Republic of Botswana

Final Report

BOTSWANA WATER ACCOUNTING REPORT 2014/15

April 2016

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Abbreviations

ABS	Australian Bureau of Statistics
BEAC	Botswana Economic Advisory Council
BMC	Botswana Meat Commission
BPC	Botswana Power Corporation
BWP	Botswana Pula
CAR	Centre for Applied Research
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
GDP	Gross Domestic Product
GDSA	Gaborone Declaration on Sustainability in Africa
GoB	Government of Botswana
IRWR	Internal Renewable Water Resources
MC	Management Centre
MCM	Million Cubic Meters
MFDP	Ministry of Finance and Development Planning
MMEWR	Ministry of Minerals, Energy and Water Resources
MoA	Ministry of Agriculture
NDP	National Development Plan
NRW	Non-Revenue Water
NSWC	North South Water Carrier
NWMP(R)	National Water Master Plan (Review)
O&M	Operation & Maintenance
PC	Per Capita
SADC	Southern African Development Community
SB	Statistics Botswana
SEEA	System of Environmental-Economic Accounting
SNA	System of National Accounts
TRWR	Total Renewable Water Resources
UN	United Nations
UNSD	United Nations Statistics Division
VA	Valued Added
WA	Water Accounting
WAU	Water Accounting Unit
WAB	Water Apportionment Board
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WB	World Bank
WSR	Water Sector Reforms
WUC	Water Utilities Corporation

Note:

Pula Value at	US$	Euro
April 2014	0.1140	0.0826
March 2015	0.1004	0.0931

1 Introduction

This report is the third SEEA styled water accounting report for Botswana and covers the period 2014-15 as well as the 2010-11 to 2014-15 trends. Two earlier reports have been published, covering the years 2010-11 to 2013-14 (DWA and CAR, 2013 and 2015). In addition, four (4) policy briefs have been prepared on the following topics: findings of the Botswana water accounts, mining and water resources in Botswana, irrigation and water resources in Botswana and Botswana's agriculture and water resources.

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

The Water Accounting (WA) activities of WAVES-Botswana can be categorized into several phases:

a. September – November 2012: preliminary account construction and analysis. The results were presented at the November 2012 BEAC meeting;
b. December 2012 – June 2013: elaboration of the water accounts and development of a road map towards full institutionalization of water accounts at the Department of Water Affairs (DWA), support institutions (e.g. Statistics Botswana (SB), Ministry of Agriculture and Water Utilities Corporation-WUC); and
c. July 2013 – June 2016: full institutionalization, up-dating and expansion of water accounts and ensuring full integration of results in National Development Plan (NDP) 11.

The current Botswana Water Accounts (WA) are based on the United Nation's System of Environmental–Economic Accounting for Water (SEEA-Water; UN 2012). The framework describes the hydrological system *(assets or stocks*) in terms of a country's water resources existing at a certain point in time, the exchanges between water resources, flows of water from the environment and within the economy in physical and monetary terms and also captures water quality issues. It also considers water-economic interactions, which is important for addressing cross sectoral and broader issues related to water resources management. SEEA- Water directly links water data to the System of National Accounts (SNA). Current water accounting efforts in Botswana focus on physical flow accounts (use and supply). Monetary aspects have focused on the revenues and costs of water supply as well as the industry value added produced per cubic meter (m^3) of water used. A separate report on physical water resources stock accounts (reservoirs) will be released at later date.

Major stakeholders in the production of water accounts are Water Utilities Corporation (WUC), Statistics Botswana (SB), Ministry of Agriculture (MoA), Botswana Chamber of Mines and Ministry of Finance and Development Planning (MFDP). The Botswana WA also provides information on the water abstraction and consumption of key industries (e.g. agriculture, mining, manufacturing and service industries) and households. Although not directly involved in the production of the Botswana WA, the MFDP plays a

significant role in the process as it provides overall coordination of the WAVES programme in the country and is one of the main users of the results together with the Ministry of Minerals, Energy and Water Resources (MMEWR).

This 2014-15 Botswana WA report has several improvements compared to the earlier reports. First, water abstraction and consumption of the irrigation sector has been estimated more accurately following pilot irrigation surveys and better irrigation data provided by the Ministry of Agriculture. Previously, water abstraction for irrigation was assumed to be constant and equal to the estimate of the 2006 Review of the National Water Master Plan (NWMP; SMEC and EHES, 2006). Secondly, all operational mines are now covered and in greater detail than before, along with better data for the electricity and coal mining industries. For example, some mines provide water to settlements, which has been reflected in the accounts for the first time. In addition, major strides have been made towards institutionalization of the Water Accounts at the Department of Water Affairs (DWA). The DWA has established a Water Accounting Unit (WAU) within its newly approved functional structure. The WAU has taken the lead in the production of the 2014-15 accounts, the preparation of this report and planning for annual future accounts.

2 Main findings of the 2014-15 Water Accounts

This chapter highlights the main findings from the compilation of the Botswana WA for the year 2014-15. It also presents the main tables and figures for the physical supply and use of water, a long-term time series of water consumption, water consumption by industry and region and water productivity by industry. The 2014-2015 Botswana WA follow the international standard of the United Nation's System of Environmental Economic Accounting for Water (SEEA-Water; UN, 2012).

The accounts show physical flows from the environment to the economy, flows within the economy and flows from the economy to the environment. Lack of data, particularly regarding water self-providers, made it impossible to prepare full monetary accounts. There is, however, coverage on water sector expenditures and costs, and water productivity.

The main findings from the current report are:

- Total water consumption in 2014-15 was 167 MCM,, which was a 2.5 % increase from 163 MCM in 2013-14;
- Water consumption by industry (Agriculture, mining, manufacturing, etc., excluding households) in 2014-15 was 133 MCM, which is a 3% decrease from 129 MCM in 2013-14;
- Water consumption by households in 2014-15 was 41.2 MCM, which was a very slight increase from the 40.8 MCM in 2013-14;
- Water extracted from the environment to support the Botswana economy in 2014-15 was 188 MCM, which was virtually unchanged since 2013-14.
- Of the total 188 MCM extracted from the environment, around 47% or 88 MCM was extracted by the water supply industry while the remaining 53% or 100 MCM was extracted directly by self-providers (mainly the agriculture sector at 68 MCM and the mining sector at 31 MCM[1]);
- The agriculture sector consumed the largest volume of water with 70 MCM, a 6% increase from 2013-14 consumption of 66 MCM; and
- The agriculture sector accounted for 42% of Botswana's total water consumption in 2014-15. The next largest water users were households with 25%, mining with 23%, other industries with 7% and government with 6%.

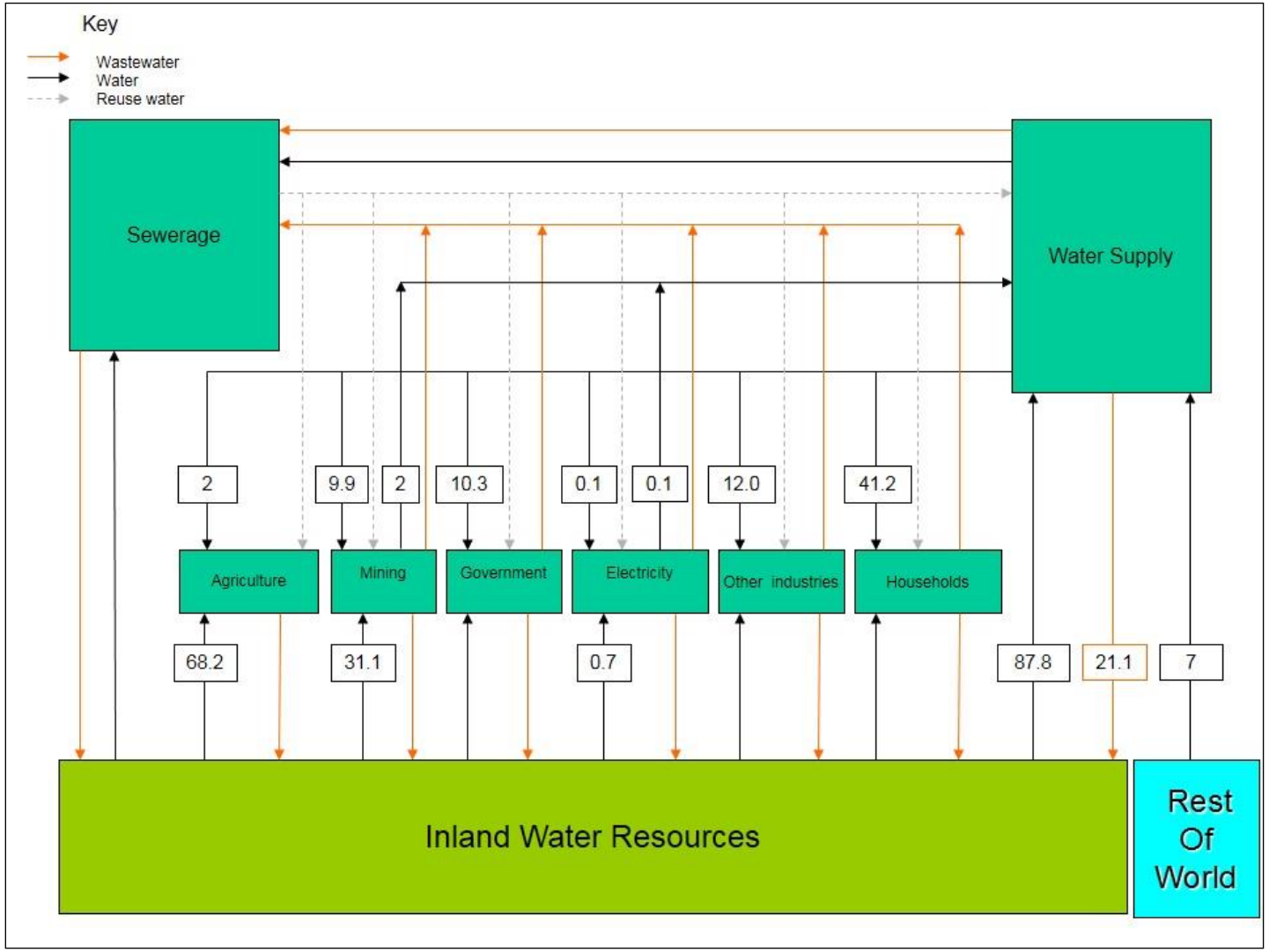
Table 2.1 shows the 2014-15 physical supply and use of water using the internationally accepted table formats, definitions and classifications of the SEEA-Water. An extended table, showing greater industry detail, is found in Appendix 1.

[1] Self-provision by the construction and tourism industries and households are not yet included in the accounts.

1Table 2.1: Physical supply and use for 2014/15 (MCM)

		Agriculture	Mining and Quarrying	Electricity	WUC	Sewage	Government	Other Industries	Total agr & ind	households	Rest of the world	Total
I. Physical use table												
From the environment	1. Total abstraction	68.2	31.1	0.7	87.8	0.0	0.0	0.0	*187.9*	0.0	0.0	**187.9**
	1i.Surface water	25.2	3.0	0.0	50.9	0.0	0.0	0.0	*79.1*	0.0	0.0	**79.1**
	1ii.Ground water	43.0	28.2	0.7	36.9	0.0	0.0	0.0	*108.8*	0.0	0.0	**108.8**
Within the economy	2. Use of water from other economic sectors	2.0	9.9	0.1	2.1	0.0	10.3	12.0	*36.4*	41.2	0.0	**77.5**
	3. Total use of water (1+2)	70.2	41.0	0.8	89.8	0.0	10.3	12.0	*224.2*	41.2	0.0	**265.4**
II. Physical supply table												
Within the economy	4. Supply of water to other economic units	0.0	2.0	0.1	66.7	1.8	0.0	0.0	*70.5*	0.0	7.0	**77.5**
Into the environment	5. Total returns	-	-	-	21.1	-	-	-	*21.1*	-	-	**21.1**
	6.Total supply of water (4+5)	0.0	2.0	0.1	87.7	1.8	0.0	0.0	*91.6*	0.0	7.0	**98.6**
	7. Consumption (3-6)	70.2	39.0	0.8	2.1	-1.8	10.3	12.0	*132.6*	41.2	-7.0	**166.8**

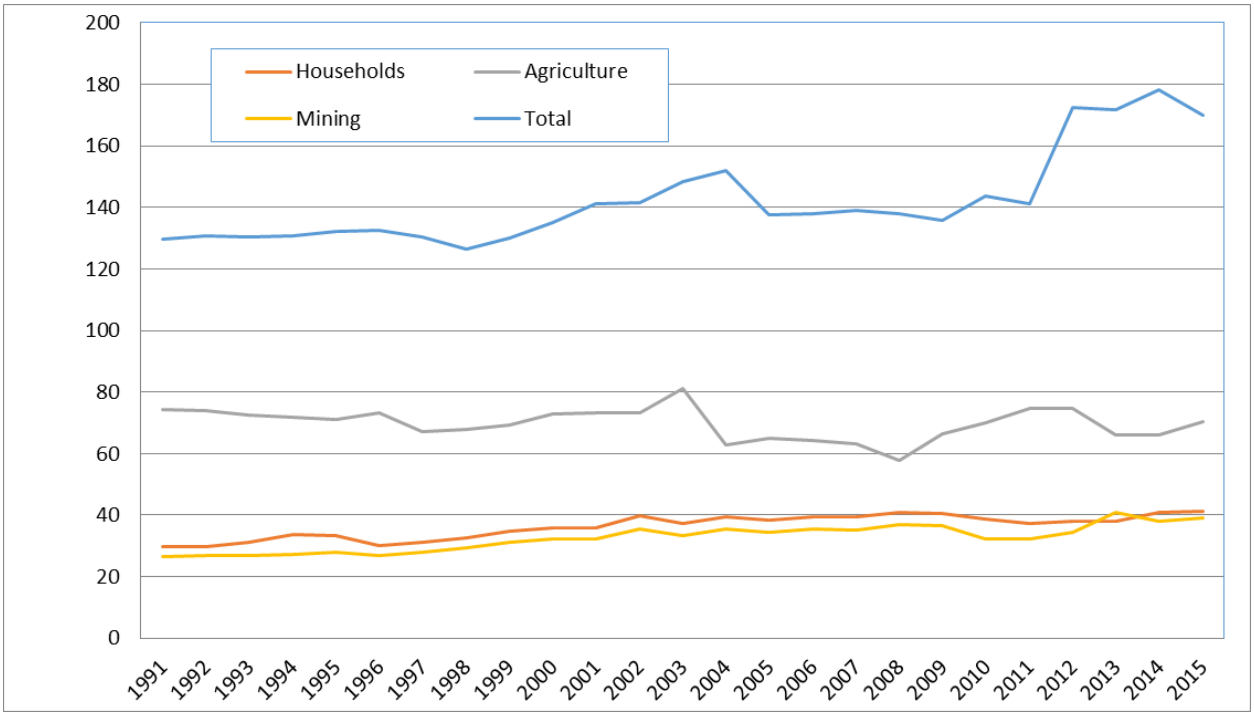
Figure 2.1: Diagram of physical water supply and use in Botswana, 2014-15 (MCM)



A schematic display of the physical water supply and use is provided by Figure 2.1 above. The figure highlights the movement of water between selected industries, households and the environment. It is worth noting that sewerage is currently not quantified as there is no measurement of waste water received or treated water released by treatment works.

The arrows without numbers in Figure 2.1 show water flows (e.g. for waste water) for which there are currently no data. The returns to the environment by the water supply industry are shown and these are the water losses (e.g. for leaky or burst pipes).

Figure 2.2: Long term time series for water consumption within selected sectors (MCM)



The long-term trend in water consumption (1990 to 2015) is shown in Figure 2.2. The time series was constructed through an intensive data manipulation exercise. A summary of this work is provided in Annex 2. Overall the time series shows increasing water consumption but with occasional decreases (e.g. in 1998 and 2004) and stabilization (2005-2010). Sectoral trends are discussed further in chapters 3-8. There is an observed jump in the total consumption for the period 2011-12. This jump coincides with the takeover of water supply by WUC and maybe caused by improved billing of water consumption.

Figure 2.3: Water consumption by economic sector, 2013-14 and 2014-15 (MCM)

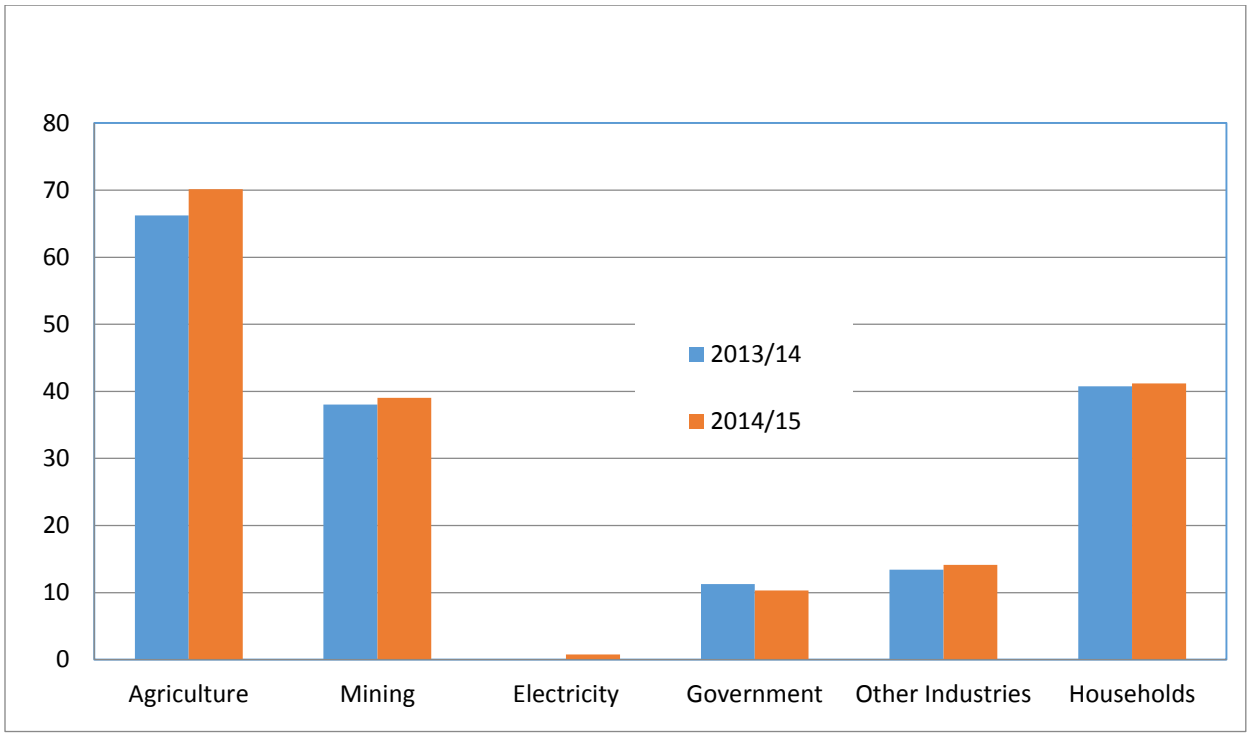
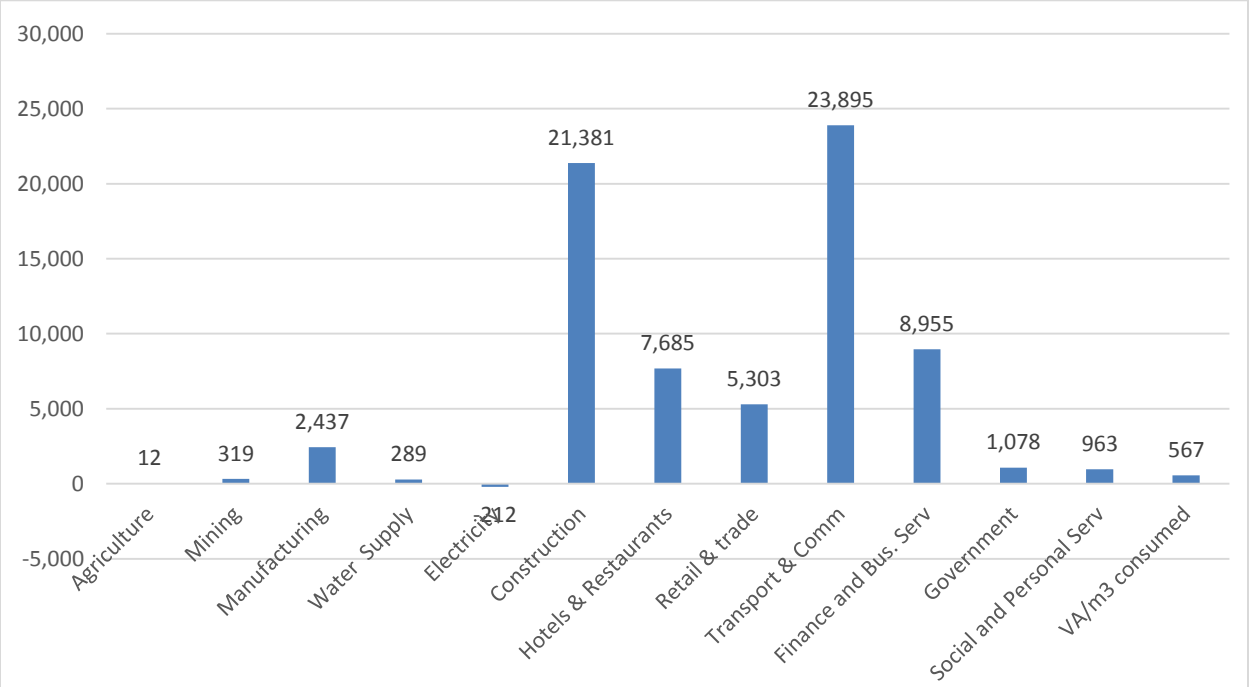


Figure 2.3 shows the water consumption by economic sectors for 2013-14 and 2014-15. Consumption is highest for agriculture followed by households and mining. This trend has been observed from the 2013-14 report as well (DWA and CAR, 2015). Figure 2.2 also highlights how agriculture and households have accounted for the majority of water consumption over a longer period (1991 to 2015). There has not been any significant variation in water consumption for the last two accounting periods. The consumption for 2013-14 and 2014-15 are similar for different industries, except for agriculture. The variation in the consumption for agriculture is mainly due to improved figures for irrigation and changes in livestock numbers (see chapter 4).

Figure 2.4: Water productivity by economic sectors (VA in constant 2006 BWP/m^3; 2014-15)



Water productivity is shown in figure 2.4. Water productivity is measured in terms of industry value added per cubic meter (m^3) in the economy. The figure shows that the productivity in agriculture is lowest and that productivity in the construction, transport and communication and finance and businesses is highest. It should be noted that the productivity in agriculture does not include the value added by the processing of meat (e.g. by the Botswana Meat Commission), which is included as part of the manufacturing industry. The high productivity of the construction industry is likely to be an overestimation as only water supplied to the sector by WUC is currently included. In reality, construction heavily relies on self-extraction from boreholes and surface water sources, which are currently not captured in the accounts. The same argument also applies, albeit to a lesser extent, to the tourism sector where own water supply outside settlements such as in the Okavango Delta has not yet been included. In future, surveys covering the construction sector, for example the Statistics Botswana (SB) business surveys, should include own water abstraction to fill this gap. The transport and communication industries are less water intensive and this is mainly driven by the telecommunications industry, which does not require water for production processes.

Figure 2.5: Share in GDP and water consumption (average for period 2010-11 to 2014-15)

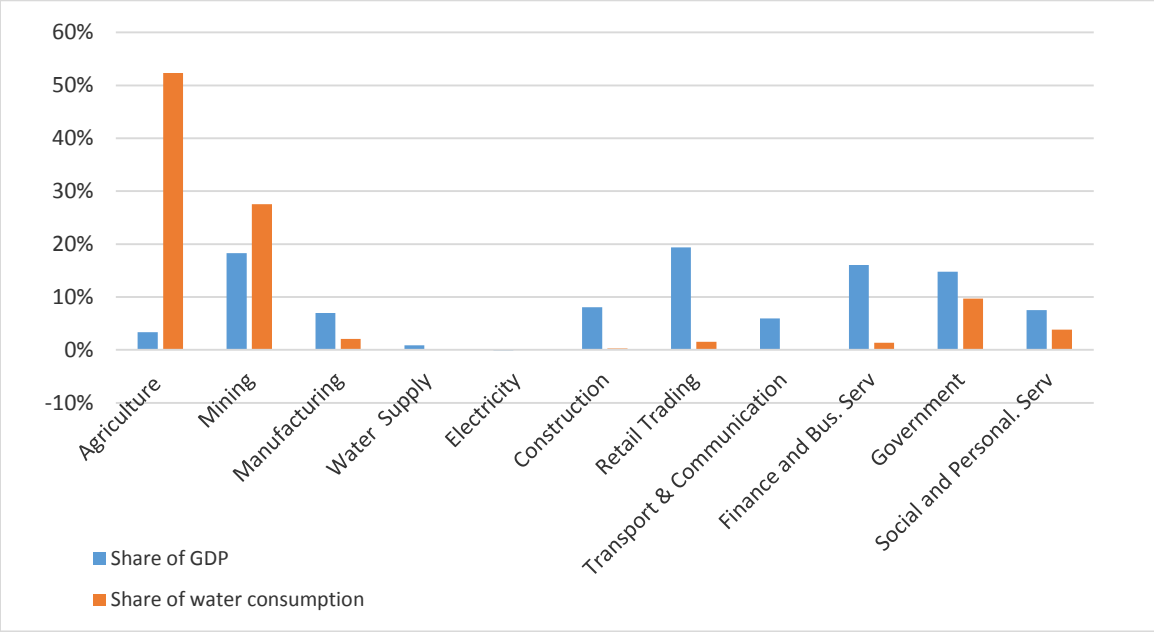
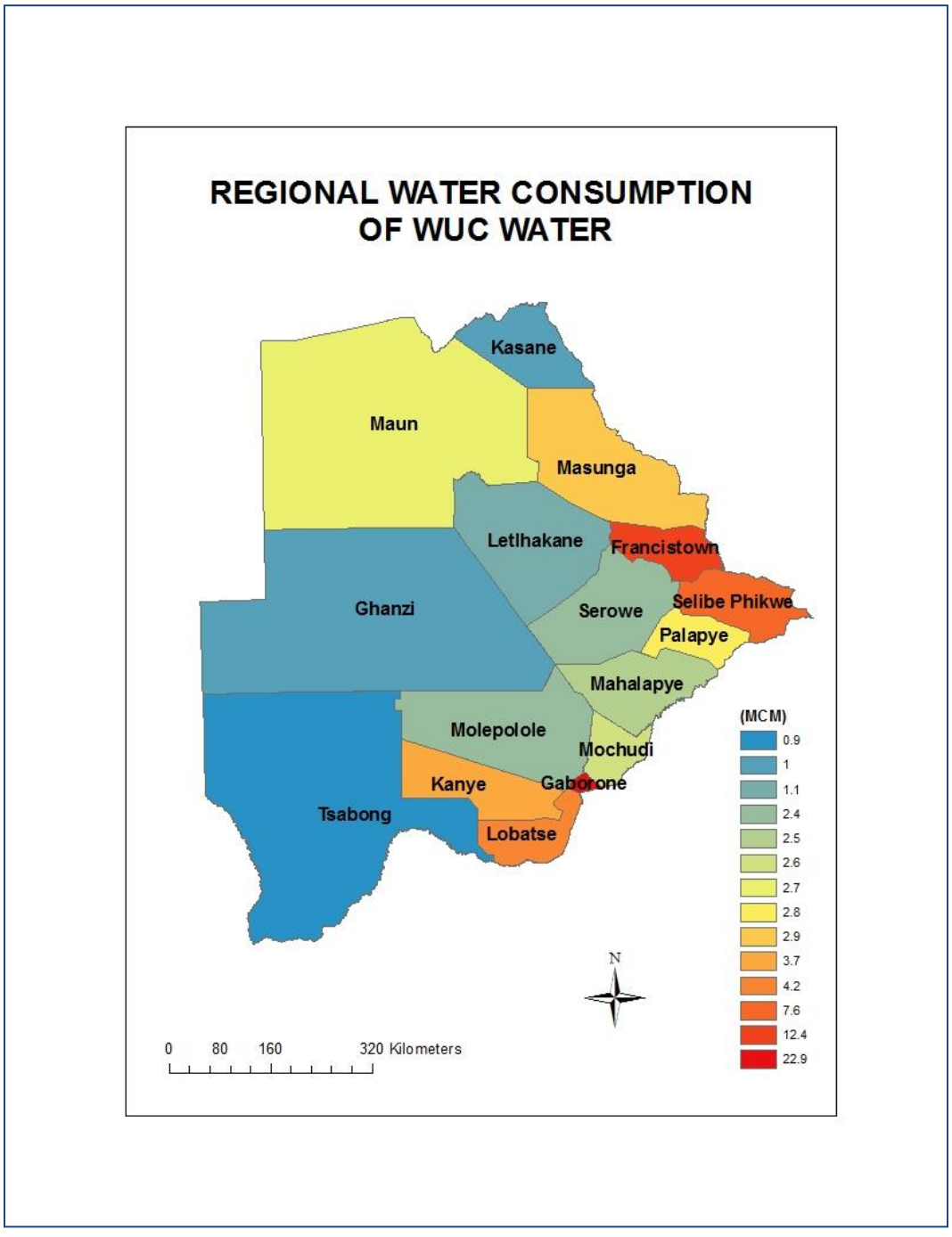


Figure 2.5 shows the industry share of gross domestic product (GDP) and water consumption. Agricultural makes a comparatively small contribution to GDP and consumes over half of the total water consumed. Mining also uses proportionally more water than its contribution to GDP while the reverse is the case for all other industries.

There are significant differences between regions in water consumption. Map 1 highlights the spatial variation in water consumption within the country. It should be noted that the map refers to water supplied by WUC only. Consumption is higher, as would be expected, in the highly populated cities and towns, such as Gaborone MC, Francistown MC, Selibe Phikwe MC and Lobatse MC. The arid Management Centre (MC) of Tsabong has the lowest consumption. The variation in consumption is due to the fact that the majority of the population and economic activities are located in eastern Botswana. The Gaborone MC accounts for 31% of the national consumption with the cities and towns of Gaborone, Francistown, Selibe-Phikwe and Lobatse combined accounting for almost two-thirds of the national consumption (~64%). It is interesting to observe that water consumption in Gaborone MC did not decreased in 2014-15 despite water restrictions and rationing, which were imposed due to the drought and drying-up of Gaborone dam.

The Gaborone MC caters for the largest population amongst all MCs. The MC depends on various water sources, including the Gaborone dam, Bokaa dam transfers, Molatedi dam transfers, North-South Carrier transfers and the Masama wellfields. The North-South Water Carrier (NSWC) transfers water from Letsibogo and Dikgatlong Dams in northern Botswana to Gaborone. It has to be noted that the high demands of the Gaborone MC are further strained by the fact that this MC transfers water to the Lobatse MC. As can be seen in Map 1, this MC also has significantly high consumption (4th highest consuming MC).

Map 1: Water consumption by WUC Management Centers



3 Water supply industry

This chapter deals with the water supply industry that distributes water to other economic sectors. Since April 2013, WUC is the only large water supplier to settlements[2]. Botswana has three sources of water: ground water, dam (reservoir) water and river water. There is very low use of treated effluent but this resource is likely to become much more important in future.
It must be noted that even though WUC is the main water supplier, some mines and the Botswana Power Corporation also provide water to other economic sectors. This concerns supply of water to WUC by the diamond sub sector and supply from the electricity sub-sector to WUC and other industries.

Table 3.1: Water supply by WUC MC 2014-15

Management Centre	Total water production (MCM)	Water source		
		Groundwater	Dam Water	River Water
Serowe	3.2	54%	46%	
Selibe Phikwe	8.0	17%	83%	
Tsabong	1.4	100%		
Francistown	14.5		100%	
Gaborone	23.7		100%	
Ghanzi	1.4	100%		
Kasane	1.9	6%		94%
Kanye	6.9	100%		
Lobatse	8.9		100%	
Maun	3.7	80%		20%
Molepolole	6.3	100%		
Letlhakane	1.5	100%		
Mochudi	3.5	6%	94%	
Mahalapye	4.6	73%	27%	
Masunga	4.6	65%	35%	
Palapye	2.9	55%	45%	
Grand total MCs	**96.9**	41.6%	56.6%	1.8%

Total water abstracted from rivers in 2014-15 amounted to 1.8% of total abstraction and this was from the Chobe and Okavango Rivers. This figure is far lower than the 7% river abstraction for 2013-14.Table 3.1 shows that 56.6% of water was abstracted for distribution from reservoirs and 41.6% from groundwater. It is worth noting that Lobatse and Gaborone MCs have some groundwater use and this will be better accounted for in the next water accounting report. The low rainfall experienced over the past three (3) years has resulted in abstraction from surface water sources (Dam and river water) declining. These overall supply deficit was partly addressed by use of groundwater resources notably Masama and Ramotswa wellfields.

Non-revenue water (NRW) is estimated to be 25% country-wide (Table 3.2). This is estimated as water production minus water sales. NRW varies widely among MCs. Molepolole has the highest NRW at 62%.

[2] Earlier, DWA distributed water to large villages and District Councils supplied other rural villages.

Other MCs with high NRW are Lobatse, Kasane, Kanye and Mahalapye (over 40%). Palapye and Gaborone have very low NRW at less than 5%. It is noted that NRW reflects both physical water losses and non-billed water that is illegally consumed reflecting the extent and efficiency of water billing.

Table 3.2: Non-revenue water by WUC MC 2014-15

MC	Production (MCM)	Water sales (MCM)	Non-Revenue Water % of production
Serowe	3.2	2.4	25%
Selibe Phikwe	8.0	7.6	4%
Tsabong	1.4	0.9	37%
Francistown	14.5	12.4	15%
Gaborone	23.7	22.9	4%
Ghanzi	1.4	1.0	29%
Kasane	1.9	1.0	44%
Kanye	6.9	3.7	47%
Lobatse	8.9	4.2	53%
Maun	3.7	2.7	26%
Molepolole	6.3	2.4	62%
Letlhakane	1.5	1.1	26%
Mochudi	3.5	2.6	28%
Mahalapye	4.6	2.5	45%
Masunga	4.6	2.9	37%
Palapye	2.9	2.8	1%
National	**96.9**	**73.1**	**25%**

4 Agriculture

Agriculture remains the leading water user in Botswana accounting for 70.2 MCM or 42% of total consumption in 2014-15. This was a small increase from the 66.2 MCM consumed in 2013-2014. Crop production is mostly rain-fed agriculture, with a small irrigation subsector. Botswana's agriculture is mostly low input traditional agriculture, with a small commercial sector of mostly fenced farms and ranches. The Agricultural Statistics 2013 (SB, 2015) show that there are 119 936 agricultural holdings of which:

- less than 1% is commercial;
- 58% has livestock;
- 63% has arable land and 58% had planted crops;

Agriculture receives small amounts of water from the Water supply industry (WUC), which is mainly used for backyard gardening and also used in government irrigation schemes (e.g. Glenn valley), which is supplied with treated effluent. Main water sources for this sector are groundwater, river water and treated effluent. Groundwater sources are the most important and contribute 61% of the total water used (Table 4.1).

It must be noted that the Botswana WA only records water abstracted from surface water (dams and rivers) and groundwater, and does not include the use of soil water used in rain-fed crop production, which is the dominant form of crop production. Therefore, the crop sub sector refers to irrigation farming only.

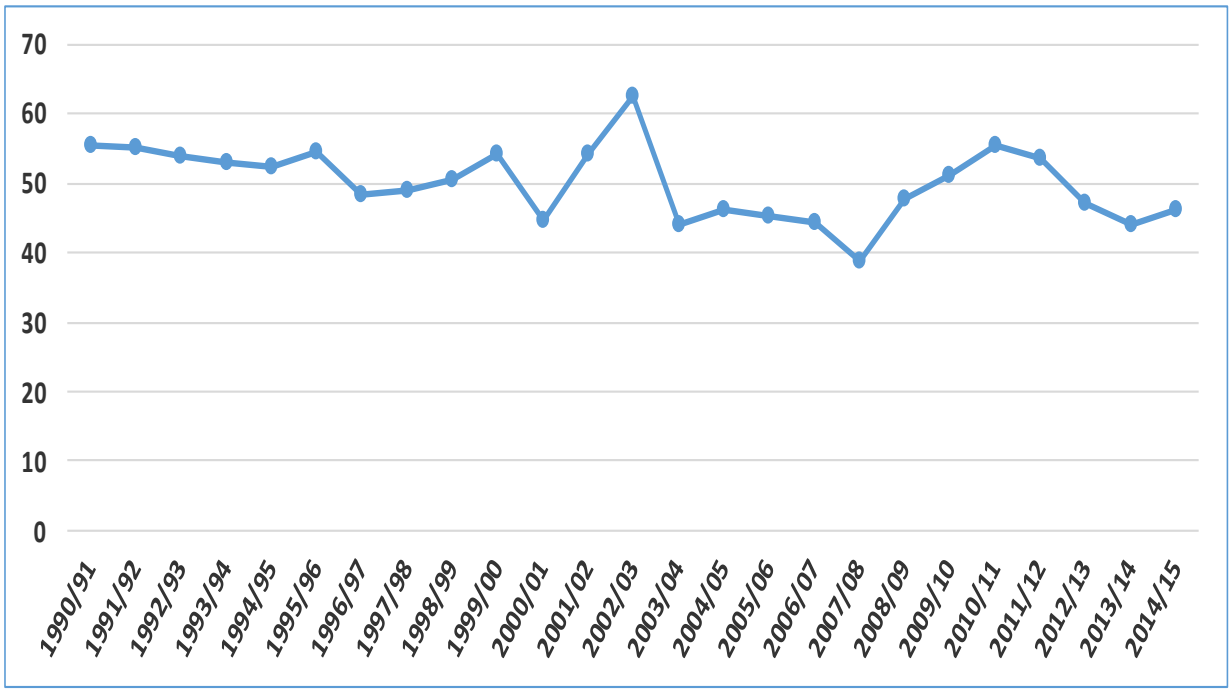
Table 4.1: Water consumption in agriculture (2014/15; MCM)

Variable	Amount
Total livestock water consumption	**46.4**
of which:	
traditional livestock sector	41.5
commercial livestock sector	4.8
of which:	
water for cattle	39.6
water for goats	3.5
water for sheep	0.6
water for donkeys	2.2
water for other animals	0.4
Total irrigation water consumption	23.7
of which	
surface water	13.6
groundwater	8.3
treated effluent	1.8
Overall water consumption agriculture	**70.2**

4.1 Livestock subsector

Livestock subsector is a major water consumer in agricultural, accounting for 66% or 46.4 MCM of agricultural water use. Of this 46.4 MCM, the traditional livestock sector consumes 41.5 MCM and the commercial livestock sector consumes only 4.8 MCM (Table 4.1). Cattle farming lead this subsector in numbers (2.2 million) and in water consumption (39.6 MCM) followed by goat farming with a population of 1.9 million and water consumption of 3.5 MCM.

Figure 4.1: Trend in livestock water consumption (1990 – 2015; MCM)



The long term trend in water consumption by the livestock subsector covers the period 1990-2015. Figure 4.1 shows a fluctuating but generally downward trend in water consumption by this sub-sector. This trend peaked at 62.5 MCM in 2003, with a minimum of 38.9 MCM in 2008. The minimum was due to unpredictable climatic conditions caused by climate variability and outbreak of diseases (e.g. foot and mouth).

Figure 4.2: Livestock water consumption by Management Centre (2013-14; MCM)

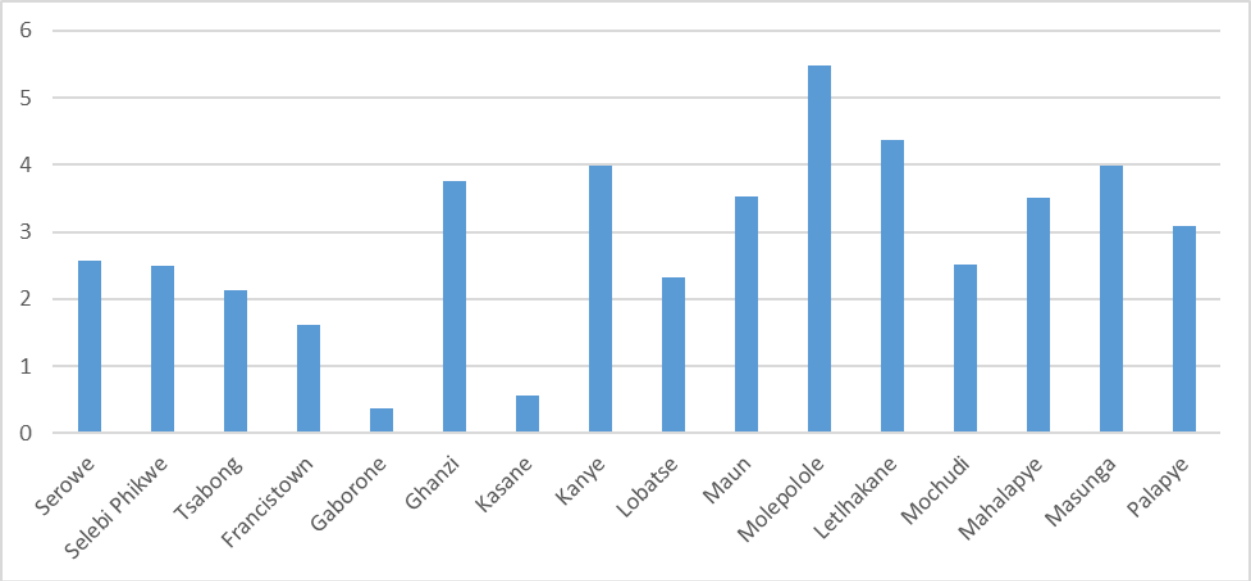


Figure 4.2 shows the water consumption by MC. Livestock water consumption is high in Molepolole MC due to high number of livestock in the area; it accounts for 11.8% of total consumption followed by Letlhakane (9.5%), Masunga (8.6%) and Kanye (8.6%). Gaborone MC is the lowest with 1%.

4.2 Irrigation sub-sector

The 2014-15 WA includes the first estimates of water consumption by the irrigation sector. Based on a pilot survey and improved data from the Ministry of Agriculture (MoA), water consumption of the irrigation sub sector was estimated to be 23.7 MCM of which 13.6 MCM is from surface water resources, 8.3 MCM from groundwater resources and 1.8 MCM supplied by WUC as treated effluent (Table 4.1). Only a small portion of treated effluent is used for irrigation at the moment.

Irrigation water consumption could not be shown by management centers due to unavailability of data. A long term trend in water consumption by this sub sector could not be established because consumption has always been estimated at 18 MCM except for this accounting period.

5 Mining

This chapter discusses water abstraction, use and consumption by mining. A record total of nine (9) mines provided comprehensive data on their water usage for 2014-15. The chapter also reviews the quantity used by different mining categories, by MC as well as the trend of water usage from 2010 to 2015. Most mines abstract water themselves (so-called "self-providers") but some receive part or all water from WUC. Some mines also distribute water to other economic sectors.

5.1 Water consumption and abstraction by the mining sector

Water abstraction refers to that water which is taken from the environment whilst consumption refers to water that is used by that specific sector. In this it deducts water supplied to other industries or returns to the environment from the amount abstracted.

In 2014-15 mining consumed 23% (39 MCM) of the total consumption of the country compared to 22% (38 MCM) in 2013-14. Diamond mining accounted for 66% of total mining consumption in 2014-15. The slight increase in water consumption by mining between 2013-14 and 2014-15 may be due to better information from mining companies. The main mine subsectors with significant abstraction and consumption are diamond and copper-nickel (Table 5.1). The diamond subsector supplies WUC with around 2 MCM of water annually.

Table 5.1: Water consumption and abstraction from the mining sector (2010/11-2014/15; MCM)

	Diamonds	Copper/nickel	Coal	Soda ash	Gold	Other	Total mining
Water abstraction							
2010-11	21.7	3.4	0.1	-	-	-	**25.2**
2011-12	23.3	5.5	0.1	0.2	-	-	**29.1**
2012-13	22.5	3.8	0.1	0.5	-	-	**26.9**
2013-14	25.0	5.1	0.1	0.6	-	-	**30.8**
2014-15	27.4	2.6	0.0	0.6	0.0	-	**31.1**
Water consumption							
2010-11	21.9	8.3	0.1	0.3	1.6	0.1	**32.4**
2011-12	23.7	7.8	0.1	0.8	2.1	0.1	**34.6**
2012-13	21.3	14.6	1.9	1.0	1.9	0.1	**40.8**
2013-14	23.3	11.9	0.7	1.0	1.1	0.1	**38.0**
2014-15	25.7	9.5	0.9	0.9	2.0	0.1	**39.0**

(Source: 2013-14 Water Accounts Report)

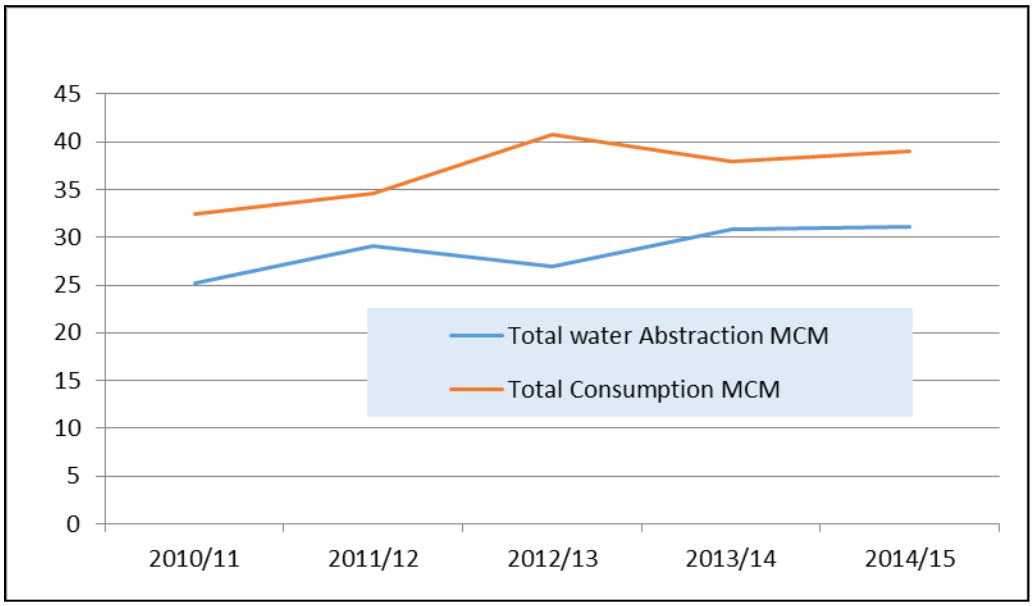
The diamond sub-sector has increased abstraction by 9.6% to 27.4 MCM in 2014-15 compared to 25 MCM the year before, whereas other mines abstracted less or similar amounts of water. There has been a 15% increase in consumption for diamond mining since 2010-11 (Table 5.1). In the years 2013-14 and 2014-15 copper–nickel and coal subsectors have reduced abstractions. Table 5.2 and figure 5.1 show comparison between consumption and abstraction in the mining sector. There is a general rise in both abstraction and consumption.

Table 5.2: Abstraction and consumption in the mining sector (2010/11-2014/15; MCM)

	2010-11	2011-12	2012-13	2013-14	2014-15
Total water abstraction	25.2	29.1	26.9	30.8	31.1
Total water use (from WUC)	7.3	5.5	15.5	9.2	9.9
Total water supply (to WUC)	2.0	2.0	1.6	1.9	2.0
Total water Consumption	32.4	34.6	40.8	38	39.0

Figure 5.1 shows the long term trend in water abstraction and consumption by the mining sector. Unlike in the livestock sub-sector, there has been a long-term trend towards increased abstraction and consumption. Fluctuations do occur however, related to down turns in the mining sector.

Figure 5.1: Trend in water abstraction and Consumption by the mining sector (2010/11 to 2014/15; MCM)

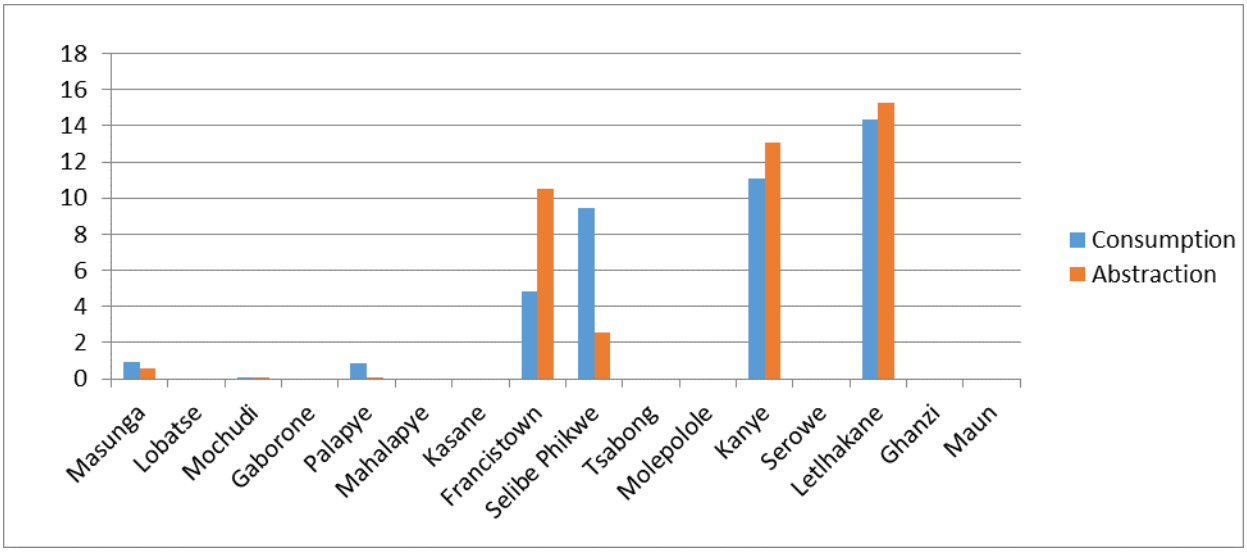


5.2 Trend in regional mining water consumption and abstraction

The WUC Management Centers (MCs) have been used as WA regions and water abstraction and consumption are depicted in Figure 5.2. Water abstraction and consumption for mines were allocated to MCs based on the location of the mine. The Letlhakane region had the highest abstraction (15,278 m^3)

followed by Kanye, Francistown, Selibe-Phikwe and Masunga. In Selibe-Phikwe, Palapye and Masunga mining consumes more than is directly abstracted due to the supply of water by WUC to the mines.

Figure 5.2: Water abstraction and consumption by the mining sector by MC (2014/15; MCM)

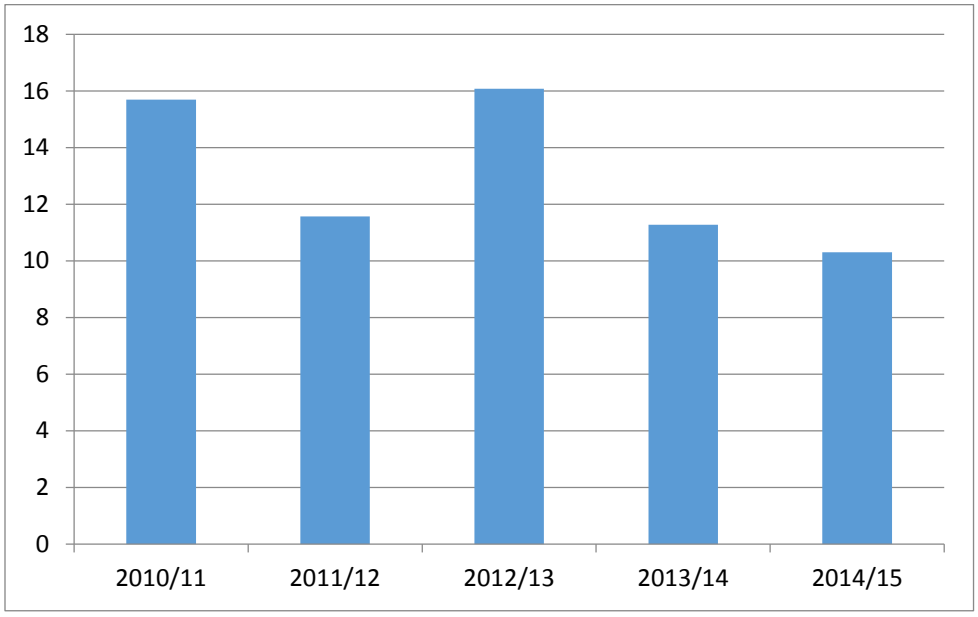


For Palapye MC there is a shared pipeline going to the Morupule Coal Mine and BPC with the supplier (WUC) reading and billing only one bulk meter. It is still unclear exactly how much water goes to BPC and how much goes to Morupule Coal Mine as WUC only bills Morupule Coal Mine. In the absence of full information and because WUC bills the Morupule Coal Mine all water use has been attributed to coal mining. However, this is an over estimation of the coal water consumption as in reality much of the water is transferred to BPC. The next edition of the water account will update this information.

6 Government

This chapter discusses water use and consumption of government for the year 2014-15 and the trend in water consumption from 2010-11 to 2014-15. Government is defined according to the International Standard Industry Classification (or ISIC) used by the SEEA-Water and this excludes Education centers and Health facilities, which are included in Other Industries (chapter 7) in this publication. Water consumption for the year 2014-15 by government was 10 MCM or around 6% of total water consumption in Botswana.

Figure 6.1: Trend in water consumption by government (2010-11-2014-15; MCM)



From Figure 6.1 water consumption by Government has fluctuated between 2010-11 and 2014-15. From 2012-13 until 2014-15 there has been a decline in water consumption. The high figure for 2012-13 may be due to normalizing of the WUC SAP system for all villages within the country.

7 Other industries and electricity generation

7.1 Other Industries

Other industries discussed in this chapter comprise manufacturing, construction, trade, hotels and restaurants, transport, finance and business, social and personal services and international organizations. These are industries that are relatively small and consume low volumes of water. Electricity generation is a large water user and is discussed separately.

The manufacturing industry includes meat processing by Botswana Meat Commission (BMC). BMC is one of the oldest manufacturing operations in Botswana and it forms the backbone of the 'meat and meat processing industry', and has significant forward and backward linkages in the rural and national economy. BMC main plant in Lobatse used 0.6 MCM of water in 2014-15. This is mainly supplied by WUC and excludes the self-extracted supply from boreholes.

Other industries consumed 12 MCM of water in 2014-15 which is 7% of the total water consumed. This water is supplied by other economic sectors, mostly WUC. Some of the industries (e.g. construction, manufacturing and tourism) abstract water for own use. Own abstraction for these industries is not yet included in the accounts due to unavailability of data. In the tourism industry most hotels, lodges and campsites within the country's national parks and game reserves are self-providers.

Figure 7.1: Water consumption by other industries (MCM)

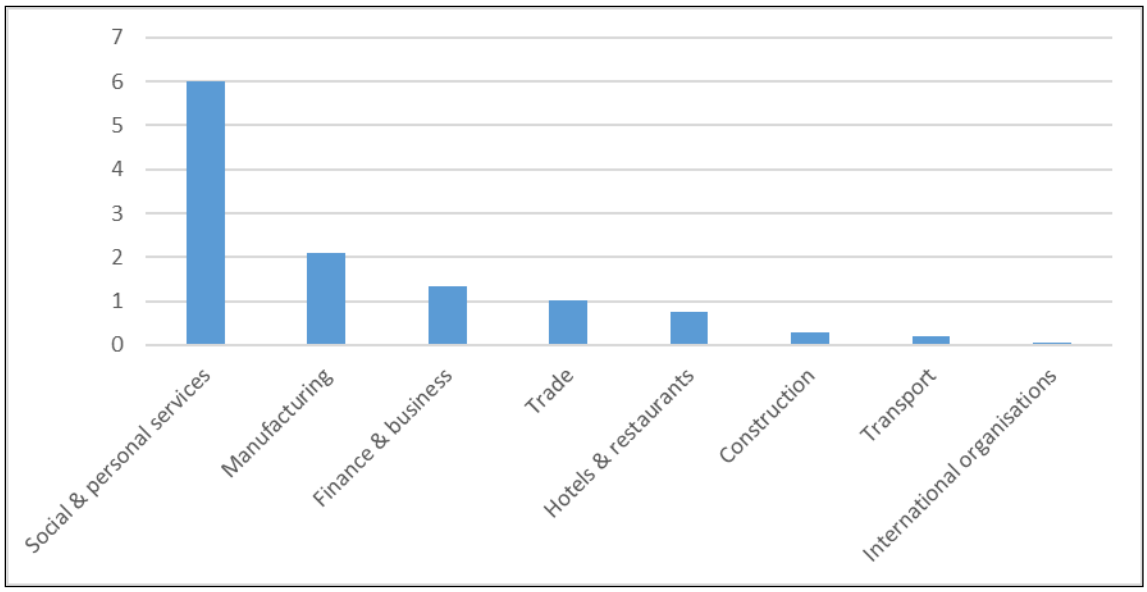
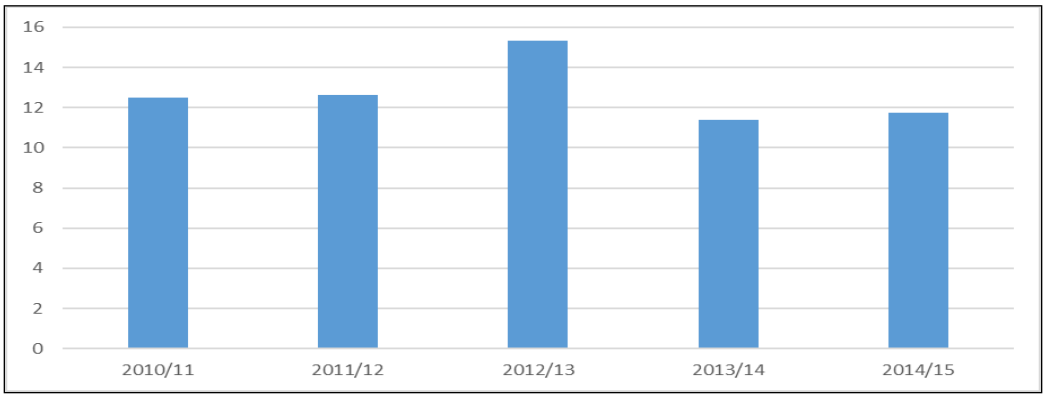


Figure 7.1 shows that social and personal service sector consumes more and it accounts for 51% of water consumed by these industries, followed distantly by manufacturing (18%) and finance and business sector (11%). International organizations are the least consuming among these industries, accounting for only 1%.

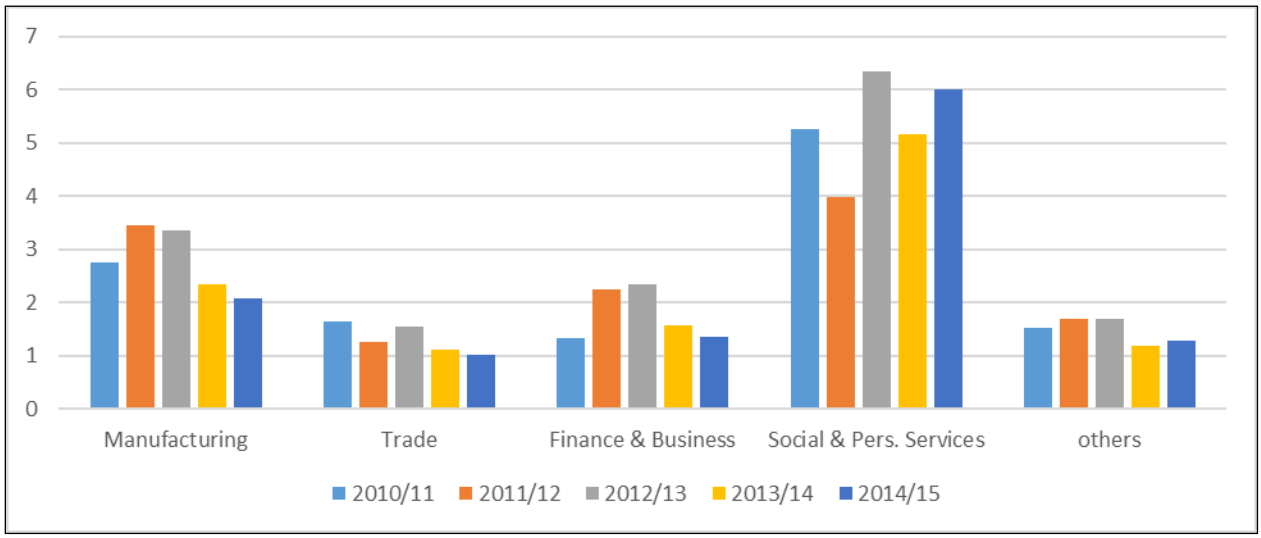
The trend in water consumption by other industries was established for the period 2010-2015. Figure 7.2 shows a fluctuating trend in water consumption over the past five year, reaching a high of 15.3 MCM in 2012-13 and a low of 11.4 MCM in 2013-14.

Figure 7.2: Trend in water consumption by other industries (MCM)



Within other industries, the social and personal services dominate water consumption. This industry is made up of, among others, schools, health facilities, dry cleaners, car washes and saloons.

Figure 7.3: Trend in water consumption by sectors within the other industries (MCM)



7.2 Electricity

Electricity refers to the national power supplier Botswana Power Corporation (BPC). The BPC has two (2) coal powered plants in Palapye and these are Morupule A and Morupule B. Morupule A is currently undergoing rehabilitation whilst Morupule B is in full operation. In addition, BPC operates two diesel powered plants.

The electricity industry abstracts water from wellfields and also gets raw and potable water from WUC. The industry also acts as a small water service provider as it distributes water to a near-by village, a private school and a vehicle workshop.

Table7.2: Use of water within the electricity sector in 2011-15 (MCM)

Item	2011-12	2012-13	2013-14	2014-15
Water abstracted from the environment	-	-	-	0.7
Water supplied from other economic sectors	0.1	0.2	0.1	0.1
Water supplied to other economic sectors	-	0.01	0.02	0.07
Water consumed by electricity industry	0.1	0.2	0.1	0.8

– denotes figures are not available

8 Households

Households consumed 41MCM in 2014-15 which represents 25% of total water consumed. Households get their water mainly from WUC but there are those households that have no access to reticulated water and so must abstract the water themselves from wells or surface water (e.g. rivers). Water consumed by households outside the WUC network is currently not accounted for. Efforts will be made in future to make estimates for this water.

Figure 8.1: Trend in household water consumption (2010-11 to 2014-15; MCM)

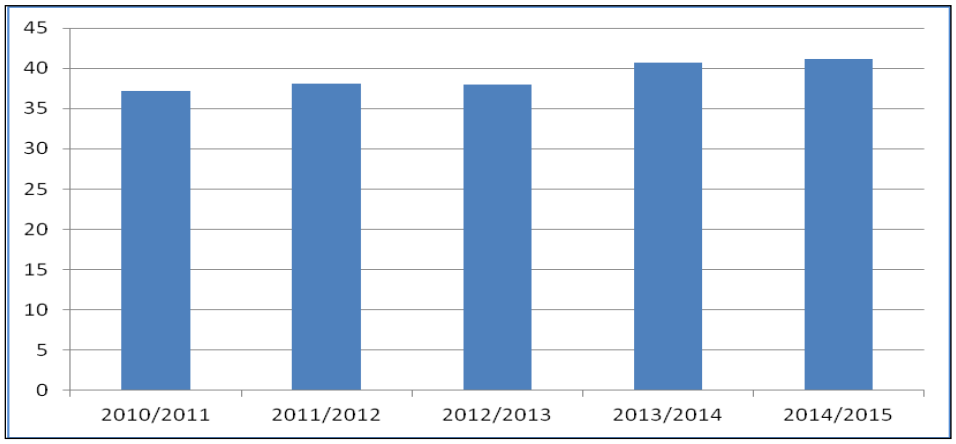


Figure 8.1 shows a 2% increase in water consumption between the year 2010-11 and 2011-12. Between 2011-12 and 2012-13 there was virtually no change in consumption but between 2012-13 and 2013-14, household consumption increased by 7% and increased only very slightly since then. Overall there is evidence of increasing household consumption over the five (5) year period (2010 to 2015)

Figure 8.2: Household Water Consumption by Region (2014-15; MCM)

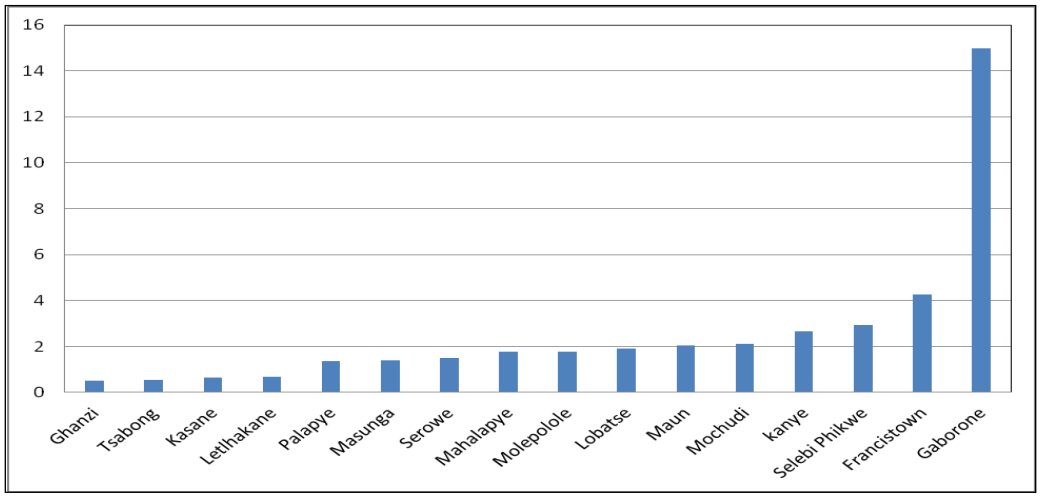


Figure 8.2 shows household water consumption by MC. Gaborone MC is the largest consumer with 15 MCM which is 36 % of the total water consumed by households.

Figure 8.3: Long term trend in household water consumption (1990-2015; MCM)

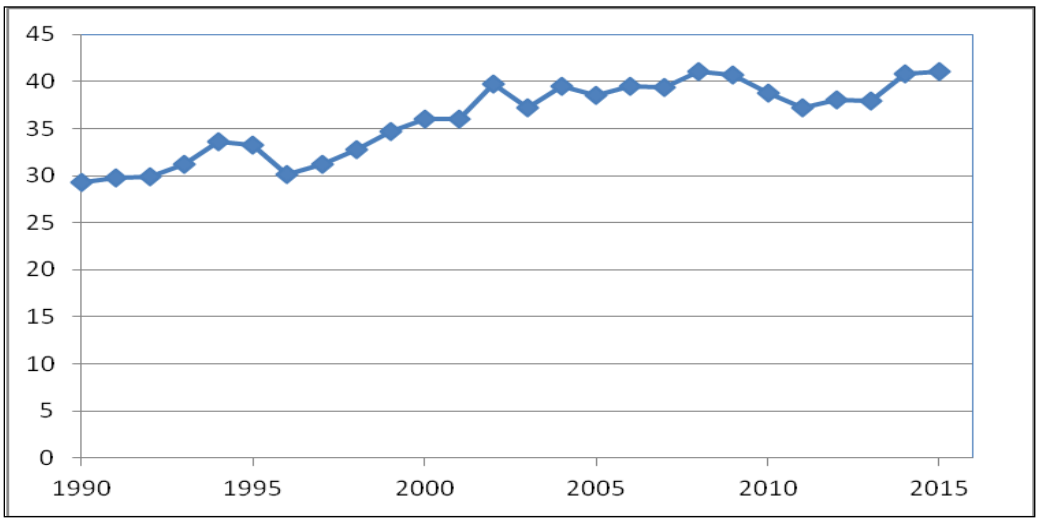


Figure 8.3 shows the long term trend in household water consumption. There is a long-term increase in water consumption but with occasional decreases due to drought and associated water restrictions. The observed recent decline may also be associated with the fact that WUC has taken over the water supply to all settlements between 2008 and 2013 and associated delays in supplies and billing in villages under its new mandate.

9 Water accounting indicators and policy issues

The Botswana water accounts contain a lot of information and data that need to be synthesised for policy and decision makers. This chapter synthesises the findings of the water accounts providing a set of policy relevant indicators. The chapter is intended for resource and development planners as well as decision makers, who need a broader picture, and not the detailed information of the accounts.

The set of policy relevant resource indicators was developed based on the SEEA-Water (UN, 2012 and UNSD, 2014) and modified to suit Botswana's situation and needs. The choice of indicators has been explained in the Botswana Water Accounting Report 2015 (DWA and CAR, 2015). In future, indicators may be expanded and/ or modified, depending on changes in policy needs as well as expansion of the water accounts.

The general purpose of indicators is to synthesize the most important findings of the WA and to detect positive and negative trends in Botswana. It also allows comparison with other countries such as SADC countries. The current indicators cover water resource availability, water use for human activities, water costs and pricing and water use efficiency.

The indicators have been compiled for the period where Botswana has SEEA styled accounts (2010-11 to 2014-15).

9.1 Water resources availability indicators

It is important for policy and decisions makers to know:

- How much renewable water resources are available
- How much of the renewable resources are internal, external or shared
- How much of these resources are actually managed through dams and well fields, and
- How the amount of renewable water resources relates to population size (per capita renewable water resources)
- The effectiveness of Government investments in the construction of dams, water transfers schemes and well fields.

The current water availability indicators to help address these questions are summarized in Table 9.1. The indicators show that the storage capacity has increased by 9% and safe yields marginally less. Taking into account population growth, per capita water availability has only increased by 1.5% over the same period. The incorporation of Dikgatlhong and Thune Dam will improve indicators of water availability.

The water asset accounts show the actual amount of water in reservoirs in comparison to the reservoir's capacities. The actual amounts of water stored in reservoirs is often well below the capacity due to high rainfall variability and semi-arid conditions.

The availability of total and internal renewable resources (TRWR and IRWR) is usually based on an average for a period. The 2014 WA report showed that for the period 2000 – 2010, the average TRWR and IRWR was 12 123 MCM and 3 683 MCM respectively. Botswana is highly dependent on water

resources which are shared with other countries and the use of which are subject to the SADC Shared Watercourse Protocol (70%). Even IRWR (mostly rainfall) are sufficiently available, as the average Motswana has 4 983 L/d available. The key policy issues are capturing more of the TRWR and IRWR, increasing the safe yields of Botswana's water infrastructure and making the water resources accessible and affordable to the population.

Table 9.1: Policy indicators for water availability of reservoirs

	Unit	2010-11	2011-12	2012-13	2013-14	2014-15
Water storage capacity reservoirs	MCM	422	422	422	462	462
Safe yields reservoirs	MCM	73.5	73.5	73.5	80.1	80.1
P.C. water storage capacity	L/p/d	582	571	560	602	591
P.C. water storage safe yields	L/p/d	101	99	98	104	102

Note: storage excludes Ntimbale, Dikgatlhong and Thune dam because of lack of data (for details see chapter 4).

Indicators need to be developed for groundwater, wastewater and water in perennial rivers. Currently, no annual accounts or indicators can be compiled due to data limitations. The following is suspected:

a. Well fields are regularly mined, i.e. abstraction exceeds the sustainable yields.
b. The amount of wastewater is rapidly increasing due to expansion of sewerage systems and wastewater treatment facilities and population growth. Only a small portion of the outflows is currently re-used or recycled (probably in the order of 10 to 20%).

In summary Botswana has a large amount of available renewable water resources (TRWR and IRWR) and high reliance on external shared water resources (Okavango, Chobe, Limpopo, Orange). Most available water resources evaporate and less than 1% results in run-off or groundwater recharge. The safe yields of reservoirs are very low when compared to their capacity and are well below per capita water consumption. There is need to develop groundwater resources, increase safe yields through interconnection of ground and surface water sources, re-use and recycle treated wastewater and increase the efficiency of water uses (DWA and CAR 2015). Moreover, methods of capturing a larger share of available water resources should be investigated.

The country needs a system that completes the loop in terms of how much water is available. There is need to account for all the available water within the country especially quantification of groundwater. This process should also provide a geographical location and water quality of all aquifers within the country.

9.2 Indicators for water use for human activities

Table 9.2: Water use indicators.

			2010-11	2011-12	2012-13	2013-14	2014-15
Total **water abstraction**		MCM	197.2	194.4	194.1	194.4	187.9
Abstraction for own use		MCM	99.5	103.4	91.5	94.9	187.9
Abstraction for distribution		MCM	97.7	91	102.6	99.5	98.1
Imported water		MCM	7.3	7.2	7.7	6.5	89.7
Abstraction by source:							
	Groundwater	MCM	99.3	103.4	95.9	99.6	108.8
	Reservoirs	MCM	82.5	75.6	83.4	80.6	79.1*
	Rivers	MCM	15.4	15.4	14.6	14.3	
Total **water consumption**			172.5	171.6	178.3	169.8	166.8
Households		MCM	37.2	38	37.9	40.8	41.2
Government		MCM	15.7	11.5	16.1	11.3	10.3
Agriculture		MCM	74.6	74.6	66.2	66.2	70.2
Mining		MCM	32.4	34.6	40.8	38	39.0
Other prod. Sectors		MCM	12.6	12.8	17.3	13.5	6.1
Per capita:							
Abstraction		L/p/d	261.8	253.2	247.3	244.9	240.2
Consumption		L/p/d	237.9	232.1	236.7	221.3	213.3
Household water consumption		L/p/d	51.3	51.4	50.3	53.2	52.7

Figure 9.1 and Table 9.2 show that there has been overall increase in water abstraction, probably reflecting supply constraints due to drought and the water sector reforms. Interestingly, more water resources are abstracted for own use than for distribution. This indicates that self-providers (mostly mines, farmers and commercial enterprises operating outside settlements) should be given more attention in the compilation of future accounts to aid the pursuit of sustainable water resource management.

Figure 9.1: Trend in water abstraction for own use and distribution and imported water (MCM; 2010/11 to 2014/15)

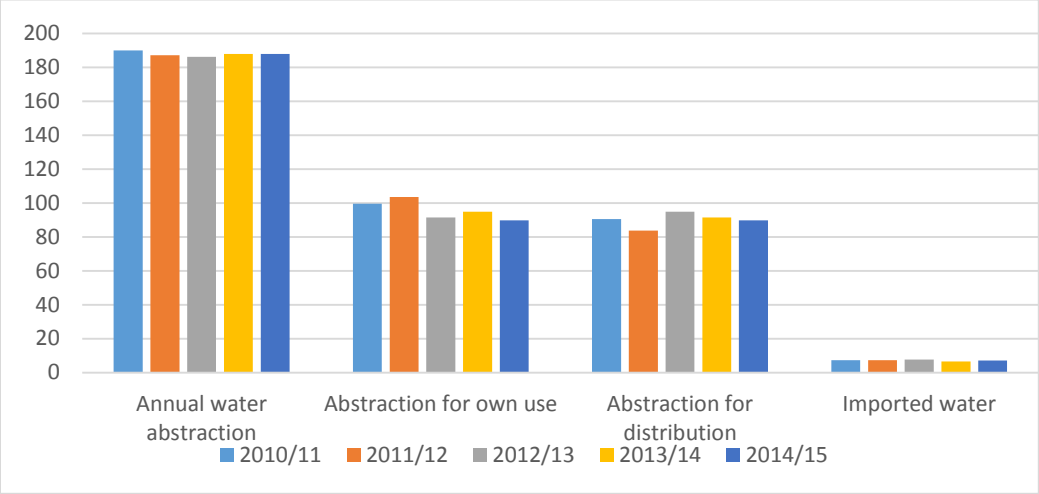


Figure 9.2: Per capita water abstraction and consumption (L/P/D)

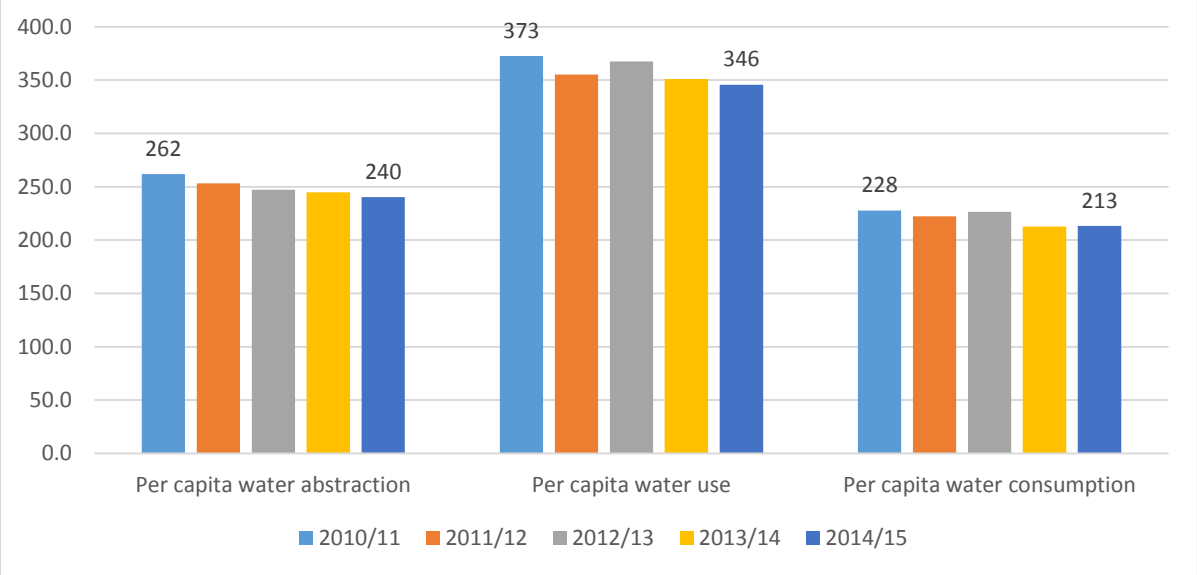
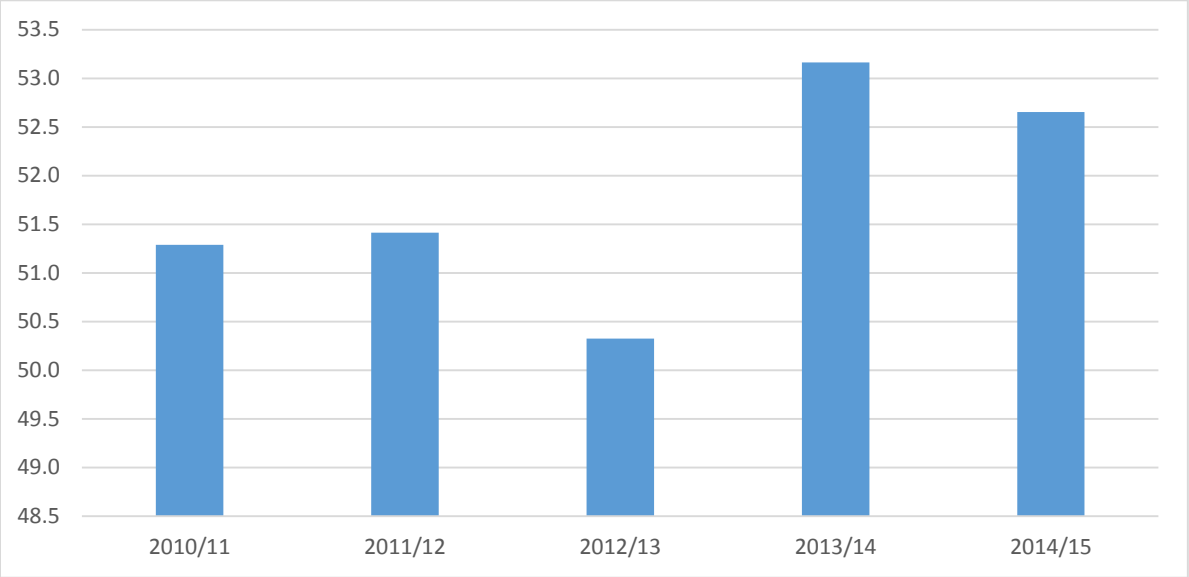


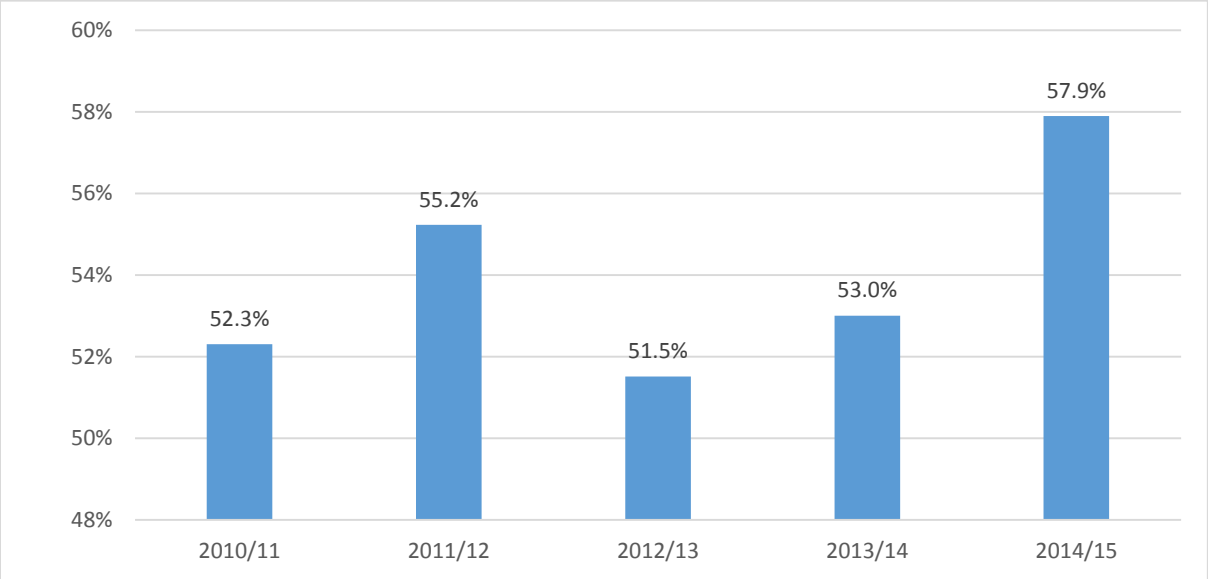
Figure 9.2 shows the per capita water consumption and abstraction, which has gone down as a result of supply constraints and population growth as well as the economic slow-down. Per capita water consumption decreased by 6.6% since 2010-11. This was mostly due to economic activity as per capita household water consumption has marginally increased (2.7%) over the same period (after an initial decrease). This is shown in Figure 9.3.

Figure 9.3: Per capita household water consumption (L/P/d)



Following the drying up of several dams, groundwater consumption has increased by 10% to 57.9% over the period 2010-2015 (Figure 9.4).

Figure 9.4: Groundwater consumption as % of total consumption (2010/11 to 2014/15)



9.3 Indicators for water costs and revenues

Water tariffs are shown in Table 9.3. Tariffs for the private sector (households and industries) are the same, but tariffs for the government sector are roughly double the tariffs for the private sector. This represents a significant subsidy of water supply activity by government. The tariff structure is an increasing block tariffs, offering incentives for water conservation and ensuring that high water users are charged more per unit that low water users. This is designed to discourage wasteful water use and to ensure that luxury uses are appropriated priced. . There is a new tariff for wastewater treatment, which will help WUC to recover the operation and management (O&M) costs. The tariffs ranges from BWP2 to 5/m^3.

Table 9.3: WUC Water Tariffs (effective 01 April 2015)

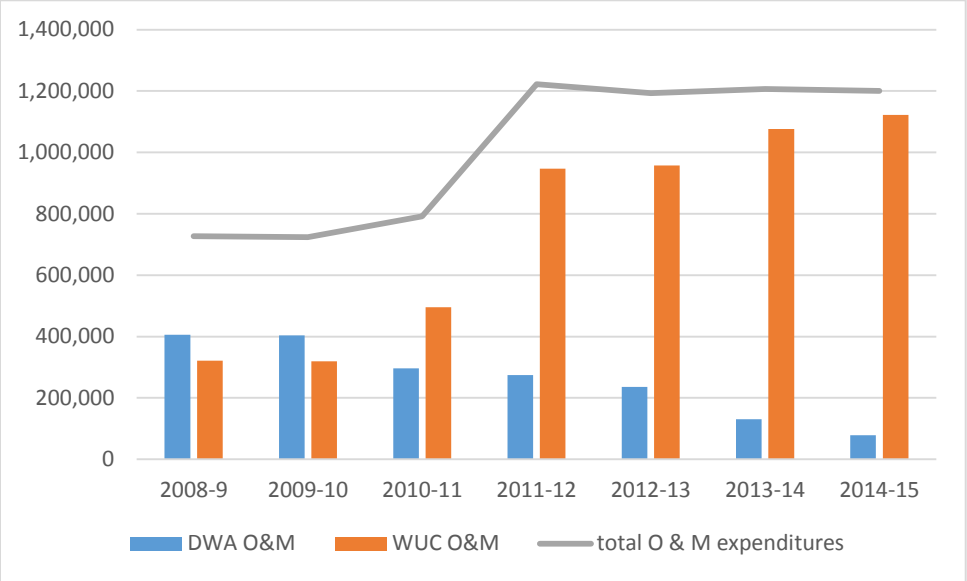
potable water	0-5 m^3	6-15 m^3	16-25 m^3	26-40 m^3	over 40 m^3
Households & industries					
schedule 2	2	8	13	20	25
Schedule 3	2	8	13	20	22
Schedule 4	2	6	11.5	15.5	22
Government	7.2	19.2	25	40	50
wastewater tariff	0.5	2	3	4	5

Other tariffs	per m^3
raw water	4.5
borehole water class 2	4.5
treated effluent	2.5
treated bulk water	18

Source: WUC and DWA.

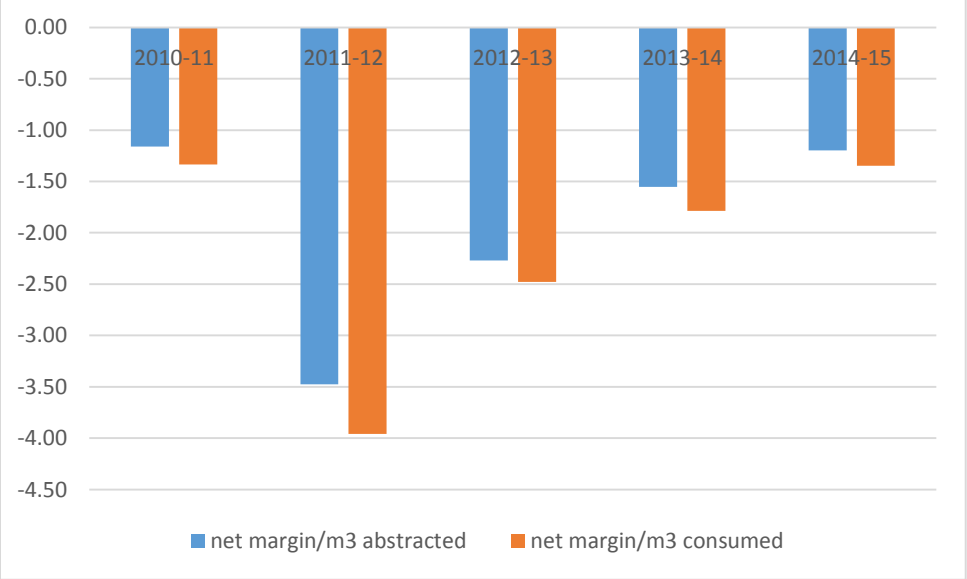
The operation and maintenance expenditure of WUC and DWA are shown in Figure 9.5 While the DWA O&M has decreased; those for WUC have increased rapidly. This reflects the new mandates of WUC and DWA following the water sector reforms (DWA and CAR 2015). The stabilization of the combined O&M expenditures since 2011-12 is encouraging as one of the aims of the WSR was to increase water delivery efficiency and reduce costs.

Figure 9.5: Trend in O&M expenditures on water resources (WUC and DWA; BWP)



Revenues have increased but do not yet cover the O&M expenditures. This is shown in Figure 9.6. It is positive, however, that the negative margin has decreased by more than half to just under BWP1.50/ m^3 sold by WUC. It is clear that government subsidies water distribution.

Figure 9.6: Trend in water revenues –O&M expenditures per m3 (BWP; 2010/11 to 2014/15)

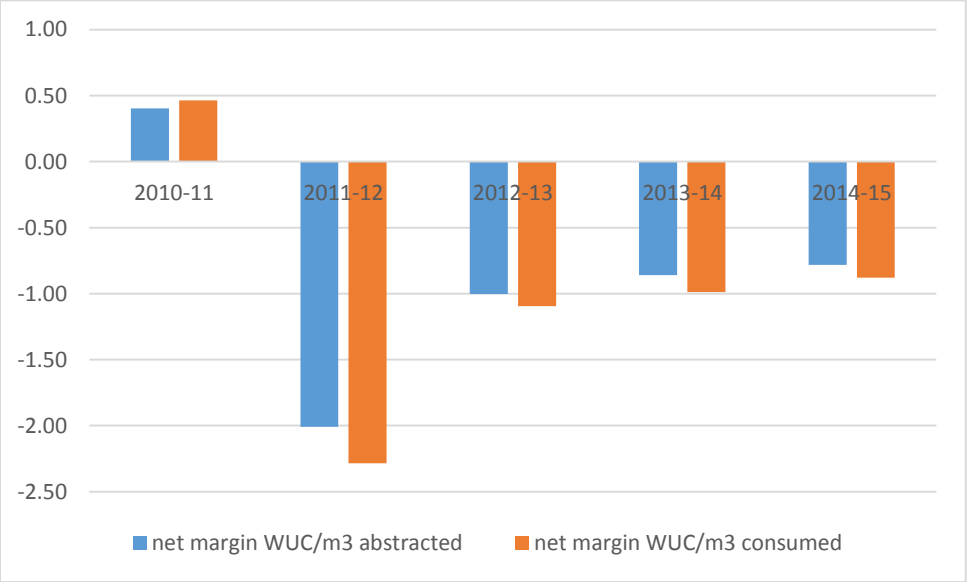


Note: O&M expenditures of DWA & WUC.

Source: calculated from DWA and WUC annual report data.

By law, WUC has to recover its costs. WUC's net margin (revenues – expenditures) is shown in Figure 9.7.The figure shows that WUC's net margin has become negative after 2010-11 but the figure is slowly improving. This may be due to tariff increases and improved revenue collection.

Figure 9.7: Trend in WUC revenues – O&M expenditures (BWP; 2010-11 to 2014-15)

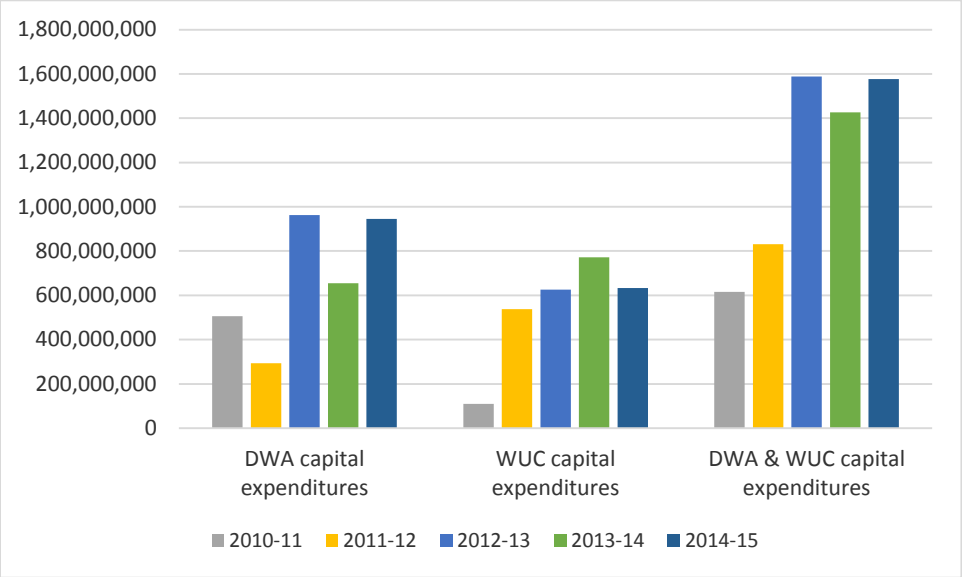


Sources: calculated based on WUC annual report data.

Figure 9.8 shows the trend in capital expenditures in the water sector. Capital expenditures have more than doubled since 2010-11 to almost BWP 1.6 billion in 2014-15. DWA is responsible for BWP 1 billion while DWA invests around BWP0.6 billion. DWA's share in capital expenditures has increased as it is responsible for development of large new water infrastructure projects. The DWA capital expenditures are financed form the general government development budget.

The indicators are summarized in Table 9.4**.**

Figure 9.8: Trend in capital expenditures of DWA and WUC (2010/11 to 2014/15)



Source: WUC annual reports and DWA data.

Table 9.4: Indicators for water costs and revenues in the public sector

		2010-11	2011-12	2012-13	2013-14	2014-15
O&M expenditures	O&M/ m^3 abstracted	8.76	14.60	12.80	13.25	13.68
	O&M/ m^3 sold	12.85	18.51	15.79	16.95	16.61
Revenues	Revenues/m^3 abstracted	6.33	6.82	8.27	10.05	11.12
	Revenues/m^3 sold	9.27	8.66	10.19	12.85	13.50
% O&M cost recovery WUC		115.4%	60.3%	80.5%	85.0%	86.9%
Non-revenue water	NRW as % of abstraction	31.8%	21.2%	18.9%	21.8%	17.6%
Capital expenditures of the public sector	BWP million	615.9	831.4	1,588.2	1,426.1	1,577.4

Sources: DWA and WUC data and WA (WUC data from annual reports)

9.4 Water use efficiency indicators

Water efficiency has been calculated in terms of industry value added and employment. No employment data are yet available for 2014, so the indicator could not be up-dated.

Table 9.5 shows the trend in water efficiency in terms of value added for productive use and for overall water use. Water efficiency has increased steadily since 2010/11 but the increase has slowed down in 2014/15, particularly for productive use. This may be related to water rationing and outages.

Table 9.5: Value added and employment creation per unit of water (2010-11 to 2014-15)

Variable	Sub variable	Unit	2010-11	2011-12	2012-13	2013-14	2014-15
Value added	VA abstracted water prod. Use	BP constant 2006/m^3	324.21	348.34	366.86	395.55	407.77
	VA consumed water prod. Use	BP constant 2006/m^3	455.39	488.36	486.92	576.04	577.53
	VA all abstracted water	BP constant 2006/m^3	355.73	382.84	400.45	420.06	458.79
	VA all consumed water	BP constant 2006/m^3	408.87	435.98	437.26	483.44	516.79
Employment	Formal employment	Jobs/000 m^3 consumed	2.3	2.5	2.5	2.5	
	All employment	Jobs/ 000m^3 consumed	4.1	4.1	4.1	4.1	

Note: water for productive use excludes domestic use and water imports.

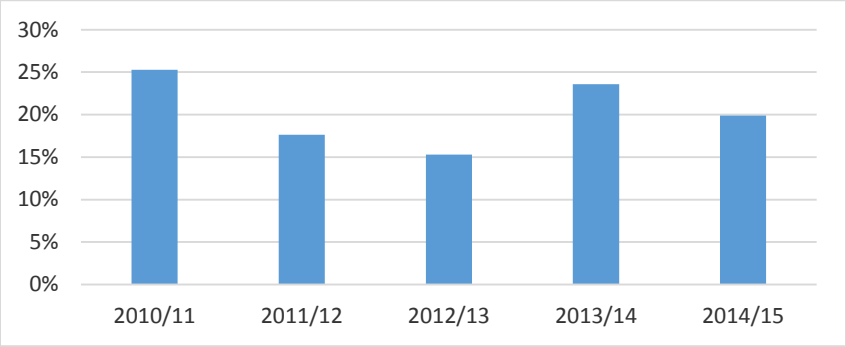
Water losses are only known for WUC. The losses are around 25% as shown in Table 9.6. The lower losses for 2012-13 cannot easily be explained but may be due to high amounts of water distributed to government and mining in this particular year.

Table 9.6: Estimated water losses by WUC (as % of abstraction & imports)

	2010/11	2011/12	2012/13	2013/14	2014/15
Water losses	25.3	25.1	17.6	25.2	25.1

Water losses and NRW can be estimated in different ways, leading to different figures. From the SEEA-WA losses can be calculated as: Losses = water abstracted for distribution + imports – water distributed to other sectors)/ (water abstracted for distribution + imports). This formula yields lower loss rates as is shown in Figure 9.7.

Figure 9.9: Trend in NRW for WUC (as %)



9.5 Emerging policy issues

A range of emerging policy issues or objectives are evident. These have been grouped under major headings and listed below. It is worth noting that all policy issues mentioned below are relevant for NDP 11 consideration.

Issues for Water Policy & IWRM Plan implementation

- Estimation of abstraction by self-providers and unit charge
- Raw water abstraction pricing strategy
- Measuring and re-use of treated effluent
- Economic diversification focused on water extensive industries (e.g. service industries)
- Water and Energy regulatory authority

Issues by industry:

- Promote water efficient irrigation in agriculture
- Promote internal reuse of water for manufacturing industry

Issues for trade, economic growth and diversification:

- Diversification in favour of service industries
- Cap irrigation fresh water use
- Building codes to incorporate rainwater harvesting tanks and plumbing

Issues for poverty reduction:

- WUC water may be too expensive for many poverty reduction projects (especially water intensive projects
- Where possible, re-use of treated effluent, use of non-conventional sources (rainwater harvesting) and spare water capacity of boreholes should be considered;
- Construction of side dams for livestock and irrigation syndicates

Issues for climate change

- Optimization of safe yields of the linked up surface and groundwater sources.
- Climate resilient water infrastructure (i.e. use of deep storage dams to overcome evapotranspiration loses)
- Managed aquifer recharge to mitigate against rising temperatures and encourage conjunctive of surface and ground water.

10 Data sources and methods

This chapter accounts for the data sources used, the methodology employed, and where necessary assumptions made to fill data gaps. Among other things, it provides details on the numerous data sources, how the data was cleaned, sorted and analyzed. The chapter also includes a data quality statement and a note on the WA revision policy.

The water accounts data comes from numerous sources and so each key data sector will be discussed. The accounts require data from various sources including Water Utilities Corporation (WUC), Department of Water Affairs (DWA), self-providers (at this stage mostly mining companies), Ministry of Agriculture (MoA), Statistics Botswana (SB). The data sources to be discussed herein are Agriculture, Mining, and the Water Service Provider (WUC). This chapter will also discuss how data scarcity was handled using estimates, assumptions and correction factors where necessary.

10.1 Agriculture

The agriculture data comprises of livestock and irrigation data.

10.1.1 Livestock

For livestock water abstraction the survey data for the national head is used. This animal population is then multiplied by daily water consumption of each animal as determined by expert guidelines. These guidelines are tabulated in table 10.1 below:

Table 10.1: Livestock standard daily water consumption

Animal	Consumption
Cattle	50 L/day/animal
Goat and sheep	5 L/day/animal
Donkey	20 L/day/animal
Horse	30 L/day/animal
Pigs	12.5 L/day/animal
Chickens	0.25 L/day/animal

Source: rural water supply guidelines.

The livestock numbers were provided by the Agricultural Statistics section. The Agriculture Statistics has data availed up to 2013-14 with figures for 2014-15 not yet available hence the need to supplement with data from the veterinary department. This data was used in conjunction with data provided by the veterinary section to get good estimates for 2014-15. The veterinary section livestock numbers for 2012-13 and 2014-15 were analysed to find the percentage change in livestock numbers for those years. The

percentage change between 2012-13 and 2014-15 for veterinary data was then applied to the 2012-13 Agriculture statistics figures to estimate 2014-15 figures. These figures were then multiplied by the consumption figures (Table 10.1) to account for water consumed by the livestock sub sector.

10.1.2 Irrigation

Water consumption for irrigation has remained constant at 18 MCM/year over the years. The 2014-15 accounting period sees this figure changing for the first time following a pilot survey done by the Water Accounting team. It was recommended that irrigation surveys be carried out to assess water abstraction and use by this agriculture subsector, to acquire better estimates for the accounts. Water Accounts team in collaboration with the Ministry of Agriculture carried out a pilot irrigation survey in South East district. Out of a total of 130 farmers in South East District, a random sample of 30 farmers was taken from different areas within the district; Tlokweng, Boatle, Ramotswa, Mogonye, Otse and Lobatse. The results from the survey were further compared with results from previous studies and data from Ministry of Agriculture to come up with a better national estimate of water use in irrigation. Based on this exercise it was concluded that; Irrigation water consumption amounts to 23.7 MCM of which 13.6 MCM is from surface water resources, 8.3 MCM from groundwater resources and 1.8 MCM supplied by WUC as treated effluent.

The survey sample of 30 farmers was used against the amount of irrigable land and actual land irrigated to get percentage of irrigable land irrigated. This data was also used to get the average amount of irrigated land per farmer. The available data sets from the Ministry of Agriculture (MoA) on number of irrigation farmers were used with this survey data to get best estimate (guess) figures. This assisted in getting the average water abstraction per hectare which was found to be 9500m^3/ha. This figure was then used against the irrigated land to get water consumption figure of 23.7 MCM.

10.2 Mining

Botswana has nine operational mines. Data collection from the mining companies was done using a data collection template, which was developed and sent out by DWA to all mining companies. The current reporting period saw a significant rise in mining companies that provided comprehensive data. Nine (9) companies provided data for the 2014-15 report compared with only five companies in the previous report. The provided data includes water abstraction for own use and distribution. The water abstraction was categorized to indicate the source of water (groundwater, surface or waste water). The mining companies also indicated how much water they receive from WUC (where applicable). The annual Water Apportionment Board (WAB) monitoring reports offered another data source and this were used to verify the data received from the mines. Mines and WUC have differing data on water provided to mines. To be consistent, WUC sales data was used for all mines that receive (some) water from WUC. The data from the mines was provided as monthly sums and this enabled easy conversion into the government financial year calendar (April to March). A water balance was then created for each mine and an overall water balance for the mining sector was produced. The overall balance for the mining sector groups the mines into similar sectors e.g. diamond, gold, coal. The data for returns into the environment was sketchy so it is assumed in this report that there are no return flows.

10.3 WUC data

10.3.1 Customer data

The water sales (volume and value) provided were not disaggregated by ISIC sector classification. WUC uses ten client categories comprising domestic, business and industries, some mines and government. As with the previous years, the link between water use and economic sector was done manually using the UN's ISIC classification. The 2014-15 client contracts were compared with the final coded list from 2013-14 to reduce the number of contracts that had to be coded. After the comparison exercise using a VLOOKUP function in Microsoft Excel, a total of 7 798 contracts could not be matched and therefore had to be coded manually. Out of this, 50% had zero consumption and therefore were ignored to concentrate on those that had consumption of more than zero. Team knowledge, internet searches, and telephone directory assisted in identifying the clients. Those that could not be identified accounted for about 23% of the 2014-15 contracts but contributes 4% to the total water sales.

The total sales for businesses and government as per the WUC customer data slightly differed from the total sales derived from the billing information provided (authorized). Therefore, to account for the difference, a correction factor of 0.99 was applied to sectoral sales such that the total for both data sets are equivalent.

10.3.2 WUC water abstraction and use

Comprehensive and up to-date WUC water abstraction data was provided by MC. For abstraction by source, we have assumed similar ratios as used in the accounts for 2013-14 (69% is abstracted from reservoirs, 30% from groundwater and 2% from rivers). There is data on the water supply from Molatedi dam and the distribution of water between MCs. Water use data is available for each MC and this was used largely to calculate the losses for each MC. However, water use for Maun MC was not available and therefore, an average water loss of 26% was applied to estimate water use in the region. It was also assumed that 75% of the total water use is for domestic or household use while the rest was distributed to other sectors.

10.4 SEEA-Water supply and use table

Water imported from South Africa (Molatedi dam) is captured in the supply table as the water supplied to other economic units by the 'Rest of the world'. It has been deducted from WUC's abstraction for distribution, as well as from water supplied by WUC to other economic units.
WUC water abstraction for own use is derived from the WUC sales to the water sector. It is deducted from WUC water abstracted, and WUC water supplied to other sectors (56.5).

Water received by WUC under the water use table includes water from the mining sector (Debswana Jwaneng). Therefore, this figure is also captured under the diamond sector as water abstracted for distribution, and also water supply to other economic units (WUC) in the supply table.

Currently water received by the electricity sector includes billed water from WUC. Water from Morupule Coal Mine has not been included as it is unclear how much it is.

Sewage and waste water have not been distinguished in the accounts. Under ISIC, sewerage is included under social and personal services.

Education and health facilities (both public and private) have been s*ubsumed within the social and personal services.

10.5 SEEA terminology

Terms	SEEA description	Comment
Water abstraction	The amount of water that is removed from any source, either permanently or temporarily, in a given period of time for consumption and production activities. Water can be abstracted for distribution or for own use (once it is used it can be delivered to another user for treatment or re-use).	Rainfall that is not captured is not abstraction. For example, rain-fed crop production uses rainfall but this is not recorded in the WA; in contrast, irrigation water is usually abstracted and stored and therefore accounted for in the WA
Water use	Water intake of an economic unit. It is the sum of water: a. provided to that economic unit by a water service provider or another economic sector; and b. water abstraction from the environment by that economic unit.	
Water consumption	That part of water use which is not distributed to other economic units and does not return to the environment because during use it has been incorporated into products, or consumed by households or livestock.	When return flows are unknown consumption becomes similar to water use. Water consumption is not equal to water sales but consumption relates to the hydrological water cycle.
Return flows	Water that is returned into the environment or another economic unit by an economic unit. Returns can be classified according to the receiving body and to the type of water, such as treated water.	Return flows can potentially be used again within the economy.
Water losses	The volume of water lost during transport through leakages and evaporation between a point of abstraction and a point of use, and between points of use and re-use.	Water losses from water infrastructure become return flows into the environment.

Source: United Nations, 2012.

10.6 Data quality statement

Data quality was assessed using the seven (7) dimensions of data quality used by the Australian Bureau of Statistics (ABS) (2009) and a traffic light approach:

- Green, data quality greater than 75% (use with some confidence)
- Amber, data quality between 50 and 75% (use with caution)
- Red, data quality below 50% (indicative only and liaise with data providers before any use)

The ABS Data Quality Framework is comprised of seven dimensions of quality, which are:

1. Institutional Environment,
2. Relevance,
3. Timeliness,
4. Accuracy,
5. Coherence,
6. Interpretability, and
7. Accessibility.

The ABS Data Quality Framework is similar to other international frameworks (eg Statistics Canada Quality Assurance Framework and the European Statistics Code of Practice).

10.6.1 Institutional environment

The overall objective of the Department of Water Affairs is to assess, develop and protect Botswana`s water resources for sustainable contribution to socio-economic growth. In order to provide effective leadership for water resources planning, development and management, the department will assist and advises in the formulation of water resources development and management policies. The Department assesses plans, develops and manages water resources for short, medium and long term purposes.

It also administers the water law and other related legislations, and liaises with the riparian users of national and international rivers on the saving, conservation and protection of water resources. WA is part of the National Water Master Plan Review of 2006 (Volume 5, Section 2: Natural Resource Accounting) and the IWRM-WE plan of 2013. Both reports call on the need to have a system in place for water accounting.

The Water Accounts are prepared by DWA by a dedicated WA unit working with the technical working group that has representatives from WUC, SB, MOA, MFDP and BCM. High level guidance provided by WAVES PSC.

At present all data exchanges occur without any formal legal agreement.

The quality of the institutional environment for 2014-15 Botswana water accounts report is amber.

10.6.2 Relevance

Botswana is a dry country and water scarcity has been identified as a national priority in a draft of the NDP 11. Understanding the impacts of the increasing population and economic growth on water supply is a critical issue.

The relevance of water accounts for Botswana is high and therefore this dimension of data quality is rated green.

10.6.3 Timeliness

The WA for 2014/15 are published 9 months after the reference period. This has improved from the previous accounts which were available 14 months after the reference period.

The timeliness of water accounts for Botswana is internationally comparable (eg Australia and Netherlands) and therefore this dimension of data quality is rated green.

10.6.4 Accuracy

The accuracy of the data varies between industries and different water flows.

- Water supply – Information from WUC is available on the volume of water used and the amount paid. The information is mostly from metered water use. Data quality green.
- Agriculture – Information was obtained from the Ministry of Agriculture, special surveys conducted by DWA as well as information from Statistics Botswana. There are several data gaps and estimates based on the available information had to be used. Data quality amber.
- Mining – Information was directly collected from the mines by DWA. Information on abstraction was good but there was limited information on return flows. Data quality green.
- Other Industries – Information was obtained from WUC but no information was available on self-abstraction, therefore the total use is likely to be underestimated significantly (eg Construction and Hotels). Data quality amber/red.
- Households – Information was obtained from WUC but no information for self-abstractors, therefore total use is slightly underestimated. Data quality green.

10.6.5 Coherence

WA for Botswana are based on the SEEA and all of the data have been aligned with key concepts and classifications of this document. Data quality green.

10.6.6 Interpretability

WA for Botswana includes tables, graphics and interpretive text to assist readers' understanding of the information. Data quality green.

10.6.7 Accessibility

WA for Botswana are available as a document which can be downloaded on a public website. The main supply and use table is also available as an excel file from the website. Data quality green.

10.6.8 Overall assessment

The overall quality of the 2014-15 Botswana water accounts report is amber. This rating is based on the fact that the data is highly relevant as key information for the accounts is available, the accounts will be completed in a timely manner, the data is of varying accuracy, much of the data is from primary sources, the data compares well over time, and information to help users understand data is provided. It is however worth noting that data was not collected under any legislation or legal agreement.

The quality of the data will be refined as and when the missing data becomes available and when new methods are revised.

If you have information or methods which will help us improve the data please contact DWA (+267 3607100, obpule@gov.bw).

10.7 Revision Policy

There will be annual reviews of published water accounts data. This will include cross-checking within DWA, feedback from selected experts and feedback from the general public who access the accounts via the DWA website and through other means. Revisions will be done where omissions or mistakes are identified. The revisions will be annexed in the water accounts report of the following year.

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Appendix 1: Physical Supply and Use Tables for 2012-13, 2013-14 and 2014-15.

A1.1 Physical supply and use table 2012-13

2012/13 Physical Supply and use (000m^3)		Agriculture		Mining and Quarrying						Manufacturing					Water												
		Irrigation/Com	Livestock	Diamond mining	Copper/nickel mining	Coal mining	Soda ash mining	Gold mining	Other mining	Meat & meat p	Textiles	Leather & leat	Other manufac	Electricity	Water service p	Construction	Trade	Hotel & restau	Transport	Finance and bi	Social & pers	Government	Int. Organisat	Total agr & ind	households	rest world	Total
	ISIC code (as per Rev 3)	11	12	1423	1320	1010	1424	1425	1426	1510	1700	1910	?	40	4100	45	50-52	55	60-64	65-74	80,85, 90-93	75,407,550	99				
I. Physical use table																											
	1a.Abstraction for own use	18,840.000	47,188.113	20,927.793	3,755.784	97.970	527.471								150.991									**91,488.121**			91,488.121
	1b.Abstraction for distribution			1,557.193											93,204.388									**94,761.581**			94,761.581
	1. Total abstraction	18,840.000	47,188.113	22,484.986	3,755.784	97.970	527.471								93,355.379									**186,249.702**	-	-	186,249.702
From the environment	1.Reservoir water	1,375.320	9,437.623	215.234	79.900										**64,610.026**									**75,718.102**		-	75,718.102
	1ii.Ground water	7,234.560	35,391.084	22,269.752	3,675.884	97.970	527.471								**26,748.099**									**95,944.820**			95,944.820
	1iii.River water	10,230.120	2,359.406												**1,997.254**									**14,586.780**			14,586.780
	1iv.Rainwater harvesting																										
	Abstraction from water resources (1i+1ii+1iii+1iv)	18,840.000	47,188.113	22,484.986	3,755.784	97.970	527.471								**93,355.379**									**186,249.702**		-	186,249.702
Within the economy	**2. Use of water from other economic sectors**	86.968	120.570	345.965	10,870.738	1837.651	445.259	1902.794	112.091	1524.719	271.453	0.533	1569.160	179.711	1557.200	446.436	1557.927	817.736	265.029	2,350.608	6,357.991	16,073.339	157.499	**48,851.379**	37.949.883		86,801.262
	3. Total use of water (1+2)	**18,926.968**	**47,308.683**	**22,830.951**	**14,626.522**	**1,935.621**	**972.730**	**1,902.794**	**112.091**	**1,524.719**	**271.453**	**0.533**	**1,569.160**	**179.711**	**94,912.579**	**446.436**	**1,557.927**	**817.736**	**265.029**	**2,350.608**	**6,357.991**	**16,073.339**	**157.499**	**235,101.081**	**37,949.883**	-	**273,050.964**
II. Physical supply table																											
Within the economy	**4. Supply of water to other economic units (4a+4b)**			1,557.193										11.250	77,528.142									**79,096.585**		7,706.900	86,803.485
	4a. Re-used water																										
	4b. Wastewater to sewerage																										
Into the environment	**5. Total returns (5.a+5.b)**														15,676.246									**15,676.246**			15,676.246
	5.a. To inland water resources																										
	5.a.1. Surface water																										
	5.a.2. Groundwater														15,676.246									**15,676.246**			15,676.246
	5.a.3. Soil water																										
	5.b. To other sources																										
	6.Total supply of water (4+5)	-	-	1,557.193	-	-	-	-	-	-	-	-	-	11.250	93,204.388	-	-	-	-	-	-	-	-	**94,772.831**		7,706.900	102,479.731
	7. Consumption (3-6)	**18,926.968**	**47,308.683**	**21,273.758**	**14,626.522**	**1,935.621**	**972.730**	**1,902.794**	**112.091**	**1,524.719**	**271.453**	**0.533**	**1,569.160**	**168.461**	**1,708.191**	**446.436**	**1,557.927**	**817.736**	**265.029**	**2,350.608**	**6,357.991**	**16,073.339**	**157.499**	**140,328.250**	**37,949.883**	**- 7,706.900**	**170,571.233**

A1.2 Physical supply and use table 2013-14

2013/14 Physical Supply and Use (000m^3)		Agriculture		Mining and Quarrying						Manufacturing					Water											
		Irrigation/Comm	Livestock	Diamond mining	Copper/nickel mining	Coal mining	Soda ash mining	Gold mining	Other mining	Meat & meat p	Textiles	Leather & le	Other manufactu	Electricity	Water service p	Construction	Trade	Hotel & rest	Transport	Finance and bus	Social & perso	Government	Int. Organisa	Total agr & ind	households	rest world	Total
	ISIC code (as per Rev 3)	11	12	1423	1320	1010	1424	1425	1426	1510	1700	1910		40	4100	45	50-52	55	60-64	65-74	80,85, 90-93	75,407,550	99				
I. Physical use table																											
From the environment	1a.Abstraction for own u	18,840.000	47,188.113	23,013.623	5,147.227	99.830	576.613								62.809									**94,928.215**			94,928.215
	distribution			1,949.331											91,042.996									**92,992.327**			92,992.327
	1. Total abstraction	**18,840.000**	**47,188.113**	**24,962.954**	**5,147.227**	**99.830**	**576.613**								**91,105.805**									**187,920.542**		-	**187,920.542**
	1i.Reservoir water	1,375.320	9,437.623	141.538	61.399										**63,051.449**									**74,067.328**		-	74,067.328
	1ii.Ground water	7,234.560	35,391.084	24,821.417	5,085.828	99.800	576.613								**26,393.065**									**99,602.368**			99,602.368
	1iii.River water	10,230.120	2,359.406												**1,661.292**									**14,250.817**			14,250.817
	1iv.Rainwater harvesting																							-			-
	Abstraction from water resources (1i+1ii+1iii+1iv)	**18,840.000**	**47,188.113**	**24,962.954**	**5,147.227**	**99.800**	**576.613**								**91,105.805**									**187,920.512**		-	**187,920.512**
Within the economy	**2. Use of water from other economic sectors**	73.530	145.618	248.099	6,743.000	620.180	380.456	1,141.342	61.811	1,099.876	187.998	0.459	1,061.656	89.072	1,949.000	320.930	1,111.578	613.672	187.666	1,563.872	5,173.935	11,277.252	78.994	**34,129.997**	40,750.485	-	74,880.482
	Total use of water (1+2)	**18,913.530**	**47,333.730**	**25,211.054**	**11,890.227**	**720.010**	**957.070**	**1,141.342**	**61.811**	**1,099.876**	**187.998**	**0.459**	**1,061.656**	**89.072**	**93,054.805**	**320.930**	**1,111.578**	**613.672**	**187.666**	**1,563.872**	**5,173.935**	**11,277.252**	**78.994**	**222,050.540**	**40,750.485**	-	**262,801.025**
II. Physical supply table																											
Within the economy	**4. Supply of water to other economic units (4a+4b)**			1,949.331										18.420	66,406.162									**68,373.913**		6,506.900	74,880.813
	4a. Re-used water																										
	4b. Wastewater to sewerage																										
Into the environment	**5. Total returns (5.a+5.b)**														24,636.834									**24,636.834**			24,636.834
	5.a. To inland water resources																										-
	5.a.1. Surface water																										-
	5.a.2. Groundwater														24,636.834									**24,636.834**			24,636.834
	5.a.3. Soil water																										
	5.b. To other sources																										
	6.Total supply of water (4+5)	-	-	1,949.331	-	-	-	-	-	-	-	-	-	18.420	91,042.996		-	-	-	-	-	-	-	**93,010.747**	-	6,506.900	99,517.647
	7. Consumption (3-6)	**18,913.530**	**47,333.730**	**23,261.723**	**11,890.227**	**720.010**	**957.070**	**1,141.342**	**61.811**	**1,099.876**	**187.998**	**0.459**	**1,061.656**	**70.652**	**2,011.809**	**320.930**	**1,111.578**	**613.672**	**187.666**	**1,563.872**	**5,173.935**	**11,277.252**	**78.994**	**129,039.793**	**40,750.485**	- **6,506.900**	**163,283.378**

A1.3 Physical supply and use table 2014-15

2014/15 Table (000m^3)		Agriculture		Mining and Quarrying						Manufacturing					Water			Construction	Trade	Hotel & reste	Transport	Finance and	Social & pers	Government	Int. Organisa	Total agr &	ind	household s	rest world	Total
		Irrigation	Livestock	Diamond	Copper/nicke	Coal	Soda ash	Gold	Other mining	Meat & meat	Textiles	Leather & lea	Other manuf	Electricity	Water servic	sewerage														
	WA code	2	1	3	4	5	6	7	8	9	10	11	12	14	13	31.1	15	16	17	18	19	20	21+22	23					
I. Physical use table																														
From the environment	1a.Abstraction for own use	21,902.8	46,271.2	25,445.2	2,600.9	46.6	580.0	467.6						743.1	56.5											**98,114.0**			98,114.0
	1b.Abstraction for distribution			2,000.4	-	-	-	-							87,735.6											**89,736.0**			89,736.0
	1. Total abstraction	**21,902.8**	**46,271.2**	**27,445.6**	**2,600.9**	**46.6**	**580.0**	**467.6**	**-**	**-**	**-**	**-**	**-**	**743.1**	**87,792.2**		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**187,850.0**		**-**	**187,850.0**
	1i.Reservoir water			2,987.4	0.0	1.2	-	-							**50,041.5**											**53,030.2**		-	53,030.2
	1ii.Ground water	8,287.6	34,703.4	24,458.2	2,600.9	45.4	580.0	467.6						743.1	**36,872.7**										**108,758.8**			108,758.8
	1iii.River water			-											**877.9**											**877.9**			877.9
	1iv.Rainwater harvesting														-											-			-
	1v.(Reservoir and river wate	13,615.3	11,567.8																							**25,183.1**			25,183.1
	Abstraction from water resources (1i-1v)	**21,902.8**	**46,271.2**	**27,445.6**	**2,600.9**	**46.6**	**580.0**	**467.6**	**-**	**-**	**-**	**-**	**-**	**743.1**	**87,792.2**											**187,850.0**		**-**	**187,850.0**
Within the economy	**2. Use of water from other economic sectors**	1,826.7	160.5	238.6	6,864.9	821.1	337.5	1,578.1	51.2	952.5	174.5	1.0	1,009.0	104.5	2,053.5		295.1	1,035.3	765.7	196.8	1,376.7	6,153.1	10,303.2	68.8	**36,368.5**	41,177.0	-	77,545.5
	Total use of water (1+2)	**23,729.5**	**46,431.8**	**27,684.2**	**9,465.7**	**867.7**	**917.5**	**2,045.7**	**51.2**	**952.5**	**174.5**	**1.0**	**1,009.0**	**847.6**	**89,845.7**		**295.1**	**1,035.3**	**765.7**	**196.8**	**1,376.7**	**6,153.1**	**10,303.2**	**68.8**	**224,218.5**	**41,177.0**	**-**	**265,395.5**
II. Physical supply table																														
Within the economy	**4. Supply of water to other economic units (4a+4b)**			2,000.4										72.8	66,653.7	1,775.9										**70,502.8**		7,042.7	77,545.5
	4a. Re-used water															1,775.9													
	sewerage																													
Into the environment	**5. Total returns (5.a+5.b)**														21,081.9											**21,081.9**			21,081.9
	5.a. To inland water resources																													-
	5.a.1. Surface water																													-
	5.a.2. Groundwater														21,081.9											**21,081.9**			21,081.9
	5.a.3. Soil water																													
	5.b. To other sources																													
	6.Total supply of water (4+5)	-	-	2,000.4	-	-	-	-	-	-	-	-	-	72.8	87,735.6	1,775.9		-	-	-	-	-	-	-	**91,584.7**	-	7,042.7	98,627.4
	7. Consumption (3-6)	**23,729.5**	**46,431.8**	**25,683.8**	**9,465.7**	**867.7**	**917.5**	**2,045.7**	**51.2**	**952.5**	**174.5**	**1.0**	**1,009.0**	**774.8**	**2,110.0**	**-1,775.9**	**295.1**	**1,035.3**	**765.7**	**196.8**	**1,376.7**	**6,153.1**	**10,303.2**	**68.8**	**132,633.8**	**41,177.0**	**-7,042.7**	**166,768.1**

Appendix 2: Time series report

Experimental long-term time-series for key water accounting aggregates for Botswana

Research Report for Consultation

14 October 2015

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ABREVIATIONS

ABS Australian Bureau of Statistics
CAR Centre for Applied Research
DWA Department of Water Affairs
UN United Nations
WUC Water Utilities Corporation

1.0 INTRODUCTION

The objective of this activity was to develop a long-term time series of key water accounting aggregates for Botswana and in particular total water consumption and water consumption by major industries (Agriculture, Mining, Other industries) as well as households.

This was to connect current and previous work on water accounting. In particular the water accounts done by Lange et al. (2001) for the years 1993 to 1998, Department of Environmental Affairs and Centre for Applied Research (2006) and the work by the Government of Botswana and CAR (2013 and 2015) for the years 2010 to 2014.

The work is experimental and will be reviewed and updated as necessary to increase the consistency of the data. Anyone with comments of the estimates is encouraged to contact the project team (contact details are included and end of the publication).

No analysis or interpretation of results is offered in this publication. The intent of this publication is to focus on the concepts, data sources and methods needed to produce a consistent time series of key aggregates. Anyone using the estimates for analytical purposes in also encouraged to contact the project team.

1.1 Timing

The project was undertaken in July 2015, with expert review of the 1st Draft in August and September and the finalized in October 2015.

2.0 CONCEPTS, DATA SOURCES AND METHODS

This section describes the general concepts, data sources and methods used to construct a consistent time series. The specific data sources and methods used for particular industries and households are presented in separate sections (see below).

2.1 Concepts

The previous work was based on the 1993 version of the System of Environmental-Economic Accounting (SEEA)(UN 1993) while the more recent work was based on the SEEA Water (UN 2012). The fundamental concepts in the two versions of the SEEA are similar. In particular, the concepts of water abstraction and water consumption are the same in UN 1993 and UN 2012. These are defined as:

Water abstraction: The amount of water that is removed from any source, either permanently or temporarily, in a given period of time for final consumption and production activities. Water

used for hydroelectric power generation is also considered to be abstraction. Total water abstraction can be broken down according to the type of source, such as water resources and other sources, and the type of use. (EDG)

Water consumption: That part of water use which is not distributed to other economic units and does not return to the environment (to water resources, sea and ocean) because during use it has been incorporated into products, or consumed by households or livestock. It is calculated as the difference between total use and total supply; thus, it may include losses due to evaporation occurring in distribution and apparent losses due to illegal tapping as well as malfunctioning metering. (EDG)

In the case of the water accounts compiled so far for Botswana consumption and abstraction by agriculture are almost identical as agriculture receives only a small fraction of water from other economic units (e.g. WUC) and water is not supplied to any other industries or households by agriculture, nor are there estimates of returns as there is no data available.

For households, only water supplied by the water supply industry is known and reported in the accounts, no water is supplied to others and wastewater to sewerage is currently unknown. As such water supplied by the water supply industry (e.g. WUC and DWA and District Councils prior to the water sectors reform which were completed in 2013) is equal to consumption.

For mining, water is abstracted directly as well as supplied to it by the water supply industry (e.g. WUC). A small amount of water is returned to the environment. As such water consumption in mining is equal to water abstracted by mining, plus water supplied to mining, less returns (discharges). In general the discharges by mining (and other industries) are unknown.

2.2 **Data sources and methods**

In addition to the three sets of water accounts produced for Botswana additional data were available on total water abstraction by the entire economy, water abstraction by source and water abstraction by agriculture and mining. Much of these data were presented in Chapter 8 (Trend Analysis) of the most recent set of water accounts (2015). These data where compiled by CAR and made available to the project.

Different methods were used for particular industries and households (see below). Two general methods were used: (1) ratio estimation and; (2) linear regression.

2.3 Data quality assessment

Data quality was assessed using the seven dimensions of data quality used by the ABS (2009) and a traffic light approach:

- Green, data quality greater than 75% (use with some confidence)
- Amber, data quality between 50 and 75% (use with caution)
- Red, data quality below 50% (indicative only and liaise with data providers before any use)

3.0 WATER CONSUMPTION BY HOUSEHOLDS

3.1 Data Sources for Household

- WUC (6 cities, covering years 1993 to 1995). Information compiled by CAR and passed to DWA.
- Local Government (rural settlements, covering years 1993 to 1998). Information compiled by CAR.
- DWA (17 Major Villages, covering years 1993 to 1998). Information compiled by CAR.
- Botswana Water Accounts reports (1 and 2, covering years 2011 to 2014 for household water consumption and total water abstraction by the economy for the years 1990 to 2014)

3.2 Methods for Households

To construct the time series for household consumption from 1990-2014, we had available data for total Abstraction by all sectors (i.e. 1990-2014) which was provided by all the sources and for data on household consumption data was available for a period from 2010/11- 2013/14. The primary data for current and previous accounts came from the water supply industry (i.e. WUC and its predecessors) from the available data of household consumption the average proportion of consumption was determined and the proportion ratio was applied across all the years with no data.

A further refinement/ improvement was made on the data using the available data from WUC, DWA and Local Government from the period 1992/93, 1993/94 and 1994/95. The consumption from the three sources was summed and the ratio was determined as a function of consumption by total abstraction by sector. The consumption ratio was applied across all the years with no data from 1990-2014.

3.3 Data Quality Statement for Households

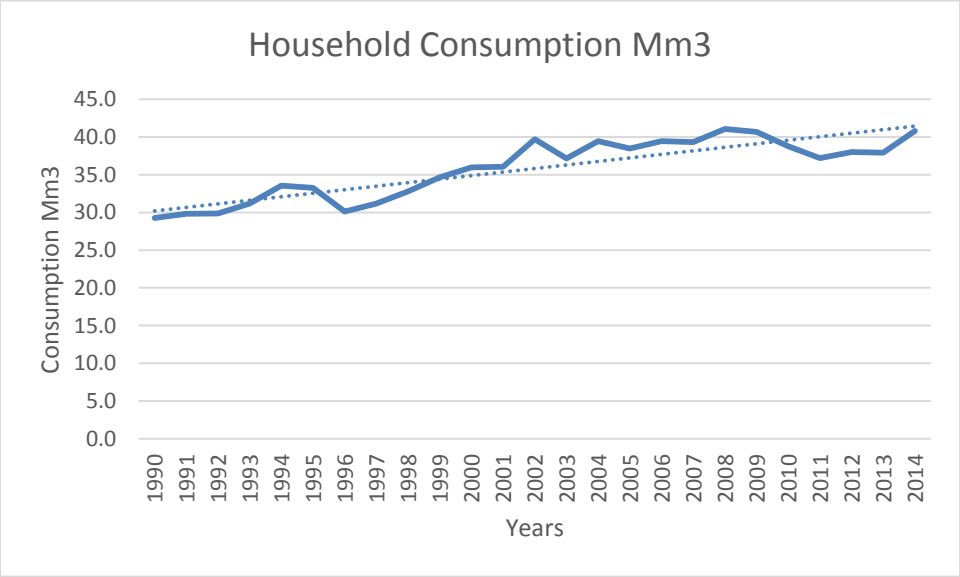
The overall quality of the time series constructed is amber (50%-75%) since we had data at the beginning of the time series (1993-1995) and the end of the time series (2011-2014) for interpolating for the missing data. Time series is useful for establishing long term trends for household consumption. The time series should not be used for year to year comparisons for the interpolated data on water consumption e, g 1990 to 1991, 1999 to 2000 etc.

The quality of the data will be refined as and when the missing data becomes available and when new methods are revised.

If you have information/methods which will help us improve the data please contact DWA (3607100).

3.4 Results for Household

Figure 1: Household consumption from 1990-2004 (second ratio for missing years)



4.0 WATER CONSUMPTION BY MINING

4.1 Data Sources for Mining

- Data sourced from the Botswana Water Accounts Report 2015:(Mining water abstraction and consumption for 2010 to 2013)
- Trend in total mining water abstraction (1990 to 2011)
- Total water abstraction (1990 to 2011). Information compiled by CAR and passed to DWA

4.2 Methods for Mining

Data for national abstractions and mining abstractions were available from 2001 to 2013. No data were available for mining water consumption (MWC) and total water consumption (TWC) in the economy except for the years 2010-2013. In order to estimate the consumption data for mining (2001 to 2009) basic ratio estimation was used, based on the average ratio of total water abstracted (TWA) and TWC (119%). Both TWA and TWC data for all of the economy came from DWA. The relationship between the calculated TWC and MWC was calculated using the 2010-13 available data, giving an average ratio of 15.7%. This ratio was used to generate estimates of MWC for the years 2001 to 2009.

4.3 Data Quality Statement for Mining

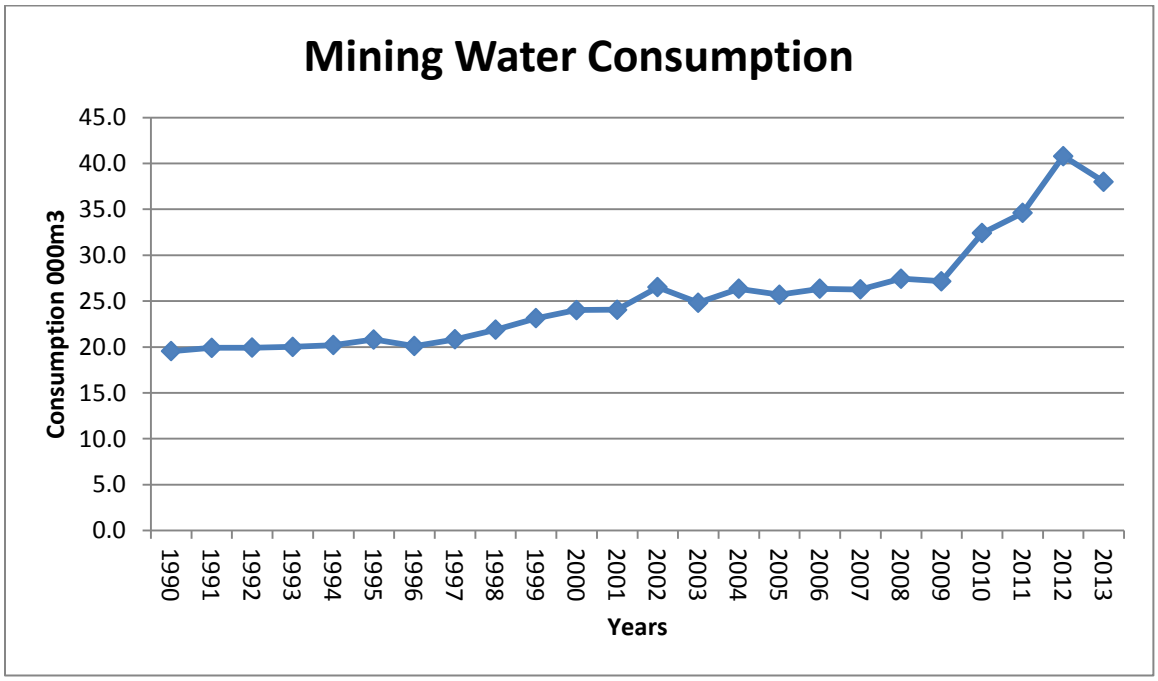
The overall quality of the time series constructed is amber due to the variability of the use of water by the mining sector in response to economic trends and commodity prices. The time series is useful for establishing long term trends for mining water consumption. The time series should not be used for year to year comparison for the interpolated data on water consumption. For year to year comparisons the data on water abstraction, which is green, can be used.

The quality of the data will be refined as and when the missing data becomes available and when new methods are revised.

If you have information and methods which can help us improve the data estimates please contact DWA.

4.4 Results for Mining

Figure: 2 Mining Water Consumption from 1993 to 2013



5.0 WATER CONSUMPTION BY AGRICULTURE AND OTHER INDUSTRIES

5.1 Agriculture

Information of agricultural water consumption was available from the Botswana Water Accounting Reports (1 and 2) for the years 1990 to 2014 and hence did not need to be estimated. The water consumption estimates for agriculture in the water accounts were based on the National Water Master Plan which used research data and estimates of livestock numbers from Ministry of Agriculture.

5.2 Other industries

The estimates of water consumption by other industries (everything excluding mining and manufacturing) were calculated as the difference between total consumption and the estimated consumption by households, mining and agriculture.

6.0 WATER ABSTRACTION BY SOURCE

6.1 Data sources for Water Abstraction by source

- CAR (source: Water Accounts Report 2015, covering years from 1993 to 2013 by source, from 1990 to 2013 total abstraction by all industries, government and households)

6.2 Methods for Water Abstraction by source

From the time series data on water abstraction by source, total abstraction values were available for the whole time series, but abstraction values for the 3 sources (groundwater, dams and river) were missing for the years 1991 and 1992, hence the need to fill the gabs in the defined years. Therefore simple linear regression was used to estimate missing values.

Using the values for the years 1993 to 2014, **scatter graphs** were created, from which **linear regression trends** were derived. Three (3) linear **equations** (for ground water, river and dam) were further derived (equations shown on the results).

Lastly, the equations were used to estimate the missing values in the years 1991 and 1992. The actual total abstraction was compared with the estimated total abstraction by source, then the difference was distributed amongst the water sources (groundwater, river and dam) with respect to their weights.

6.3 Data Quality Statement for Water Abstraction by source

Overall, the quality of the data is green. This is because only two years were estimated for a total of 23 years. In addition the estimated values by source were consistent with the

reported values for total abstraction. Provides a good long term trend analysis but cannot be used for year to year comparison. i.e. 1991 to 1992 and 1992 to 1993.

The quality of the data will be refined as and when missing data becomes available and when new methods are reviewed.

6.4 Results for Water Abstraction by source

Figure: 3 Water Abstraction from Dams from 1990 to 2014

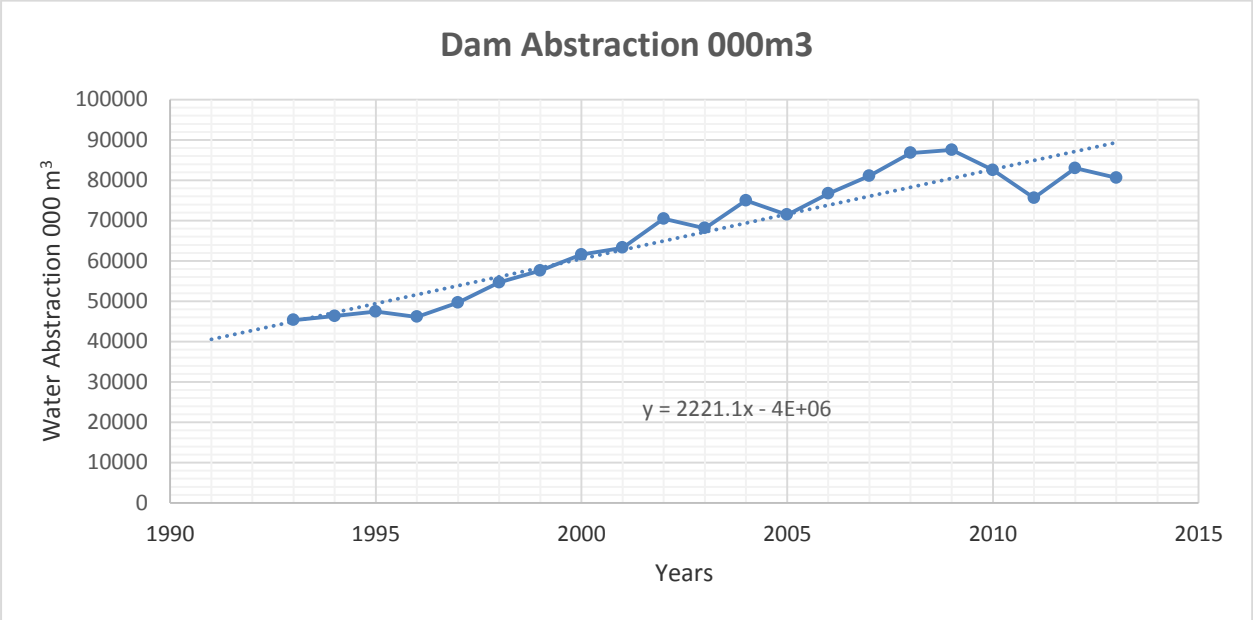


Figure: 4 Water Abstraction from Groundwater from 1990 to 2014

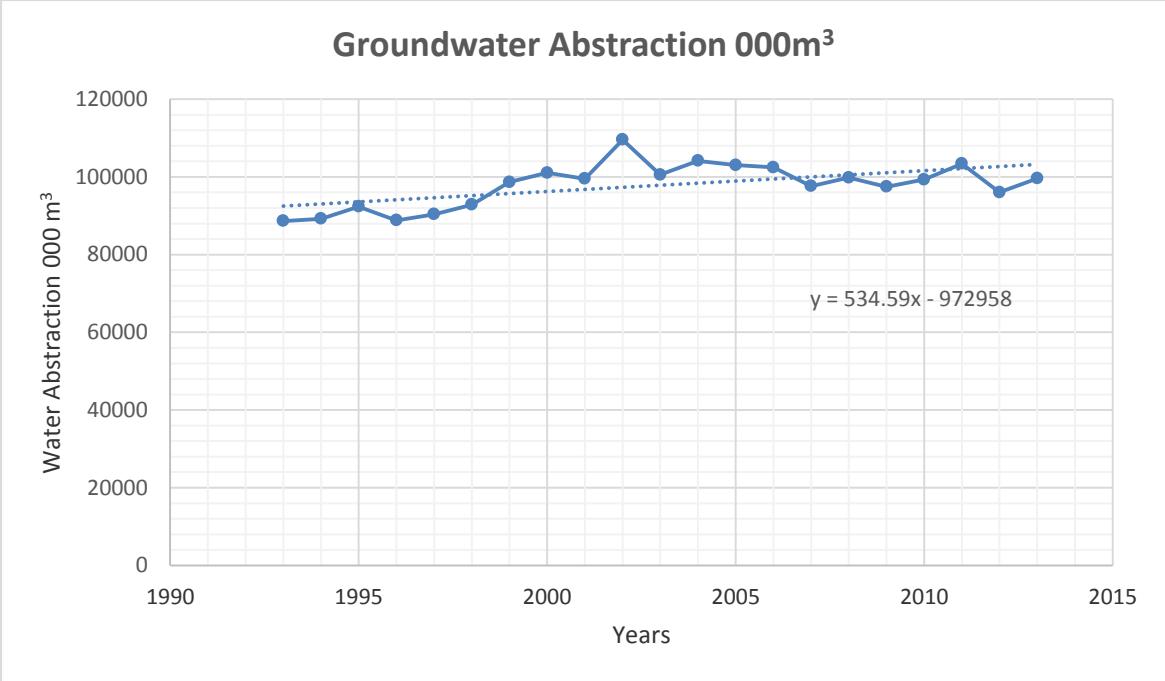
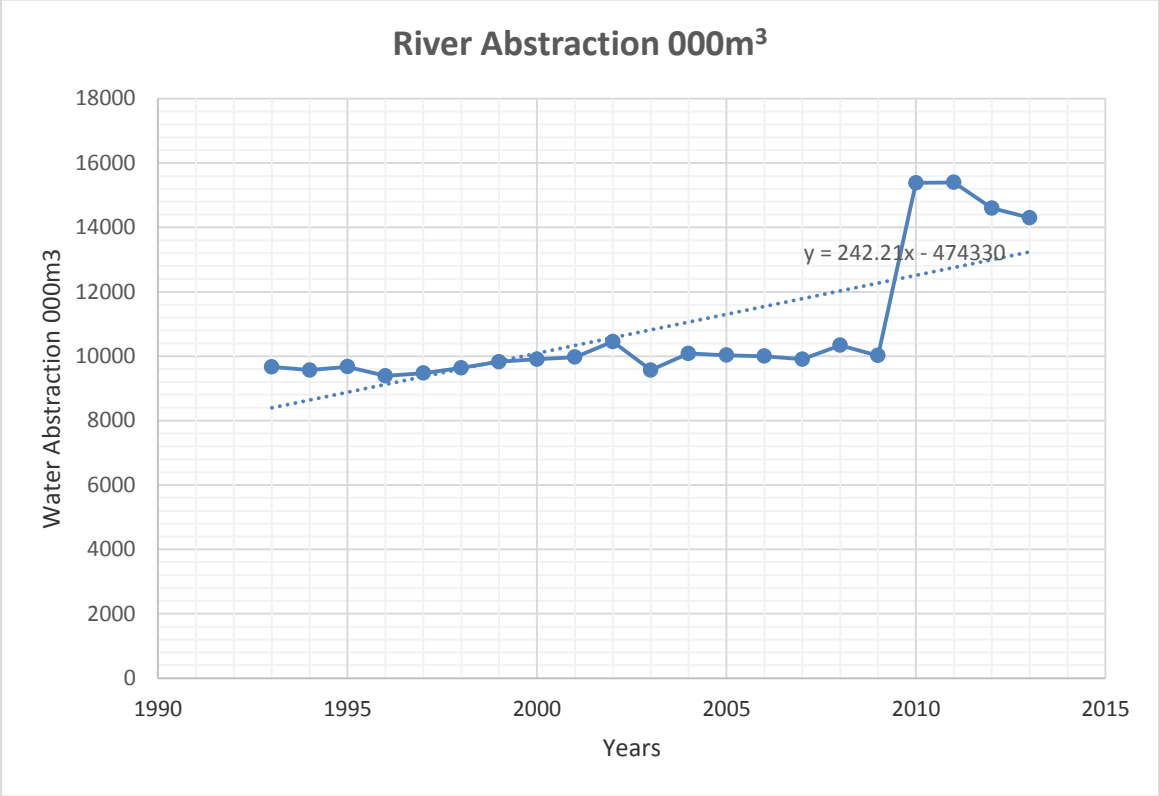


Figure: 5 Water Abstraction from Rivers from 1990 to 2014



7.0 TIME SERIES (version 2, 29 July 2015)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total water abstraction	Mm^3	**140.3**	**142.9**	**143.1**	**143.7**	**145.1**	**149.5**	**144.3**	**149.5**	**157.1**	**166.1**	**172.5**	**172.8**	**190.4**	**178.2**	**189.2**	**184.5**	**189.1**	**188.6**	**196.9**	**195**	**185.8**	197.2	194.4	194.1	194.4
Abstraction by source:																										
Groundwater	Mm^3		92.8	91.3	88.7	89.2	92.4	88.8	90.4	92.8	98.6	101.0	99.5	109.5	100.5	104.1	103.0	102.5	97.6	99.8	97.5	99.3	103.4	96.0	99.6	99.6
surface water	Mm^3		40.4	42.2	45.3	46.3	47.4	46.1	49.7	54.6	57.6	61.6	63.3	70.4	68.1	75.0	71.4	76.7	81.1	86.7	87.5	82.5	75.6	83.0	80.6	80.6
Imports	Mm^3		9.7	9.7	9.7	9.6	9.7	9.4	9.5	9.6	9.8	9.9	10.0	10.5	9.6	10.1	10.0	10.0	9.9	10.3	10.0	15.4	15.4	14.6	14.3	14.3
Total water consumption		124.5	126.8	127.0	127.5	128.8	132.7	128.0	132.7	139.4	147.4	153.1	153.3	169.0	158.1	167.9	163.7	167.8	167.4	174.7	173.0	164.9	172.5	171.6	178.3	169.8
Households	Mm^3	29.3	29.8	29.8	31.2	33.6	33.3	30.1	31.2	32.8	34.6	36.0	36.0	39.7	37.2	39.5	38.5	39.4	39.3	41.1	40.7	38.8	37.2	38.0	37.9	40.8
Agriculture	Mm^3	72	74.2	74.0	72.6	71.7	71.2	73.3	67.2	67.9	69.4	73.0	73.1	73.2	81.3	62.8	65.0	64.2	63.3	57.8	66.6	70.1	74.6	74.6	66.0	66.0
Mining	Mm^3	19.5	19.9	19.9	20.0	20.2	20.8	20.1	20.8	21.9	23.1	24.0	24.1	26.5	24.8	26.3	25.7	26.3	26.3	27.4	27.2	32.4	32.4	34.6	40.8	38.0
Other industries & gov	Mm^3	3.7	2.9	3.2	3.7	3.3	7.4	4.6	13.5	16.9	20.2	20.1	20.1	29.5	14.8	39.3	34.5	37.9	38.4	48.5	38.6	23.7	12.6	12.8	17.3	13.5

8.0 CONTACTS

The project team would welcome feedback on the estimates presented in this report. Please contact:

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9.0 ACKNOWLEDGEMENTS

The project team would to thank CAR for access to data and the World Bank for providing the resources needed for the project. Jaap Arntzen (CAR), Glenn-Marie Lange (World Bank) and Steve May (ABS) provided comments on a draft of this report.

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Gaborone Dam Levels 2012-2016
FULL
EMPTY
2012
2013
2014
2015
2016
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