WAVES TECHNICAL REPORTS

Accounting for Water in Botswana

May 2014

WORLD BANK GROUP

Global Partnership for Wealth Accounting and Valuation of Ecosystem Services (WAVES)

Wealth Accounting and Valuation of Ecosystem Services (WAVES) is a global partnership led by the World Bank that aims to promote sustainable development by mainstreaming natural capital in development planning and national economic accounting systems, based on the System of Environmental-Economic Accounting (SEEA). The WAVES global partnership (www.wavespartnership.org) brings together a broad coalition of governments, UN agencies, nongovernment organizations and academics for this purpose.

WAVES core implementing countries include developing countries—Botswana, Colombia, Costa Rica, Guatemala, Indonesia, Madagascar, the Philippines and Rwanda—all working to establish natural capital accounts. WAVES also partners with UN agencies—UNEP, UNDP, and the UN Statistical Commission—that are helping to implement natural capital accounting. WAVES is funded by a multi-donor trust fund and is overseen by a steering committee. WAVES donors include—Denmark, the European Commission, France, Germany, Japan, The Netherlands, Norway, Switzerland, and the United Kingdom.

Country work on natural capital accounting and their policy applications are reported in a publication series, WAVES Technical Reports.

This report was prepared by the Centre for Applied Research and the Department of Water Affairs, Botswana

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Acknowledgements

This report has been prepared by the Department of Water Affairs (DWA) and the Centre for Applied Research (CAR) as part of the WAVES Botswana partnership with major contributions from the Department of Water Affairs (DWA), Water Utilities Corporation (WUC), Ministry of Agriculture (MoA) and Statistics Botswana (SB). The report has also benefited from comments by Ricardo Martinez, United Nations Statistics Department, who also facilitated the workshop on Economic Accounting for Water, held in Mauritius in May 2013.

Abbreviations

BWP	Botswana pula
CAR	Centre for Applied Research
DC	District Council
DWA	Department of Water Affairs
GDP	Gross Domestic Product
ISIC	International Standard Industrial Classification
IWRM	Integrated Water Resources Management
m^3	Cubic meters
$000m^3$	Thousands of cubic meters
MC	Management Centre
Mm^3	Million cubic meters
MoA	Ministry of Agriculture
NDP	National Development Plan
NSC	North South Carrier
NWMP	National Water Master Plan
SB	Statistics Botswana
SEEA	System of Environmental-Economic Accounting
SEEA-Water	System of Environmental-Economic Accounting for Water
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WUC	Water Utilities Corporation

Executive Summary

Botswana is a semi-arid, water-scarce country. It has exploited most of its domestic water resources and increasingly relies on water from shared international rivers, where allocations are subject to agreement under the Southern African Development Community's International Waters Protocol. With a growing economy and population, careful management of scarce water resources has become a priority. Water accounting has been adopted in Botswana as an important tool to support sustainable development.

Botswana pioneered water accounting in the late 1990s and early 2000s. The work was led by the National Conservation Strategy Agency (now reorganized under the Ministry of Environment, Wildlife, and Tourism as the Department of Environmental Affairs) and produced accounts for the supply and use of water (by volume) from 1993 to 2003, as well as partial information about water stocks. The work in Botswana, together with the work of other countries and international organizations, contributed to the development of System of Environmental and Economic Accounting for Water (SEEA-Water), an internationally agreed methodology, which was adopted by the UN Statistical Commission in 2012.

Work on water accounts was taken up again by Botswana in 2012, when the government of Botswana joined the World Bank WAVES global partnership (www.wavespartnership.org). The WAVES steering committee approved the updating of water accounts as a key component of the WAVES work plan, and this activity was further endorsed as a priority by the Botswana Economic Advisory Council. The government 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 toward sustainability.

The International Framework for Water Accounting: SEEA-Water

The System of Environmental and Economic Accounting (European Commission et al. 2012) has been under development since 1993, with two interim manuals provided and tested out by countries before the final version was adopted by the UN Statistical Commission as an international statistical standard in 2012. These earlier manuals were used to guide water accounting in Botswana in the 1990s and 2000s. After the adoption of the SEEA 2012, several specialized manuals were also developed, including SEEA-Water.

SEEA-Water provides a conceptual framework for organizing hydrological and economic information in a sound and consistent manner to show the interactions between the economy and water resources. It is a satellite system to the UN's System of National Accounts that is used for compiling economic statistics and deriving economic indicators such as 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 a set of statistics that are particularly suited for economic decision making about resource utilization and management.

Two major features of the SEEA-Water framework are distinguished:

1. The framework considers important water-economic interactions, which is important for addressing cross-sectoral and broader issues related to water resources management, such as Integrated Water Resources Management (IWRM). Countries are expected to compile a set of standard tables as per SEEA-Water, using harmonized definitions and classifications (Appendix 1).
2. Unlike other environmental information systems, SEEA-Water directly links water data to the System of National Accounts, as they share similar sets of definitions, concepts, and

classifications. For instance, both the System of National Accounts and SEEA-Water use the UN's International Standard Industrial Classification (ISIC), which gives a breakdown of industrial or sectoral activities. ISIC is regularly updated; the current set is ISIC Revision 4. Botswana uses ISIC Revision 3 and this has been adopted in the water accounts (Appendix 2).

The SEEA-Water system captures information on the water stocks and flows from the environment and within the economy in physical and monetary terms and water quality issues.

Water Accounting in Botswana

In addition to the earlier accounts for water use and supply from 1993–2003, water accounts have been updated for 2010/11 and 2011/12 based on the new SEEA-Water. The updated water accounts include physical flow accounts (use and supply) and partial water stock accounts (only water stored in reservoirs, but not yet groundwater). Monetary aspects of the accounts focus on water productivity (GDP per cubic meters (m^3)) and a partial review of revenues and costs of water supply. Combining the two sets of accounts provides a time series for the water sector of more than 20 years.[1]

Stock Accounts

The stock accounts in Botswana are of three types: surface water stocks (reservoirs and rivers) groundwater stocks, and wastewater stocks. The stock accounts exercise concentrated on stock accounts for five water supply reservoirs: 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 received 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

Since 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. Here, we highlight some of the main findings.

Water use has increased from nearly 150 million cubic meters (Mm^3) per year in 1993 to just under 200 Mm^3 in 2010/11 (Figure 1). The increase has been slower than population and economic growth, due to water efficiency increases and changes in the structure of the economy. Although water use has grown by nearly one-third over the period, there has been significant "decoupling" of water use from economic growth and population growth. Per capita water use has declined nearly 12 percent over the same period (Figure 2).

[1] The methodology in the new SEEA-Water differs in some details, but the basic accounts for water use are comparable over the entire period.

Figure 1: Long-Term Trend in Water Use in Botswana (1990–2012)
(thousands of cubic meters)

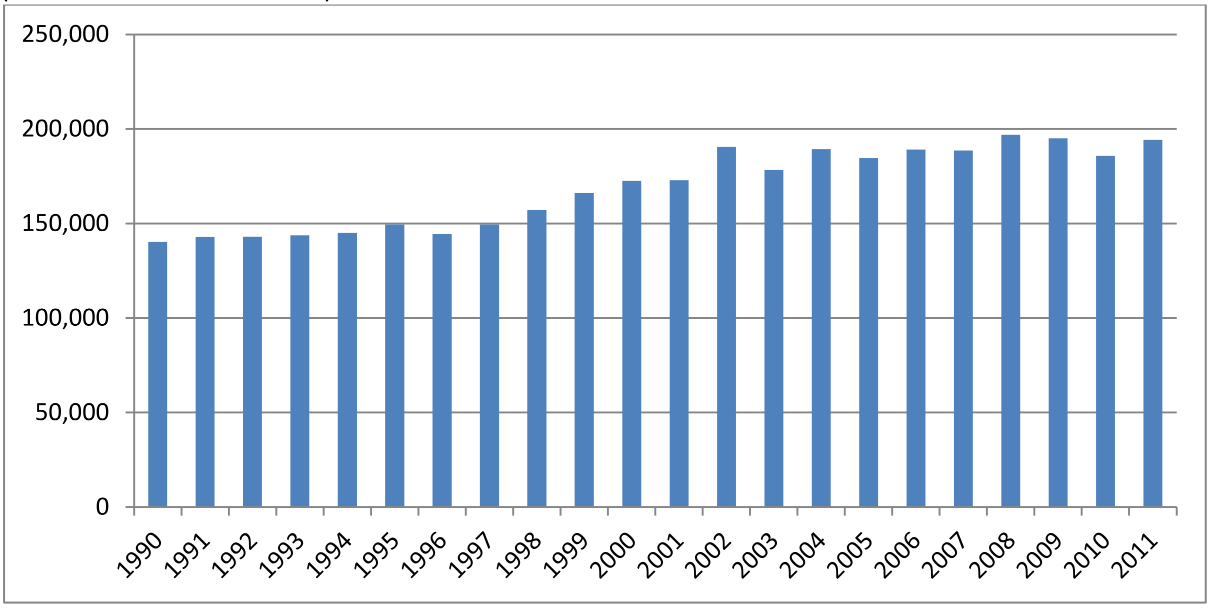
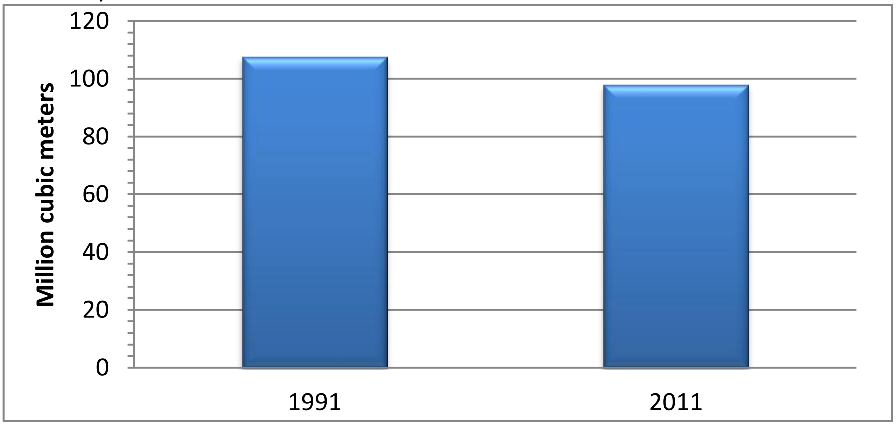
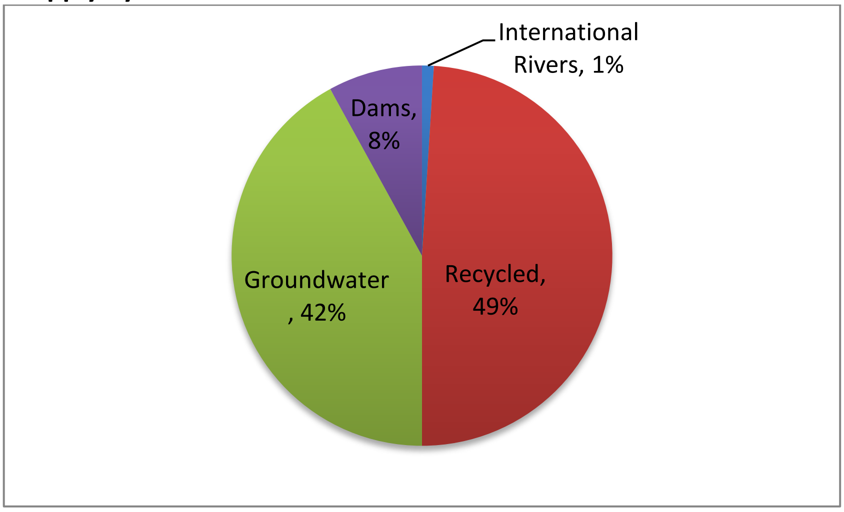


Figure 2: Water Use Per Capita in Botswana (1991 and 2011)
(million cubic meters)



Water supply accounts show that groundwater is the major source of water used in Botswana, (49 percent), followed by water stored in reservoirs (42 percent), and a smaller share provided by international rivers (Figure 3). Recycled water accounts for only about 1 percent at this time.

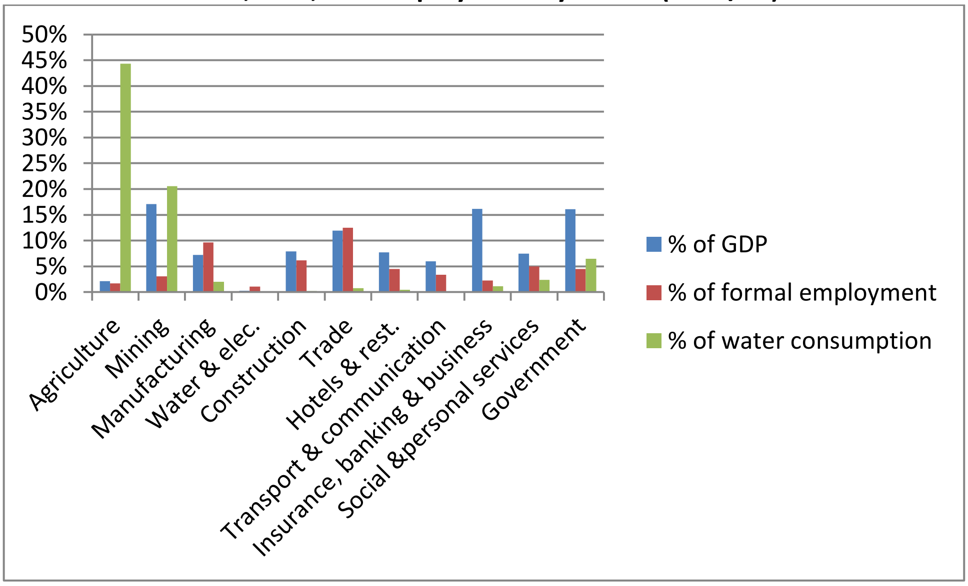
Figure 3: Water Supply by Natural Source



Self-providers supply most of the water (52 percent in 2012), mainly for their own use in the agriculture and mining sectors, with a small amount provided to other users. Given the large share of self-providers, their water abstraction and consumption require greater attention for water resources management. Water service providers, the Water Utilities Corporation (WUC) and the Department of Water Affairs (DWA), provide the remaining 48 percent.

Reviewing water use by sector, water consumption is highest for the agricultural sector (44 percent), followed by households and mines (Figure 4). Comparing water use and economic benefits by sector, 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, but 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.

Figure 4: Shares of Water Use, GDP, and Employment by Sector (2011/12)

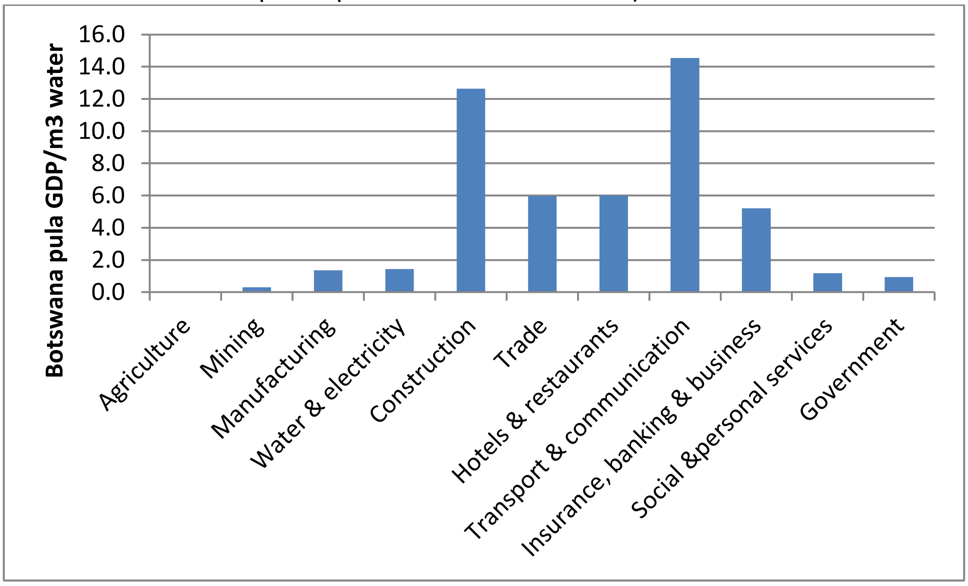


Water Use for Irrigation

Irrigation is a major user of water, so it is important to have reasonably accurate data to monitor its productivity. However, water use for irrigation is not measured and cannot be reliably estimated at present. More work is needed on water abstraction for irrigation, especially if new irrigation projects are developed. The estimate in the earlier water accounts of 18 Mm^3 was calculated as the average annual water use per hectare, times the total serviced irrigable land. It is probably an overestimate, since only around one third to one half of the land was actually used in recent years. Irrigation heavily relies on groundwater (60 percent); 34 percent of the farmers use water from rivers, while 6 percent use dam water. Most farmers (more than two-thirds) abstract water themselves, about a quarter use piped village water supply, and a few (3.2 percent) use water from government irrigation facilities. A more detailed study, (Appendix 4), was done for the irrigation sector, looking at a few major irrigation sites, like the Glen Valley Irrigation Scheme.

At the national level, water productivity (GDP/ m^3) has increased over this period, from just more than Botswana pula (BWP) 0.20/m^3 in 1993 to more than BWP 0.37/m^3 in 2012. At the sectoral level (Figure 5), there is a great deal of variation, with agriculture and mining showing the lowest water productivity, and the services sectors—the least water-intensive—showing the highest water productivity.

Figure 5: Water Productivity by Sector in Botswana (2011/12)
(sectoral GDP in constant 2006 prices per cubic meter of water)



WUC has been successful in recovering operating costs over the last decade, but since 2009, operating costs have rapidly grown as WUC has taken over responsibility for delivering water to towns previously served by DWA. Costs exceeded revenues in 2011/12, a situation that is not financially sustainable.

<u>Water Accounts at the Regional Level</u>
National water accounts provide a good overview of the water situation, but information at a more spatially disaggregated level is also useful for water management. Both water resources and the demand for water can vary enormously by region, so some decisions must be made at the regional level. Regional water accounts at the regional level can help assess the best use of water, given the available supply. Some countries use catchment or river basin as the spatial area for accounts. This study used the WUC management centers (MCs), which largely reflect infrastructure development, as the water management areas. The bulk of the water transfers between MCs originate from the North South Carrier (NSC) (Gaborone MC receives more than 50 percent of this water) and a limited amount through imports from Molatedi Dam (for Gaborone and Mochudi MCs). Among the MCs, water consumption is highest in the Gaborone (26 Mm^3), the nation's capital, followed by

Letlhakane (19 Mm^3 with the Orapa/ Letlhakane mines), Francistown (16 Mm^3), Kanye (15 Mm^3 with the Jwaneng mine), Selebi-Phikwe (14 Mm^3 with the BCL mine), and Lobatse (12 Mm^3).

Policy Implications, Recommendations, and the Roadmap for Institutionalization

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 investment in water infrastructure would have had to increase faster. Nevertheless, with a growing economy and population, and the greater variability and uncertainty in the future expected from climate change, further efforts will be required to meet Botswana's water needs.

Water Accounts and Water Sector Reforms

DWA's water sector reform program will be based on IWRM, which requires a strong focus on data for implementation and monitoring. Water accounting provides a useful framework for collecting and organizing these data, and the reform program will ensure, over time, improvements in data available for the water accounts. However, in the short term, there are data problems, including data gaps, incompatibilities, discrepancies, as well as a risk that water supply is solely prioritized 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 Botswana National Water Master Plan (NWMP) and the integrated water resources management and water efficiency plan, and result in significant long-term costs.

Priorities for more accurate data and analysis include the following:

- Water abstraction and use figures for **small settlements in rural areas**, to facilitate better planning and management of rural water infrastructure.
- Water abstraction and use by the **irrigation sector**, where data is missing or fragmented and need validation. Analysis of the irrigation sector performance in terms of its contribution to national income, employment, and food security is needed.
- **Self-providers** account for half the water consumption, and yet they are often overlooked in discussions about water resource management. Self-providers should annually report their water use and losses, and DWA should monitor and oversee their water abstraction and consumption.
- Records on the amounts of **wastewater** (inflows and outflows) do not exist, but are urgently needed if Botswana is to meet the target for reuse and recycling of wastewater in the 2003 National Management Plan for Water, Wastewater, and Sanitation.
- Data on and analysis of **monetary water accounts**, specifically WUC revenue and expenditure, are needed to assess the financial sustainability of water supply and solutions to the current financial imbalance. Possible solutions include raising water tariffs, adding a wastewater treatment fee to the water tariff, and cost reduction.
- Mapping of water resources, including both surface and groundwater, to water demand on a **regional basis** will provide for more accurate water management. This is particularly important for new mining developments and agriculture.

Water Accounting and the 11th National Development Plan

Water accounting results need to be fully integrated into the National Development Plan (NDP) 11 preparation process, which started in 2014. Many water management issues go beyond the jurisdiction of DWA and require coordination across several ministries, something the NDP 11 is designed to do. Issues that should be considered in NDP 11 include the following:

- Basing future water allocation on social and economic merits of alternative sector water uses. The best use of its Chobe-Zambezi water allocation is an important decision to be considered in the preparation of NDP 11.
- Developing a strategy for wastewater reuse, to achieve the reuse target of the National Management Plan for Water, Wastewater, and Sanitation, with a focus on opportunities to accelerate reuse efforts by the Ministry of Agriculture and WUC. New wastewater treatment plants should be constructed with a reuse component included.
- Assessing the opportunity costs of agricultural water consumption; these are generally low for the livestock sector, but could be high for irrigation, and vary a great deal by region of the country
- Fully assessing the economy-wide implications of measures—such as increased water tariffs—to address financial sustainability of WUC, and the distribution of the financial burden among the government, households, and the private sector
- Integrating water scarcity considerations in the economic diversification drive so that economic diversification does not inadvertently promote water-intensive sectors, but encourages the development of a water conservation industry for the local and export markets.

<u>The Roadmap for Institutionalization of water accounting</u>
Institutionalisation requires commitments to staffing and regular reporting of results. Botswana is well on its way toward institutionalization on both counts.

- A set of indicators that would be reported on regularly has been proposed that covers four main topics: water resources availability, water abstraction and use, water use productivity, and the technical and financial performance of water service suppliers.
- DWA has proposed to the Department of Public Service Management the establishment of a three-person water accounting unit, as part of its overall restructuring plan. To support the work of DWA, a technical working group for water accounting has been established, led by DWA with members from WUC, the Ministry of Agriculture, the
- Department of Mines, Statistics Botswana, and the Department of Geological Surveys.

Chapter 1 The Changing Context of Water Resources and their Management

During the 1970s and 1980s, Botswana made enormous progress to expand its water supply. Under the rural water supply program, groundwater exploration programs were carried out countrywide to identify and develop sources for village water supply reticulation. This was further enhanced in the 1990s by the construction of the North South Water Carrier 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 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 under construction is to access water from the Chobe-Zambezi river basin, an international river basis where country allocations of water are subject to the SAADC Water Protocol. The government has since acquired annual abstraction rights of 495 Mm^3 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.

1.1 History of Water Accounts and Water Resources Management in Botswana

Water accounts were first compiled in Botswana in the 1990s by the National Conservation Strategy Agency (later reorganized as the Department of Environmental Affairs) and the Central Statistics Office under the Natural Resource Accounting Program. The accounts covered the period 1992/93–2003 and focused exclusively on physical supply and use accounts with analysis of water productivity.

No further work on water accounting was done until the Botswana government entered into a partnership with WAVES in 2011. WAVES Botswana established a Steering Committee that approved a work plan that included water accounts. In 2012, a presentation was made of the early water accounts to the Botswana Economic Advisory Council,[2] which strongly endorsed prioritizing water accounting in the work plan. In response, 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 Botswana Economic Advisory Council meeting.

The Botswana WAVES program is anchored within the Ministry of Finance and Development Planning; it is led by a program coordinator and a high-level project steering committee composed of deputy permanent secretaries. The water accounting activities of WAVES-Botswana have been split into several phases:

Phase 1 (September–November 2012): preliminary account construction and analysis

[2] A small group of ministers and private sector representatives, chaired by the President of Botswana, to provide advice on key development issues.

Phase 2 (December 2012–June 2013): elaboration of the water accounts and development of a road map toward full institutionalization of water accounts at DWA and support institutions (e.g., SB, MoA, and WUC)
Phase 3 (July 2013–2015): full institutionalization, updating, and expansion of water accounts and ensuring full integration of results in NDP 11

This report covers the activities and findings of phase 1 and 2 and indicates the road map for institutionalization in phase 3 (July 2013–2015). It is an interim report, as water accounting will continue and soon be institutionalized at DWA (phase 3).

Botswana's water sector is evolving and it has now taken the direction of 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, with different stakeholders engaged and participating to ensure sound planning and development and sustainable management of the available water resources. The NWMP review of 2006 recognized the need to arrange existing water legislation, policies, and institutional arrangements in the sector to meet the needs of the growing population and overall economy. Additionally, an integrated water resources management and water efficiency plan was recently developed and is awaiting approval by the government. Water accounting is recognized in IWRM as an important tool for management

1.2 Water Sector Reforms

Botswana continues to experience increasing water demand and limited water resources. The challenges have been to ensure a sufficient and good-quality supply to all users; increase efficiency in water allocation and use; and strengthen the policies, laws, and organizational structures in the water sector. In the past, water and sanitation services were provided by a variety of agencies (WUC in urban areas, 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 the government, hence there is a 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 NWMP review recommended a reform of the water sector—a process that is being implemented (2008 to 2014). The reform will result in WUC having overall responsibility for water service provision as well as wastewater 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 overall responsibility for overseeing and allocating water resources, as well as a Water and Energy Regulator, which will be responsible for service standards. Policies and legal instruments are also being reviewed under the reform. The main outputs of the water sector reform process are indicated briefly in Table 1.

Table 1: Main Outputs of Botswana's Water Sector Reform 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 WUC's customer information system. 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 ongoing activity. All the wastewater treatment facilities are 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	• The National Water Policy has been approved by the cabinet and now needs to be approved by the parliament to take effect. • Establishment of the board and regulator depends on approval of the policy. • The DWA restructuring process is being implemented.
Communication and participation	Communication strategy Consultation with stakeholders on the process and National Water Policy	The strategy is available and consultation reports have been prepared.

Source: based on DWA 2013

1.3 Policies and Plans for Water Resources Management

There is renewed impetus for integrated, holistic water resources management in Botswana. The national development planning frameworks recognize 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.

<u>National Development Plan 10</u>

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

<u>National Water Master Plan Review (2006)</u>

The report identifies the outstanding recommendations from the 1991 NWMP, such as review of the Water Act, development of a water pricing policy, and establishment of the Water Resources Board. The NWMP review calls for implementation of IWRM and water demand management, with emphasis on the need to reform the sector as well as incorporate environmental issues in the management of water resources. Regarding water demand management, the review calls for water monitoring, the establishment of a water user forum, review of the 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, and 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 reuse more attractive because treatment plants are close to population centers.

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 and diversification and poverty eradication. The policy adopts a decentralized 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 that has the responsibility for equitable and sustainable allocation of water resources, development of water related policies, and the efficient implementation of the IWRM plan. In addition, a water regulator will be established that will be mainly responsible for ensuring financial sustainability in the water sector, guiding and monitoring development and implementation of water tariff structures, and ensuring that service providers comply with service standards. The policy distinguishes 11 focus areas that address IWRM at the local, national, and international[3] levels. The policy is yet to be approved by parliament.

National integrated water resources management and water efficiency plan (2013)

In the quest to fulfil its obligation to the 2002 Johannesburg World Summit on Sustainable Development, Botswana has developed the national integrated water resources management and water efficiency plan, parallel to the water sector reform 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 Global Water Partnership-IWRM toolbox, the plan distinguishes 10 strategic areas with specific objectives and 55 activities to be implemented under the 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 water sector reform. The Water Resources Board 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 17-year plan (2013-2030) is awaiting approval and will strengthen the enabling environment for implementation of IWRM in the country.

[3] This refers to transboundary management issues, as well as the catchment management approach.

Chapter 2 Trend Analysis for Water Use

2.1 Trends in Water Supply and Use by Sector

Since 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. 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 (updating the DEA 1999 report data to 2003). Therefore, time series existed for the period 1990–2003 before the WAVES water accounting.

There was no internationally agreed standard methodology for water accounting prior to 2012, although general guidelines on water supply and use were available and followed in Botswana. Under WAVES, the new SEEAW guidelines were followed and a more comprehensive set of accounts were compiled for 2010/11 and 2011/12. This chapter presents the findings of a quick update of the earlier water accounting results, leading to a 20-year time series in water use.[4] The trend analysis is meant to link the earlier water accounts (1994–2003) and the new SEEA-modelled water accounts (2010/11 and 2011/12).The main overall findings of this analysis are:

- Water use has increased from less than 150 Mm^3 a year in 1993 to just less than 200 Mm^3 in 2010/11. The increase is slower than the population and economic growth due to water efficiency increases and changes in economic structure;
- Water is most productively used (in terms of value added and formal employment) in the transportation, trade, tourism, and other service sectors.
- WUC has been successful in recovering operating costs over the last decade largely due to low supply costs compared to revenues. However, since 2009, operating costs have rapidly grown and exceed revenues in 2011/12. This situation cannot continue on the long run and cost control (e.g., greater operations and maintenance 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.

2.2 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 for 2010/11 and 2011/12. As a result, the abstraction figures slightly differ. The following assumptions were used for the trend analysis:

- For small villages, the water use is assumed to increase annually by 1.9 percent (this is the annual population growth in the period 2001–2011). Water use and abstraction in small villages was never recorded by the DCs and therefore had to be estimated. The water use of small villages in the earlier water accounts was estimated based on measurement of water use in each village over a one-month period for a single year. For that year, annual per capita water use was calculated; for all other years the per capita water use was multiplied

[4] Due to methodological differences, the results for individual years (2010-11 and 2011-12) are not fully comparable.

by the population size for total water us in each village. This figure was considered to be too old to be used for the update.

- DWA supplied all large villages until 2009/10. Tlokweng and Mogoditshane were transferred to WUC in May 2009 and other large villages followed in 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 breakdown and a correction factor (0.49) was applied to be consistent with the overall DWA production and consumption file (this procedure was used earlier also).

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 was on economic sector water use and water sources in the new accounts (Appendix 4).

The trend in water use is shown in Figure 1. Botswana's water use has increased by a third from under 150 Mm^3 in 1991/2 to 194 Mm^3 in 2011/12. Driven by the mining sector, the growth in water use was rapid in the second half of the 1990s, but stabilized in the first decade of the 21st century (with annual fluctuations). This can be attributed to agricultural stagnation and lower economic and population growth.

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 2 implies a decrease in average per capita water use (calculated as the national water use/national population size) from 107.7 m^3/person in 1991, to 102.8 m^3/person in 2001 and 95.3 m^3/person in 2011. Since during the same period, access to safe water has increased to almost 100 percent of the population, 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^3 instead of 194.3 Mm^3. This water efficiency finding forms a good foundation for future IWRM efforts.

Water is mostly supplied from groundwater followed by reservoirs (dam storage water) and river water. Figure 6 illustrates water abstraction by source of water for 2011/12. The growth of surface water, both dam and river, is likely to increase further in the future, with new dam developments and more connections to the NSC. 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.

Self-providers account for more than half of all water abstracted in Botswana (Figure 6). Some of the self-providers, like mining companies, have records of their water abstraction. But self-providers for agriculture do not measure their water use and the figures must be estimated.

Figure 6: Water Abstraction by Supply Institution: Self Providers vs. Water Distribution Agencies (2011/12)

(Million cubic meters of water)

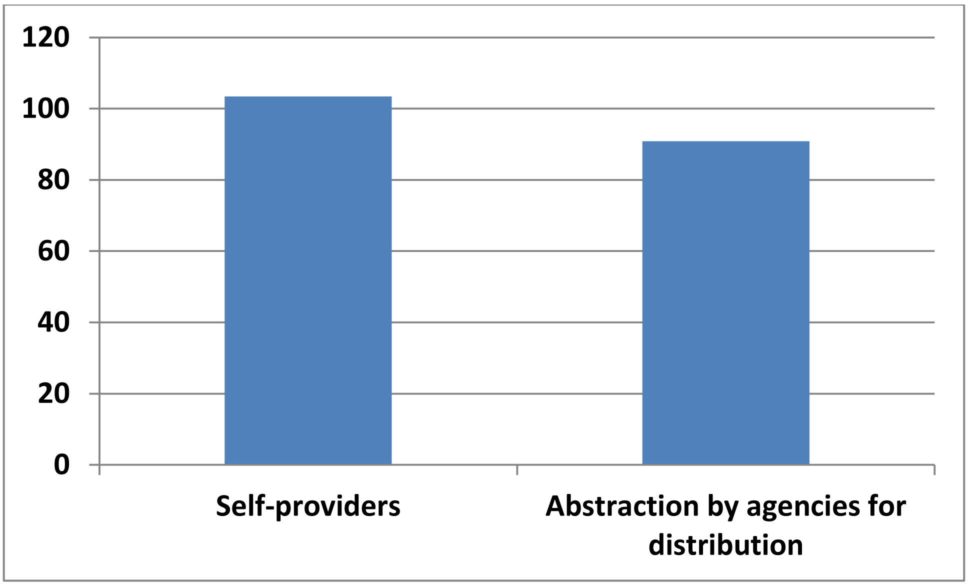


Figure 4 shows the sectoral contributions to GDP, formal employment, and water consumption. The agricultural sector consumes a large amount of water but contributes little to GDP and formal employment. The mining sector makes a large contribution to GDP and consumes a significant amount of water. Its 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:

1. The opportunity costs of agricultural water consumption need to be carefully considered in development planning; and
2. Water consumption and requirements should be considered as part of the economic diversification drive and trade policies. From an IWRM perspective, diversification should favor the service sectors, and trade policies must recognize Botswana's comparative disadvantage in water resources.

2.3 Trend in Water Use Productivity

For a water scarce country, it is important to improve water productivity and decouple economic growth from water use. At the national level, water productivity is measured as GDP per cubic meter of water; at the sectoral level, water productivity is measured as sectoral value-added (a sector's contribution to GDP) per cubic meter of water used. One indicator of the social contribution of water use in a sector is employment creation. Trends in water productivity have been measured in terms of GDP and employment creation. The GDP per m^3 was estimated for the period 1994–2010 using figures provided by SB (constant 2006 BWP in thousands) and the annual water use from the water accounts. The results are shown in Figure 7. National water productivity increased by 50 percent from BWP 0.21/m^3 in 1994 to BWP 0.32/m^3 in 2010. Further analysis is needed to determine how much of this improvement may be attributed to changes in the economic structure of the country toward less water-intensive sectors and how much to greater water efficiency in existing use sectors.

Figure 7: Trend in Water Productivity

(GDP in constant 2006 Botswana pula per cubic meter of water)

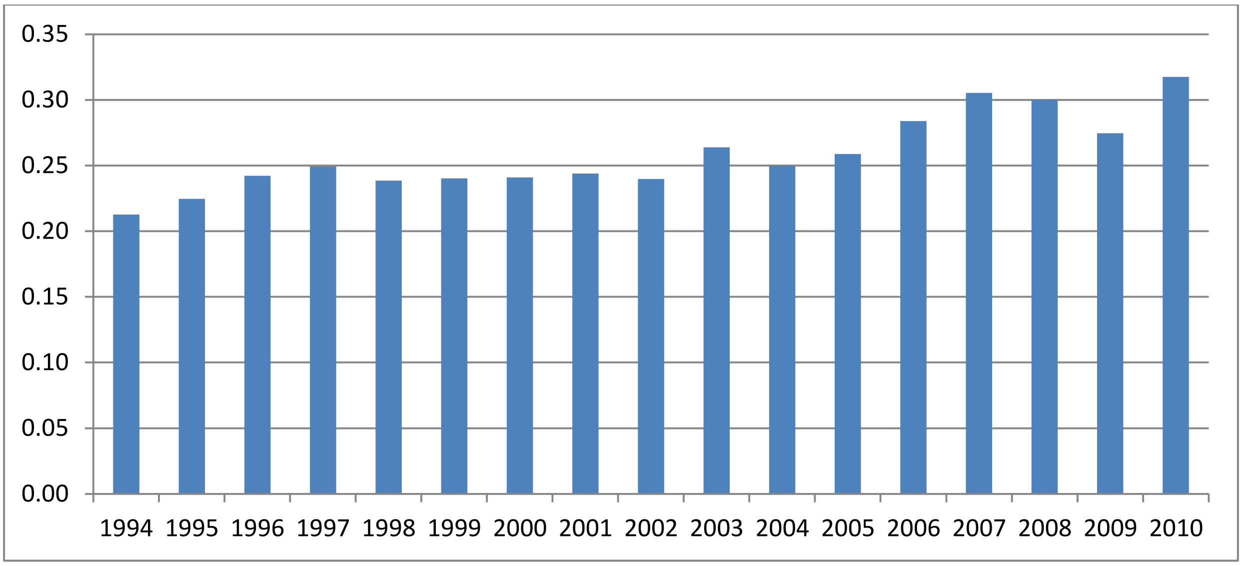
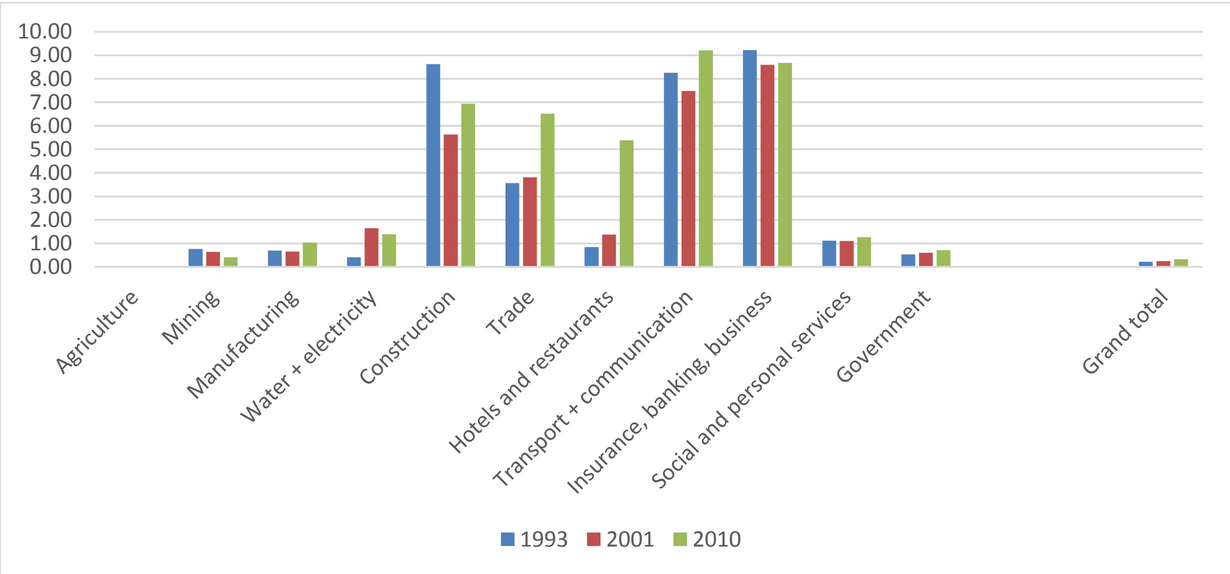


Figure 8 shows sectoral water productivity for three years. The sectoral value added/m3 has increased in the trade and hotel/restaurant sectors as well in social and personal services and the government. Value added/m^3 has decreased in the mining sector.

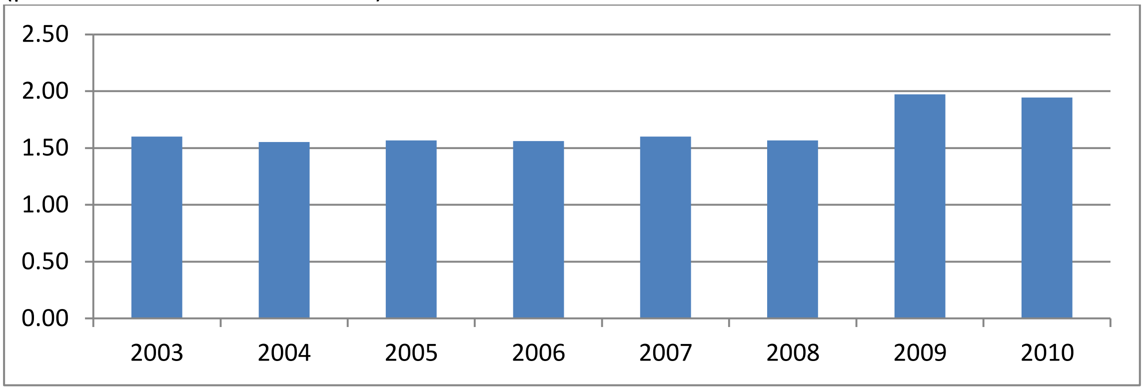
Figure 8: A Comparison of Sectoral Water Productivity (1994, 2001, and 2010)

(sectoral value-added in constant 2006 Botswana pula per cubic meter of water)



The trend in water use per formal job was assessed for the period 2003–2010. Figure 9 shows that formal employment associated with water increased from 1.6 jobs/thousands of cubic meters (000m3) in 2003 to 1.9 jobs/000m3. The relationship between water use and formal employment is fairly stable. The increase in 2009 and 2010 is due to the Ipelegeng program, which has boosted formal employment without using much water.

Figure 9: Trend in Formal Jobs
(per thousands of cubic meters)

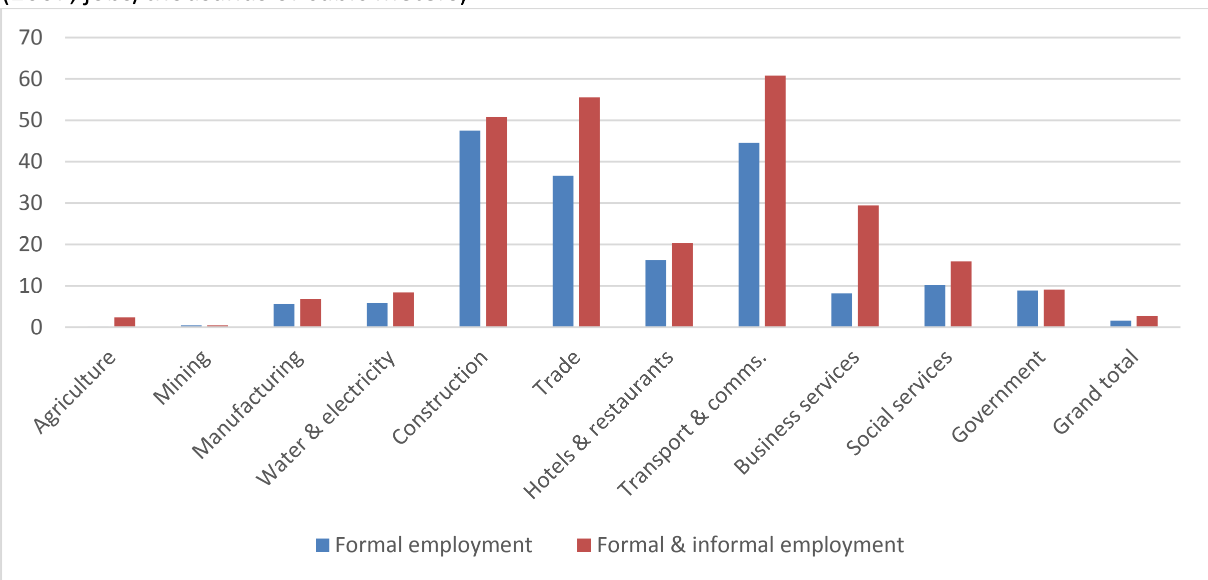


Note: the surge in formal employment from 2009 onward is due to the Ipelegeng program.

Informal employment is important for livelihoods and its inclusion in the indicator gives a better perspective on the employment creation/m^3. Formal and informal employment data is available for the year 2007 and the employment generation/000m3 was calculated for that particular year (Figure 10). Informal employment figures are taken from the Informal Sector Survey. In addition, data from Agricultural Statistics were used to estimate informal employment in the agricultural sector, assuming that all agricultural holdings have one informal job, i.e., self-employment of the farmer (110,810). Moreover, agricultural workers data was used from the same statistics (23,056).

Inclusion of informal employment, as described, shows in Figure 10 that on average, 2.7 jobs are associated with 1,000 m3 of water use (2007). This is almost double that of formal sector employment (1.5 jobs). Job generation in the agricultural sector more than doubles but the employment/000m3 remains low compared to economic sectors, other than mining.

Figure 10: Formal and Informal Employment by Sector
(2007, jobs/thousands of cubic meters)

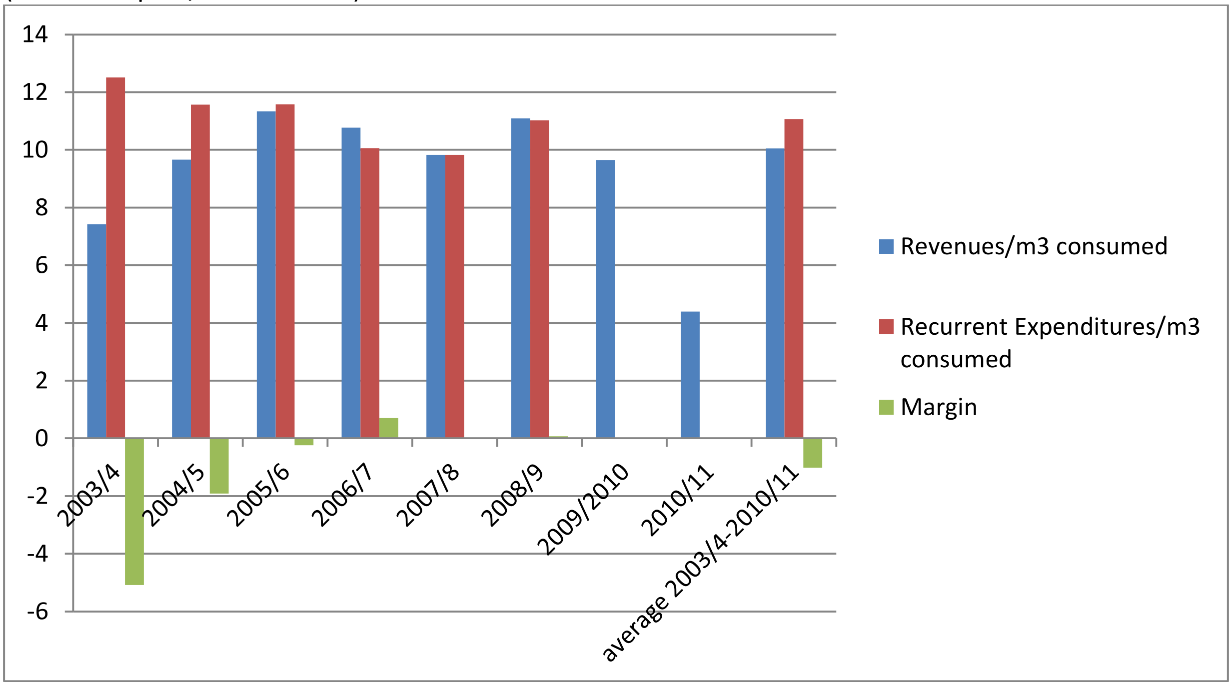


Sources: Employment figures derived from the 2007 Informal Sector Survey and annual employment statistics.

2.4 Toward Monetary Water Accounts: Trend in Revenues and Costs

In addition to physical water accounts, monetary accounts are also very useful for resource management. Monetary accounts include 1) the costs of water supplied to each sector and 2) the payments for water for each sector. The costs of water supplied should include both operating costs and capital costs. Payments for water are most often compiled from the billing records of water service providers which record revenues of these providers. No data exist for DC, but DWA and WUC have documented their annual recurrent revenues and costs (but not their capital costs). Figure 11 shows the trend over the last decade of annual average revenues and recurrent costs per m^3 as well as the margin (i.e., revenues minus recurrent costs). Over this period 2003/4 to 2010/11, DWA did not recover its recurrent expenditures. The average revenues/m^3 used was BWP 10.05, compared with recurrent expenditures of BWP 11.06, leading to a 10 percent shortfall.

Figure 11: Trends in Department of Water Affairs Unit Revenues and Recurrent Expenditures (2003/4–2010/11)
(Botswana pula/cubic meters)



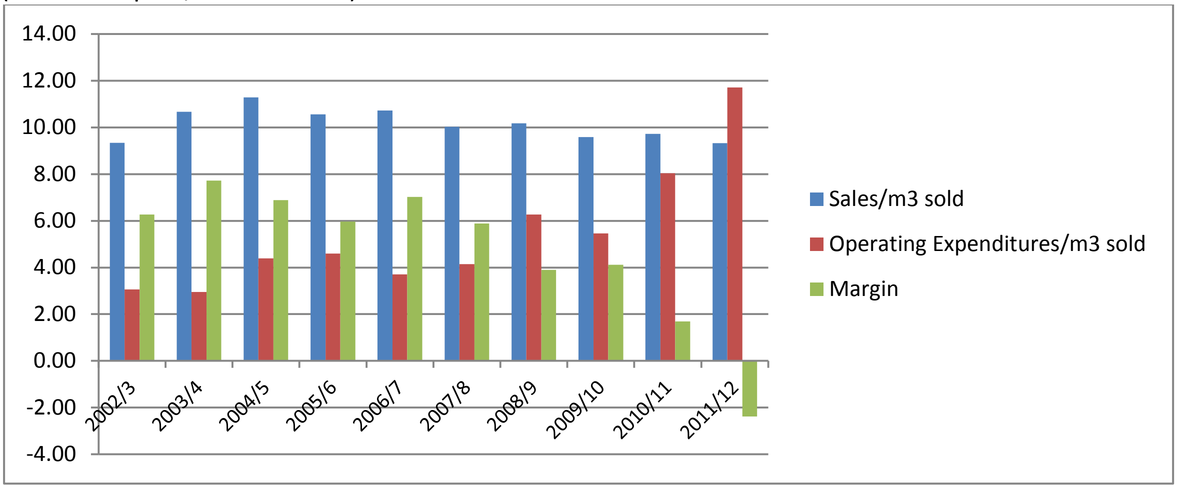
Note: no recurrent expenditure figures available for 2009/10 and 2010/11.
Source: DWA P and C data for large villages

In contrast, and as required by law, WUC has recovered its operating expenditures in the period 2002/3 to 2011/12 (Figure 12). The average revenues/m^3 sold was BWP 10.14 compared to recurrent expenditures of BWP 5.43. The revenues were similar to those of DWA, but the operating expenditures were less than half of DWA's. 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 in the longer term and requires further analysis[5] and action.

[5] 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 12: Trend in Water Utilities Corporation Unit Revenues and Operating Expenditures (2003/4–2011/12)

(Botswana pula/cubic meters)



Source: WUC data on revenues and operating expenditures

2.5 The 2010/11 and 2011/12 Flow Accounts Using the SEEA-Water Approach

The international standards for water accounting, SEEA-Water, were only adopted in 2012, although there was a lot of experimentation with water accounting before that time using a simpler framework. The figures presented above combine the older water accounts with comparable information from the more recent water accounts, which were compiled using SEEA-Water. The full water flow accounts for 2010–12 following the SEEA-Water framework are presented here. These distinguish water supply and use tables representing water flows from the environment, within the economy, and from the economy back 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 producers, 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 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 ISIC, Revision 3 (see also Appendix 2).

2.6 Physical Water Use and Supply Accounts

Tables 2 and 3 are abridged versions of the physical use and supply tables for 2010-12. A detailed table is provided in Appendix 3.

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. The bottom part of each table is the physical supply table. 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^3. Abstraction declined slightly in 2011/12 to 194.6 Mm^3. Abstraction for own use and for distribution is almost equal. Self-providers abstracted 51.8 percent of the water in 2011/12, compared to 48.2 percent for service providers. Imports for distribution, in this case water imported from the Molatedi dam in South Africa, are 3.7 percent 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 groundwater. Abstraction from rivers (Chobe and Limpopo) was approximately 1 percent in both years, with irrigation accounting for about 66 percent of the abstraction from rivers. Water use from other economic sectors is water distributed by service providers to different economic units. In 2010, 51 percent of the water distributed was used by households, while 49 percent of water use is spread through the rest of the economy. Water loss (i.e., the difference between abstraction and distribution) is shown to be 25.2 percent in the period 2010–12.

Water supply accounts show that 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 percent and 56 percent in 2010/11 and 2011/12, respectively). In some cases, water supplied to other sectors can be in the form of reused 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 wastewater treatment works, this should be possible. Return flows are only known for water service providers, whose losses mostly seep into the groundwater. 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.

2.7 Overall Water Abstraction, Use, and Consumption

Tables 2 and 3 show the following overall results:

Water abstraction	197.2 Mm^3 (2010/11)	194.4 Mm^3 (2011/12)
Water use (incl. distribution)	270.2 Mm^3 (2010/11)	262.5 Mm^3 (2011/12)
Water consumption (use minus supply)	172.5 Mm^3 (2010/11)	171.6 Mm^3 (2011/12)

Water abstraction is just under 200 $Mm^{3,}$ while consumption is just over 170 Mm^3. Botswana's water consumption has decreased marginally from 173 Mm^3 in 2010/11 to 172 Mm^3 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 percent in 2010/11 and 44 percent 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^3 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 utilization should be enhanced in major sectors that do not necessarily require potable water use. Treated wastewater needs to be incorporated in future flow accounts.[6]

Figure 13 shows the share in water abstraction and consumption by economic sector and for households (as reflected in Table 2). Water service providers and self-providers account for the abstractions. Water consumption is dominated by the end users, such as households and the government, as well as the large self-providers (irrigation, mines, and the livestock sector).

The water accounts results can also be put in the broader perspective of a water balance of the country. This is reflected in Figure 19. The figure shows that an estimated 98.5 percent of the precipitation evaporates (241,860 Mm^3) and is not available for abstraction and use. The remainder (a mere 1.5 percent of precipitation) is equally divided between runoff into river and reservoirs and groundwater recharge (1,840 Mm^3). The groundwater recharge refers to recharge countrywide, and not only to recharge of well fields. After the completion of the Dikgatlhong Dam, the reservoir capacity is 440 Mm^3, or around a quarter of total runoff through rivers. The average inflow from water from abroad is 8,440 (for the period 2000–2004), most of which evaporates in the delta. The outflow refers to runoff through the Limpopo River system (the figure is based on old estimates, which need to be updated 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 20 shows the flows of water resources in the economy (2010/11). In essence, it depicts Table 3 in a figure. Question marks for flows in Figure 20 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 2 and 3 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 percentages of use (e.g., 80 percent 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 reuse and recycling to reduce abstraction of fresh water resources.

[6] This should be possible after WUC starts to monitor and record the inflows and outflows of wastewater treatment plants.

Table 2: Physical Use and Supply Tables of the Flow Accounts (2010/11)
(thousands of million cubic meters)

Physical use table	**Agriculture**	**Mining**	**Manufacturing**	**Electricity**	**Water service providers**	**Construction**	**Trade**	**Hotels**	**Transportation**	**Finance**	**Social services**	**Government**	**Int'l organs**	**Agriculture and industries**	**Household**	**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
1. Total abstraction	74,315	25,167	-		90,425	-	-	-	-	-	-	-	-	189,907	-	7,300	197,207
Reservoir water	12,470	-			62,727									75,197		7,300	82,497
Groundwater	48,841	25,167			25,317									99,325			99,325
River water	13,004				2,381									15,385			15,385
Abstraction from water resources	74,315	25,167	-		90,425	-	-	-	-	-	-	-	-	189,907		7,300	197,207
2. Water from other economic sectors	264	7,275	2,758	80		369	1,645	786	258	1,329	5,254	15,686	104	35,809	37,218		73,027
																	-
3. Total use of water (1+2)	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

Physical supply table

4. Supply of water to other economic units					65,727									65,727		7,300	73,027
																	-
5. Total returns					24,683									24,683			24,683

Groundwater					24,683									24,683			24,683
6.Total supply of water (=4+5)	-	-	-	-	90,410	-	-	-	-	-	-	-	-	90,410	-	7,300	97,710
7. Consumption	**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 3: Physical Use and Supply Tables of the Flow Accounts (2011/12)

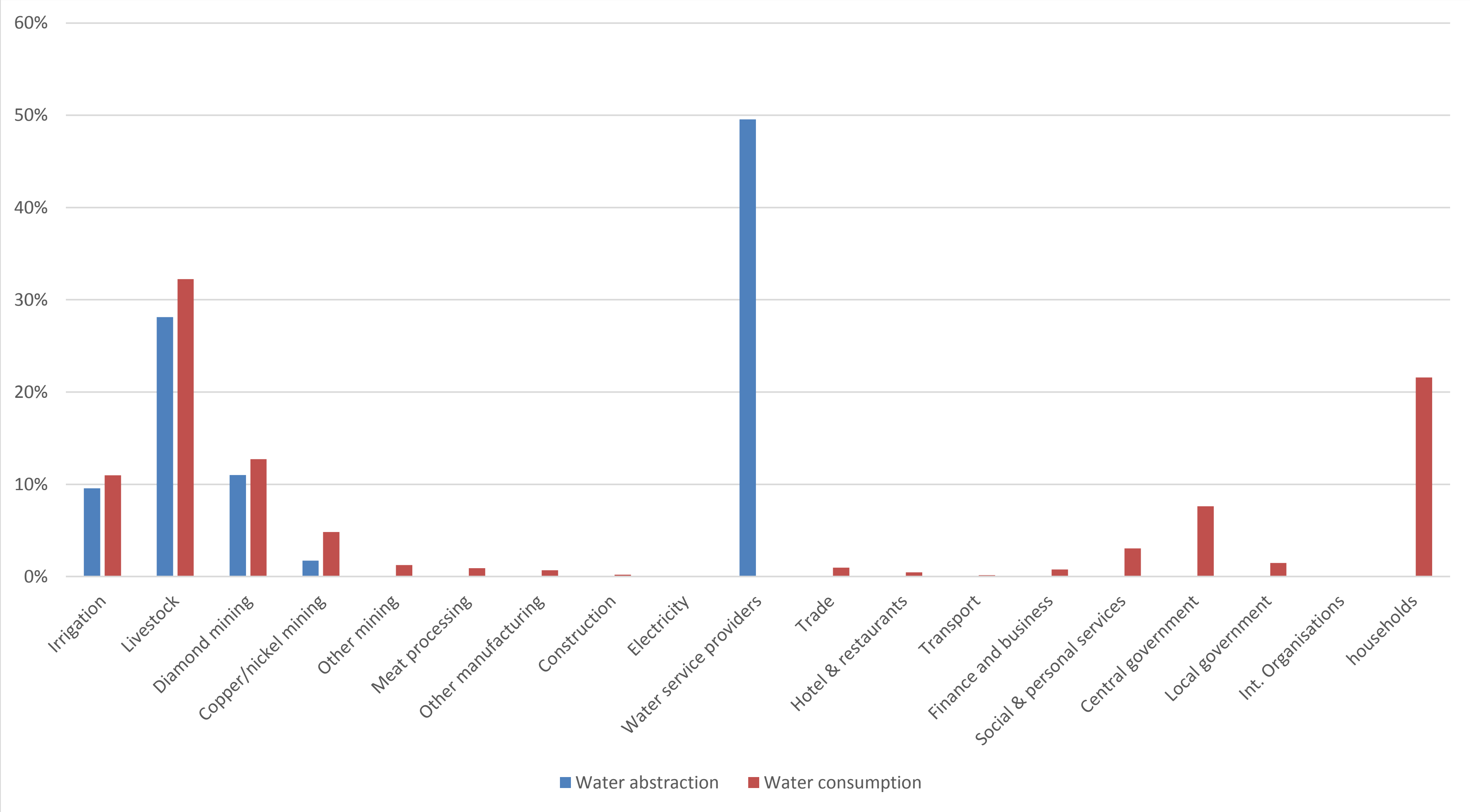
(thousands of million cubic meters)

Physical use table	**Agriculture**	**Mining**	**Manufacturing**	**Electricity**	**Water service providers**	**Construction**	**Trade**	**Hotels**	**Transportation**	**Finance**	**Social services**	**Govt**	**Int. organs**	**Agric and industries**	**Household**	**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
1. Total abstraction	74,315	29,108	-	-	83,740	-	-	-	-	-	-	-	-	187,164	-	7,200	194,364
Reservoir water	12,470	-			55,935									68,405		7,200	75,605
Groundwater	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
2. Water from other economic sectors	289	5,467	3,446	103		405	1,259	872	258	2,254	3,983	11,563	156	30,054	38,048		68,103
3. Total use of water (1+2)	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

Physical supply table

4. Supply of water to other economic units					60,903									60,903		7,200	68,103
																	-
5. Total returns					22,813									22,813			22,813
5. a.1. Surface water														-			-
5. a.2. Groundwater					22,813									22,813			22,813
6.Total supply of water (=4+5)	-	-	-	-	83,715	-	-	-	-	-	-	-	-	83,715	-	7,200	90,915
7. Consumption	**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 13: Shares of Economic Sectors and Households in Water Abstraction and Consumption (2010/11)



Chapter 3 Water Stock Accounts

The stock accounts in Botswana are of three types: surface water stocks (reservoirs and rivers), groundwater stocks, and wastewater stocks. For reservoirs, there is data on 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 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: 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 well-fields are explored, the use of groundwater will increase. On the other hand, groundwater resources are vulnerable to over-exploitation. Therefore, future efforts must be directed at constructing groundwater stock accounts to help ensure their sustainable use.

Previous work indicates that there are sufficient wastewater resources that can be exploited. This can help reduce pressure on the scarce surface and groundwater resources. Therefore, this also must be a part of future efforts.

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

Dam	Full Supply Capacity (MM3)	Annual Yield (MM3)
Gaborone	140.5	9.4*
Bokaa	18.5	-
Nnywane	1.75	-
Shashe	87.9	25.3*
Letsibogo	100	60

*Based on pre-siltation volumes

Data required for stock accounts include

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

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 4 shows the stock accounts for the above dams.

The data is summarized in Figure 14. 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 groundwater and wastewater resources.

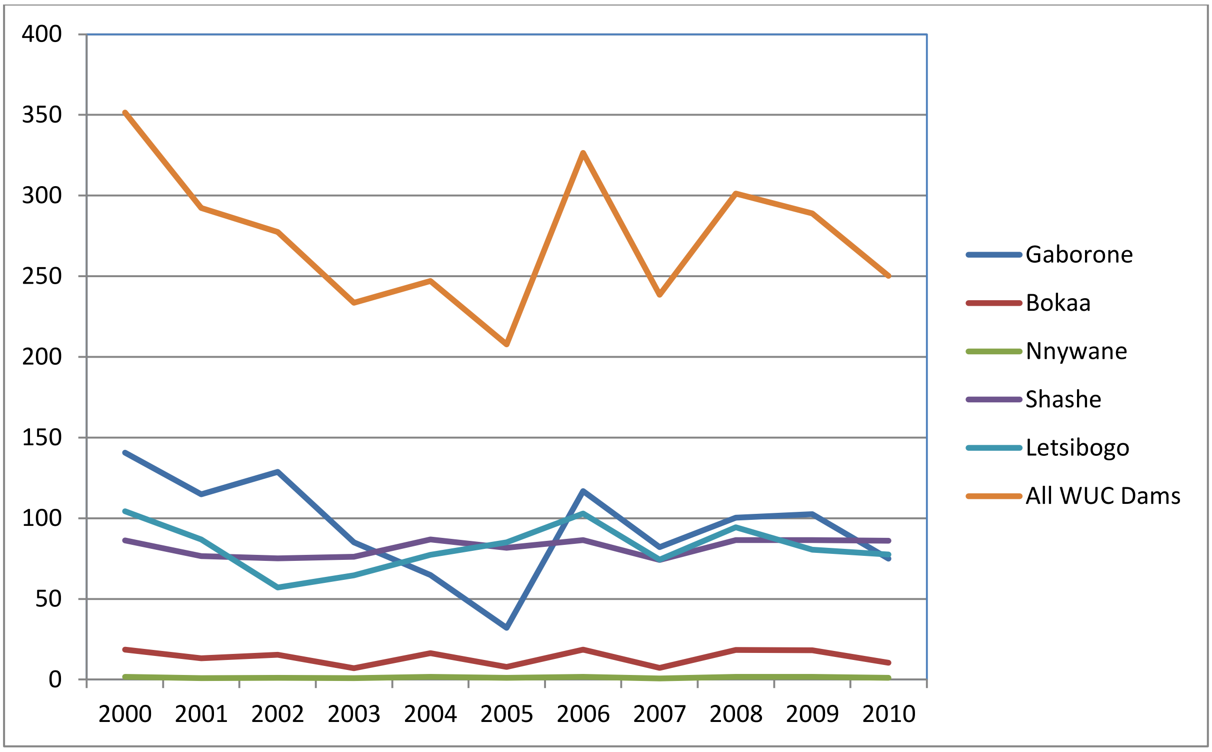
Table 4: Stock Accounts of Water Utilities Corporation Dams
(million cubic meters)

Gaborone dam	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Opening volume (MM3)	140.59	114.9	128.7	85.06	64.74	32.09	116.77	82.04	100.25	102.44	75.03
Inflows (MM3)	**17.40**	**57.25**	**8.39**	**19.7**	**8.08**	**138.88**	**0.58**	**72.05**	**41.18**	**12.35**	**87.03**
Incoming transfers Bokaa (MM3)	0	0	0	0	0	0	0	0	0	0	0
Incoming transfers Molatedi (MM3)	2.9148	5.798	6.314	4.21	5.522	0.00	6.11	4.14	2.70	2.72	7.6
Abstraction **000M^3**	13573	15862	22372	24842	19605	17800	8000	18700	22300	26350	26400
Evaporation (MM3)	24.53	23.39	20.52	14.38	9.30	14.29	19.09	17.50	19.46	17.04	19.01
Outgoing transfers (MM3)	0	0	0	0	0	0	0	0	0	0	0
Closing volume (MM3)	114.9	128.7	85.06	64.74	32.09	116.77	82.04	100.25	102.44	75.03	122.98
Bokaa dam	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	2007	**2008**	**2009**	**2010**
Opening volume (MM3)	18.5	13.2	15.3	6.98	16.34	7.8	18.5	7.29	18.38	18.2	10.44
Inflows (MM3)		18.46		20.11	2.41	21.74	5.55	25.3	13.56	4.86	17.74
Incoming transfers (MM3)	0	0	0	0	0	0	0	0	0	0	0
Abstraction **000M^3**		5409	3068	2800	1900	1200	2400	3800	5300	8100	6900
Evaporation (MM3)	3.804	3.42	2.674	2.798	2.897	3.156	3.0948	3.0804	4.3896	3.4368	2.544
Outgoing transfers (MM3)	0	0	0	0	0	0	0	0	0	0	0
Closing volume (MM3)	13.2	15.3	6.98	16.34	7.8	18.5	7.29	18.38	18.2	10.44	10.76
Nnywane dam	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	2007	**2008**	**2009**	**2010**
Opening volume (MM3)	1.71	0.802	1.14	0.91	1.74	1.11	1.75	0.62	1.73	1.72	1.11
Inflows (MM3)	0.38	1.53	0.86	1.86	0.47	1.78	0.19	2.24	1.12	0.54	1.67
Incoming transfers (MM3)	0	0	0	0	0	0	0	0	0	0	0

Abstraction **000M^3**	1014.3	992	700.00	700.00	500.00	700.00	900.00	800.00	290	460	210
Evaporation (MM3)	0.3466	0.268	0.283	0.366	0.393	0.3946	0.3270	0.3243	0.4761	0.3905	0.3767
Outgoing transfers (MM3)	0	0	0	0	0	0	0	0	0	0	0
Closing volume (MM3)	0.802	1.14	0.91	1.74	1.11	1.75	0.62	1.73	1.72	1.11	1.62
Shashe dam	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	2007	**2008**	**2009**	**2010**
Opening volume (MM3)	94.03	76.5	75.2	75.97	87.9	81.7	86.5	71	86.5	86.5	86.1
Inflows (MM3)	21.4	52	38.9	44.6	48	70.3	25	51	43.3	48.9	29.5
Incoming transfers (MM3)	0	0	0	0	0	0	0	0	0	0	0
Abstraction **000M^3**	11635	9082	9200	9100	12900	13400	14600	14400	16290	17310	13530
Evaporation (MM3)	26.602	23.67	23.58	25.56	26.46	26.239	24.57	24.57	26.988	26.9256	26.3484
Outgoing transfers(MM3)	0	0	0	0	0	0	0	0	0	0	0
Closing volume (MM3)	76.5	75.2	75.97	87.9	81.7	86.5	71	86.5	86.5	86.1	82.8
Letsibogo dam	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	2007	**2008**	**2009**	**2010**
Opening volume (MM3)	104.4	86.82	57.11	64.58	77.28	85.1	102.96	74.42	94.32	80.46	77.6
Inflows (MM3)	21.54	13.45	38.42	59.01	66.71	52.95	19.18	53.361	87.883	29.73	47.03
Incoming transfers (MM3)	0	0	0	0	0	0	0	0	0	0	0
Abstraction **000M^3**	5170	12642	15650	14555	18623	11100	16600	13100	3200.0	12020	11030
Evaporation (MM3)	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 (MM3)	86.82	57.11	64.58	77.28	85.1	102.96	74.42	94.32	80.46	77.6	
All WUC dams	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	2007	**2008**	**2009**	**2010**
Opening volume (MM3)	351.501	292.2	277.5	233.6	248	207.8	326.48	238.57	301.18	289	250.28

Inflows (MM3)	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 (MM3)	0	0	0	0	0	0	0	0	0	0	0
Incoming transfers Molatedi (MM3)	2.9148	5.798	6.314	4.21	5.522	0	6.1050	4.1440	2.6962	2.72	7.6
Abstraction (000M3)	31392	43988	50990	51997	53528	44200	42500	50800	47380	64240	58070
Evaporation (MM3)	90.88	68.01	61.67	60.13	58.53	66.65	68.36	65.72	72.29	66.76	57.59
Outgoing transfers (MM3)	0	0	0	0	0	0	0	0	0	0	0
Closing volume (MM3)	292.22	277.5	233.6	248	207.8	326.48	238.57	301.18	289	250.28	218.16

Figure 14: Water Volumes in Water Utilities Corporation Dams (2001/2–2010/11)



Chapter 4 Water Flows and Use by Region

The distribution of water resources can vary significantly by region within a country; similarly the demand for water varies regionally. Decentralized water management is one of the IWRM principles, which is anchored in Botswana in the draft National Water Policy and in the 2013 integrated water resources management and water efficiency plan. However, Botswana has not yet defined and agreed on the water resource management regions. Many countries use the catchment and river basin as the management area (e.g., South Africa and Namibia), while other countries, like Mexico, may rely on a combination of surface and groundwater resources to define the water management area. The only functional regional division at the moment is the MC, which WUC distinguishes for the provision of water to all parts of the country. Therefore, a regionalization of water flows exercise was undertaken to compile water abstraction and use information by WUC MCs. DWA is expected to initiate and lead a process of determining water management regions in the near future.

The exercise carried out for the water accounts 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 was collected and analyzed 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 was collected and analyzed. The 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.

4.1 Data Requirements and Sources

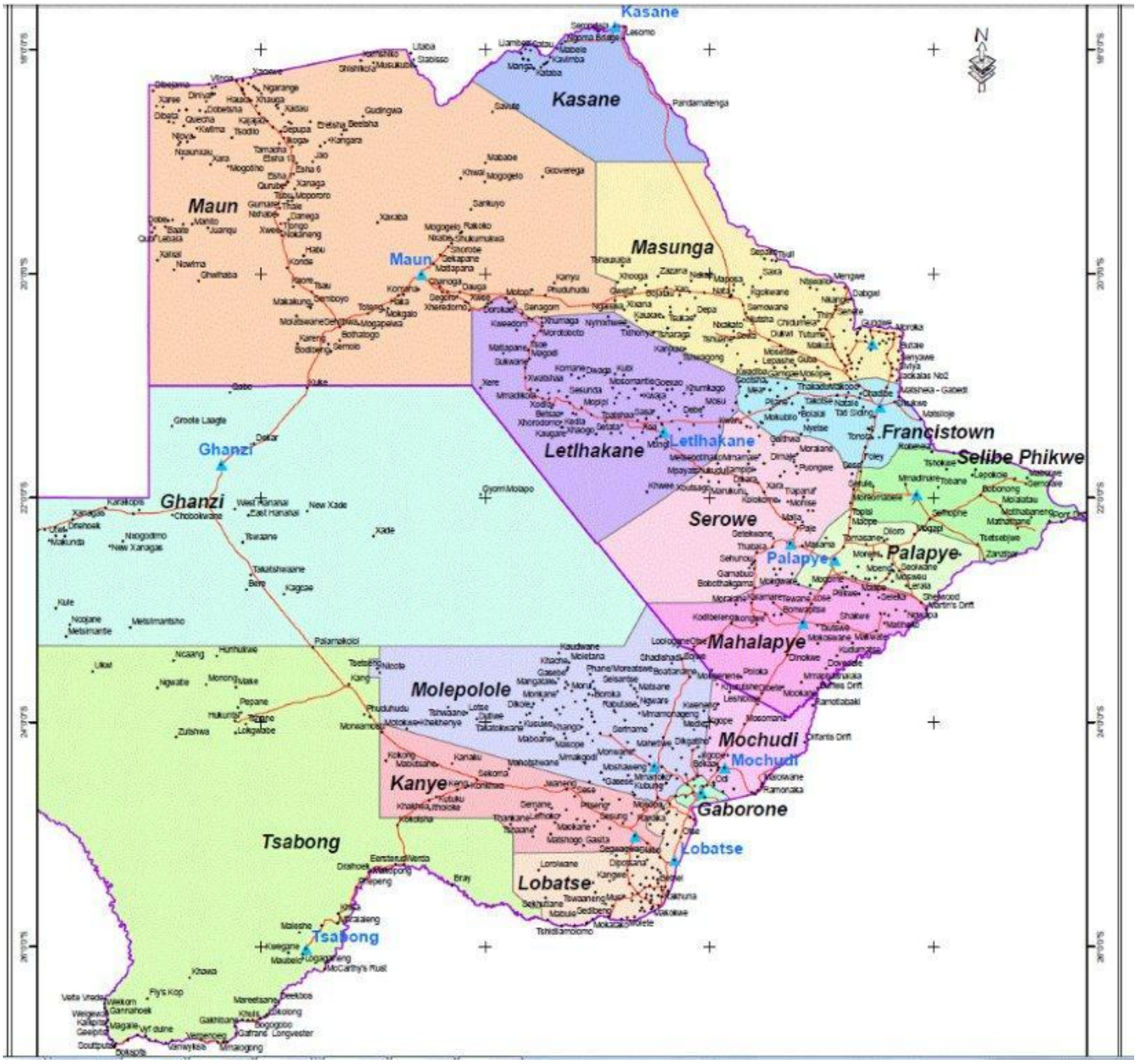
Regionalization of water abstraction and use requires data on abstraction, use, and losses by source of water, MC, and supplying institution, as well as by the sector using the water. Costs and revenues are also necessary for the monetary accounts. Water abstraction data was available for three quarters of 2012/13, while losses were availed 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 liters/person/day (L/p/d)[7] 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 for former DWA villages (135 L/p/d)[8] with the 2011 population figures. Costs and revenue data for Maun were also not available for the accounts. To fill the data gaps, a number of assumptions were used in the study.

[7] This figure is the average of all metered small villages.

[8] This figure is the average daily water abstraction in all former DWA villages for nine months (the period for which data is available).

Map 1: Water Utilities Corporation Management Centers



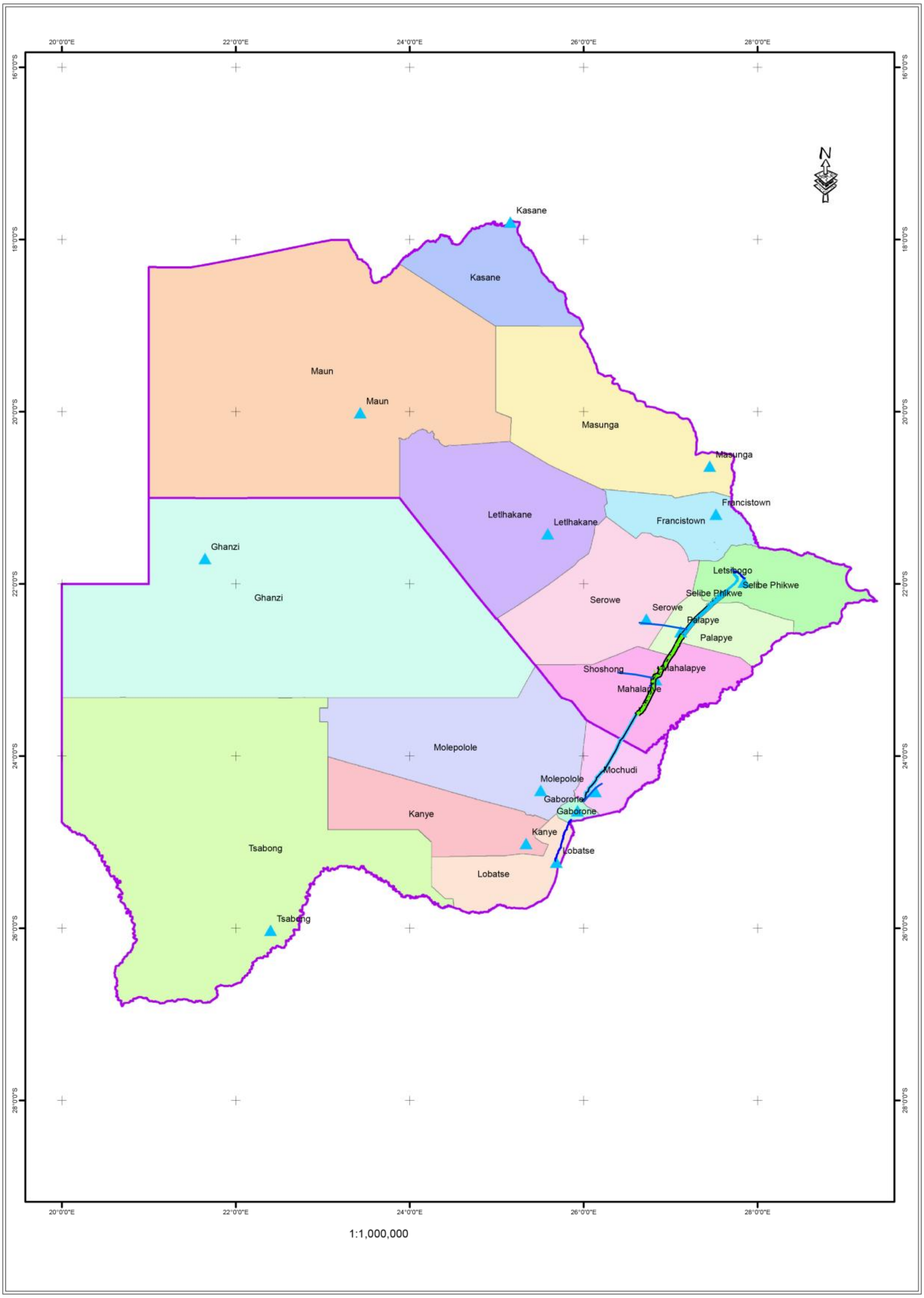
Source: WUC

4.2 Findings

4.2.1 The North South Carrier Program and Water Imports

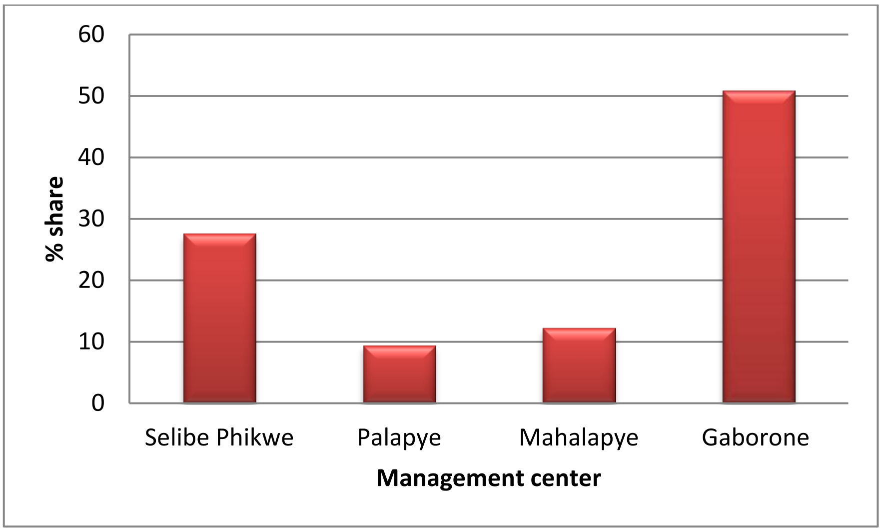
Water resources and supply are unevenly distributed in Botswana. Some MCs have sufficient water resources (reservoirs) while others depend on limited groundwater that is often saline. Most large reservoirs are found in the north-eastern part of the country. Due to this uneven distribution of water, water is transferred among MCs through the NSC (Map 2). The quantity of water abstracted and transferred through the NSC was about 18.6 Mm^3 between April and December 2012. Most of the water is transferred to Gaborone MC (about 51 percent; see Map 2 and Figure 15). Selibe Phikwe receives around 28 percent of water from the NSC, while Mahalapye and Palapye account for 12 percent and 9 percent, respectively. However, the NSC experiences occasional breakdowns, causing water constraints in recipient MCs. WUC continues to encourage water conservation and management measures by consumers to reduce pressure on the NSC. It is expected that once NSC 2 is in place, it will augment the water supply to the southern part of the country.

Map 2: The North South Water Carrier



Source: WUC

Figure 15: Proportion of Water Transferred from North South Carrier to Management Centers (April–December 2012)



Source: based on WUC data

Additionally, Botswana also has an annual water quota of 7.3 Mm^3 from Molatedi Dam in South Africa (reduced to half when the dam level is below 26 percent). The imported water (reflected in the SEEA water supply and use tables; Tables 2 and 3) 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 Regionalization report.

4.2.2 Water Abstraction and Distribution by Management Center

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^3 in 2010/11 and 194 Mm^3 in 2011/12, including abstraction for mines and livestock sectors. DCs constituted about 15 Mm^3 in 2010/11 and 6 Mm^3 in 2011/12. The decline in water abstraction is due to WUC's takeover of water provision in most settlements.

Table 5: Water Abstraction by Management Center and Institution

	2010/11						2011/12					
	Service providers			Self-providers			Service providers			Self-providers		
MC	**WUC**	**DWA**	**DCs**	**Mines**	**Livestock**	**Total**	**WUC**	**DWA**	**DCs**	**Mines**	**Livestock**	**Total**
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
Maun	-	1,957.1		-	5,015.0	6,972.1	-	1,738.1		1,675.0	4,665.8	8,078.9
Total	**70,559**	**14,787**	**15,414**	**30,100**	**66,348**	**197,207**	**93,188**	**1,907**	**6,463**	**31,938**	**60,868**	**194,364**

4.3.3 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 abstraction estimates for many small villages, with an average daily per capita water abstraction figure of 72 liters/day/person (water abstraction figures from WUC divided by population size).

Water abstraction from groundwater is higher than abstraction from reservoirs. There is greater abstraction of dam water by service providers, while self-providers mostly use groundwater.

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

Chapter 5 Indicators for Water Management

Prudent water resource management should be informed by key resource indicators and policy analysis of the results of water accounting. Indicators are particularly useful to summarize detailed results, monitor the trends through time series, and compare Botswana with other countries (cross-country comparison). Based on the IWRM framework, which is also adopted in Botswana's draft National Water Policy and 2013 IWRM-Water Efficiency Plan, SEEA-Water suggests the following group of indicators that can be derived from water accounts:

- Water resource availability;
- Water use for human activities, pressure on water resources, and opportunities to increase water efficiency;
- Opportunities to increase effective water supply through return flow management re use and system losses; and
- Water cost and pricing.

The current Botswana water accounts can provide figures for indicators in each category. These are further discussed below. The indicators focus on the period 2010/11 and 2011/12, when the accounts followed the SEEA-Water template. The comparison with results of earlier water accounting studies must be treated with caution (beyond the results discussed in chapter 2 that focus on water abstraction, value added/m^3, and water costs).

This chapter first summarizes key indicators developed in conjunction with the water accounts (section 5.1). Chapter 6 proceeds to analyze the results of water accounting for policy and resource management. Further work on water accounting will include discussion of, and agreement on, a set of key indicators needed to support policy and decision making.[9]

5.1 Water Resources Indicators

The current water accounts generate several indicators that are indicative of the use of water as natural capital, which are discussed below.

5.1.1 Water Resources Availability

It is important for policy and decision makers to know how much renewable water resources are available, how much of these are internal and/or external, how much of these resources are managed through dams and well fields, and how the amount of renewable water resources relates to population size (per capita renewable water resources). Botswana is a semiarid country and most of its surface water sources have external links (e.g., Okavango, Chobe-Zambezi, Limpopo, and Orange) and their use and management is subject to the Southern African Development Community Protocol on Shared Watercourses. Some groundwater water sources are also transboundary. The stock accounts show the actual amount of water in reservoirs in contrast to the reservoir's capacities. The actual amounts of water stored in reservoirs is often well below the capacity. The current water availability indicators are summarized in Table 6.

[9] Similar and additional indicators can be found, among others, in Aquastats (FAO) and the World Water Reports.

Table 6: Indicators for Water Availability in Botswana

Water availability indicator	Source	Period	2010/11	2011/12
Internal renewable water resources (IRWR)	Fig 4 & 5	3 683 Mm^3 Av. for 2000–2010		
Total renewable water resources (TRWR)	Fig 4 & 5	12 123 Mm^3 Av. for 2000–2010		
Dependency ratio (1 – IRWR/TRWR)	Fig 4 & 5	70%		
Per capita IRWR		4 983 L/p/d		
Water storage capacity in reservoirs	Stock accounts		422 Mm^3	422 Mm^3
Storage capacity as % of internal runoff		24%; Av. for 2000–2010		
Safe yields from reservoirs	Hydro data for reservoirs; stock accounts		73.5 Mm^3	73.5 Mm^3
Safe yields as % of storage capacity	Stock accounts		17.4%	17.4%
Water storage capacity per capita	Stock accounts & population data			522 L/p/d
Safe yield storage capacity per capita	Stock accounts & population data			96 L/p/d

Note: Av. = average; L = liter; p = person; d = day.

The indicators show a large amount of available water resources and a high reliance on external water resources; most available water resources evaporate and only a fraction results in runoff or groundwater recharge (Figures 18 and 19). Furthermore, the safe yields of reservoirs are very low compared to their capacity, and safe yields of reservoirs are well below per capita water consumptions (see below). From an IWRM perspective, there is a need to develop groundwater resources, increase safe yields through interconnection ground and surface water sources, and increase the efficiency of water uses. Moreover, methods of capturing a larger share of available water resources need to be investigated.

5.1.2 Water Use for Human Activities

Understanding water use is important for policymakers and decision makers, as it shows the water resource use productivity (both trends and differences between economic sectors), as well as differences between water abstraction and consumption and associated water losses, and the amounts of reuse and recycling. Furthermore, the accounts show per capita water consumption and abstraction. Importantly, it also gives insights into existing water stress situations, for example, by comparing per capita water consumption with per capita annually stored water. Finally, the accounts provide insights into the importance of water service providers and the self-providers (whose role is often overlooked in IWRM), and in reliance on groundwater and surface water (reservoirs and rivers). The SEEA-Water framework also provides for handling issues such as water quality and reuse/recycling of treated wastewater. However, these aspects are not yet covered in the Botswana water accounts, and no indicators have been developed. The current indicators are presented in

Table 7: Indicators for Water Use for Human Activities

	Source:	2010/11	2011/12
Annual water abstraction of which: Groundwater Reservoirs Rivers	Supply accounts	197.7 Mm^3	194.4 Mm^3 103.4 Mm^3 75.6 Mm^3 15.4 Mm^3
Abstraction for own use Abstraction by service providers	Supply accounts	99.5 Mm^3 98.2 Mm^3	103.4 Mm^3 91 Mm^3
Annual water use Of which: Households Government Agriculture Mining Other productive sectors (e.g., manufacturing and services)	Use accounts		 38.0 Mm^3 11.6 Mm^3 74.6 Mm^3 34.6 Mm^3 28.1 Mm^3
Annual per capita water use Of which domestic per capita use	Use accounts and population data		266.6 L/p/d 50.4 L/p/d
Water efficiency Value added in constant 2006 BWP/m^3 Formal employment/000m3 Formal employment and traditional Agricultural employment/000m3	Use accounts and national accounts	340 2.3 3.5	367 2.3
Water losses of service providers	Supply and use accounts	24.7 Mm^3 or 25.3%	22.8 Mm^3 or 25.2%

Note: L = liter; p = person; d = day.

The indicators show that water abstraction is just less than 200 Mm^3. The self-providers play a major role in the water sector, as their combined abstraction (mostly mines and farmers) exceeds that of water service providers. IWRM therefore needs to focus more on self-providers than it has previously. Botswana is reliant on groundwater, as per capita total water use is 267 L/p/d, compared with safe yields from reservoirs of 96 L/p/d. The new water reservoirs are urgently needed, and should increase the safe yields and reduce the pressure on well fields, many of which are mined. Agriculture is the largest water-using sector, followed by the mining sector. Households use more water than the mining sector, so water demand management campaigns need to target households, too. Once returns are fully incorporated into the accounts, the indicators will show how much water is abstracted from the environment and how much is returned to it through losses and discharges. While this is important information to assess how much water is left for the environment, the accounts will not specify the ecological water requirements.

5.1.3 Water Costs, Pricing, and Incentives for Water Conservation

Water costs and pricing are important for decision makers to guide tariff setting, provide incentives for water conservation, and monitor the country's competitiveness compared to other countries. At the moment, the main water service provider, WUC, is required to recover full costs. The government subsidizes the household and private sector by paying higher water tariffs than the latter. Most self-providers pay their own capital and recurrent expenditures; some farmers benefit from subsidies (e.g., irrigation and livestock). Rising costs without tariff increases burdens government finances.

The current water accounts provide some information on the recurrent expenditures and revenues of WUC and DWA (provided water to major villages). The indicators show the following:

- ✓ For DWA, the average revenues/m^3 used was BWP 10.05, compared with recurrent expenditures of BWP 11.06, leading to a shortfall of 10 percent (period 2002/3–2010/11; see figure 11).
- ✓ For WUC, the average revenues/m^3 sold of BWP 10.14 compared with recurrent expenditures of BWP 5.43 (period 2002/3–2010/11), leading to a considerable surplus of 87 percent. However, WUC revenues dropped below the rising recurrent costs in 2011/12 (see figure 12).

The indicators show that WUC provided water in urban areas at around half of the recurrent costs of DWA, which supplied large villages. The water sector reforms, which make WUC responsible for water supply countrywide, seems to be justified. However, the recurrent expenditures of WUC have sharply increased since the implementation of the water sector reforms, while the revenues dropped, leading to financial losses. This is unsustainable and needs to be urgently addressed (see Chapter 6).

Chapter 6 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., the Okavango River). The inflow from the Okavango is more than three times the internal renewable water resource, leading to a very high dependency ratio (70 percent). The annual internal renewable water resource is estimated to be less than 5000 L/p/d.

The water accounts show that Botswana abstracts 194.4 Mm^3 from groundwater (103.4 Mm^3), reservoirs (73.5 Mm^3, and rivers (15.4 Mm^3). The abstraction from reservoirs (75.6 Mm^3) marginally exceeds the safe yields of the reservoirs (73.5 Mm^3).[10] This is risky and explains why several reservoirs are drying up during drought periods. The construction of the new reservoirs needs 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 groundwater: if the abstraction (103.4 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.[11] Total daily water use is estimated to be 267 L/p/d. This is well below the safe yields of reservoirs (96 L/p/d) and shows the country's continued reliance on groundwater. Households use on average 50 L/p/d, while the remainder (217 L/p/d) goes to agriculture, mining, the 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 percent in 2011/12 for water service providers (mostly WUC). Reaching the water loss target of 15 percent losses would save 6.3 Mm^3 of water or close to 5 percent of the country's water use. The current accounts do not record return flow. In earlier work, these were estimated to be 20 Mm^3 to 30 Mm^3, offering also a significant source for fresh water savings (10 percent to 15 percent). Both measures together could thus generate 15 percent to 20 percent more water resources for development.

The water account findings to date have some important policy implications. It is encouraging[12] to note that the increase in water use is slower than the increases in the population and the economy at large (Figure 20). 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.

[10] This excluded the new dams Dikgatlhong, Thune, and Lotsane. The safe yields have increased to 139.7 Mm^3 in 2013.

[11] The decrease only occurs for abstraction for distribution.

[12] 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.

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 analyzed 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, and high water supply costs during the 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 to reduce the level of future tariff increases.

Records on amounts of wastewater inflows and outflows do not exist. This data gap hampers the reuse and recycling of wastewater as targeted by the 2003 National Management Plan for Water, Wastewater, and Sanitation, which has the target of 96 percent reuse of the outflows. It is essential that WUC starts measuring wastewater inflows and outflows as soon as possible, and that the reuse of wastewater is metered and recorded. The amount of wastewater has rapidly increased (estimated at 27.1 Mm^3 in 2003 by DEA and CAR 2006). Because wastewater is generated close to population centers, it is a valuable resource for irrigation and other potential users of non-potable water. 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^3. Moreover, more than half of the current irrigation programs are not under cultivation, and there is a need to fully use serviced irrigation land. This should inform new large irrigation projects (e.g., from Chobe-Zambezi). All new wastewater treatment plants need to be constructed with adjacent facilities for reuse 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 the future by increasing the 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 integrated water resources management and water efficiency plan for 2013–2030.

The water sector reform program has important potential advantages for WA 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)
- An 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 prioritized 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 Botswana NWMP and the integrated water resources management and water efficiency 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^3 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

- 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, the government needs to discuss the best use of its Chobe-Zambezi allocation.
- NDP 11 should contain a detailed wastewater reuse strategy to achieve the reuse target of the National Management Plan for Water, Wastewater, and Sanitation. Reuse efforts need to be accelerated by the MoA and WUC.
- The costs of water management should be fully assessed and the financial burden should be fairly and evenly distributed between the 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.
- Water scarcity should become one of the considerations in the economic diversification drive. It should discourage economic diversification toward water intensive sectors; and encourage the development of a water conservation industry for the local and export markets.

Water scarcity should become one of the considerations in the economic diversification drive. It should discourage economic diversification toward water intensive sectors; and encourage the development of a water conservation industry for the local and export markets.

6.1 Recommendations

Water resource management

- Include water resources availability in economic diversification and trade policies
- Prioritize water demand management for MC shortage areas (there is a need to augment water supply with nonconventional water sources, such as treated wastewater)
- Further increase water efficiency gains
- Conduct regular data collection and analysis
- Encourage reuse of treated wastewater and saline water for sectors such as irrigation, mining, and construction
- Increase safe yields from the water infrastructure system
- Conduct better monitoring of self-providers
- Implement user-pays and polluter-pays principles
- Expand water accounts with stock accounts for major aquifers/well fields, physical flow accounts for treated wastewater, and monetary accounts (starting with the costs and revenues of water supply)

- Analyze the findings of new water accounts annually in terms of implications for policy and development planning

Water service providers

- WUC should include the economic sector classification in its client details database. DWA, SB, and WUC need to agree on a uniform economic classification system based on ISIC.
- Providers should adopt an agreed-upon, 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 the spatial data layer (as done for livestock).
- DWA needs to establish a water accounting unit and other stakeholders (WUC, SB, MoA, and the Department of Mines) need to have water accounts support staff regularly update water accounts. Form partnerships between the stakeholders to support the water accounting process.
- Providers should regularly assess and discuss the policy implications of the results with stakeholders to ensure their future cooperation and the actual implementation of the recommendations.
- Providers should direct significant efforts toward reducing losses in areas with high loss rates.

Irrigation

- Improve data collection and 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 annual agricultural statistics report.
- Give priority to increasing the use of serviced irrigation land; unused land should be reallocated to productive farmers, especially successful farmers who cannot expand.
- Achieve close and effective collaboration between the irrigation and horticulture divisions of the MoA.
- Privatize government irrigation programs and National Agricultural Master Plan for Arable and Dairy Development farms to make them more productive.
- Give priority to more productive use of water in current irrigation programs. This requires, among other measures, adjustment of the irrigation programs.
- Encourage use of treated effluent, accompanied by water quality monitoring. Its use also should be based on economic merits (value added, employment, food security, and poverty reduction).
- For bigger programs and irrigation farms, introduce metering to allow more accurate water use estimates.

Self-providers

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

Chapter 7 Road Map for Institutionalizing Water Accounting

7.1 Introduction

Proper institutionalization 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 institutionalize the water accounts because of several recent developments. First, the water sector reforms (2009–2014) mandated the DWA to assume responsibility for integrated water resource management. Water accounts are an important management tool. There are references to the need to establish water accounts in policy documents including the 2006 Review of the NWMP, the draft National Water Policy, and the 2013 integrated water resources management and water efficiency plan. Second, natural capital accounting has high-level policy support in Botswana, through the presidential signing of the May 2012 Gaborone Declaration on Sustainability in Africa and two 2012 meetings of the Botswana Economic Advisory Council, which prioritized the development of water accounts as the first activity of the WAVES Botswana program (CAR and Econsult 2012). These developments offer a favorable environment for successful institutionalization of the water accounts.

Below, the proposed data collection structure is outlined (section 7.2) followed by the organizational structure (7.3). 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.

7.2 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), SB, and line ministries/departments (the MoA’s Crop Production and the Ministry of Mineral, Energy, and Water Resources’ Department of Mines). Data should be annually collected by DWA based on an agreed template with the data providers. It is important that WUC incorporate an economic classification in its client’s base and there has been an agreement to do so. This will increase the accuracy and consistency of the economic classification, and reduced the work load significantly.[13] DWA will verify the data and enter it into the accounting framework and Excel spread sheets. The next step is to annually analyze the findings and policy implications of the data with the water sectors and development planning stakeholders. The last step is critical to ensure that water accounts will affect IWRM and development planning. The compilation and analysis process is summarized in Figure 16.

The link between water accounts and the national development planning process is shown in Figure 17. 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 midterm review, which leads to adjustments in the NDP when necessary. Moreover, findings—such as some of the indicators—can be used in NDP annual budget speeches to briefly describe the water resources situation.

[13] The annual WUC water use data provision would become a fast, fully computerized exercise. For the current work, a team of up to nine people worked for more than two weeks on assigning economic classification codes to WUC customers.

Figure 16: Proposed Water Accounts Compilation and Analysis Process

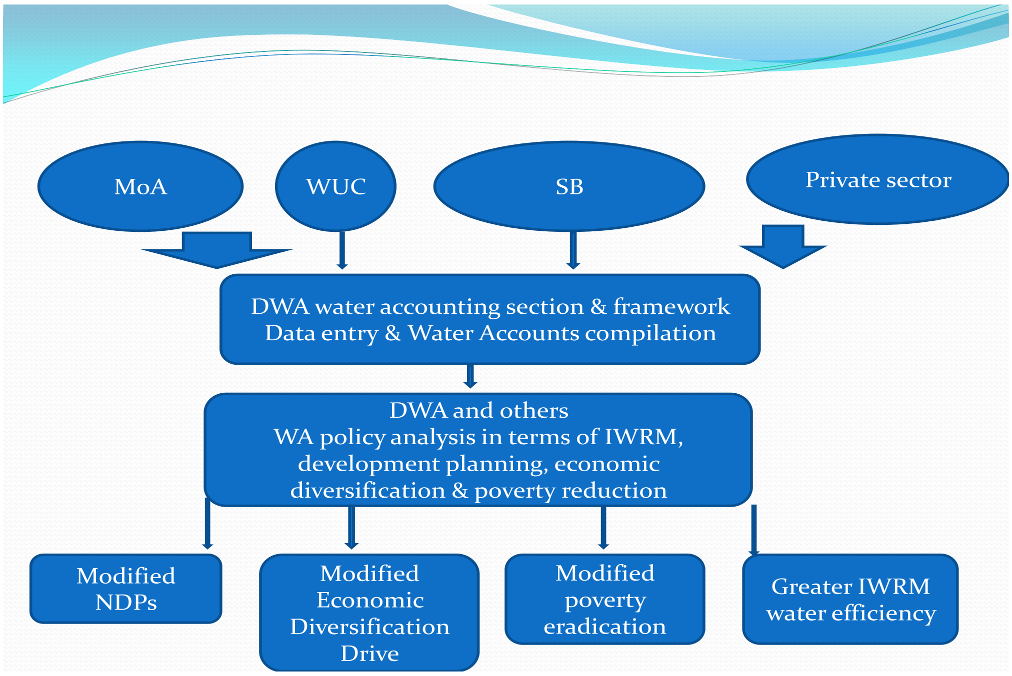
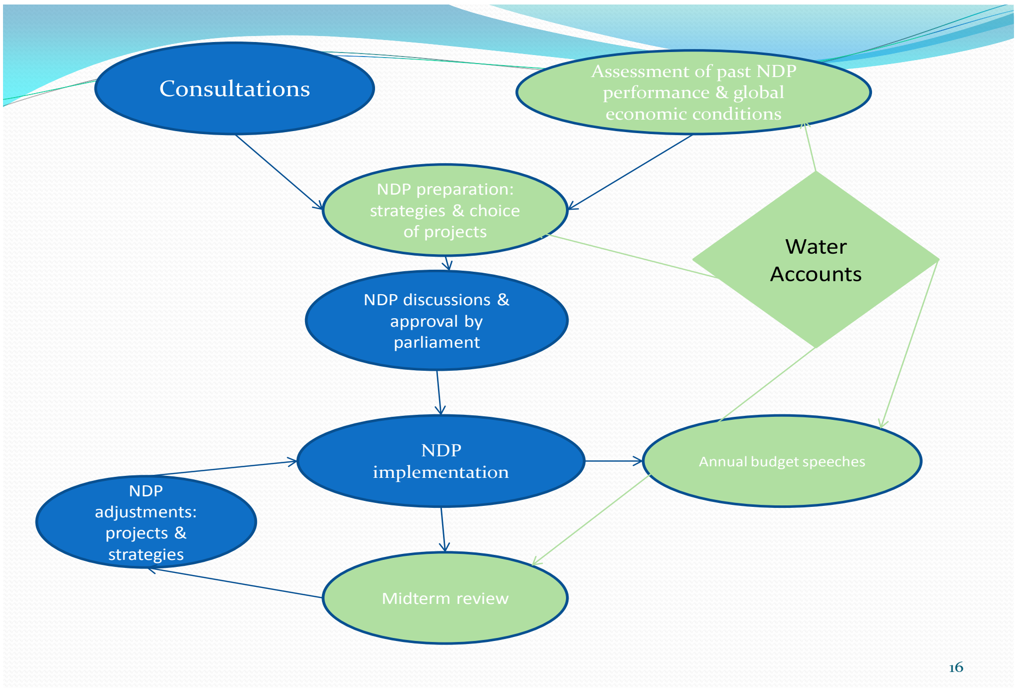


Figure 17: Water Accounting and the National Development Planning Process



7.3 Organizational Structure

With its water management mandate, DWA needs to be the lead and coordinating institution for water accounting. This is consistent with the draft National Water Policy and the integrated water resources management and water efficiency plan for 2013–2030. DWA plans to establish a water accounting unit with four staff (two juniors, one senior, and one 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 water accounts, and policy analysis of the results. The unit also needs to maintain regular contacts with the private sector and civil society. The following working groups are envisioned:

- **Water management regions**. WUC MCs have been used; however, there needs to be a discussion about which regional classification is most appropriate in view of the need to work at the level of water catchment areas and to bring in data from agricultural regions and administrative districts. This group deals mostly with regional data on water abstraction, consumption, losses, and costs and revenues from WUC and self-providers. The group should have members from DW, WUC, SB, MoA, Department of Mines, and major self-providers.
- **Irrigation sector**. This group will deal with water abstraction, use, and consumption for irrigation. While water use is modest now, it is expected to grow in the future. The group members consist of DWA, WUC, MoA (irrigation and horticulture), SB, Ministry of Lands, and Water Apportionment Board/Water Resources Board.
- **Mining sector**. This group will deal with water abstraction and use by the mining sector (mostly self-providers). The group members will be DWA, WUC, Department of Mines, mining companies, SB, Water Apportionment Board/Water Resources Board, and Ministry of Lands.
- **Water stock accounts**. This group mostly deals with stock accounts, initially of dams and later also of aquifers. The group members consist of DWA, WUC, SB, and the Department of Geological Survey.
- **Policy analysis of water account findings**. This group is aims specifically to regularly review the results of water account and their implications for development planning, IWRM, and land use planning. The members include the government (e.g., DWA, WUC, Ministry of Finance and Development Planning, Ministry of Lands, MoA, Department of Mines), private sector, and civil society.

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

The Ministry of Mineral, Energy, and Water Resources needs to hold regular meetings with the main stakeholders to ensure that data is provided to DWA, review progress, and resolve any challenges that emerge. The deputy permanent secretary for the Ministry of Mineral, Energy, and Water Resources and the WAVES coordinator will discuss progress in the WAVES Steering Committee that is established and chaired by the Ministry of Finance and Development Planning. The Steering Committee guides the overall WAVES activities in Botswana, ensures institutionalization of water accounts and other accounts that will be developed, and ensures that policy discussions and recommendations emerging from the natural capital accounting findings are incorporated in development planning—in particular the preparation of NDP 11 and the work of the four thematic working groups formed by the National Strategy Office.

7.4 Timeline for Institutionalizing Water Accounting

The proposed road map for water accounting in WAVES phase 3 is presented in Table 8. There will be regular DWA seminars and training workshop for all major stakeholders, including the Ministry of Finance and Development Planning, to ensure that natural capital accounting will be fully incorporated in the next development planning cycle (NDP 11). It is envisioned that by the end of the WAVES program, the water accounts will be fully institutionalized and maintained by DWA.

Milestones

November 2013:	Establishment of water accounting unit within DWA Introduction of water accounts at second day of WaterPitso
December 2013:	Formation of mining sector and policy analysis working groups Finalization of water accounting support structure and responsibilities at MoA, SB, and Department of Mines
2014:	Updated 2012/13 water accounts and policy analysis Updated 2013/14 water accounts Water regionalization and Geological Information Service Policy analysis and initial inputs into NDP 11 preparation
2015:	Water accounts results fully integrated into NDP 11

Table 8: Road toward Institutionalization of Water Accounting (2013/14)

	Activity	July 13- June 14	July 14 – June 15	July 15 – June 16	Lead agent	Technical support
1	Annual updating of the water account (starting with 2012/13)	2012/2013 2013/2014	2014/2015	2015/2016	DWA	Only in 2013/14
2	Capacity building and institutionalization	Establishment of water accounts unit in DWA (August '13) Establishment of support capacity in key stakeholders (WUC, MoA, SB, Department of Mines) and water accounts working groups (October '13) 1 technical training workshop (November '13) Quarterly water accounts seminars at DWA	1 technical training workshop (September '14) Quarterly DWA water accounts seminars	1 technical training workshop (September '15) Quarterly DWA water accounts seminars		Technical assistance for training workshops, water accounts unit, and water accounts working groups
3a	Water accounts sub regions and Geological Information Service: Agreement about use of and links between MC, catchment areas, agricultural areas, and administrative districts	Design of most appropriate regionalization for water accounts	Geological Information Service work and water accounts on regionalization		DWA with contributions from WUC and MoA	Technical assistance
3b	Design of a relevant uniform economic classification for SB, WUC, and other accounts	Establishment of working group to identify relevant economic sector classification and uniform corporate classification (October '13) Incorporation of sector classification in WUC client base (March '14)			SB and WUC	Technical assistance
4	Policy analysis and recommendations	Policy analysis at 2nd day of 2013 Water Pitso: development planning and implementation of the integrated water resources management and water efficiency plan and National Water Policy	Policy brief and policy analysis workshop Position paper on water accounts for NDP 11 (June '15?)	Policy brief and policy analysis workshop	DWA and the Ministry of Finance and Development Planning	Technical assistance
5	Monetary aspects of water accounts	Analysis of WUC revenues and costs, as well as tariffs			WUC and DWA	Technical assistance

6	Technical expansion of water accounts	Agricultural dam accounts Irrigation water abstraction and use Water losses	Wastewater subject to metering Groundwater stock accounts Mining sector		DWA	Technical assistance

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Appendix 1: System of Environmental-Economic Accounting for Water Framework and Application in Botswana

The Botswana water accounts for 2010-12 are based on SEEA-Water. To date, the work involved small working groups from DWA, WUC, and MoA, which mainly focused on three areas:

- **Stock accounts**. These assess the quantity of water resources in the country at the beginning and end of the year and the changes that occur during this period.
- **Flow accounts.** This category was divided into two groups:
    1. *Regionalization 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; and
    2. *Irrigation water use*, to determine use of water for irrigation in Botswana, primarily focusing on large government irrigation programs and major private farms.

Detailed information about the working groups and their activities are given in Chapter 7. An important feature of the working groups is the interaction between the different institutions—MoA, DWA, SB, and WUC. Discussions were initiated to address data issues, economic benefits of irrigation water use, and water distribution in the different MCs.

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.

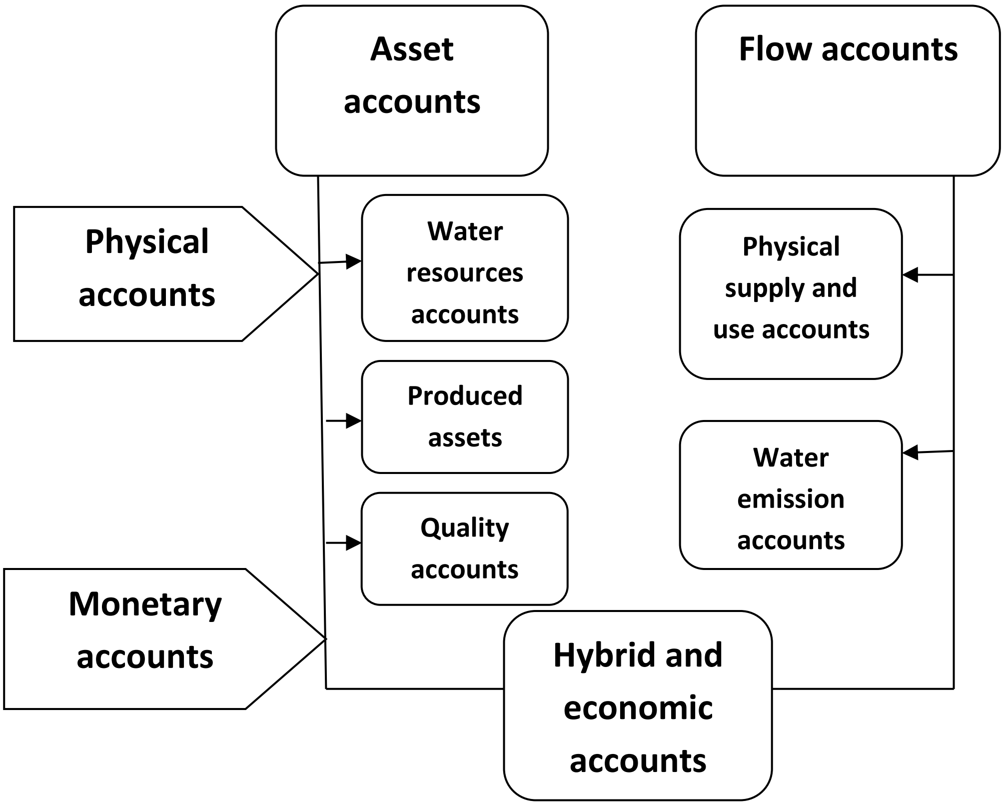
- **Produced assets**. These include infrastructure used for the abstraction, distribution, and treatment of water. They are included already in the national accounts as fixed assets. They provide information on the economy's ability to mobilize and treat water, such as investment in infrastructure and depreciation of this infrastructure.

a. **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 year). These changes may be naturally induced (e.g., rainfall, evaporation, or runoff) or occur as a result of human activities (abstractions or discharges). The accounts consider all types of water resources; groundwater, reservoir water, river water, and wastewater are relevant for Botswana.[14] These are commonly compiled in physical units but could also be compiled in monetary terms.

- **Water quality accounts**. Asset accounts can be compiled in terms of the quality of water—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.

[14] Wastewater was not considered for the accounts. WUC has assumed the role of managing this resource and therefore needs to provide information in the future to be included in the accounts.

Figure 18: SEEA-Water Framework



Source: United Nations 2012

<u>Flow accounts</u>

These 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 them 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.
- Flows from the economy back to the environment, which 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 means 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 that 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, and the destination of the emissions (water resources). These accounts have not been developed for Botswana.

<u>Hybrid and economic accounts</u>
These describe in monetary terms the supply and use of water-related products and identify the following:

- Costs associated with the production of these products (operations);
- Revenues generated by their production;
- Investments in water infrastructure;
- Maintenance costs; and
- 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 to show the information given 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.

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^3 and job creation/m^3 by economic sector.

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 SB.

<u>WUC</u>
Ideally, the following data is required from WUC:

- Water abstraction and use by source and MC;
- Water abstraction and use by economic sector;
- Water distribution among MCs, including imports and exports;
- Water losses by MC; and
- 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 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 annual water use by economic sectors (for 2010/11 and 2011/12). The customer information 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 incorporate economic sector classification into its customer information system, as this would allow for automatic generation of water use figures by sector.

Water abstraction and sales data was 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 WUC agreed that these data issues needed to be addressed before they could be used. Water losses were available for 2011/12 by MC, while they were available for one quarter in 2012/13.

Data for physical stock accounts obtained from WUC was augmented with data from DWA, and with estimates using the water balance where no measurements were 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.

<u>DWA</u>

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.

<u>Self-providers</u>

The main self-providers are mines and the 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.

<u>MoA</u>

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

- Water abstraction and use for irrigation;
- Water sources (dams, rivers, or groundwater) and institutional setup (provided by service providers or own water abstraction; and
- 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 programs.

SB has been resourceful in providing economic data on value added and formal employment figures by economic sector. It 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 the following:

- In estimating water abstraction for settlements, it was necessary to assume population figures for 2010. The average intercensal (2001–2011) growth rate of 1.9 percent was applied across all villages to estimate settlement population from the 2011 population census.

- WUC took over villages and settlements in phases between 2009 and 2013. The most common take-over dates were February and October 2010 and 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 areas supplied by WUC and those supported by DWA and DC. The phase 1, 2010–12 accounts were updated with this information.
- 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/p/d and 135 L/p/d, respectively).
- For 2010–12 water sources proportions for water use, it was assumed that the proportions for water abstracted are similar to proportions for water used in WUC service areas. In other words, water losses are the same irrespective of the source.
- For water use in settlements without metering, it was assumed that
    - The per capita water abstraction was the same as the average for metered settlements; and
    - The losses were the same as the average DWA loss rate of 26 percent (2010/11).
- For self-providers, it was unclear whether the available figures referred to abstraction or use. This needs further investigation. For the time being, it is assumed that abstraction equals use (hence, zero losses).
- To determine livestock water abstraction and use by MC, agricultural districts were superimposed 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 the Geological Information Service is needed to estimate the proportions more accurately.

For stock accounts, the following assumptions were made:

- 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
- The difference between the closing stocks as measured and the amount calculated using the water balance was attributed to seepage losses, which are not monitored.

Figure 19: Water Flows to and from Botswana Inland Water Resources
(million cubic meters)

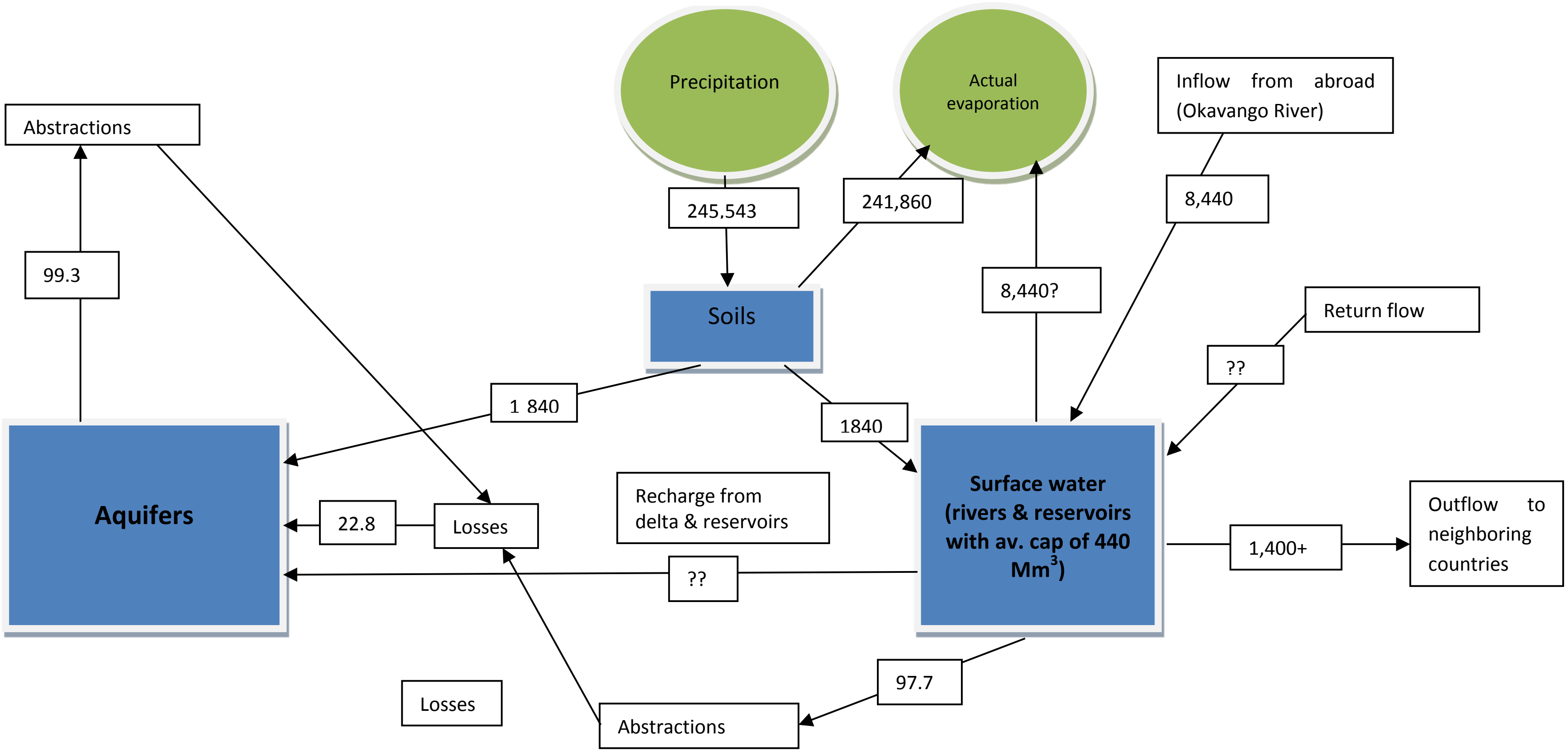
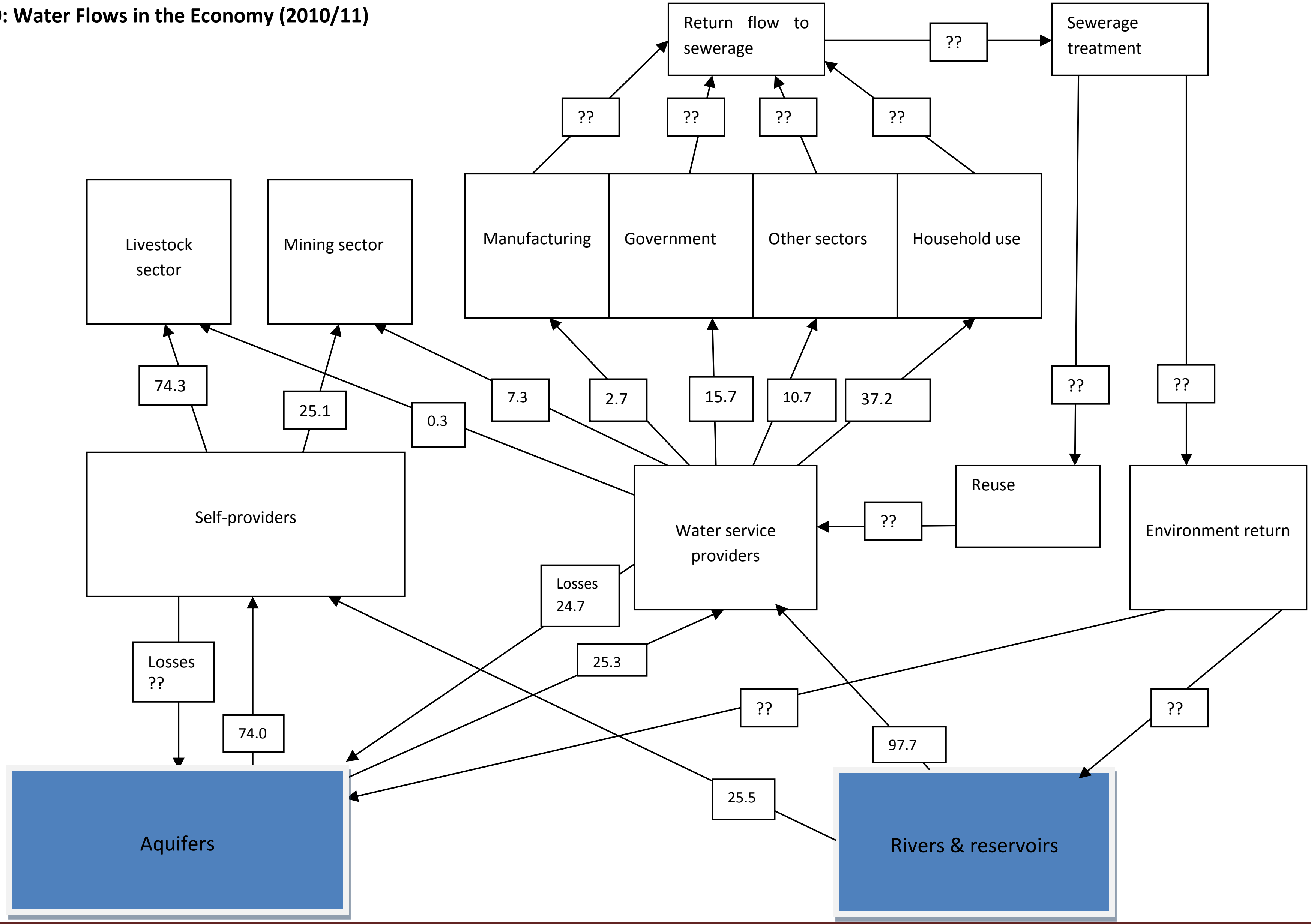


Figure 20: Water Flows in the Economy (2010/11)



Terminology

Term		Source
	Water resources types	
Water resources	Fresh and brackish water in inland water bodies, including groundwater and soil water. (5.475) Brackish water has a salinity content between that of freshwater and marine water.	SEEA Central Framework 2012 SEEA-Water 2012
Inland water resources	Surface water (rivers, lakes, artificial reservoirs, snow, ice, and glaciers), groundwater, and soil water within the territory of reference. (3.187)	SEEA Central Framework 2012
Transboundary water	Surface or groundwaters that mark, cross, or are located on boundaries between two or more states. Wherever transboundary waters flow directly into the sea, they 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	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, streams, snow, ice, and glaciers. (5.478)	SEEA Central Framework 2012 SEEA-Water 2012
Groundwater	Water that collects in porous layers of underground formations known as aquifers. (5.480 and SEEA-2003)	SEEA Central Framework 2012 SEEA-Water 2012
Soil water	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	Discarded water that is no longer required by the owner or user. (3.86) Water that 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**
	Water flow concepts	
Abstraction of water	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. Also, water used for hydroelectric power generation. 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 treatment.	SEEA-Water 2012
Water consumption	The part of water use that 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	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	The amount of water that is delivered to an economic unit from another	SEEA-Water 2012

received from other economic units	economic unit.	
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
Runoff	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 to the environment by an economic unit during a given period of time after use. Returns can be classified by the receiving media (water resources and sea water) and by the type of water, such as treated water and cooling water.	SEEA-Water 2012
Water losses in distribution	The volume of water lost, through leakages and evaporation, during transport 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
Term		**Source**
	Water infrastructure	
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 and Husbandry Services, e.g., Artificial Insemination, Irrigation
0150	Hunting and Trapping
0200	Forestry (All)

Group B: Fishing

0500	Fishing (All)

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 and equipment)

1510	Meat and meat products
1520	Dairy products
1530	Grain mill products (includes maize, sorghum, millet, human feeds, and 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 (includes 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 Tires, 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 Foundries
2800	Fabricated metal products, excluding Machinery and equipment
2900	Machinery and equipment, including refrigerators and other domestic equipment
3000	Office, accounting, and computing machinery, e.g., Photocopying Machines
3100	Electrical machinery and apparatus, e.g., Lightning Arresters, Voltage Limits
3200	Radio, television, and communications equipment and apparatus
3300	Medical, precision, and optical instruments; watches and clocks
3400	Motor vehicles, trailers, and semi-trailers
3500	Other transportation equipment, e.g., Ships and Boats, Railway Locomotives
3610	Furniture (all types including of wood, also mattresses)
3691	Manufacturing of Jewelry
3692	Manufacturing of other products not elsewhere classified, e.g., Pens, Pencils
3700	Recycling and Processing of Metal and Nonmetal 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, and 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 Conditioning)
4540 Building and repairing completion work, including Painting, Tiles, and Carpets
4550 Renting of construction or demolition equipment, including cranes

Group G: Wholesale and Retail Trade (includes repair of motor vehicles and 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 motorcycles
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 and Watches.

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

Group I: Transportation, Storage, and Communications
6010 Rail transportation
6023 Freight transportation by road
6024 Passengers road transportation, e.g., Buses and Taxi/Combi Companies
6025 Taxis/Combis (sole or small operators only)
6030 Transportation by pipeline
6100 Water transportation
6200 Air transportation
6304 Travel agents, tour operators, safari operators
6305 Cargo handling, storage, warehousing
6309 Other transportation 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 Transportation 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 and 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 centers)

Group O: Other Community, Social, and Personal Service Activities
9000 Sewage and refuse disposal, sanitation, etc., excluding pest control
9110 Business, employer, and professional organizations
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)

Group Q: Foreign Missions, International Organizations
9900 Foreign missions, International organizations

Appendix 3: Total Water Use by Economic Subsector and Source of Water (2010-12)

(thousands of million cubic meters)

		2010/11				2011/12			
Economic sector	**Sub-sector**	**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	-	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
Transportation		-	52.4	-	203.1	-	-	-	257.9
Finance & 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
International Organizations		-	-	-	104.4	-	-	-	155.9
Households		-	6,225.0	437.5	30,220.3	-	670.2	360.9	34,815.8
Total		**64,987.3**	**92,763.9**	**14,773.2**	**172,524.4**	**59,821.7**	**96,928.9**	**14,800.4**	**171,551.0**

Notes:
1. The consumption of water supplied by DCs (4.5 Mm^3) could not be allocated to specific subsectors, but is included in the overall total consumption.
2. '-' represents data that is not available.

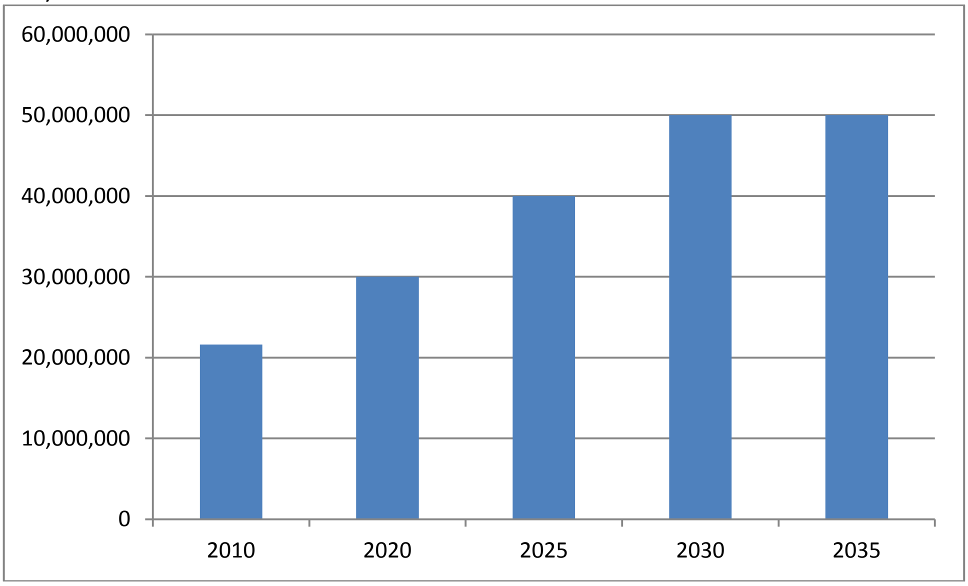
Appendix 4: Water Use in the Irrigation Sector

Introduction

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

Climate change and variability, and the desire to increase domestic food production,[15] are expected to boost irrigation in future. The review of the NWMP (SMEC Holdings and EHES 2006) envisions significant growth of water use for irrigation, from 21.6 Mm^3 in 2010 to 50 Mm^3 in 2030 (Figure 21).

Figure 21: Forecasted Growth of Water Use for Irrigation
(cubic meters)



Source: adapted from SMEC Holdings and EHES 2006

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

In previous water accounts (Department of Environmental Affairs and Centre for Applied Research 2006), water use by irrigation was kept constant at around 18,800 Mm^3/year (1,200 hectares at 15,000 m3/hectares), equally divided among groundwater, 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 analyzed irrigation data from agricultural regions and undertook case studies of two government irrigation programs and an irrigation farm. Through this

[15] Botswana imports most of its cereal requirements.

working group, government institutions started to collaborate in the field of water use and irrigation. Within 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 the future, because a number of “farmers” who have been allocated irrigated land leave it undeveloped and idle.[16]

Data requirements and sources

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

- Water abstraction, use, and consumption for irrigation;
- Water sources (dams, rivers, groundwater, or wastewater) and institutional setup (provided by service providers or own water abstraction; and
- 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 programs 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 programs 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 hectares x water use/hectares

The estimates are more accurate if the equation is specific for crops and irrigation technology. For example, in the Irrigation Manual of the Food and Agriculture Organization of the United Nations (Savva and Frenken 2002) it is argued that localized 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 a program), field canal efficiency (from an entry point program to each field hydrant), and field application efficiency (efficiency within the field).

For water accounts, water return flows need to be estimated in terms of return to the environment through groundwater recharge or surface water flows. In the visited programs, 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.

Conclusions

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

[16] The MoA does not have the names of these “farmers.”

The estimate of 18 Mm^3 previously used in water accounting probably is an overestimate, 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^3 and 7.5 Mm^3 in 2011/2 and 2012/3, respectively (excluding Talana farms). With the estimated water use of 5.5 Mm^3 at Talana Farms, the total water use of the irrigation sector would be in the range of 10–12.5 Mm^3. There is no outflow from irrigation farms and programs. 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 into water providers and the water sources used. More than two-thirds of the farmers (68.8 percent) use their own water supply (so-called self-providers, i.e., direct water abstractions from the environment by the agricultural sector); more than a quarter (28.2 percent) use village water supplies (backyard gardens; water supplies from ISIC 36 to the irrigation sector); and a few (3.2 percent) use government irrigation programs (Dikabeya, Glenn Valley, and Kubung). Irrigation heavily relies on groundwater (60.2 percent of farmers), while 34 percent of farmers use water from rivers and 5.8 percent uses dams.[17] This result differs from the previous assumption of a quarter each for river, dams, and groundwater.

Data collection and analysis need to be improved significantly 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 underutilization of land. Therefore, priority should be given to fully use serviced irrigation land and increase its productivity.

Detailed findings of irrigation study

<u>The national picture of the irrigation sector</u>

The 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 was initially collected from the districts through the Irrigation Division. Later on, data on irrigated land and production was also provided by the 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.

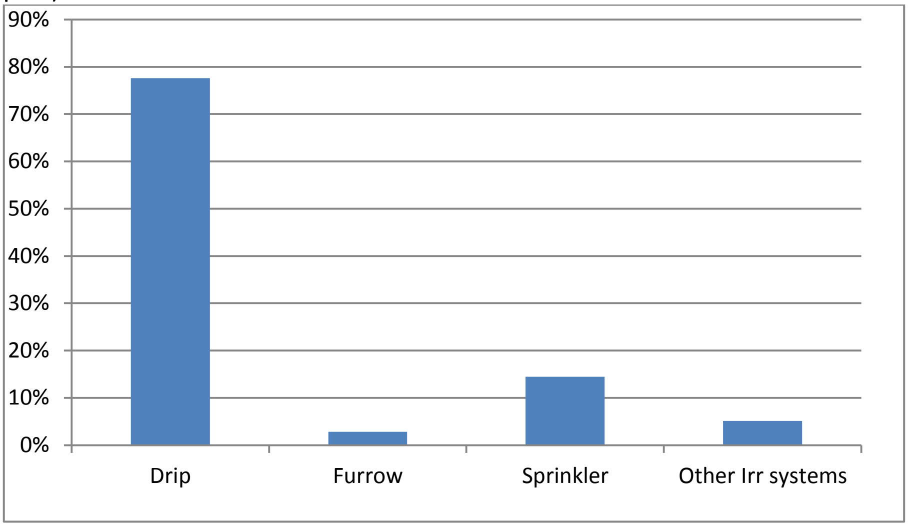
The earlier data was based on quarterly reports and completion of a data template submitted to the districts. The data showed significant gaps for the period 2010–2013. The initial data provided showed that the MoA has registered 459 irrigation farmers, including more than 100 backyard garden farmers. Adjustments were made for incomplete data: 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 percent of the 459 farmers, totaling 798.6 hectares. The adjusted irrigation land is therefore calculated as (100/84.7)*798.6 hectares, i.e., 942.3 hectares.

[17] The actual amount of water use by source was not yet established.

Only a third to a half of the irrigation land was irrigated: 35.6 percent in 2011/2 and 53.1 percent in 2012/3. This suggests that doubling of irrigation is possible without allocating and developing more irrigation land.

Drip irrigation is the most common technology used (Figure 22). More than three-quarters of the farmers use this technology, with sprinkler irrigation a distant second. Sprinkler irrigation is mostly used in the northeast 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 22: Irrigation Systems Used by Farmers
(% of techniques)



Notes:
1. Jet irrigation is the second most commonly used irrigation system.
2. A few farmers use two systems.

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

Water use is estimated in Table 9, using three different assumptions for water use and the above distribution of use among river, ground, and dam sources. The Horticultural Division uses the norm of water abstraction of 40 m^3/hectares (8 hours of irrigation @5 m^3/hour). This would give an estimated water use of 4.9 Mm^3 and 7.3 Mm^3 for the years 2011/2 and 2012/3, respectively. The use of an average figure of 15,000 m3/hectares/year (a common figure in the literature) yields very similar results (Table 9). Drip irrigation permits greater water efficiency in the order of 7,500 to 10,000 m3/hectares/year, which would lead to water savings of 33 percent to 50 percent.

Table 9: Estimated Water Use by the Irrigation Sector under Different Assumptions
(in million cubic meters)

	2011/2				2012/-13			
Assumption:	**River**	**Groundwater**	**Dam**	**Total**	**River**	**Groundwater**	**Dam**	**Total**
Water use of $5m^3$/hour/hectare for 8 hours/day	2.7	1.9	0.4	4.9	4.0	2.8	0.5	7.3
Use of 15,000 m3/hectares/year	2.7	1.9	0.4	5.0	4.1	2.9	0.6	7.5
Use of 10,000 m3/hectares/year	1.8	1.3	0.2	3.4	2.7	1.9	0.4	5.0
Use of 7,500 m^3/hectares/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, groundwater, and dam water (see above).

No regional data was available on produce output, sales revenues, or production costs. Therefore, it is impossible to indicate the irrigation productivity/m^3 in terms of food security, employment, or value added.

In May 2013, new irrigation data was provided by the MoA's Horticultural Division (2011/12 and 2012/13). These data was 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. The data included irrigation in freehold blocks (e.g., Tuliblock). This data set covers 756 horticultural projects in 10 districts (compared with 459 projects for earlier data). A total of 4,012 hectares of irrigated land is allocated, of which 66 percent is developed and 55 percent (2,209 hectares) 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 2011/12 could have been 2,000 hectares, water use would be 33.1 Mm^3 (@ 15,000 m3/hectares) or 22.1 Mm^3 (@ 10 000 m3/hectares). This is much higher than the estimates of Table 9 and also higher than the water use in the flow accounts (18.4 Mm^3).

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

<u>Three case studies of government irrigation programs</u>

Glenn Valley Irrigation Program

The Glenn Valley Irrigation Program (GVIS) is managed by MoA and uses treated effluent from the Gaborone Wastewater Treatment Works. Water abstraction and use are not metered but estimated to be 1.1 Mm^3/year (assuming eight hours 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 summarized.

Total GVIS area: 203 hectares
Cultivated area 2011/12: 124 hectares (a different figure of 70 hectares was also provided)
Cultivated area 2012/3: 135 hectares

<u>Production</u>
Produce grown:

- Maize, tomatoes, green pepper, butternut, cabbage, flowers (few), green mealies, rape, lettuce, sweet potatoes, spinach, and Swiss chard
- No root crops because of water quality constraints associated with treated wastewater

Production 2011/12: 1 642 metric tons (a lower figure of 530 metric tons was also provided)
Production 2012/3: 1 792 metric tons

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 metric tons /hectares/year (low cultivated area and high production figures).

Water use

Water rights for the entire program have been obtained from the Water Apportionment Board for a maximum of 3,000 m3/day. The water rights are fully used, even though only part of the land is irrigated. The water efficiency is low due to the underutilization of the program and the fact that farmers do not pay for water. To avoid pipe bursts, hydrants of unused 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 m3/hectares is available unless water rights are expanded. In the future, the merits of expanding water rights for effluent reuse need to be weighed against alternative uses of treated water.

There are around 40 active farmers cultivating less than 60 percent of the program. 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 nondevelopment of the land is the low land rental of BWP 3,500/year/ hectares. MoA intends to privatize the program. 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 utilization.

Dikabeya Irrigation Program

The Dikabeya Irrigation Program (DIS) started in 2005. It uses water from Dikabeya Dam, which was constructed by the MoA in 1992,[18] initially for the purpose of livestock watering. The dam's design capacity is 1.85 Mm^3. The program is managed by the MoA, but its management is planned to be privatized.

Irrigation water is abstracted from the dam at a rate of 33 L/second. The water abstraction is not metered, but estimated to be 1,069 m^3/day based on nine hours of pumping/day, or 390,258 m^3/year. Water is pumped through a 2-kilometer pipeline into a reservoir of 1,000 m3 inside the irrigation program. Water is then 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 (a maximum of 5 m^3/week free of charge).

Below, key figures are summarized:

Land resources

[18] Initially operated by a livestock farmers' syndicate.

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

Production
Production 2011/12: 9.2 metric tons (another figure of 26 metric tons was also provided)
Production 2012/3: 204 metric tons (another figure of 261 metric tons was also provided)

Farmers cultivate maize, tomatoes, green pepper, green mealies, butternut, cabbage, sweet potatoes, water melons, rape, carrot, onions, and lettuce. One farmer produced 120 metric tons of tomatoes from 4 hectares 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 metric tons/hectare. Productivity is generally low but increasing, mostly due to the impact of one of the farmers.

Water use
The irrigation program does not appear to have a daily volume water abstraction right from the Water Apportionment Board; water abstraction is estimated to be 390,258m^3/year; this implies a high water use of 18,600 m^3/hectares for 21 hectares of irrigation. In fact, the current abstraction should be sufficient for the entire program (8,130 m^3/hectares for 48 hectares). 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 hectares.

Farmers use drip irrigation. The water quality is good and does not require pretreatment. However, farmers experienced mud problems and have to regularly filter the water. The farmers have proposed that the open channels be replaced by pipelines to increase distribution efficiency, and that inlet hydrants be constructed at each allocated plot.[19] The National Agricultural Master Plan for Arable and Dairy Development farm (8 hectares) is being privatized to increase productivity. The farm is underused and performs poorly. On average, only 4.1 hectares is cultivated annually and the actual production is around 12.5 metric tons, compared with the estimated production of 110 metric tons. The average annual productivity is 2.9 metric tons/hectare for the period 2010–2013.

Irrigation at Talana Farms

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

Production
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 hectares of vegetables are produced annually, with an approximate value of BWP 28 million depending on climatic conditions (BWP 70,000 gross revenues/hectare, or four times the average gross revenues countrywide). About 90 percent of the

[19] This would reduce the accumulation of mud in the water supply system.

farm's produce is sent to Botswana Horticultural Market, 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 hectares), and assuming water use of 5 m^3/hour/hectare for 8 hours/day, the annual water use would be 5.5 Mm^3. If one assumes an average water use of 15,000 m3/hectares/year, the water use would be 5.7 Mm^3.

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

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