Analysis of new water rights applications in Botswana (2002-2018)

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Abbreviations

CAR	Centre for Applied Research
CORB	Cubango-Okavango River Basin
DWA	Department of Water Affairs
IWRM-WE	Integrated Water Resources Management -Water Efficiency.
LIMCOM	Limpopo Watercourse Commission
MSIOA	Multisector Investment Opportunity Analysis
NWMP	National Water Master Plan
OKACOM	Permanent Okavango River Basin Water Commission
ORASECOM	Orange-Senqu Water Commission
RWA	Requested Water Abstraction
SADC	Southern African Development Community
TDA	Transboundary Diagnostic Analysis
TWM	Transboundary Water Management
WAB	Water Apportionment Board
WRA	Water Resource Application
WRB	Water Resources Board
WUC	Water Utilities Corporation
ZAMCOM	Zambezi WaterCourse Commission

1 Introduction

Botswana has limited water resources and very few opportunities for new dams (Centre for Applied Research-CAR and Department of Water Affairs- DWA, 2013 and CAR, 2006). Water supplies are limited due to limited surface water and low groundwater recharge while demand continues to rise. The resulting water scarcity threatens economic production and livelihood security. In brief, water is a finite and valuable resource that needs to be allocated and used efficiently for the benefit of current and future generations. Currently, Botswana uses a system of water rights to allocate water resources, guided by the 1968 Water Act. However, there are no detailed guidelines for efficient water allocation. The 2016 Water Policy covers water allocation but does not detail how allocative efficiency should be pursued.

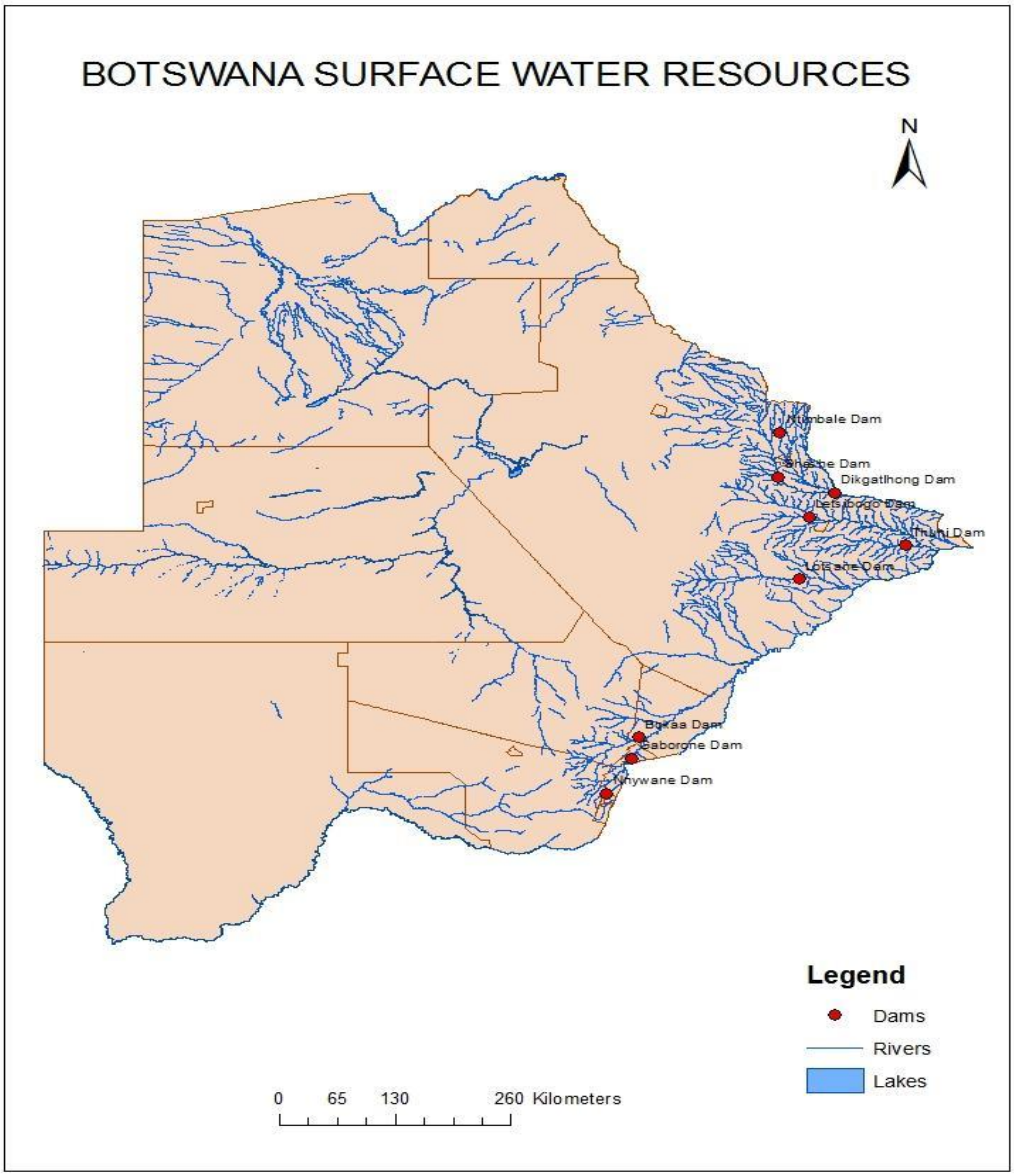
1.1 Water resource situation

Three quarters of the population live in eastern Botswana, which has higher rainfall levels than in the western region of the country. At least 11% of the population resides in Gaborone in the South East, indicating the difficulty of both catching and transporting water to the capital (Setlhogile and Harvey, 2015). Botswana's mean annual rainfall is 416 mm, ranging from 650 mm in the north to 250 mm in the extreme southwest. The country's freshwater resources refer to surface and groundwater, the former mostly from ephemeral rivers and dams (Figure 1). Western Botswana has no surface water and relies entirely on very limited groundwater, which is often saline. The Chobe and Okavango Rivers are the only perennial rivers, located in the extreme north[1]. The sustainable yield of the dams is estimated at 146.4Mm^3 and is very low when compared to the available dam capacity and abstractions. The current stress on the water supply implies a need to investigate options for water conservation and demand management. Subject to licensing by the WAB, water is abstracted by the Water Utilities Corporation (WUC) as well as by self-providers. Livestock farmers, mines, tour operators, outside settlements as well as construction companies are the most important self-providers (see Botswana water accounts' reports).

The population increase, economic growth and increased living standards have led to an increase in water demand and consumption, putting pressure on available water resources. Water demand is forecast to reach 339.7 Mm^3 per year by 2035 (DWA, 2017), whereas it was only 233 Mm^3 in 2015. Mines and agriculture are the largest industrial consumers, despite a relatively small proportion of arable land being under irrigation. Total water abstraction has generally increased from 198 Mm^3 in 2010/11 to 201 Mm^3 in 2015/16 with groundwater abstractions contributing more than 55% per annum. Other sources of water such as treated wastewater are not yet adequately exploited but have a potential to augment potable water and enhance water demand management.

[1] The Limpopo River was classified as perennial in the past but is no longer permanently flowing.

Figure 1: Botswana's surface water resources



1.2 The water allocation process in Botswana

Water allocation is mainly guided by the 1968 Water Act supported by the 2013 national Integrated Water Resources Management -Water Efficiency (IWRM-WE) plan, the 2016 national Water Policy, the 1991 National Water Master Plan (NWMP) and its 2006 review/ up-date. According to the Water Act, all water users outside water works areas, where Water Utilities Corporation (WUC) supplies water, need to have water abstraction rights. As per the Act, a *"water right"* means a water right granted or deemed to have been granted under the Act and, subject to the provisions of section 10, and includes an existing right. Application for the grant of a water right is made to the Water Apportionment Board (WAB) which may grant to any person the right to divert, dam, store, abstract, use or discharge of effluent into public water. A water right does not guarantee that the amount of water requested for abstraction is available and it may be revoked if unutilised within three years.

Large water abstractors such as mines are required to submit annual monitoring reports to WAB. WAB secretariat representatives carry out site visits to these major users to corroborate the reports.

In performing its functions under the Water Act, the Board regards any relevant international agreement regulating the use of water to which Botswana is party to, but it does not have specific provision for transboundary water use and allocation. The WAB, through the Water Registrar, keeps an inventory of all water abstraction rights. To this effect, a national database of existing water rights has been developed at the DWA, but its coverage and level of detail are unclear. The data base could not be accessed.

In terms of demand prioritisation in the allocation of water, the Water Act prioritises domestic water use/public water supply. The Water Policy recognises water as a basic human right and hence in its allocation, this must receive priority. The second priority is given to the environment as it is the pillar for economic growth and social development. This is followed by agriculture and commercial/industrial uses. The national IWRM-WE plan strongly promotes efficient water allocation and calls for establishment of prioritisation of demand sectors in the water policy. It recommends the following priorities: 1. Basic human needs; 2. Strategic use (e.g. energy generation and food security); 3. Environmental requirements; 4. Other demands based on various efficiency indicators such as livelihoods security, poverty eradication and value added (CAR and DWA, 2013). It also calls for setting targets for sectoral water use and conservation as well as development of water allocation and efficiency guidelines for DWA and Water Resources Board (WRB)[2]. Implementation of prioritisation as well as allocation guidelines awaits the anticipated review of water laws and other guiding instruments for the sector.

The purpose of this paper is to analyse the trends in applications for water rights in terms of rights by economic sector, by water source and by area. It also covers the requested abstractions and spatial distribution of the applications. This is based on an inventory and analysis of water rights applications (WAR) published in the Government Gazette for the period 2002 to (part of) 2018.

2 Approach

The assessment involved a spatial and temporal analysis of water right applications across Botswana. Such applications are published in the Government Gazette and CAR has kept a record of the published applications for water rights since 2002. This data base formed the basis of the analysis. The rights are available for 2002 to date and provide the following information: names of applicants (individual or company), their location, source of water (and name or ID of the source) and district, intended use of water as well as the maximum allowable abstractions. Our analysis focussed on two major groups of variables:

1. Number of water rights applications per annum by:
   - Source of water;
   - Intended use; and
   - Location.
2. Maximum requested abstractions (in m^3) per day and annum by:
   - Source of water;
   - Intended use; and
   - Location.

[2] This entity will replace WAB and will be responsible for equity and sustainable allocation of water resources as well as monitoring of water resources.

The analysis distinguished four main sources of water, i.e. boreholes, rivers, dams and open wells. For the intended use of water, the records categorise irrigation, livestock, domestic use, construction, industrial, mining, tourism, integrated farming, village water supply and others. For the analysis, we have distinguished irrigation, livestock farming, domestic use (individuals), construction, industrial, village water supply and mining. Other uses of water were subsumed within the 'others' category. Moreover, a category for 'multiple use' was created to cover applications with more than one intended use of water.

There were some data inconsistencies and gaps; in some cases, assumptions had to be applied. The following are noted:

1. The data base refers to applications for water rights. It does not provide information about the actual acquisition of such rights. It is possible that applications have been turned down by WAB;
2. There is virtually no monitoring of the use of water rights. Therefore, the amount that can be abstracted based on the permits may differ from the actual abstracted amount. Some rights may not be used; others may be used more than the abstraction ceiling;
3. The data set refers to **new** water right applications. It does not capture the water rights and abstractions that existed prior to 2002; therefore, it does not reflect the total abstractions;
4. For the earlier years, minimal applications were captured; this may be due to missing data (Gazettes not attained) or reflect that indeed few people applied for water rights at the time;
5. Water rights for livestock use are not available or very minimal from 2002 to 2011 despite the sector's heavy reliance on ground water, especially in areas with no surface water such as Kgalagadi and Ghanzi districts. It may be that the rights for livestock may be recorded under domestic use for the same years. It may also be because livestock farmers first obtain borehole drilling rights from the Land Board and -later on- do not apply to the WAB for actual abstraction rights;
6. Some dam rights for domestic use did not reflect requested abstraction amounts and therefore the average figure for domestic use (i.e. 18 m^3/day) was assumed to apply to dams too;
7. Where applications had more than one water use, these were categorised under a new category of multiple uses;
8. Some hard copies for years 2012 and 2015 of water right applications went missing and therefore the digitised data could not be validated. The data was thus used in its current state;
9. In the case of borehole rights, some applications had more than one borehole. These were not separated and therefore treated as one application with multiple boreholes rights; and
10. The data for 2018 covers January to August only.

A request was made to DWA to avail their records of approved water rights to allow for a comparative analysis of the two data sets. However, the data has not yet been obtained.

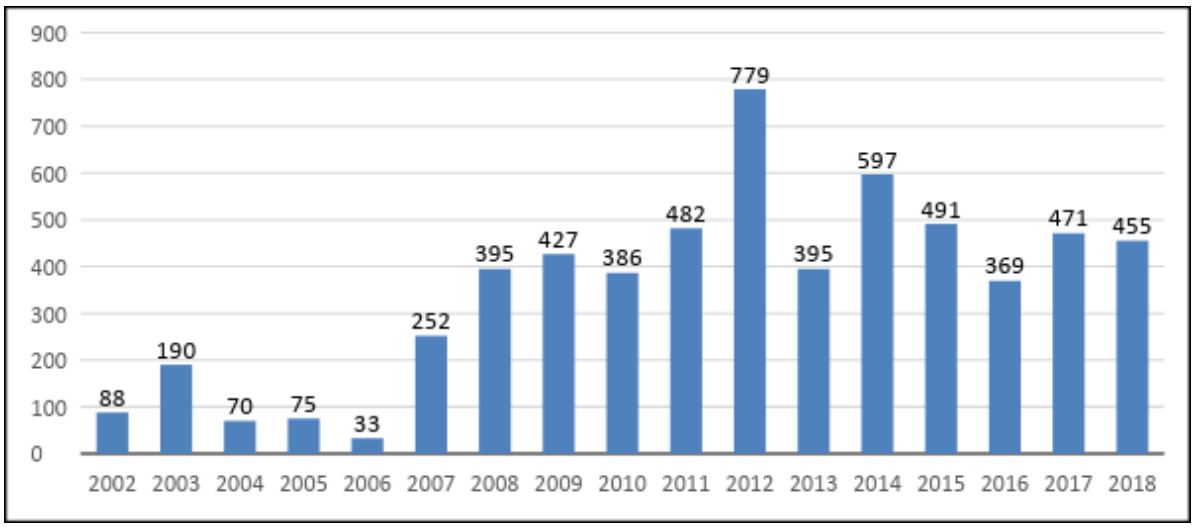
3 Main findings

3.1 Number of water rights applications

A. Total water rights

A total of 5,955 water rights applications (WRA) were recorded for 2002 to 2018 (Figure 2). The number of applications were very low before 2007 (between 1 and 4% of the total WRA) and increased to between 400 to 600 applications in the following years. Applications peaked in 2012 to 779. However, there is no clear trend towards increased applications in the last decade. The low figures recorded for pre-2007 could be due to lack of data or that there were indeed a few requests for water rights. This has not yet been validated with DWA. The WRA for 2018 is likely to be around 600 by the end of the year since only three quarters have been covered thus far.

Figure 2: Total water rights applications (2002-2018)



B. WRA by district

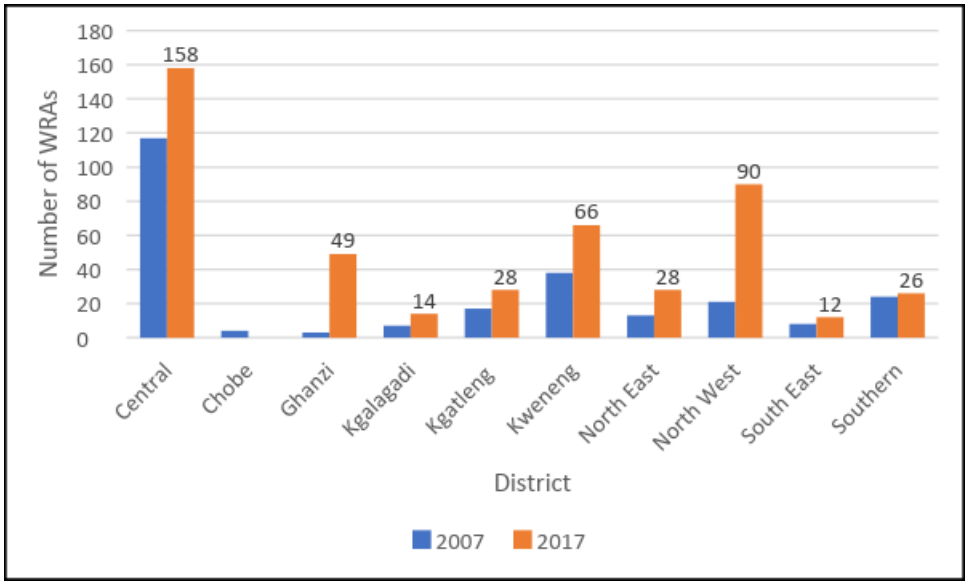
In terms of spatial distribution, Central district has the highest number of applications constituting 37% of the total rights during the 16-year period (Table 1). It is the largest district in terms of size (accounts for one quarter of the total landmass; Ngwato Land Board, 2000) and population (32% of total population; Statistics Botswana, 2013). Kweneng follow suit with 14 and 12% respectively; this is still less than half of the applications recorded for Central district. The lowest applications are found in Chobe district with a mere 1%. One of the possible reasons could be that Chobe had been integrated within the Ngamiland district in some years. However, population wise, Chobe is also one of the smallest districts with limited industrial activities. Most of the water rights for the district are for river abstractions.

Table 1: Water resource applications by district (2002-2018)

District	WRA	% WRA
Central	2,230	37%
Chobe	32	1%
Ghanzi	329	6%
Kgalagadi	303	5%
Kgatleng	379	6%
Kweneng	689	12%
North East	550	9%
Ngamiland	804	14%
South East	255	4%
Southern	384	6%
Total	**5,955**	100%

Applications have rapidly increased in Ghanzi, Ngamiland, Kweneng and Northeast districts (between 2007 and 2017; Figure 3) with modest fluctuations within the same period. Ghanzi and Ngamiland have experienced higher increases of WRA, while applications for Chobe reached zero by 2017. The latter may have been subsumed within Ngamiland/Northwest district. After 2011, WRA for livestock use were more apparent, which may have also contributed to the rapid increase in WRA by 2017. Prior to 2011, there were minimal livestock related WRAs.

Figure 3: Number of WRA by district (2007 and 2017)

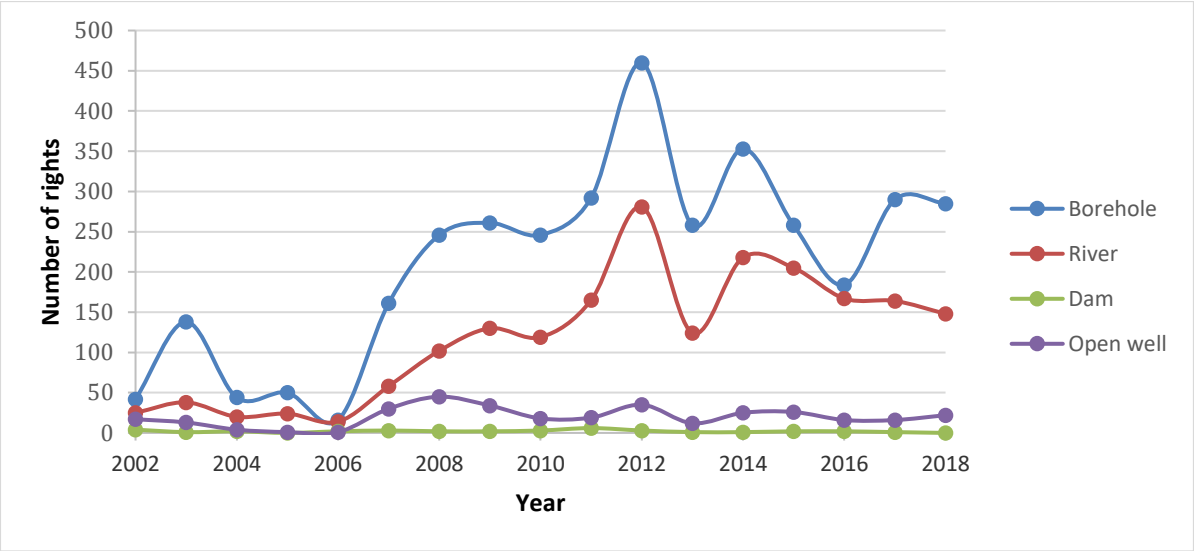


C. <u>WRA by source of water</u>

Figure 4 shows the number of WRA by source of water. About 60% of the applications refer to groundwater followed by river rights and open well at 34% and 6% respectively. Groundwater supports most rural villages, mining and the livestock sector. Rivers, mostly ephemeral, are important for irrigation farming while domestic uses are also becoming important, especially where groundwater is limited. Borehole applications are volatile, while river applications seem to be declining since 2014. Dam rights are minimal and have been fluctuating over time with a high of 6 applications recorded in

2011. Dams are mostly developed and managed by government (and WUC) for public water supply and agricultural activities hence the limited number of dam rights. The direction for complimentary dam utilisation has been commercial and recreational fishing and more recently dam tourism is being pursued to enhance tourism diversification away from wildlife resources.

Figure 4: Number of WRA by source (2002 – 2018)



By location, applications for all the sources of water are highest in Central district especially open well and borehole rights. Of the 3,584 borehole applications, 36% are in Central while 66% of the open well rights are also found in Central district. Borehole rights for Kweneng stand at 17% and Southern district at 10% of total borehole applications, while the applications for the rest of the districts are all less than 10% (Table 2). The two districts depict the same pattern for dam applications although slightly on the higher side (26% and 20%). The distribution of river rights provides a clear picture of limited surface water in the southern and western parts of the country. River rights are more common in the eastern corridor and northern Botswana and this where the main perennial and shared waters of Limpopo (Kgatleng, South East, eastern Central and North East), Okavango in the Ngamiland and Chobe rivers are located. Major abstractions from these resources are subject to agreements with riparian countries and therefore monitoring of rights and abstractions from these resources is critical for the sustainable management of the transboundary resource.

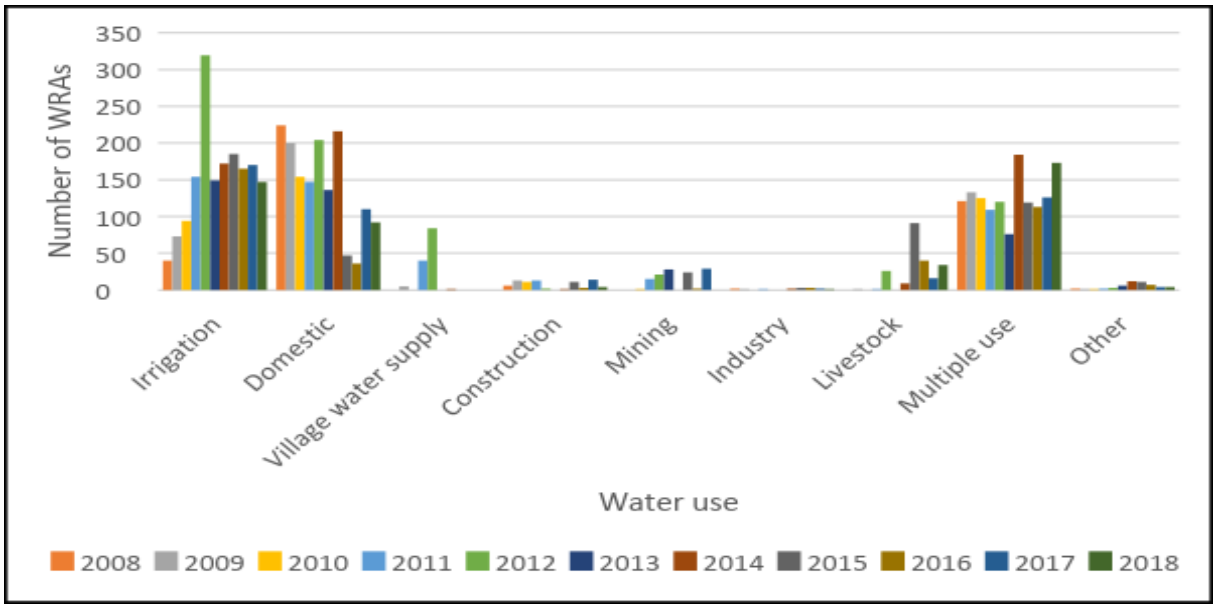
Table 2: Water resource applications by source of water (2002-2018; as %)

District	Borehole	River	Open Well	Dam	Total
Central	36%	35%	66%	37%	37%
Chobe	0%	1%	0%	0%	1%
Ghanzi	9%	0%	1%	0%	6%
Kgalagadi	8%	0%	1%	0%	5%
Kgatleng	6%	8%	0%	3%	6%
Kweneng	17%	2%	5%	26%	12%
North East	2%	23%	4%	11%	9%
Ngamiland	5%	28%	19%	0%	14%
South East	6%	1%	1%	3%	4%
Southern	10%	1%	1%	20%	6%
Total	100%	100%	100%	100%	100%

D. WRA by type of use

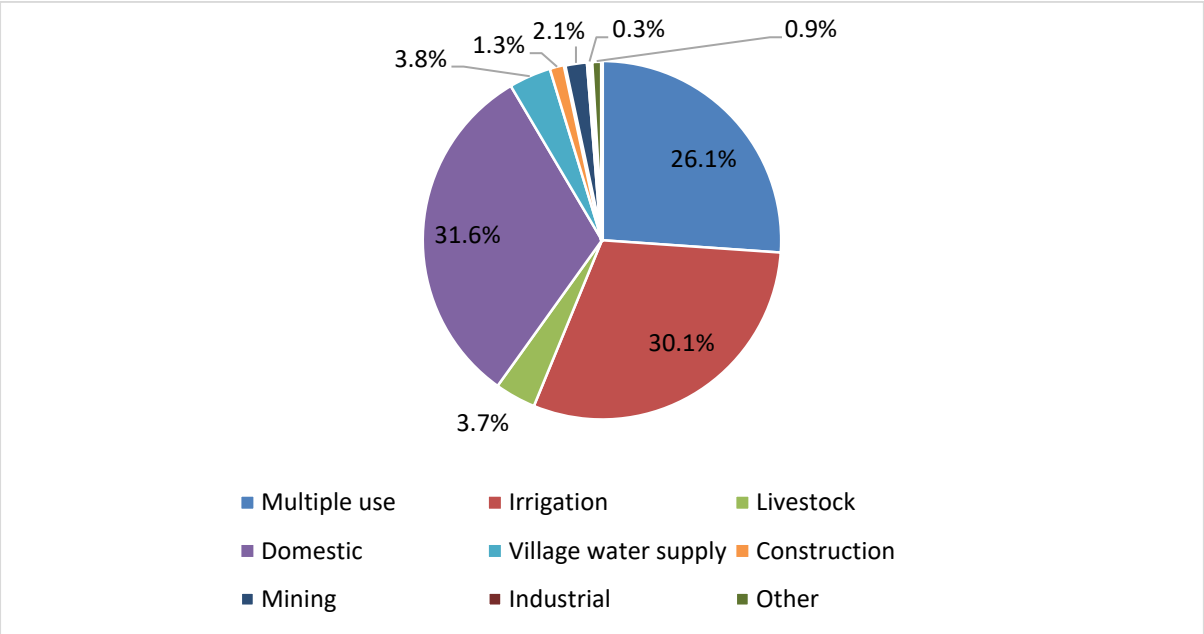
Water rights are required for various uses in different sectors. Figures 5 and 6 show the trend in WRAs from 2008 to 2018 & 2002 to 2018 respectively. The rights are mainly applied for domestic, irrigation and multiple uses. Domestic use from 2002 to 2018 accounts for 31.6% of the applications closely followed by irrigation at 30.1% (see figure 5). The time series generally indicates a growing number of applications for the irrigation sector with modest fluctuations after 2013. However, the use of water for irrigation[3] may be more, particularly from small reservoirs and treated waste water which is mainly supplied by WUC. In the advent of erratic climate, scarce water resources, and pressure on existing supplies, there is growing potential and incentives for re-use and recycling of wastewater especially for irrigation. WRA for domestic use is declining and only experienced increases in 2017 & 2018. Decline in WRA for domestic use might be due improved water connection system in the country with most of the population now having access to piped water. Multiple use is the third largest type of use and this encompasses various types of uses. In many cases throughout the years, customers apply for more than one type of use, especially irrigation and domestic as well as domestic and livestock.

Figure 5: Water resource applications by use for 2008 to 2018.



[3] The irrigation sector is not well documented in terms of irrigated land and water consumption for the sub-sector.

Figure 6: Aggregate water resource applications by use (2002-2018; as % of total)



Sectors depend on different water sources (Table 3). Typically, mining depends on groundwater (see DWA and CAR, 2014 and 2015)[4]. Table 3 shows that 99% of the applications for village water supply are for abstraction from boreholes. These are applications mostly by district councils pre- water sector reform process while in recent years WUC has been the one seeking rights to supply villages since now it is responsible for service provision in the villages. The objective is to ensure that all settlements (including remote areas) have access to adequate water supply. Groundwater is also most important for domestic, livestock and multiple use. In contrast, about 80% of industrial and construction use applications are for river abstractions while irrigation rights are also largely for abstraction from surface water (68%).

Table 3: New water right applications by source and use of water (2002-2018; as %)

Water source	MU	Irrigation	Livestock	Domestic	VWS	Construction	Mining	Industrial	Other
Borehole	69.8%	31.2%	64.1%	74.8%	98.7%	21.3%	100.0%	20.0%	41.1%
River	27.5%	67.7%	17.7%	11.4%	1.3%	77.5%	0.0%	80.0%	50.0%
Dam	0.5%	0.1%	0.5%	1.3%	0.0%	0.0%	0.0%	0.0%	1.8%
Open well	2.3%	1.1%	17.7%	12.5%	0.0%	1.3%	0.0%	0.0%	7.1%

Note: M.U- multiple use, VWS- village water supply

3.2 Amount of requested abstractions

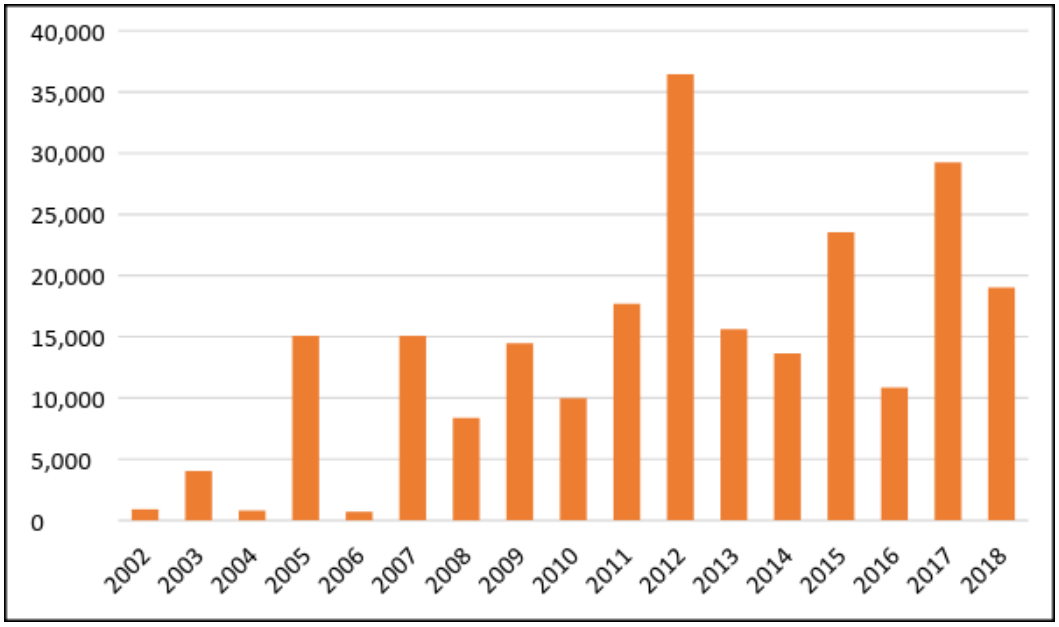
A. Trends in new requested water abstractions (RWA)

Figure 7 shows annual RWA levels with total RWA applications of 224 Mm^3 from 2002 to 2018. This figure exceeds the estimated annual water abstraction (around 200 Mm^3) and shows that not all

[4] According to the water accounts reports, the mining sector abstracts about 98% of water from groundwater resource. However, some mines receive water from WUC, particularly those in proximity to large reservoirs operated by WUC.

applications may have been granted and/or that right owners do not abstract the requested amount. There is a trend in increasing RWA over the years even though there are reductions between some of the years (see Figure 7). Increases in RWA are expected due to rising water demand associated with population and economic growth and improved livelihoods.

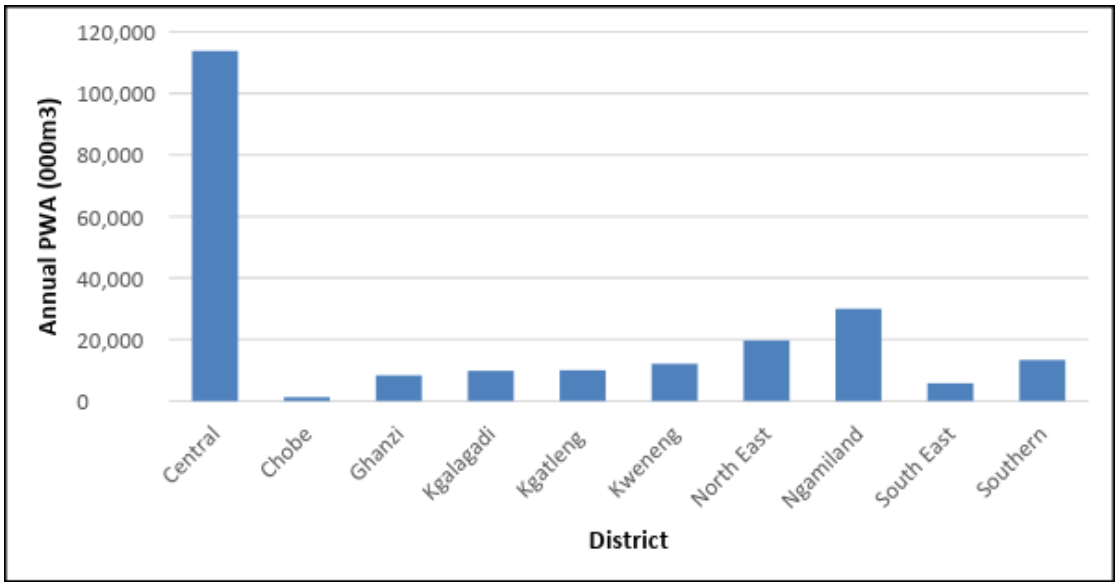
Figure 7: New requested water abstraction for 2002 -2018 (000 m^3)



B. RWA by district

A spatial analysis of RWA by district was also conducted and the findings are presented in Figure 7. Like the WRA, Central district has the highest number of abstractions as compared to the other districts and accounts for just over 50% of total RWA. As indicated earlier, it is the largest district in Botswana and has received the highest number of WRA in the given period. Furthermore, the high RWA may also be due to the presence of mines and their expansions, new mining explorations and growth of the irrigation sub-sector which demand large volumes of water (see Figure 8). Ngamiland district has the second highest RWA at 13.4% followed by North East at 9%. These regions also have significant surface water resources. Southern district follows suit at 6% while the rest of the districts are around 5% or less.

Figure 8: Annual new RWA by district (2002-2018; 000 m^3)



Further, Table 4 shows average RWA and RWA per WRA by district from 2002-2018. Central district has the highest annual average RWA at 6, 691 m^3 and the average RWA per WRA of 51 m^3. Ngamiland has the second highest annual average of 1,766 m^3 from 2002 to 2018. Kweneng district has the lowest RWA per WRA.

Table 4: Annual average RWA per district & aggregate RWA per WRA (2002 -2018; 000m^3)

District	Av annual RWA (000 m^3/year)	Aggregate RWA per WRA (000m^3)
Central	6,691	51.0
Chobe	73	38.8
Ghanzi	489	25.5
Kgalagadi	577	32.0
Kgatleng	588	26.4
Kweneng	711	17.5
North East	1,157	35.8
Ngamiland	1,766	37.3
South East	339	22.6
Southern	784	34.7
National	**13,177**	**37.6**

C. Water abstraction by source

Nationally, RWA are higher for groundwater (boreholes) at 59%. These are then followed by river rights at 40%, while dam RWA are less than 1%. (DWA, 2013). The findings show that the country depends much on groundwater for consumption. Borehole, river and open well abstractions are higher in Central district while the most RWA from dams is in Kweneng district at 34% of all dam abstractions (Table 5). These dam abstractions are mostly requested by village dam groups or syndicates that want to conserve flood flow to provide water for domestic utilisation. Dam user rights are not common. River water abstractions are more prominent in areas close to main rivers such as the Okavango, Chobe, Limpopo, Shashe and their tributaries.

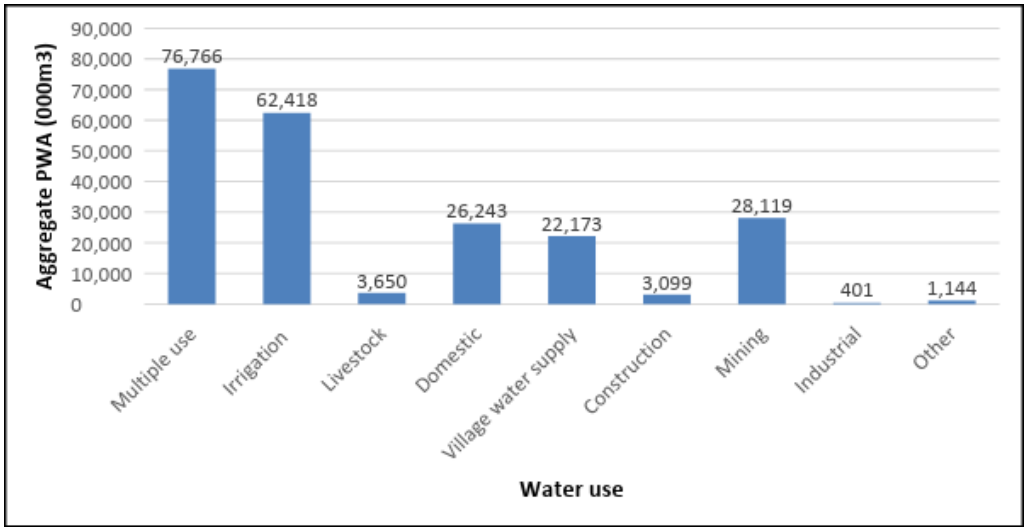
Table 5: Water abstraction by source per district (2002 -2018; 000 m^3)

District	Borehole	River	Dam	Open Well	Total
Central	70,127	42,495	99	1,022	113,743
Chobe	29	1,212	-	-	1,241
Ghanzi	8,299	-	-	20	8,318
Kgalagadi	9,790	-	-	17	9,806
Kgatleng	3,871	6,150	-	3	10,024
Kweneng	11,115	727	134	113	12,089
North East	1,218	18,314	42	88	19,661
Ngamiland	9,134	20,575	-	320	30,029
South East	5,007	737	18	7	5,769
Southern	12,719	498	100	14	13,331
Total	131,307	90,709	394	1,603	224,013
% of total	59%	40%	0%	1%	100%

D. Water abstraction by use

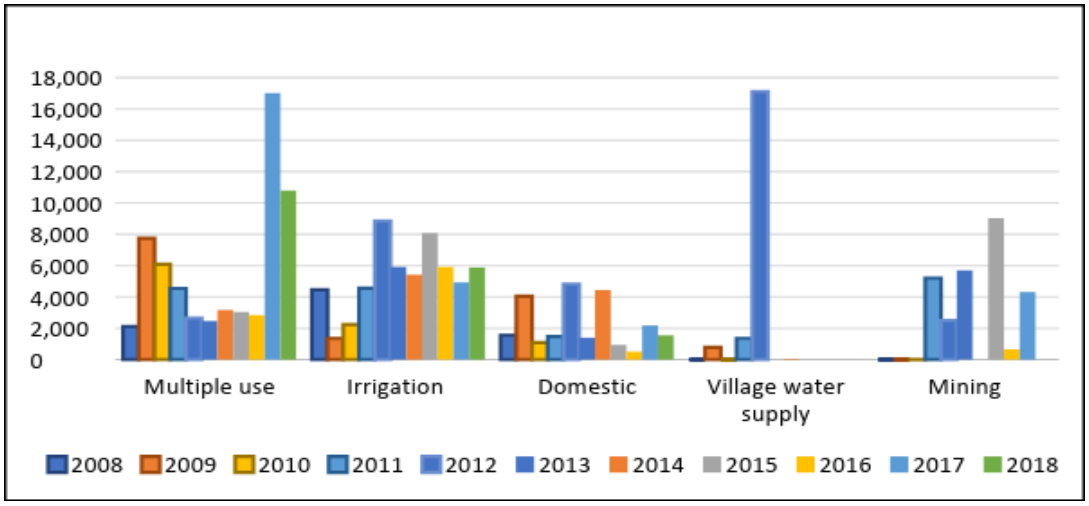
Abstraction by use is highest for multiple uses (76.8 Mm^3; which is mostly a combination of irrigation and domestic; Figure 9). Irrigation has the second highest RWA at 62.4 Mm^3, mostly from rivers. RWA for industrial use and construction is very low. For irrigation, the average RWA per annum is estimated at 3.5 Mm^3 but this is likely to be more since the sector usage is also subsumed within multiple use category. Though small, the sector is anticipated to grow in the future both in terms of land allocated and volumes of water required. It is predicted that by 2030, abstractions for irrigation will reach about 50 Mm^3 by 2030 (SMEC *et.al.*, 2006). Furthermore, if large scale irrigation plans such as the Pandamatenga materialise, water use for irrigation could be in the order of 300 to 400 Mm^3 per annum (DWA and CAR, 2013). This growth is expected to put more pressure on available water resources. Therefore, allocative efficiency should be considered when allocating water to sectors considering productivity of the sectors and competing water uses. Treated waste water has high potential for use in the irrigation sector and should highly be promoted. According to the 2006 National Water Master Plan Review, irrigation and landscaping are acceptable uses of treated waste water.

Figure 9: New requested water abstractions by use (2002-2018; 000 m^3)



The trends in annual RWA for five major water uses from 2008 to 2018 are captured in Figure 10. The WRA for all uses do not show clear trends, but abnormal peaks in water use are observed in 2017 and 2012 due to village water supply through WUC (2012)[5] and irrigation purposes in the Limpopo River as well as for multiple use (2017). Higher RWA for village supply might be due to procedural WRA by WUC after its water supply takeover from DWA. Throughout the 2002-2018 period, most RWA are for multiple uses followed by irrigation. Even though mining has lower number of WRA annually, it remains one of the major water uses (see also CAR, 2015). For example, abstraction amounts per WRA are highest for mining (226 000 m^3/WRA/year) followed by village water supplies (98 000 m^3/WRA/year). The results are possible since mining needs higher abstractions for its large-scale and water intensive operations. Livestock, domestic use, industrial and others have the lowest abstractions while irrigation and construction are at medium levels. Domestic use has the least annual abstraction per WRA of 14 000 m^3.

Figure 10: Annual new requested water abstractions for five major uses (000m^3; 2008 -2018).



Furthermore, RWA by source and use are indicated in Table 6. Multiple use rights are from all the water sources but highest for boreholes at 58.7%. Irrigation water abstractions were mostly applied from surface water (rivers) but less for dams and open wells at 1% and less. Groundwater RWA for irrigation are estimated at only 19.3% of all the abstractions for irrigation. This may be due to salinity of the resource which may not be suitable for crops. Most of RWA for mining, village water supply and domestic use are from groundwater resources located throughout the country. This re-emphasises the importance of groundwater for rural areas.

Table 6: Percentage of national RWA by use and source for five major uses (2002 – 2018)

Abstraction by source and use	Multiple use	Irrigation	Domestic	Village water supply	Mining
Borehole	58.7%	19.3%	80.6%	97.1%	100.0%
River	40.9%	80.4%	14.6%	2.9%	0.0%
Open Well	0.2%	0.1%	0.6%	0.0%	0.0%
Dam	0.2%	0.2%	4.2%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

[5] This may be caused by WUC formally applying for village water rights after they have taken over village water supplies from the District Councils. This needs to be further investigated.

4 Thematic analysis

4.1 Growing groundwater pressure?

Botswana relies mostly on groundwater resources for mining, livestock, and village water supplies due to limited surface water availability (SMEC *et al.,* 2006). However, the resources are limited in both quantity and quality and are also not evenly distributed. Most of the wellfields are in the north east and eastern corridors (DWA and CAR, 2013). Therefore, increasing demands for groundwater will likely pile more pressure on the current groundwater resources in Botswana. Figure 11 presents trends in sectors with higher requested groundwater abstractions from 2008-2018.Even though irrigation might not be the highest user of groundwater in Botswana, it shows constant annual growth of requested groundwater abstraction of around 64% between 2008 and 2018. The growth reflects the growing number of boreholes applications in 'masimo', which were minimal in the past, and it is higher than that of multiple use and mining, which have the highest total requested groundwater abstractions from 2008-2018. The growing trend might exert further pressure on the resource which is already under immense burden from resource mining and the recharge is low (DWA and CAR, 2013 and Statistics Botswana, 2009). Furthermore, abstractions exceed their sustainable levels in many wellfields. For example, 6 of the 9 wellfields in Table 7 are 'mined'. Abstractions for sectors like agriculture are also likely to be above requested abstractions given that there is insufficient groundwater data and monitoring of abstractions is limited. Monitoring of abstractions is only done for large abstractors like mines and WUC.

Figure 11: Trends in groundwater RWA by use (2008-2018; 000 m^3)

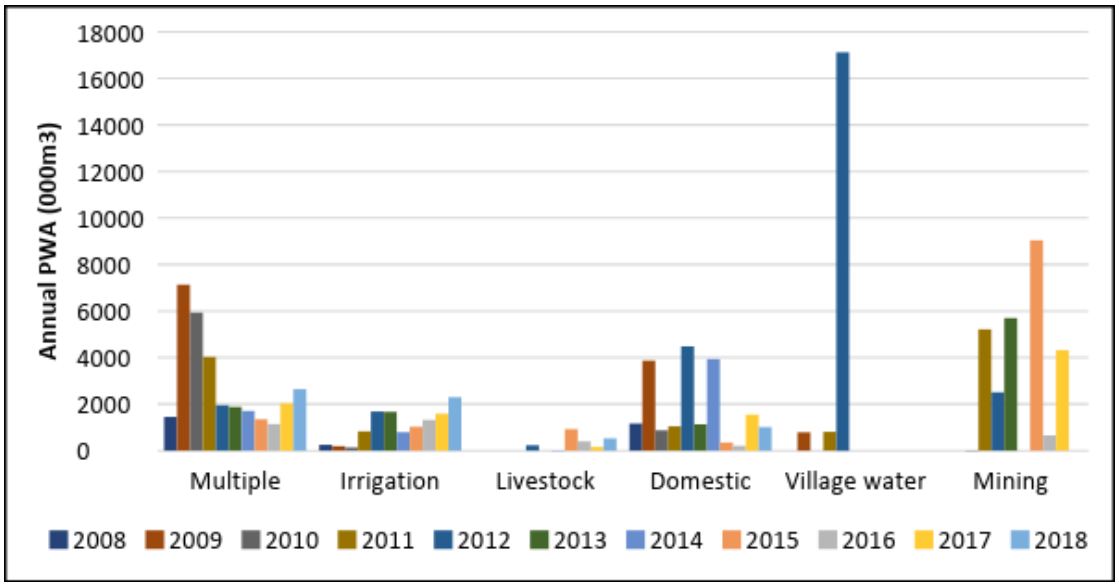


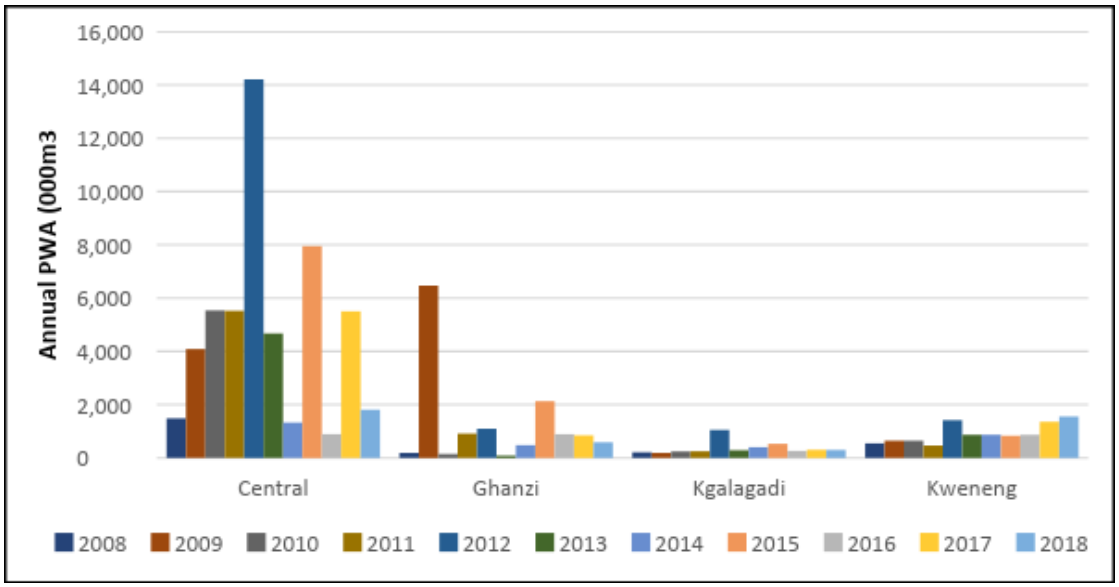
Table 7: Groundwater abstraction levels and sustainable yields (m^3/day)

Well fields	Sustainable yield	Abstraction
Dukwi	600	6 600
Mahalapye	4 000	4 000
Ghanzi	1 850	1 850
Kanye	3 950	6 900
Letlhakane	950	1 500
Palapye	2 700	3 200
Ramotswa[6]	5 000	4 000
Serowe	3 500	4 500
Tsabong	300	1 600

Source: Statistics Botswana, 2009.

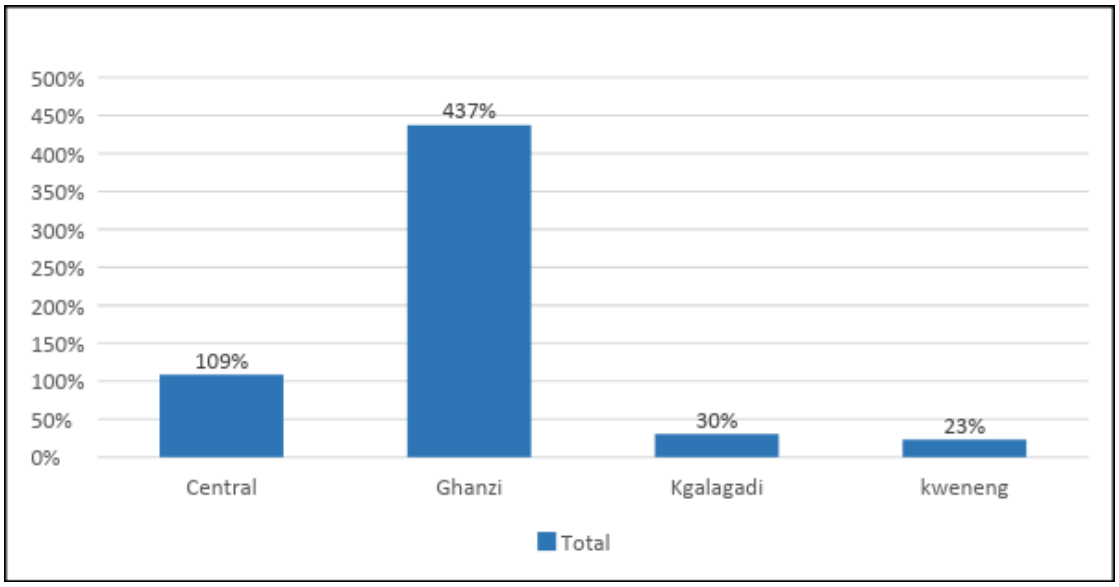
Figure 12 shows trends in RWA (groundwater) for four districts with higher groundwater abstractions being Central, Ghanzi, Kgalagadi and Kweneng districts. The annual RWA demands are growing at higher rates for all districts (figures 12 & 13). Cumulatively Ghanzi district (at 437%) shows higher growths for requested groundwater mining since 2008 followed by Central district (at 109%). Higher cumulative growths were influenced by expansions in the Gope diamond mining in the central Kalahari game reserve for Ghanzi district in 2009 and village water supply for central district in 2012. These growths will negatively affect available resources as the resource is already limited in these areas, and among others, Ghanzi and Dukwi wellfields are over exploited (DWA and CAR, 2013)

Figure 12 : Trends in RWA (groundwater) for selected districts with higher RWA (2008-2018; 000 m^3)



[6] The Ramotswa well field was decommissioned in 1996 due to pollution but was re-opened for use in 2014 after treatment facilities were constructed.

Figure 13: Average annual growth of RWA applications (2008-2018; %)



4.2 Requested water abstractions and actual national water abstraction

The results indicate RWA of 224 Mm^3 from 2002 to 2018. This is around 10% more than the estimated national water abstraction of 201 Mm^3 (Table 8). While the figure may differ from actual abstractions, it raises concern for integrated water resource management and sustainability of the limited ground water resources. Increasingly it will become difficult and costly to access surface water resources to meet the rising water demand because of limited dam sites and obligations to observe agreements for use of shared waters. The 2006 Review of the National Water Master Plan argues that continued reliance on conventional water supply augmentation will make water unaffordable in future, mostly because of the required long-distance water transfer schemes. Therefore, there is need to explore options to reduce demand and to augment water supply from conventional and non-conventional sources (e.g. wastewater, rain and storm water harvesting). Increased wastewater re-use, particularly for irrigation, can relieve pressure on fresh water (SMEC *et. al*., 2006). Government has set itself an ambitious target of 96% reuse and recycling by 2030 (SMEC, 2003) but there is insufficient progress to date.

Groundwater resources are not yet adequately analysed throughout the country. Therefore, further groundwater explorations are needed to determine the potential for developing additional well fields. Recently Ramotswa wellfield was rehabilitated and Masama was developed to increase water supply in southern Botswana.

Table 7: Estimated water abstraction and consumption for selected years (Mm^3; 2010-2016)

	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Total water abstraction	197.2	194.4	194.1	194.4	187.9	201.3
Abstraction by source:						
Groundwater	99.3	103.4	95.9	99.6	108.8	89
Reservoirs	82.5	75.6	83.4	80.6	79.1*	112.3*
Rivers	15.4	15.4	14.6	14.3		
Total water consumption	172.5	171.6	178.3	169.8	166.8	170

*Figures cover both rivers and reservoirs

Source: CAR and DWA (2014 and 2015); and DWA (2016 and 2017).

In addition to augmenting water supply, efficient water allocation is also critical. RWAs for self-providers such as mines are significant and require policy attention. Policy tends to focus more on service providers but there should be a shift towards the former. There is need for more management and monitoring of large abstractors through a systematic review of their performance (including water losses) and water management strategies.

4.3 New water rights applications in transboundary river basins

Most of Botswana's surface water resources are shared with neighbouring countries. Some of the aquifers also transcend the country's borders. The shared rivers include (DWA and CAR, 2013):

- Orange-Senqu River, its tributaries (Nossop/Molopo rivers) are part of the southern border between Botswana and South Africa. This river is shared with Lesotho, South Africa, Namibia and Lesotho;
- Limpopo River in eastern Botswana is shared with South Africa, Mozambique and Zimbabwe;
- Chobe/Zambezi River in northern Botswana extends through Angola, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe. It is the fourth largest river in Africa and the largest river basin in SADC; and
- Cubango-Okavango River (CORB), which comprises mainly the Okavango Delta and its outlets as well as portions of Boteti River into the Makgadikgadi pans. The river is shared with Namibia and Angola.

The use and management of shared water courses is governed by the 2001 SADC Protocol on Shared Waters and riparian countries are obliged to adhere to this. There are no formal water allocation agreements yet for the use of the shared waters, but one is currently under development for the Cubango-Okavango River Basin (CORB).

Table 5 in the earlier sections shows that the applications for water rights from the shared rivers are significant, particularly from the Limpopo River basin (68 Mm^3 of aggregate water right applications). Abstraction rights for the CORB amount to 20.1 Mm^3 while such rights are low for Chobe (only 1.2 Mm^3). Previous studies[7] indicate that Botswana's estimated abstractions from the CORB range between 4 and 20 Mm^3 (MSIOA and TDA respectively; the Water audit estimated the abstraction at 12.4 Mm^3). The higher estimate largely corresponds to the RWA indicated above for the CORB. Abstractions are not adequately measured and may therefore be significant in the future.

Though not heavily utilised, growths in Botswana's use of shared water is inevitable given the rising water demands and constrained internal water resources in the advent of climate change and its impacts. Any abstraction should comply with Botswana's commitments to the SADC Protocol and agreements for specific shared river basins (i.e. OKACOM, LIMCOM, ZAMCOM and ORASECOM). As other riparian states also seek to develop their parts of the basins, pressure on shared water resources will increase as the total abstractions for the river basin are now expected to reach around 32 Mm^3 in the year 2024/25 and 81.3 Mm^3 in 2049/50 due to the developmental needs of the riparian states (World bank, 2017). It will therefore be imperative to optimally utilise it in an efficient way, the use of local resources should be explored first before requesting use of the shared water. This emphasises the need for water demand management, optimal water allocations and to utilise other internal sources of water such as rainwater and treated effluent.

[7] Multi-sectoral Investment Opportunity Analysis (MSIOA; ECA & JG Africa, 2017), Water audit of the CORB (FAO, 2014) and the Transboundary Diagnostic Analysis (OKACOM, 2011).

5 Conclusions and recommendations

This paper reviewed the application for water rights over the period 2002-2018. These can be considered as the demand for water; it is uncertain whether all applications have been approved. This can only be established through the analysis of the DWA data base. In the absence of monitoring, there is no guarantee that right holders conform to the stipulated amount of water that may be abstracted. Some may be over utilised; other rights may be underutilised or not used at all. Botswana urgently needs a comprehensive data base for water abstraction rights, with regular monitoring.

The analysis showed the following. Firstly, at least 5 955 water right applications were made during the period 2002-2018; this is around 350 per year, fluctuating between a low of 33 in 2006 to a high of 779 in 2012. The number of applications for 2018 is estimated to be around 600. There are relatively large fluctuations in annual applications. Secondly, there are no signs to suggest that the growing water scarcity problems have led to an increase in WRA in Botswana. However, groundwater is regularly mined and applications in western Botswana are rapidly increasing (Figure 11). Therefore, desalination options in western Botswana need to be explored to improve the quality of the resource and add to the fresh water supply. Research and development for desalination options are critical as well as adequate cost benefit analysis of the options. Spatial data for groundwater availability and current abstractions are also crucial to compare sustainable yields per district. Therefore, more work should be carried out to assess the sustainable amounts of the resource that can be used at regional and national level to enhance support growing water demand.

Thirdly, water rights are mostly applied for domestic, irrigation and multiple use and are concentrated in the Central District because of its large size, mining presence and the growing irrigation sector. Surprisingly, WRA for livestock are low, possibly due to failure of livestock owners to register their boreholes after they have obtained drilling rights from the Land Board or due to the fact that there is no more space for livestock boreholes. Livestock boreholes are normally spaced between 6 and 8 km. Irrigation WRA are limited but show a growing trend. This reflects growing interest in and development of the irrigation sector to increase food security and domestic food production.

The findings suggest that WRA are positively related with the volumes of abstraction as RWA are also high for multiple, irrigation and domestic use from 2002-2018. However, this does not necessarily apply for sectors such as mining as the sector demands higher volumes of water for its operations and the WRA are small. Most of the RWA from 2002-2018 are from groundwater resources reflecting the limited availability of surface water. Most of the groundwater is required for multiple use, mining and village water supply. The resource remains important for rural communities especially those in the south-western part of the country where it is the sole source of supply. It is costly to transfer surface water to these areas. There is also an increasing trend of growing groundwater RWA for irrigation; this is notable as RWA for irrigation are also subsumed in multiple use which have the highest groundwater RWA.

Abstractions of rivers are subject to the SADC Protocol on Shared Water Courses and individual agreements for shared basins. The applications for river abstractions from the Limpopo and Okavango Basin are significant (68 Mm^3 and 20.1 Mm^3 respectively).

Evidently if water abstraction is not prioritised and water abstraction levels are not monitored, this will cause water stress on the available water resources as the current abstractions are not sustainable. Currently there is no progress on implementation of effective strategies for water management (e.g. National Water Master Plan (and review), National IWRM-WE plan, Master Plan for Sanitation and Wastewater).

The following is recommended:

1. Make WAB rights registry public and up-to date and regularly analyse the data base. This would include all existing WRA and the RWA and will give an adequate indication of the trends in applications vis-à-vis actual allocated rights.
2. It is unclear how applications are currently analysed and processed. It seems that virtually all applications are approved. In future, based on the WRA registry, new applications should be assessed at the basin or aquifer level to ensure that total rights do not exceed the sustainability level, e.g. groundwater mining is avoided.
3. The analysis suggests that water rights probably far exceed the annual abstraction, certainly considering that existing water rights prior to 2002 were not included in our analysis. In other words, there are 'hidden' water rights that may be exercised in future. These water rights need to be identified and cancelled if not used.
4. The use of water rights needs to be properly monitored and linked to the country's water accounts.
5. The WRA and RWA provide a picture of sectoral water allocations and use. Collectively with data from other assessments such as the water accounts, this can be used to inform allocative efficiency. There is need for more management and monitoring of large abstractors through a systematic review of their performance (including water losses) and water management practices.

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