Policy Brief

Irrigation and water resources in Botswana

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Prepared by Department of Water Affairs & the Centre for Applied Research

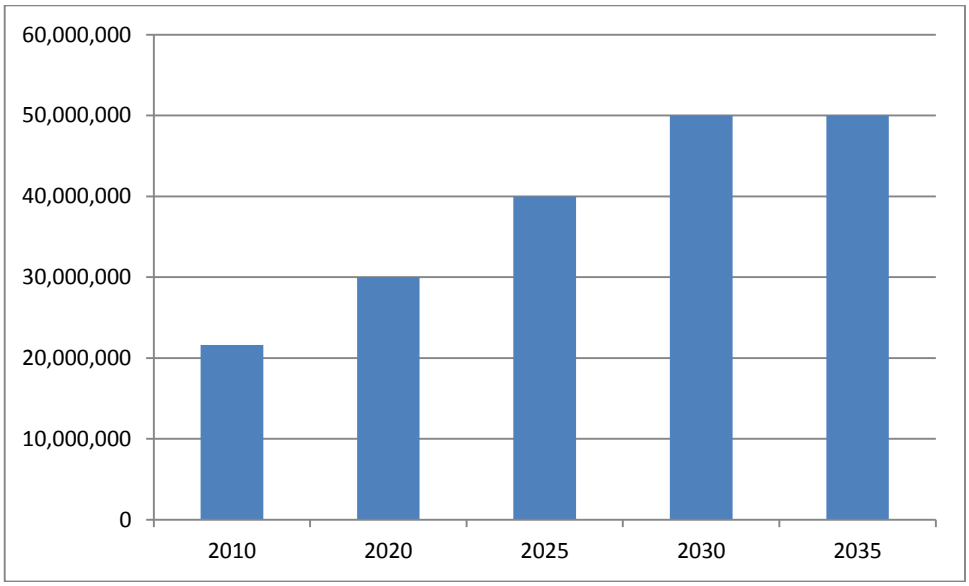
1 Introduction

This policy brief focuses on the irrigation sector as it is a major user of water world-wide, and Botswana has plans for significant growth of this sector.

Currently, Botswana's livestock sector uses much more water than irrigation, but water demand from livestock (55.6 Mm^3) is spread evenly over most of the country, and in many parts there are no alternative uses (this will be explained in a separate policy brief). The situation is different for irrigation where water use is localised and competing uses exist. This justifies the focus of this policy brief.

In Botswana, the crop production is small and has hardly grown over the last decades in terms of are planted and production; the sector comprises mostly rain-fed subsistence farming. The irrigation sector is very small. Annually around 200 000 ha is planted and the estimated irrigated area is around 1 200 ha with associated water use of 18 Mm^3 (less than 10% of the country's annual water use). However, the 2006 Review of the National Water Master Plan (SMEC and EHES, 2006) predicts growth of water use for irrigation to around 50 Mm^3 (Figure 1). Such growth will be partly driven by the fact that climate change will make rain fed farming even riskier than it is already is to-date. Water storage and irrigation would be adaptations to achieve food security. If the large irrigation scheme near Pandamatenga will materialise, water use for irrigation could be in the order of 300 to 400 Mm^3 per annum.

Figure 1: Forecasted growth of water use for irrigation (in m^3)



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

Given the water intensity of irrigation, food security concerns and irrigation expansion plans, it is important to document and review current water use of the irrigation and learn lessons for the future. Therefore, this policy brief aims to:

a. Describe the irrigation sector;
b. Document irrigation's water use, production and efficiency linked to the value added by this sector;
c. Make recommendations for improving water use and overall productivity of the sector to stimulate efficient growth of the sector.

2 Botswana's irrigation sector

The irrigation sector in Botswana is poorly documented. Data were initially collected from the districts through the Irrigation Division, responsible for technical assistance for irrigation systems. Later on data on irrigated land and production were also provided by Horticultural Division and its District officers, who advise farmers on growing crops and marketing. Unfortunately, both data sets are incomplete and differ significantly. Finally, data were also collected from the Water Apportionment Board, which is responsible for granting of water rights[1].

The initial data provided by the Irrigation Division shows that the Ministry of Agriculture has registered 459 irrigation farmers (Figure 2), including over 100 back yard garden farmers. Later data from the horticultural division suggested a total of 756 irrigation farmers. These figures are much lower than the over 2 000 farmers who have been granted water rights for irrigation by the WAB[2]. Assuming that the Ministry of Agriculture has better insight in the actual irrigation farmers, we estimate their number in the range of 500 to 750 farmers.

The exact amount of irrigation land is not known. The serviced irrigation land is estimated in the order of 950 to 2 250 ha. Generally, only around half of the serviced land is annually used[3] and only part of the land allocated for irrigation is serviced (e.g. 2 650 ha out of 4 012 ha in 2012/13). The conclusion is that a large part of irrigation water rights are un-used or used for other purposes and that allocated and serviced irrigated land is underutilised. This creates short term opportunities for expansion of the irrigation sector. It has also to over-estimation of the sector's water use at around 18 Mm^3 (as this assumes that all land is being used).

The sector comprises mostly small individual farmers, irrigating up to 2 ha[4] and a few large farms (e.g. Talana farm with 380 ha irrigation with potential for 650 ha). In addition, the Ministry of Agriculture operates two smallholder irrigation schemes at Glenn Valley (200 ha), using treated waste water, and Dikabeya (60 ha), using reservoir water; a third scheme at Kubung is at the design stage.

Irrigation in Botswana is predominantly for horticulture, mostly vegetables and citrus crops.

Irrigation farms are typically found along ephemeral rivers (e.g. Tati, Shashe and Limpopo), near dams (e.g. and close to wastewater treatment works (Glenn Valley). Plans exist to develop irrigation schemes in conjunction with new wastewater treatments works.

In terms of water resources, over two thirds of the farmers (68.8%) supply their own water; over a quarter (28.2%) use village water supplies (mostly backyard gardens) and a few (3.2%) use the earlier mentioned government irrigation schemes. In terms of number of farmers, irrigation heavily relies on groundwater (60.2% of farmers), but in terms of the amount of water abstracted river water is the most important source (54.2%), followed by groundwater (38.4%) and dam water (7.3%). Treated wastewater is only used in one of the government irrigation schemes (mostly for vegetable production) and by a few individual farmers (mostly for fodder production). There is considerable potential to increase the use of treated wastewater if the wastewater quality is sufficient. This is a challenge to-date.

[1] Some farmers and schemes may operate without formal water rights. For example, one of the government schemes does not have water rights from the Water Apportionment Board (WAB) in terms of volumes/day.

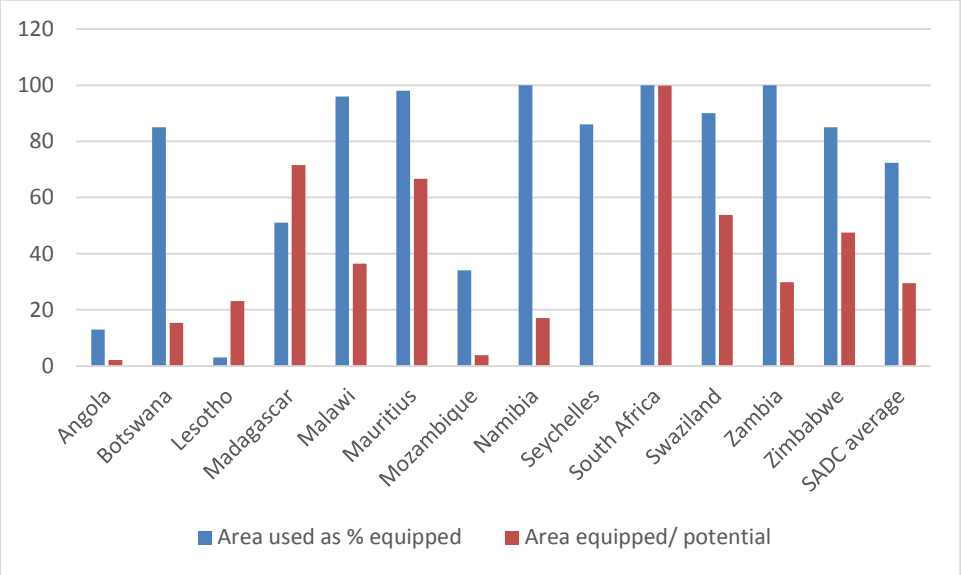
[2] The difference may be caused by farmers using these rights for other purposes (e.g. livestock) or do not use them at all. The large number of water right allocation raises concern about the resource sustainability as rights may locally exceed recharge. There is need for monitoring of resource rights.

[3] Irrigation division data: 35.6% in 2011-2 and 53.1% in 2012-3; horticultural division data: 4 012 ha of irrigated land is allocated, of which 66% is developed and 55% (2 209 ha) cultivated in 2012/3

[4] Tahal Consulting Engineers (2000) National Master Plan for Agricultural Development. Volume 1.

In comparison to most SADC countries, Botswana's irrigation sector is small, and only similar in size to Lesotho and Seychelles (FAO, 2014). Under-utilisation of land is shared with most SADC countries except for Namibia, South Africa and Zambia, countries that use all serviced land (Figure 2). SADC wide, only 30% of the land suitable for irrigation is equipped and around three quarters of the equipped land is actually used. This indicates that the irrigation sector has good a good growth potential in most SADC countries except for South Africa which has equipped all potential irrigable land; Madagascar and Mauritius have equipped over two thirds of the suitable land and Botswana around 15% (FAO, 2014).

Figure 2: Land utilisation in the irrigation sector in SADC



Source: based on data from FAO, 2014.

2 Water use of the irrigation sector

It is important to distinguish several terms that are in practice loosely (and often wrongly) used. Water *abstraction or withdrawals* refer to water abstracted from the environment for use in irrigation. Water *use* refers to the water entering the irrigation schemes or farms. This is usually lower because of losses during abstraction and delivery to the schemes or farms. Water *consumption* refers to the use of water minus the return flows. Water consumption is lower than the use when there is a water flow leaving the scheme or farm, either through leakage into the ground or through surface outflows. Return flows benefit the environment or other economic sectors. The different figures for abstraction, use and consumption can only be estimated with sufficient data. Inflows and outflows are not recorded either and therefore at present the abstraction, use and consumption of water by irrigation cannot be differentiated.

According to the 2006 Review of the National Water Master Plan (SMEC & EHES, 2006), groundwater, river withdrawals, wastewater, and small dams are the main water sources for irrigation. Unfortunately, water abstractions are not metered and therefore water abstraction and use must be estimated based on different assumptions.

The Ministry of Agriculture (horticultural division) assumes that boreholes yield on average 5m^3/hour/ha and run for 8 hours/day. This implies a water abstraction of 40 m^3/ha/day or 14 600

m^3/ha/year. A standard figure of 15 000 m^3/ha/year is often used in the literature. Alternative assumptions (associated with drip irrigation based on Sava & Franken, 2012) refer to greater water use efficiency, e.g. 10 000 m^3 and 7 500 m^3/ha/year. The results are summarised in Table 1.

Table 1: Estimated water use by the MoA irrigation farmers under different assumptions (in Mm^3)

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

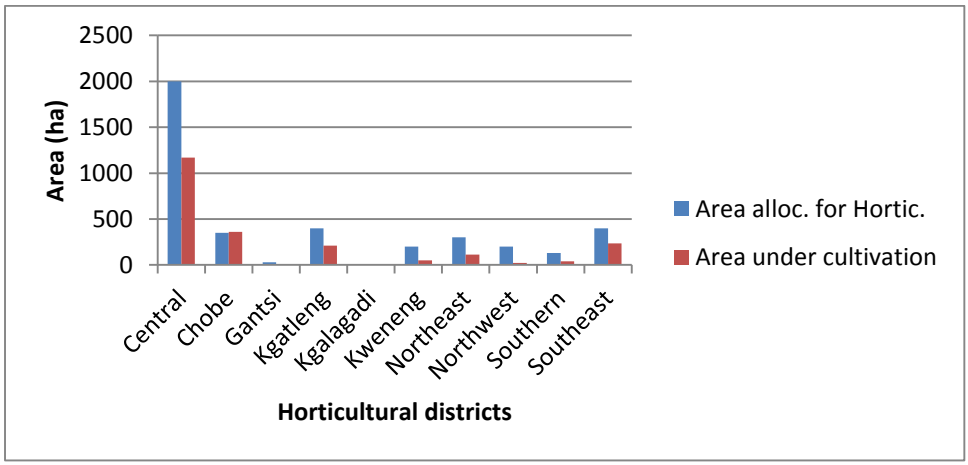
Note: water abstraction has been divided by source using the percentage of area using river, ground and dam water (see above).

The water use for the MoA registered farmers varies between 3.5 to 7.5 Mm^3. Adding the water use of Talane farms would led to a rough figure of water use of 9 to 12 Mm^3. Around 10% of this is re-used treated wastewater (part of river water above).

3 Use of irrigable land

The irrigation sector doe no fully utilise the land developed for irrigation. Figure 4 shows that with the exception of Chobe, about half of the land available for irrigation in all the districts is not used (Figure 3)[5]. Therefore, priority must be given to utilising serviced irrigation land and increasing production.

Figure 1: Utilisation of land available for irrigation



[5] The analysis is based on the 2012/13 horticultural data from the Ministry of Agriculture (Division of Horticulture). Data collected from the irrigation division for the same year shows even greater disparity and it has not been used for this policy brief.

For example, there are 40 active farmers farming who use less than 60% of the land available for irrigation at Glenn Valley. Yet, the irrigation scheme is designed such that the entire land area needs to be irrigated (whether it is actually used or not). This leads to water wastage and low water use efficiency. The productivity of irrigation varies a great deal but is generally low. In the Dikabeya Irrigation Scheme, productivity varies between 0.6 and 21 tonnes/ha in 2011/12 and 2012/13. The 8-ha NAMPAADD farm (a process is on-going to lease it to a private farmer) within Dikabeya is under-utilised and performs poorly.

4 Water use efficiency in irrigation

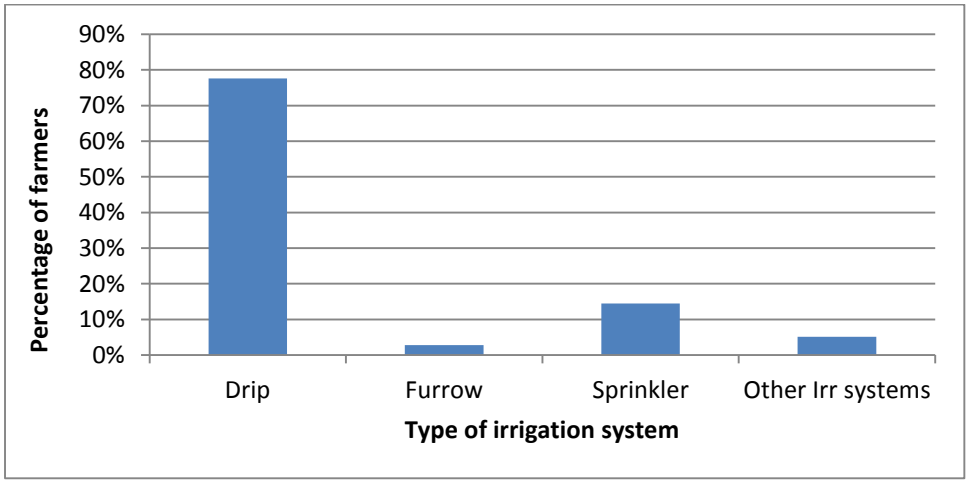
The FAO Irrigation Manual (Sava & Frenken, 2002) argues that irrigation water efficiency is the result of three factors:

- ✓ Conveyance efficiency (between water inlet and entry into scheme);
- ✓ Field canal efficiency (from entry point scheme to each field hydrant); and
- ✓ Field application efficiency (efficiency within the field).

The conveyance efficiency refers to water losses between the inlet point (e.g. dam or borehole) and the irrigation scheme or farm. The efficiency cannot be determined at the moment due to lack of measurement and recording. Losses are not monitored. The same applies to the field canal efficiency, but qualitative comments can be made. Firstly, one of the government schemes is designed in such a way that all farms on the scheme have to be irrigated to avoid pipe bursts due to high pressure. As half of the farms are not used, half of the water is effectively wasted. Secondly, the other government scheme uses open canals which are exposed to high levels evaporation, reducing the field canal efficiency. Without measuring, the magnitude of the losses cannot be assessed.

Field application efficiency is primarily determined by the choice of irrigation technology and the way farmers use the technology. Sava & Frenken (2002) show that localised irrigation such as drip irrigation uses less than half the amount of water of surface irrigation technologies (e.g. sprinklers). In Botswana, most irrigation farmers use water efficient drip irrigation technology (Figure 3). Therefore farmers are well placed to utilise water efficiently. In practice, this may not happen as the available (incomplete) data suggests that water use for drip irrigation on government schemes remains around or over 1 500 m^3/ha per annum.

Figure 2: Irrigation systems used by farmers



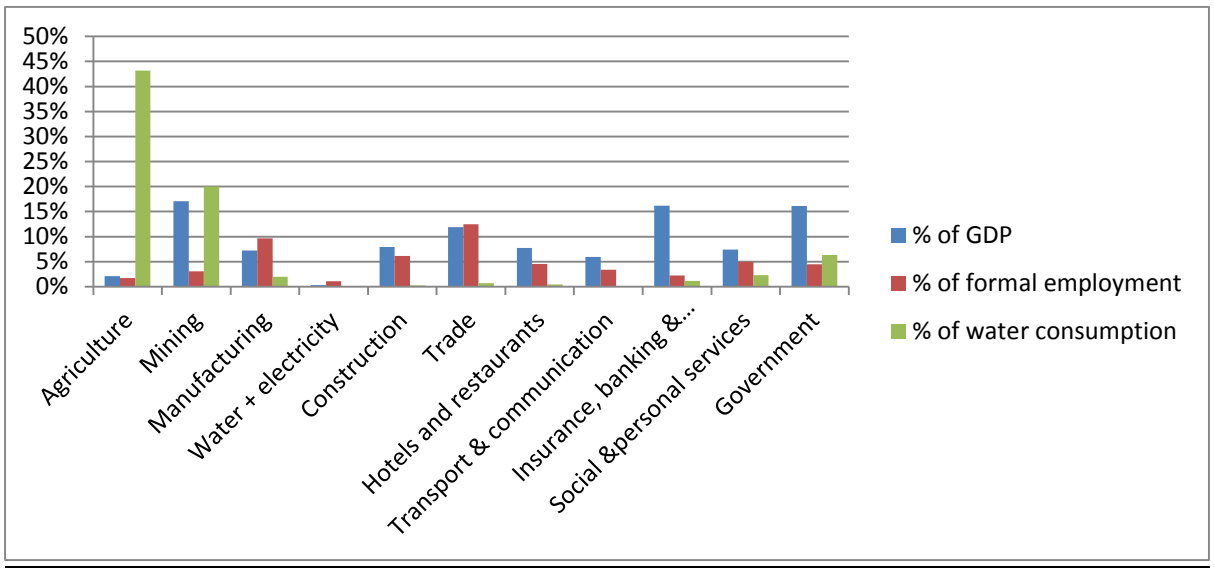
That farmers do not seem to realise the water saving potential may be caused by the fact that they do not pay for water and have therefore no incentive to conserve water and that water resources are abundant on government schemes. It could also be due to inadequate irrigation practices, such as irrigating at the wrong time etc. As an example, the Dikabeya Irrigation Scheme abstract water from a dam, pumped at a rate of 33 L/s. The water flow is not metered but it is estimated to be 390 258 m^3 per annum, which translated to 18 600 m^3/ha. This is high for farmers that use drip irrigation and indicates low overall efficiency. The farmers are not charged for the water used except the electricity used to pump water from the sumps.

5 Lack of accounting for water use in irrigation

There are two areas of concern.

Firstly, the production and value added of the irrigation sector is not known and data to estimate the value are incomplete and inadequate. This makes it impossible to compare the economic benefits of an m^3 of water used in irrigation with that in competing sectors such as mines, manufacturing and the service industry. Figure 6 compares the agricultural sector as a whole with other sector and shows that agriculture uses a lot of water and generates limited value added and formal employment.

Figure 6: Sector's share in water consumption, output and employment (2010/11)



Source: Department of Water Affairs and Centre for Applied Research, 2013.

It is necessary to collect data for the irrigation sub-sector to assess its competiveness for water resources. The experience of neighbouring countries such as Namibia and South Africa is that the value added per m^3 in irrigation is much lower than in other economic sector (Lange and Hassan, 2006). There is need to estimate the economic benefits per m^3 in irrigation and consider this during sectoral water allocations.

Secondly, water abstraction, use and consumption for irrigation are not directly measured. In addition, there is lack of monitoring on the use of water rights for irrigation. In some instances, there is lack of understanding among farmers about water requirements for irrigated crops in terms of required supply reliability and water quality. The 2013 National IWRM Water Efficiency Plan observes that irrigation farmers do not pay for water, or pay very little, which discourages efficient water use.

6 Little use of waste water

The available treated wastewater is estimated to be 27.1 Mm^3 (Department of Environmental Affairs and Centre for Applied Research, 2006), and only around 10% (or 2.5 Mm^3) is being re-used, around 1 – 1.5 Mm^3 for irrigation and the remainder for water golf courses, game parks and the construction sector. The available wastewater is sufficient to irrigate at least 1 800 ha. Concerns exists about the variable and generally low quality of treated wastewater. As wastewater is located close near population centres, it is a valuable resource for irrigation and other potential users such as the construction sector.

The 2003 National Master Plan for Wastewater and Sanitation (NMPWWS) estimates an increase in wastewater to over 73Mm^3 in 2030. This would be sufficient to cover the sector's forecasted needs (Figure 1, excluding the Pandamatenga scheme). Clearly however, irrigation has to compete for treated wastewater with other economic sectors including recycling of wastewater into WUC water supplies.

7 Main conclusions and recommendations

There is considerable potential to improve the economic performance of the current irrigation sector in Botswana through better use of the currently allocated land and (waste) water resources. This can happen immediately and lessons learnt should be incorporated into plans for the sector's expansion.

The irrigation sector is currently poorly documented in terms of size, productivity and resource use. To be able to compete for scarce water resources in future, it is recommended to collect regular data on the following: amount of land under irrigation (equipped and used), amount and type of water resources abstracted, used and consumed, economic (value added) and other benefits (e.g. employment and food security) of irrigation.

The potential of water conservation in irrigation offered by drip irrigation is currently not exploited. Irrigation schemes need to be (re-) designed to maximise water efficiency in conveyancing, field canals and field applications. Farmers need to pay for water and to be trained in more efficient water use in order to realise the water saving potential of drip irrigation.

Irrigation land is currently underutilised. Farmers should be encouraged to equip and utilise more allocated irrigated land. This can be done through higher land rentals and repossessing of un-used allocated irrigation land (in line with the land agreement).

Treated wastewater is abundant but re-use of treated wastewater for irrigation is low and should be increased provided that the irrigation sector provides tangible economic and other strategic benefits. The 2003 NMPWWS target of 96% re-use and recycling of wastewater in 2030 needs to be rigorously pursued. Design and construction of new wastewater treatment works should be accompanied by re-use and recycling plans, including development of irrigation schemes. The water quality of treated wastewater causes for concern and needs to be improved and monitored (inflows and outflows) by WUC. It should meet the standards for re-use in irrigation.