water resource management:

- ✓ Include water resources availability in economic diversification and trade policies;
- ✓ Prioritise water demand management for MC shortage areas; there is need to augment water supply with non-conventional water sources such as treated waste water;
- ✓ Further increase water efficiency gains;
- ✓ Regular data collection & analysis;
- ✓ Encourage re-use of TWW and saline water for sectors such as irrigation, mining and construction;
- ✓ Increase safe yields from water infrastructure system;
- ✓ Better monitoring of self providers;
- ✓ Implement user-pays-principle and polluter-pays-principles;
- ✓ Expand water accounts with stock accounts for major aquifers/ well fields, with flow accounts for treated wastewater and with monetary accounts (starting with costs and revenues of water supply); and
- ✓ The findings of new water accounts should be annually analysed in terms of policy and development planning implications.

#### Water service providers:

- a. WUC should include the economic sector classification in its client details data base. DWA, SB and WUC need to agree on a uniform economic classification system based on ISIC.
- b. Agreement should be sought about a suitable regional classification for the water accounts. This should be based on the current WUC MCs, catchment areas and aquifers (in line with IWRM) and other relevant spatial classifications (e.g. administrative or agricultural). Future differences in spatial data can be bridged by overlaying difference spatial classifications (as done for livestock).
- c. DWA needs to establish a Water Accounting Unit and other stakeholders (WUC, SB, MoA and Mines) need to have WA support staff to regularly up-date water accounts. Partnerships between the stakeholders should be formed to support the water accounting process.
- d. The policy implications of the results should be regularly assessed and discussed with stakeholders to ensure their future cooperation and the actual implementation of the recommendations.
- e. Significant efforts should be directed towards reducing losses in areas with high loss rates.

**Irrigation:**

- a. Improve data collection & management to improve the irrigation water use estimates in the water accounts and to improve performance assessment. The data could form a separate commercial irrigation section in the Agricultural Statistics;
- b. Land use: Priority should be given to increasing the use of serviced irrigation land; unused land should be re-allocated to productive farmers, especially successful farmers, who cannot expand.
- c. There is need for close and effective collaboration between the Irrigation and Horticulture Divisions of the Ministry of Agriculture;
- d. Government irrigation schemes and NAMPAAD farms should be privatised to make them more productive.
- e. Priority should be given to more productive use of water at current irrigation schemes. This requires, among others, adjustment of the irrigation schemes;
- f. Use of treated effluent should be encouraged but be accompanied by water quality monitoring but its use should also be based on economic merits (value added, employment, food security and poverty reduction);
- g. For bigger schemes and irrigation farms, metering should be introduced to allow more accurate water use estimates.

**Self providers:**

- a. Self providers should annually report their water abstraction, consumption and losses to DWA and the WRB;
- b. DWA should monitor and oversee water abstraction and consumption of self providers.

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[www.wavespartnership.org](http://www.wavespartnership.org)

[www.worldbank.org/waves](http://www.worldbank.org/waves)

## Appendix 1: Terminology

Term		Source
<b>Water resources types</b>		
Water resources	Water resources consist of fresh and brackish water in inland water bodies including groundwater and soil water. (5.475) Brackish water with a salinity content between that of freshwater and marine water.	SEEA Central Framework 2012 SEEA Water 2012
Inland water resources	Inland water system comprises surface water (rivers, lakes, artificial reservoirs, snow, ice, glaciers), groundwater and soil water within the territory of reference. (3.187)	SEEA Central Framework 2012
Transboundary water	Surface or ground waters which mark, cross or are located on boundaries between two or more States; wherever transboundary waters flow directly into the sea, these transboundary waters end at a straight line across their respective mouths between points on the low-water line of the banks.	SEEA Central Framework 2012
Surface water	Surface water comprises all water that flows over or is stored on the ground surface regardless of its salinity levels. Surface water includes water in artificial reservoirs, lakes, rivers and streams, snow and ice and glaciers. (5.478) Water which flows over, or is stored on, the ground surface. It includes artificial reservoirs, lakes, rivers and streams, glaciers, snow and ice.	SEEA Central Framework 2012 SEEA Water 2012
Ground water	Groundwater comprises water that collects in porous layers of underground formations known as aquifers. (5.480) Water which collects in porous layers of underground formations known as aquifers. (SEEA-2003)	SEEA Central Framework 2012 SEEA Water 2012
Soil water	Soil water consists of water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface. (5.481) Water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface that can be discharged into the atmosphere by evapotranspiration.	SEEA Central Framework 2012 SEEA Water 2012
Wastewater	Wastewater is discarded water that is no longer required by the owner or user. (3.86) Water which is of no further immediate value to the purpose for which it was used or in the pursuit of which it was produced because of its quality, quantity or time of occurrence. However, wastewater from one user can be a potential supply of water to a user elsewhere. It includes discharges of cooling water.	SEEA Central Framework 2012 SEEA Water 2012
Recycled water	The reuse of water within the same industry or establishment (on site).	SEEA Water 2012
Reused wastewater	Wastewater delivered to a user for further use with or without prior treatment. Recycling within industrial sites is excluded.	SEEA Water 2012
Term		Source
<b>Water flow concepts</b>		
Abstraction of water	Abstraction is the amount of water that is removed from any source, either permanently or temporarily, in a given period of time. (3.195) The amount of water that is removed from any source, either permanently or temporarily, in a given period of time for final consumption and production activities. Water used for hydroelectric power generation is also considered to be abstraction. Total water abstraction can be broken down according to the type of source, such as water resources and other sources, and the type of use. (EDG).	SEEA Central Framework 2012 SEEA Water 2012
Abstraction for distribution	Water abstracted for the purpose of its distribution.	SEEA Water 2012
Abstraction for own use	Water abstracted for own use. However, once water is used, it can be delivered to another user for reuse or for treatment.	SEEA Water 2012
Water consumption	That part of water use which is not distributed to other economic units and does not return to the environment (to water resources, sea and ocean) because during use it has been incorporated into products, or consumed by households or livestock. It is calculated as the difference between total use and total supply; thus, it may include losses due to evaporation occurring in distribution and apparent losses due to illegal tapping as well as malfunctioning metering.	SEEA Water 2012



Final water use	Final water use is equal to evaporation, transpiration and water incorporated into products. (3.222) (Also referred to in water statistics as “water consumption”)	SEEA Central Framework 2012
Use of water received from other economic units	The amount of water that is delivered to an economic unit from another economic unit.	SEEA Water 2012
Supply of water to other economic units	The amount of water that is supplied by one economic unit to another and recorded net of losses in distribution.	SEEA Water 2012
Run off	The part of precipitation in a given country/territory and period of time that appears as stream flow. Urban runoff is that portion of precipitation on urban areas that does not naturally evaporate or percolate into the ground, but flows via overland flow, underflow, or channels, or is piped into a defined surface water channel or a constructed infiltration facility. (3.213)	SEEA Water 2012 SEEA Central Framework 2012
Actual evaporation	The amount of water that evaporates from the land surface and is transpired by the existing vegetation/plants when the ground is at its natural level of moisture content, which is determined by precipitation	SEEA Water 2012
Groundwater recharge	The amount of water added from outside to the zone of saturation of an aquifer during a given period of time. Recharge of an aquifer is the sum of natural and artificial recharge.	SEEA Water 2012
Water returns	Water that is returned into the environment by an economic unit during a given period of time after use. Returns can be classified according to the receiving media (water resources and sea water) and to the type of water, such as treated water and coolingwater).	SEEA Water 2012
Water losses in distribution	The volume of water lost during transport through leakages and evaporation between a point of abstraction and a point of use, and between points of use and reuse. Water lost due to leakages is recorded as a return flow as it percolates to an aquifer and is available for further abstraction; water lost due to evaporation is recorded as water consumption. When computed as the difference between the supply and use of an economic unit, it may also include illegal tapping.	SEEA Water 2012
<b>Term</b>		<b>Source</b>
<b>Water infrastructure</b>		
Artificial reservoirs	Man-made reservoirs used for storage, regulation and control of water resources.	SEEA Water 2012
Aquifer		

## Appendix 2: International Standard Industrial Classification (Botswana ISIC Adaptation – Revision 3)

### Group A: Agriculture, Hunting and Forestry

0100	Traditional or Subsistence agriculture
0110	Commercial crop farming
0121	Commercial livestock farming
0122	Commercial poultry farming
0123	Commercial wild game farming e.g. ostrich
0124	Other commercial livestock farming e.g. bees
0130	Commercial mixed farming
0140	Agricultural & Husbandry Services, e.g. Artificial Insemination, Irrigation
0150	Hunting and trapping
0200	Forestry (All)

### Group B: Fishing

0500	Fishing (All)
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### Group C: Mining and Quarrying

1010	Coal Mining
1320	Copper / Nickel mining
1423	Diamond mining
1424	Soda ash and salt mining
1425	Gold Mining
1426	Quarrying and other mining

### Group D: Manufacturing (includes repair of machinery & equipment)

1510	Meat and meat products
1520	Dairy products
1530	Grain mill Products includes maize, sorghum, millet etc. human & animal feeds
1541	Bakery products
1545	Other food products not elsewhere classified (e.g. Chocolates, Sweets)
1550	Beverages, (Beer including Traditional Beer, Soft Drinks, etc.)
1600	Tobacco Products
1700	Textiles (excluding Clothing)
1800	Clothing and other wearing apparel (Inc. Leather)
1910	Tanning and leather products (excluding Clothing / Footwear)
1920	Footwear
2000	Wood and Wood Products excluding furniture but including building materials and straw products
2100	Paper and Paper Products, e.g. Newsprint, tissues
2200	Printing and Publishing (including periodicals, journals etc.).
2400	Chemical and Chemical Products (including Soap, Paint, Fertilizers and Pesticides etc)
2500	Rubber and Plastic Products (including Tyres, Retreading)
2610	Cement Manufacturing
2620	Non-Metallic mineral products excluding cement but including glass ceramic and cement products e.g. bricks, tiles, pots.
2700	Basic metals, e.g. Iron Foundaries
2800	Fabricated metal products exc. Machinery and equipment
2900	Machinery and equipment including refrigerators and other domestic equipment
3000	Office, accounting & computing machinery, e.g. Photocopying Machines
3100	Electrical machinery and apparatus e.g. Lightning Arresters, Voltage Limits
3200	Radio television and communication equip and apparatus
3300	Medical, precision, optical instruments, watches, clocks
3400	Motor vehicles, trailers and semi-trailers
3500	Other transport equipment, e.g. Ships & Boats, Railway Locomotives
3610	Furniture (all types including of wood, also mattresses)
3691	Manufacture of Jewellery
3692	Manufacturing of other products not elsewhere classified Pens, Pencils
3700	Recycling, Processing of Metal & Non Metal Waste

**Group E: Electricity, Gas and Water Supply**

- 4010 Electricity generation and supply (Not household / building electricians)
- 4020 Gas manufacture and distribution
- 4030 Steam / hot water supply
- 4100 Collection, purification, distillation of water (including village supply for sale)
- 4200 Borehole Syndicates

**Group F: Construction**

- 4510 Site preparation, e.g. demolition and clearing of sites
- 4521 Construction of Buildings and Houses including repair
- 4522 Construction / Civil Engineering (Roads, Dams, Water Projects)
- 4530 Building installation work (Plumbing, Electrical, Air Conditioners)
- 4540 Building completion work including Painting, Tiles, Carpets including repair of these
- 4550 Renting of construction or demolition equipment including crane hire

**Group G: Wholesale & Retail Trade (includes repair of Motor Vehicles & Personal Household Goods)**

- 5010 Sale of motor vehicles
- 5020 Maintenance and repair of motor vehicles
- 5030 Sale of motor vehicle parts and accessories
- 5040 Sale, maintenance and repair of motor cycles
- 5050 Sale of automotive fuel /Petroleum products (filling stations)
- 5100 Wholesale and commission trade (excluding cattle dealers)
- 5151 Cattle Dealers
- 5210 Non specialized retail trade e.g. General Department Stores
- 5221 Retail stores specializing in food, beverages and tobacco excluding Bottle Stores
- 5222 Bottle Stores
- 5230 Retail stores specializing in goods except food, beverages and tobacco
- 5252 Retail trade through informal outlets: stalls, markets, hawkers, etc.
- 5260 Repair of personal and household goods e.g. Televisions, Videos and Watches.

**Group H: Hotels and Restaurants**

- 5510 Hotels and other short stay accommodation e.g. hostels, camp sites
- 5521 Restaurants, cafes and canteens
- 5522 Bars / Bottle Stores (& shebeens)

**Group I: Transport, Storage & Communications**

- 6010 Rail transport
- 6023 Freight transport byroad
- 6024 Passengers road transport. E.g. Buses and Taxi / Combi Companies
- 6025 Taxis / Combis (Sole or small operators only)
- 6030 Transport by pipeline
- 6100 Water transport
- 6200 Air transport
- 6304 Travel agents, tour operators, safari operators
- 6305 Cargo handling, storage, warehousing
- 6309 Other transport not elsewhere classified, e.g. Handcarts, Donkeys
- 6411 Postal services
- 6412 Courier activities
- 6420 Telecommunications

**Group J: Financial Intermediaries**

- 6510 Banking
- 6590 Financial leasing and credit granting (banking / insurance)
- 6600 Insurance and pension funds
- 6700 Other financial activities (e.g. stock brokering)

**Group K: Real Estate, Renting and Business Activities**

- 7000 Real estate
- 7110 Transport Rental e.g. Hire Car Rental
- 7120 Other Rental excluding Person and Household Goods, e.g. Machinery
- 7130 Rental of Household and Personal Goods e.g. Video Tapes
- 7200 Computing and related activities
- 7300 Research and Development

7410	Legal, accounting, bookkeeping, auditing: business / management consultancy
7421	Geological exploration and Prospecting
7422	Architectural, engineering and other technical activities e.g. surveying
7430	Advertising
7480	Security Organizations
7490	Business activities not elsewhere classified

**Group L: Public Administration**

7540	Central Government Administration
7550	Local Government Administration

**Group M: Education**

8010	Primary education (including pre-primary)
8021	Secondary education
8022	Technical & Vocational Education
8030	Higher education
8090	Adult and other education

**Group N: Health and Social Work**

8510	Human health activities (Hospitals, etc)
8520	Veterinary activities
8530	Social work activities (including Children's day care centre)

**Group O: Other Community, social and Personal Service Activities**

9000	Sewage and refuse disposal, sanitation etc. excluding pest control
9110	Business, employer and professional organisation
9120	Trade Unions
9191	Religious organizations
9192	Political Organizations
9198	Burial Societies
9199	Other membership organizations
9210	Motion picture, radio, television, other entertainment
9220	News agency activities
9231	Libraries and Archives
9232	Museums and other cultural organizations
9240	Sporting and other recreational activities
9300	Other services (including dry cleaning, hairdressing, personal services, informal car washing, etc)

**Group P: Private Households with Employed Persons (for Household Surveys only)**

9500	Private households with employed persons (Maids, Gardeners, and Security)
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**Group Q: Foreign Missions, International Organizations**

9900	Foreign missions, International organizations
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### Appendix 3: Total water consumption by economic sub-sector and source of water (2010-12; 000 Mm<sup>3</sup>)

Economic sector	Sub-sector	2010/11				2011/12			
		Dams	Groundwater	Rivers	Total use	Dams	Groundwater	Rivers	Total use
Agriculture									
	Livestock production	11,095.0	41,625.2	2,774.3	55,611.9	11,095.0	41,606.2	2,773.8	55,654.4
	Crop production	1,375.3	7,258.6	10,231.8	18,919.0	1,375.3	7,238.1	10,232.0	18,932.2
Mining									
	Diamond mining	-	21,700.0	-	21,933.7	-	23,316.+0	-	23,682.7
	Copper/nickel mining	-	3,390.0	-	8,335.0	-	5,402.4	75.0	7,781.6
	Coal mining	-	77.5	-	85.5	-	69.5	-	80.8
	Soda ash mining	-	-	-	343.1	-	245.6	-	787.9
	Gold mining	-	-	-	1,645.1	-	-	-	2,093.9
	Other mining	-	-	-	99.5	-	-	-	148.2
Manufacturing									
	Meat & meat products	-	42.6	10.6	1,531.2	-	14.7	7.9	1,535.1
	Textiles	-	-	-	171.4	-	-	-	285.0
	Leather & leather products	-	-	-	-	-	-	-	0.2
	Other manufacturing	-	-	-	1,000.0	-	-	-	1,554.7
Electricity, gas & water supply									
	Water	-	-	-	15.2	-	-	-	25.0
	Electricity	-	-	-	79.8	-	-	-	103.1
Construction		-	18.5	1.2	348.2	-	2.0	1.1	395.1
Trade		-	302.0	-	1,328.2	-	-	-	1,259.4
Hotel & restaurants		-	116.3	7.0	656.7	-	12.6	6.8	811.3
Transport		-	52.4	-	203.1	-	-	-	257.9
Finance and business		-	84.0	42.3	1,196.7	-	63.0	33.9	1,950.1
Social & personal services		-	1,062.9	-	4,137.2	-	-	-	3,982.9
Government									
	Central government	-	510.5	91.5	12,497.4	-	120.9	65.1	9,132.1
	Local government	-	26.3	4.2	2,524.7	-	16.8	9.0	1,766.6

Int. Organisations		-	-	-	104.4	-	-	-	155.9
Households		-	6,225.0	437.5	30,220.3	-	670.2	360.9	34,815.8
<b>Total</b>		<b>64,987.3</b>	<b>93,036.8</b>	<b>14,675.7</b>	<b>172,524.4</b>	<b>59,821.7</b>	<b>96,928.9</b>	<b>14,800.4</b>	<b>171,551.0</b>

Note: The consumption of water supplied by District Councils could (4.5 Mm<sup>3</sup>) not be allocated to specific sub-sectors, but is included in the overall total consumption.

## Appendix 4: Detailed findings of irrigation study

### The national picture of the irrigation sector

The Ministry of Agriculture (MoA) offers technical support to irrigation farmers through its District extension staff. The Irrigation Division of the Department of Crop Production advises on the technical design and requirements of irrigation projects. The Horticultural Division of the same department advises farmers on crop production and keeps records of irrigated areas, type of crops grown, production, revenues and costs.

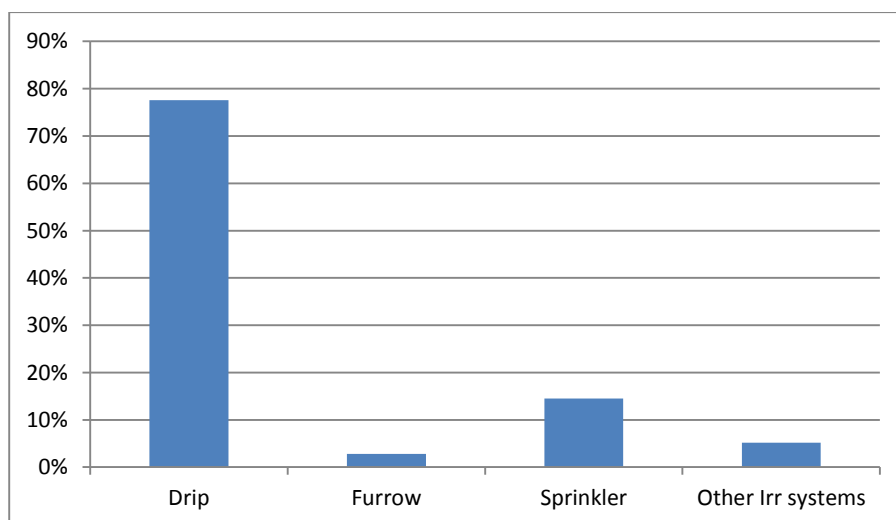
Data were initially collected from the districts through the Irrigation Division. Later on data on irrigated land and production were also provided by Horticultural Division. The data sets differ significantly and need to be reconciled before the existing estimate for water use in the irrigation sector can be adjusted.

The earlier data were based on quarterly reports and completion of a data template submitted to the districts for completion. The data showed significant gaps for the period 2010 – 2013. The initial data provided show that the Ministry of Agriculture has registered 459 irrigation farmers, including over 100 backyard garden farmers. Adjustments were made for incomplete data as follows: farmers without specific data are assumed to be similar to the average farmer with data. For example, the aggregate size of irrigation land is known for 84.7% of the 459 farmers, totalling 798.6 ha. The adjusted irrigation land is therefore calculated as  $(100/84.7) \times 798.6$  ha, i.e. 942.3 ha.

In terms of land use, only a third to half of the irrigation land was irrigated: 35.6% in 2011-2 and 53.1% in 2012-3. This suggests that doubling of irrigation is possible without allocating and developing more irrigation land.

In terms of irrigation technology used, drip irrigation is most common (Figure 19). Over three quarters of the farmers use this technology followed at a large distance by sprinkler irrigation. Sprinkler irrigation is mostly used in the North East and Central Districts near rivers. Drip irrigation is water efficient but expensive and the widespread use of drip irrigation shows that farmers have a water-efficient infrastructure in place.

**Figure 19: Irrigation systems used by farmers (% of techniques)**



Notes: 1. Jet irrigation is the most other irrigation system; 2. A few farmers use two systems.

In terms of water resources, over two thirds of the farmers (68.8%) use their own water supply (so-called self providers); over a quarter (28.2%) use village water supplies from service providers (backyard gardens) and a few (3.2%) use government irrigation schemes (Dikabeya, Glenn Valley and Kubung). Abstraction is mostly from river water (54.2%), followed by groundwater (38.4%) and dam water (7.3%).

Water use is estimated in Table 7 using three different assumptions for water use and the above distribution of use over river, ground and dam sources. The Horticultural Division uses the norm of water abstraction of 40 m<sup>3</sup>/ha (8 hours of irrigation @5 m<sup>3</sup>/hour). This would give an estimated water use of 4.9 Mm<sup>3</sup> and 7.3 Mm<sup>3</sup> for the years 2011-2 and 2012-3 respectively. The use of an average figure of 15 000 m<sup>3</sup>/ha/annum (a common figure in the literature), yields very similar results (Table 7). Drip irrigation permits greater water efficiency in the order of 7 500 to 10 000 m<sup>3</sup>/ha/annum, which would lead to water savings of 33 to 50%.

**Table 7: Estimated water use by the irrigation sector under different assumptions (in Mm<sup>3</sup>)**

Assumption:	2011-2				2012-13			
	River	Groundwater	Dam	Total	River	Groundwater	Dam	Total
Water use of 5m <sup>3</sup> /hr/ha for 8 hrs/day	2.7	1.9	0.4	4.9	4.0	2.8	0.5	7.3
Use of 15 000 m <sup>3</sup> /ha/year	2.7	1.9	0.4	5.0	4.1	2.9	0.6	7.5
Use of 10 000 m <sup>3</sup> /ha/year	1.8	1.3	0.2	3.4	2.7	1.9	0.4	5.0
Use of 7 500 m <sup>3</sup> /ha/year	1.4	1.0	0.2	2.5	2.0	1.4	0.3	3.7

Note: water abstraction has been divided by source using the percentage of area using river, ground and dam water (see above).

No regional data were available on produce output, sales revenues and production costs. Therefore, it is impossible to indicate the irrigation productivity/ m<sup>3</sup> in terms of food security, employment or valued added.

In May 2013, new irrigation data were provided by the Horticultural Division, MoA (2011/12 and 2012/13). These data were also incomplete (e.g. 2010/11 was missing) and only provided in a few aggregate tables, making verification and comparison with the earlier figures difficult). Data included irrigation in freehold blocks (e.g. Tuliblock). This data set covers 756 horticultural projects in ten districts (compared to 459 projects for earlier data). A total of 4 012 ha of irrigated land is allocated, of which 66% is developed and 55% (2 209 ha) cultivated in 2012/3. This figure is more than four times the earlier figure. The cultivated area for 2011/12 was unknown.

Assuming that the cultivated area in 2011/2 could have been 2 000 ha, water use would be 33.1 Mm<sup>3</sup> (@ 15 000 m<sup>3</sup>/ha) or 22.1 Mm<sup>3</sup> (@ 10 000 m<sup>3</sup>/ha). This is much higher than the estimates of Table 7 and also higher than the water use currently in the flow accounts (18.4 Mm<sup>3</sup>).

The different estimates demonstrate the need to get better data on cultivated area, water use and production for the irrigation sector.

#### Two case studies of government irrigation schemes

##### *Glenn Valley Irrigation Scheme*



The Glenn Valley Irrigation Scheme (GVIS), is managed by MoA and uses treated effluent from the Gaborone Waste Water Treatment Works. Water abstraction and use are not metered but estimated to be 1.1 Mm<sup>3</sup>/annum (assuming 8 hrs pumping/day and a pumping rate of 100 L/second). The distribution efficiency and field allocation efficiency cannot be assessed. Below, the main figures are summarised.

Total GVIS area:	203 ha.
Cultivated area 2011/2:	124 ha (a different figure of 70 ha was also provided)
Cultivated area 2012/3:	135 ha

#### Production:

Produce grown:

- ✓ No root crops because of water quality constraints associated with treated wastewater;
- ✓ Grown: maize, tomatoes, green pepper, butternut, cabbage, flowers (few), green mealies, rape, lettuce, sweet potatoes, spinach, swiss chart.

Production 2011/2:	1 642 T (a lower figure of 530 T was also provided)
Production 2012/3:	1 792 T

The productivity is uncertain because of the different estimates for production and cultivated area. It may be in the range of a low of 4.3 (high cultivated area and low production figures) to a high of 23 T/ha/annum (high production and low cultivated area figures).

#### Water use

Water rights for entire scheme have been obtained from the Water Apportionment Board (WAB) for a maximum of 3 000 m<sup>3</sup>/day; the water rights are currently fully utilised, even though only part of the land is irrigated. The water efficiency is low due to the underutilisation of the scheme and the fact that farmers do not pay for water. To avoid pipe bursts hydrants of un-used farms need to be opened. Due to the high pressure, no on-farm pumping is necessary. Farmers consider the water quality to be fine. At full cultivation, 5 000 m<sup>3</sup>/ha is available unless water rights are expanded. In future, the merits of expanding water rights for effluent re-use need to be weighed against alternative uses of treated water.

There are around 40 active farmers farming less than 60% of the scheme. The other farmers do not use their land. The repossession clause in case of non-use is not invoked by the Department of Lands. One reason for non-development of the land is the low land rental of P3 500/annum/ ha. MoA intends to privatise the scheme. Farmers would then run and pay for the water infrastructure (electricity, water and land). Hopefully it will offer expansion opportunities for active farmers and lead to higher land utilisation.

#### Dikabeya Irrigation Scheme

The Dikabeya Irrigation Scheme (DIS) started in 2005. The irrigation scheme uses water from Dikabeya Dam which was constructed by the Ministry of Agriculture in 1992<sup>17</sup>, initially for the purpose of livestock watering. The dam's design capacity is 1.85 Mm<sup>3</sup>. The scheme is managed by the Ministry of Agriculture, but its management is planned to be privatised.

Irrigation water is abstracted from the dam at a rate of 33 L/s. The water abstraction is not metered but estimated to be 1 069 m<sup>3</sup>/day based on 9 hrs pumping/ day or 390 258 m<sup>3</sup> p.a. Water is pumped through a 2 km pipeline into a reservoir of 1 000 m<sup>3</sup> inside the irrigation scheme. Water is then

<sup>17</sup> Initially operated by a livestock farmers' syndicate.

released into cemented channels that run across the farm allowing each farmer to draw water from sumps, which are filled by the channels. Each channel can be opened and closed to divert the water to the sump. All farmers use drip irrigation. At the time of the field visit (March 2013), the dam was quite full and there was sufficient water for irrigation. The dam is mainly used by livestock farmers (free of charge) and some construction enterprises (maximum of 5m<sup>3</sup>/week free of charge).

Below, key figures are summarised:

#### Land resources

Total area of DIS:	60 ha (12ha is considered barren as it has rocks)
Cultivated area 2011/2:	5.4 ha (another figure of 40 ha was also provided)
Cultivated area 2012/3:	21 ha (another figure of 40 ha was also provided)

#### Production

Production 2011/2:	9.2 T (another figure of 26 T was also provided)
Production 2012/3:	204 T (another figure of 261 T was also provided)

Farmers cultivate maize, tomatoes, green pepper, green mealies, butternut, cabbage, sweet potatoes, water melons, rape, carrot, onions, lettuce. One farmer produced 120 tonnes of tomatoes from 4 ha in a week, employing 40 workers a day to harvest the produce. Depending on the cultivated area and production figures used, productivity varies from 0.2 to 21 T/ha. Productivity is generally low but increasing mostly due to the impact of one of the farmers.

#### Water use

The irrigation scheme does not appear to have a daily volume water abstraction right from the Water Apportionment Board (WAB); water abstraction is estimated to be 390 258m<sup>3</sup>/annum; this implies a high water use of 18 600 m<sup>3</sup>/ ha for 21 ha of irrigation. In fact, the current abstraction should be sufficient for the entire scheme (8 130 m<sup>3</sup>/ ha for 48 ha). The farmers are not charged for water; they are only charged electricity to pump water from the sumps while the electricity bill for the pump house is paid by MoA. Each farmer pays an annual land rental of BWP 2 500 per ha.

Farmers use drip irrigation. The water quality is good and does not require pre-treatment. However, farmers experienced mud problems and have to regularly filter the water. The farmers have proposed that the open channels should be replaced by pipelines to increase distribution efficiency and to construct inlet hydrants at each allocated plot<sup>18</sup>. The NAMPAAD farm (8 ha) is being privatised in order to increase productivity. The farm is currently underutilised and performs poorly. On average only 4.1 ha is annually cultivated and the actual production is around 12.5 T compared to the estimated production of 110 T. The average annual productivity is 2.9 T/ha for period 2010-2013.

#### *Irrigation at Talane Farms*

Talana Farms is located in the Tuli block in eastern Botswana and is fully owned by the Botswana Development Corporation, a parastatal company. The farms are operated by Botswana Ventures, of which the BDC is a shareholder (33%) and the remaining 67% is held by a private farmer. The total land area of the farm is 1 800 ha but only 380 ha is currently under irrigation with a potential to increase that to 650 ha. The centre pivot and drip irrigation systems are used on site.

#### Production

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<sup>18</sup> This would reduce the accumulation of mud in the water supply system.

The crops produced at the farm include tomatoes, onions, butternuts, green pepper, potatoes, beetroot, carrots, broccoli, lucerne, maize and lettuce. Most fields grow two crops per year and crops are rotated. Approximately 400 ha of vegetables are produced annually, with an approximate value of P 28 million depending on climatic conditions (BWP 70 000 gross revenues/ha or 4 times the average gross revenues countrywide). About 90 per cent of the farm's produce is sent to Botswana Horticultural Markets while the rest is sold in its outlets in Selebi-Phikwe.

#### Water use

The farm uses water from boreholes that are recharged by the Motloutse and Limpopo rivers. The farms are not equipped with water meters to measure the volumes of water used, hence no reliable data exist for Talana Farms on the amount of water abstracted. Using the total area under irrigation (380 ha), and assuming water use of  $5\text{ m}^3/\text{hr}/\text{ha}$  for 8 hrs/day, the annual water use would be  $5.5\text{ Mm}^3$ . If one assumes an average water use of  $15\,000\text{ m}^3/\text{ha}/\text{year}$ , the water use would be  $5.7\text{ Mm}^3$ .

It was not yet possible to get more detailed data and information. Further investigation of Talane farms is needed.