

WATER DEMAND MANAGEMENT IN BOTSWANA: CHALLENGES OF A DIMINISHING RESOURCE

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ABSTRACT

Water is one of the most important elements essential to attain food and health security, as well as economic development of any country, particularly for a semi-arid country like Botswana. Effective utilisation of this valuable but scarce resource has necessitated emphasis on demand management as opposed to supply management, such that sustainable use of the resource to meet the increasing demand can be achieved. This paper examines the various strategies made/proposed in the country to manage the growing demand for water. The strategies encompass the use of tariffs, water reuse/recycling and water restrictions. Other attempts encourage water conservation through rainwater harvesting and implementation of technological innovations with exploration of non-conventional sources.

Keywords: Botswana, development strategy, non-conventional sources, population density, semi-arid, urban centres, wastewater, water demand management, water security.

1 INTRODUCTION

With a population of just over 1.68 million [1] spread over an area of 582,000 km², Botswana is one of the world's most sparsely populated countries. Although the country's population is small in absolute terms, it seems adequately populated in relation to its natural resource endowment. This is because Botswana is highly dependent on its natural resources such as land, water, vegetation and minerals to support economic activities such as mining, agriculture and wildlife-based tourism and its growing tertiary sectors. There are two distinct economies in the country. One consists of the agricultural sector in which the majority of the people practise subsistence agriculture, while a small minority is involved in commercial agricultural activities. The other is a commercial sector based on export-oriented mining and industrial activities controlled or dominated by a minority (a majority of whom are foreign nationals who are the owners of capital investments). The consequences of these are a highly skewed distribution of income and access to resources that characterise Botswana, which in turn cause the population to exert considerable pressure on land and water resources.

The physical environment is semi-arid with an annual rainfall mostly ranging between 350 and 500 mm and evaporation rates reaching as high as 2,000 mm/year. These, combined with a flat topography and deep sandy soils, result in low rates of surface runoff that average, for the whole country, in the order of only 1.2 mm/year. Furthermore, all endogenous rivers originating in Botswana are ephemeral with annual periods of river flow averaging between 10 and 70 days. As a result, the groundwater remains the most important source of water supply throughout the country. Estimates, however, show that the mean annual recharges of aquifers over the country average to about 3 mm [2].

Further, based on the global climatic change projections, there is a concern that water supplies are running short and the situation is going to worsen in the coming decades, particularly in the Southern African region [3]. Increased harvesting of ephemeral surface water would divert water from downstream users and negatively affect the ecosystem and the vegetation necessary for agriculture and wildlife, as well as groundwater recharge. Indications are that the water demand will continue to grow as the economy and population grow (see Tables 1 and 2), especially in the urban centres unless used in a sustainable manner. Hence, water is likely to be the single most important constraint to Botswana's development in the future. Consequently, a water management policy ensuring water

security should be seen as a critical component of Botswana's development strategy. To maintain the path and pace of economic growth, it is necessary to secure the available water through both water conservation and demand management strategies. This paper examines the critical problems associated with water supply in Botswana and examines the strategies that would assist in reducing water scarcity in the short-to medium-term along with limitations of such approaches.

2 WATER SUPPLY AND DEMAND SCENARIO

The country has five major drainage systems, namely Limpopo, Makgadikgadi, Okavango, Kwando/Linyanti/Chobe and Molopo systems, with catchment areas of approximately 80,000, 30,000, 97,000, 26,000 and 71,000 km² respectively. The mean annual flows from the first four systems are of the order of 662, 110, 300 (at Maun) and 1,310 Mm³ respectively, with almost no runoff from the Molopo system. Since the perennial river systems in the country do not coincide with high population density areas, water supply in the latter is heavily dependent on the exploitation of fossil groundwater accumulated over thousands of years and possibly under wetter conditions. Ephemeral river systems are more characteristic in the high population density areas. Thus, the physical characteristics show that the available water in Botswana is limited. This situation is likely to be aggravated by the rapidly changing socio-economic scenario on the ground as manifest in the following paragraphs.

Since independence (1966), Botswana has undergone a remarkable economic transformation due to the discovery of minerals, especially diamonds. The direct income from minerals accounts for over half of the total government revenues and over 85% of the country's exports. The rapid expansion of the economy through the 1980s was largely fuelled by the growth in diamond output, significant increases in the real price of diamonds and favourable movement in cross exchange rates. The increases in government revenues throughout the years permitted major expansion of public expenditure programmes across all sectors of the economy. This has resulted in a 'boom' in the construction industry with a consequent increase in the built-up areas [2, 4].

Population growth has been correlated with economic growth and infrastructural developments. Botswana has experienced one of the fastest growing populations in Africa and this is attributed to rapid economic development. Before independence, less than 5% of Botswana's population was classified as urban. There has been an upward trend since the mid 1970s as shown in Table 1.

Due to the availability of good arable land and a concentration of centres of economic activities, the eastern part of the country is relatively densely populated. As a result, the density of population in towns (most of which are located in this part of the country) presently averages around 440 persons/km² compared to the country's average population density of around 2.6 persons/km². The change in the socio-economic scenario, as exemplified by the increase in urban population along with other economic development activities such as mining, energy and agriculture, resulted in the increase in water demand. It is estimated that water demand under various categories with a medium-term forecast is most likely to double in the next two decades as given in Table 2 [2].

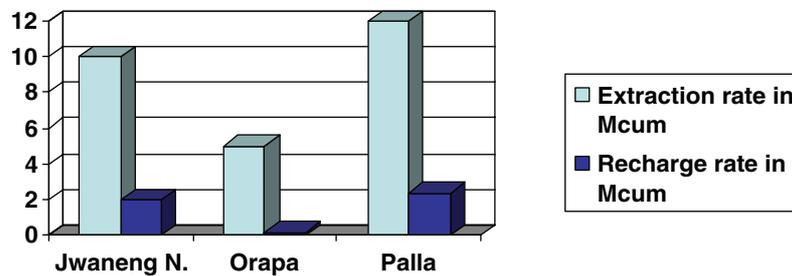
In many well fields, the recharge is far below the rate of extraction making the use of groundwater unsustainable (Fig. 1). So, there have been ongoing efforts to harness the available surface water through the creation of reservoirs against all odds, such as sandy beds, flat topography, low rainfall

Table 1: Urbanisation in Botswana (1971–2000).

Year	1971	1981	1991	1997	2000
Urban %	9.0	17.7	45.7	48.7	51.6

Table 2: Water demand projections in Botswana till 2020 (Mm³).

Water use in different sectors	Year 1990	Year 2000	Year 2010	Year 2020
Urban centres	20.9	45	72	103.1
Major villages	8.2	21.5	35.4	51.9
Rural villages	5.3	9.2	12.7	6.5
Other settlements	1.9	2.3	2.7	3.0
Mining energy	22.5	35.7	56.5	63.7
Livestock	35.3	44.8	34.3	44.1
Irrigation and forestry	18.9	28.9	38.5	46.9
Wildlife	6.0	6.0	6.0	6.0
Total	11.9	193	258.1	335.2

Figure 1: Extraction and recharge rates (Mm³) in some typical well fields of Botswana; SMEC [2].

and high rate of evaporation, to meet the water demand. As such, the country has constructed four reservoirs in the Limpopo basin, namely, Gaborone, Letsibogo, Bokaa and Shashe, while another is being, or about to be, constructed in the lower Shashe. All of these will have a total storage capacity of 350 Mm³, which is expected to meet the demand up to 2020. But a recent study by Desankar and Magadza [5] has shown that some of the rivers like the Limpopo and Orange in the Southern African region, due to the effect of climate changes, are likely to experience as high as 10%–35% reduction in flows. Consequently, there is likely to be a shortfall in meeting the projected water demand.

Further, from Table 2, it is evident that there is going to be a rapid increase in demand under various settlements compared to other categories. Water demand is also bound to be skewed in certain parts of the country because population, socio-economic activities and hydrological factors are not uniformly distributed. However, a rapid increase in the water demand in the major population centres would generate a substantial amount of wastewater. It is estimated that by 2020, as much as 70 Mm³ would be generated as wastewater at six major urban centres in Botswana as given in Table 3 [6]. With the development of water reticulation in other major population centres, production of more wastewater is anticipated. Faced with rapidly increasing demand and development constraints associated with river systems, it is imperative that wastewater should be recovered as a major potential source of water in the future.

In order that water supply is made sustainable, there is a need to develop a water demand management (WDM) strategy as it offers an alternative to new resource development and conservative use of existing supplies.

Table 3: Estimated return flow in Mm³ at various urban centres of Botswana per annum.

Urban centre	Year 1990	Year 2020
Gaborone	5.3	38
Francistown	1.8	13
Selebe-Phikwe	1.6	8
Lobatse	1.2	3
Jwaneng	0.5	1.4
Maun	0.1	1

3 STRATEGIES FOR WATER DEMAND MANAGEMENT

It is well recognised that water is an essential factor towards poverty reduction. It contributes towards food security, generated not just from agriculture but also from gardens and orchards and even from water bodies through the harvesting of aquatic plants and fish. Besides, water is also an essential input towards livestock production, which in turn is an input for livelihood activities such as employment generation. Growth in industrial and service sectors is also largely dependent on the availability of water as an essential production factor or input. Therefore, improving the water security of poor people is likely to help reduce poverty and support sustainable development in many ways.

It is estimated that by 2025, nearly half of the world's population could live under conditions of severe water stress, especially in the continent of Africa, the Middle East and South Asia [7]. The World Summit on Sustainable Development Report, 2002, placed water at the top of the development challenges facing most countries throughout the world. Botswana is clearly one of the water-stressed countries of the world where a number of people live without direct access to potable water, particularly in rural areas. This therefore calls for an improvement in water delivery services through appropriate WDM strategy, which could bring about sustainable water resource development in the country.

Based on the general definition formulated by the International Union of Conservation of Nature (IUCN), WDM is generally conceived as a 'management approach that aims to conserve water by controlling demand. It involves the application of selective, mostly economic incentives to promote efficient and equitable use of water' [8, 9]. Since such a conceptualisation may not be very accurate on accounts that the nature of demand and the impact of the economic instruments of demand are not well articulated, Tate [10] suggests that WDM is possibly better described as 'any socially beneficial measure that reduces or reschedules average or peak water withdrawals or consumption from surface or ground water sources of maintaining and mitigating the extent to which return flow are degraded'. In other words, the need for demand management is not only aimed at reducing average or peak water demands, but also emphasises the need to integrate use of ground and surface water as well as water quality consideration. A further emphasis is that WDM should also be socially beneficial. In a different sense, Tate [10] also makes a distinction between water demand and water use by linking the former to water payment and the latter to no payment for the resource. This seems situational because in the case of Botswana, water demand refers to water use plus the suppressed demand associated with inadequate access to reticulated water. Considering all these aspects, a WDM strategy can be developed on five components: reuse of water, water saving technology, land-use planning, educational initiatives and water pricing [8]. Arntzen *et al.*, [8] argue that in the Botswana context,

the key objectives of WDM would practically be to reduce the need for continuing expansion of the conventional water supply systems, such as dams and boreholes, in order to meet water demand on a sustainable basis. So, the WDM may consist of two main strategies, viz. increasing the water supply from non-conventional sources and the conservation through reduction of water consumption and reduction of losses of conventional supply sources.

Although the analysis is plausible, the suggestion for the use of non-conventional sources can best be described as providing a stopgap measure because it is essentially on the supply side, i.e. it increases supply. If the critical issue about the instruments is to modify behaviour, the argument advanced falls short of expectation. It is not convincing that providing water through non-conventional sources will change consumption and water use behaviour. Instead, it reinforces the status quo in terms of opening up new frontiers for continued search for new supplies.

Considering various aspects, as said above, two situations could emerge. Firstly, WDM may have net social and private benefits and government intervention may not be necessary, as water users have an incentive to implement WDM measures. Whereas in the second situation, WDM measures may have net social benefits but negative private benefits, in which case the government needs to design instruments which will increase the attractiveness of WDM measures [8]. Such instruments could be a combination of legislative instruments (on water use restrictions and building and product specifications), which prescribe the desired behaviour to water users; economic instruments (viz. water charges, subsidies), which remove the difference between the private and the social net benefits; and consultative instruments (agreement with major water-consuming sectors) aimed at a solution close to the optimal situation for the society.

Although the choice of instruments could be a part of a well-established WDM policy, no formal WDM policy exists in Botswana. Yet a wide variety of WDM measures, such as implementing high water charges and use of non-conventional sources, e.g. desalination, reuse of effluents and recycling, are being practised presently. The Department of Water Affairs, however, recognises the importance of a WDM policy and is already working on it.

4 WATER DEMAND MANAGEMENT APPROACHES IN BOTSWANA

As indicated above, a policy on WDM is not fully developed in Botswana. Yet, there are attempts at undertaking or plans to undertake WDM in various forms. A recent study by Arntzen et al. [8], has summarised them as follows:

4.1 Development of sanitation and water reuse

Presently, the city of Gaborone, with a partial sewage system, is generating wastewater to the tune of about 20 Mm³, which by 2020 is estimated to go up to 38 Mm³ per year with a possible improvement in the reticulated water supply and the provision of sewage systems to the self-help housing areas (SHHA). Studies are on to assess possible reuse of such a huge amount of wastewater generated from the capital city, whose experience can then be extended to other urban centres of the country. Attempts are also being made by several city councils to develop sanitation in the districts, for example, through the creation of sewage ponds, improved oxidation ponds, construction of activated sludge plants, etc. These create a high potential for irrigation using wastewater. In particular, there is special emphasis on the reuse of effluent for the irrigation of fodder on about 100 ha in the downstream of sewage treatment plants and ponds of Gaborone, Francistown and Selebi-Phikwe. Also, attempts to increase the capacities of sewage stabilisation ponds in Kgatleng district have been proposed during the period of District Development Plan 5.

4.2 Private water connections

In an attempt to solve some of the problems associated with the provision of community standpipes, the government encourages households to obtain private water supply connections into their yards. For example, in the peri-urban villages like Odi, Matebele and Modipane in the vicinity of Gaborone, private connections have been granted for the use of potable water supply made through the Water Utilities Corporation (WUC). Also, similar provisions to the SHHA complex in Gaborone have been made in the National Developmental Plan 8, besides the District Development Plan of several districts.

4.3 Rainwater collection

Generally, due to the erratic nature of rainfall in many towns, institutions (schools) have big water tanks to collect rainwater, which is mostly used for gardening due to little knowledge of its quality. In view of this, research will be conducted followed by pilot projects for rainwater collection besides runoff diversion and collection of storm water [4].

4.4 Restrictions

Urban water restrictions were successfully carried out during the drought spells of the 1980s, resulting in reduced consumptions up to 45% in Gaborone. During the drought spells of 1992 to 1994, restrictions imposed in a number of villages and towns, which included Maun, Mochudi, Molepolole and Moshupa, also yielded good results in terms of restricted consumptions.

4.5 Loss reduction and efficiency in water use

The loss rates in the urban sector have been reported to be around 20%, which by international standards are not excessively high [2]. In spite of this, WUC is making efforts to reduce the loss rate through the rehabilitation of the distribution network wherever possible. In order to achieve efficiency in water use, SMEC [2] has suggested the following strategies:

- the use of economic methods such as pricing policies;
- socio-political methods including consumer education;
- encouragement of the use of water-efficient appliances and other technological means of reducing consumption;
- operational methods such as reduction of leaks from distribution network, use of low pressure, recycling of water in industry and improvement in the irrigation efficiency.

Due to the fact that water supply systems are becoming technically more complex and the opportunities to use additional supply sources are limited, there has been an emphasis on the use of economic instruments in Botswana, which will not only be helpful in managing demands but also raise additional revenues to finance water supply schemes. To arrive at a reasonable pricing structure, attempts have been made to study the current rates of water consumption, current pricing and subsidies in the water sector, including affordability to pay and its impact on socio-economic development. Without sufficient data to enable the quantification of the effects of pricing, SMEC [2] recommended changes to the existing urban tariffs charged by WUC to reflect the marginal costs that include

- reduction of the concessionary band from 15 m³/month to 10 m³/month;
- reduction of the threshold on the upper band from 40 m³/month to 25 m³/month;
- Introduction of a flat rate for households using standpipe supplies.

Table 4: Envisaged reductions of subsidies to the water sector [8].

	Expenditures in million pula		
	1990–1999	2000–2009	2010–2019
Urban centres	69.1	52.2	84.1
Major villages	54.2	40.5	34.8
Rural villages	49.8	43.2	50.5
Total	173.1	135.9	169.4
Subsidies %	49.3	39.8	29.2

Further demand control is carried out through staggered rates with low charges for low-use band and increasing charges in successive user bands, with different rates for rural and urban areas. However, the water charges are likely to rise further in the near future due to withdrawal of most donors and the intention of the government to reduce subsidies (Table 4).

5 LIMITATIONS OF WATER DEMAND MANAGEMENT APPROACHES

This section examines some of the socio-economic problems that emerge from the WDM approaches, which need close consideration to avoid the syndrome of initiatives with ‘good intentions but bad results’. The most popular and widely used, and perhaps the most effective, instruments in Botswana are economic, especially tariffs. Although tariffs have been acclaimed to be successful in Botswana and may be among the highest in the region, Arntzen et al. [8] showed that this instrument failed to attract business enterprises to the low-priced water services in the northern part of the country. This can be explained in two ways. Firstly, the fact that water cost remains an insignificant component of companies’ production costs compared to other production inputs and secondly because of low price elasticity of demand, i.e. water demand hardly changes due to price change. But tariffs have proven effective for individuals and small enterprises where water input contributes significantly to production costs. At another level, continued increase of water tariffs to effect price elasticity may jeopardise productivity and discourage investors if Botswana’s utilities’ cost are not competitive relative to others in the region. Emphasis on making tariffs effective is risky as it may also marginalise the poor people, particularly in households headed by females in rural areas, given the role of women as caretakers of their families. A further issue of concern regarding tariffs based on cost recovery is whether the threshold for this criterion coincides with that of the desired conservation or reduction in water use. A pertinent question here is whether cost recovery also caters to water conservation or the two are different approaches with distinct objectives.

This calls for the setting of priorities in selecting instruments for WDM. Obviously, WDM may be driven by a number of objectives encompassing both economic (e.g. employment) and social benefits (personal needs, health, etc.). Priority should be given to water uses that are beneficial (e.g. in a productive enterprise) and not those that are wasteful of the resource (e.g. swimming pools, washing cars, etc.).

Legislative instruments have also been used in Botswana, although confined to drought periods or periods of extreme scarcity. It is evident that they have, however, been used only as a stopgap measure. For example, water restrictions in the 1980s saw the prohibition of wasteful water use, as

well as use in construction and related water-intensive activities. This is an easier version that lends itself without difficulty to legislative control. The other more difficult part would involve policing, which is costly both in time and financial resources. Therefore, it may not bring about maximum benefit without the necessary infrastructure for effective enforcement. For water restrictions to be effective as a demand management strategy, it has to be incorporated as an essential component of a long-term policy.

Technological approach promises more success in bringing about both private and social benefits. The problem, as with tariffs, is that it may not be accessible to certain sections of the population. But these could be overcome through a system of tax credits and subsidies to urge companies and individuals toward sustainable use of the water resource. A compelling and rather fundamental approach is the communicative instrument because it brings accurate and up-to-date information to the target group [11], which makes them appreciate the problem and its context. This would lead to the involvement and active participation of the target group in resource management. Therefore, education and training or communication is central and fundamental to effective resource management. As Hens [11] suggests, communication is a condition that makes other instruments (legal, economic or physical) work. We see these instruments as paramount because they may lead to a more permanent change in behaviour, irrespective of environmental, economic or physical conditions, and thus make voluntary water conservation possible.

6 CONCLUSIONS

Water in Botswana has always been a key resource for livelihood and development because the country is semi-arid. Water has therefore been a concern of the government, which is reflected in the fact that water is the only natural resource for which the government has prepared a long-term plan (1990–2020). In contrast to this, the growth in economic activities has resulted in an influx of population and growth of industrial activities resulting in an increase in water demand. This has therefore necessitated the implementation of strategies for WDM with the assumption that a reduction in the growth of water demand was seen as a possible way to defer capital expenditure on water supply.

During policy formulation, policy makers usually tend to deal with economic, social and environmental issues separately because Botswana does not have a comprehensive WDM approach, though bits and pieces of policy statements are available. To realise sustainable development, it is quite crucial for the government and the private sectors dealing with the water sector to employ appropriate strategies for its supply. There is therefore a need to integrate economic growth with community welfare. Presently, emphasis on three aspects of WDM, namely water tariffs, water restrictions and water reuse is in vogue. These strategies have proved quite successful; particularly the high water tariffs and increasing block tariffs have been credited with the relatively low per capita water consumption, which means a saving for big businesses. The successful application of water tariffs notwithstanding, this paper has argued that this approach also has limitations that include marginalisation of the poor rural people, especially women, and the fact that tariffs have failed, in the case of Botswana, to attract companies to locate in areas of low water tariffs because of the potential influence of other production factors.

The shortcoming in the tariff system underscores the need to diversify demand management strategies. As argued earlier, most of the strategies have limitations, but some are more so than others. A careful combination of strategies, rather than mere selection, seems appropriate. It is therefore encouraging that the Department of Water Affairs of the Government of Botswana has embarked on a project on developing demand management and conservation policy for the water resource. This is a step in the right direction.

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