A CASE STUDY OF INTEGRATED WATER RESOURCE MANAGEMENT IN WINDHOEK, NAMIBIA

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ABSTRACT

Integrated water resource management is crucial in meeting and managing the increasing water demand in Namibia. Recent studies have shown that as part of that process both water demand management measures and non-conventional water supply augmentation schemes are considerably cheaper than developing more traditional pipeline schemes. This paper presents a case study of Windhoek, describing the different initiatives adopted by the municipality in conjunction with the bulk water supplier, NamWater and the Department of Water Affairs in the Government to integrate traditional supply systems, WDM and non-conventional supply initiatives to manage and meet this demand. The case study provides an indication of what can be achieved and what are feasible and practical interventions. The case study shows that lessons that have been and continued to be learnt in Windhoek can apply to many other areas in Namibia as a way to promote sustainable water resource use yet meet increased demand.

KEYWORDS:

Integrated water resource management, supply augmentation, conjunctive use, water demand management

BACKGROUND

Namibia is Southern Africa's most arid country. Its rainfall and consequently its surface and ground water sources in the interior are extremely limited and variable. Potential evaporation exceeds precipitation by a factor of between two and five. There are no natural resources of perennial surface water other than rivers on the borders of Namibia. It is estimated that 56% of water consumption is derived from groundwater, 20% from ephemeral rivers and 24% from perennial border rivers. Of the low total rainfall of between 20 and 700mm, 83% evaporates, only 1% contributes to groundwater recharge and 2% can be harvested in surface storage facilities.

With a population growth of over 3% and a growing economy, water supply is becoming an increasing constraint for Namibia. Until the beginning of the 1990s emphasis has been placed on supply augmentation. Over the last 40 years surface water dams have been built to collect run off from ephemeral rivers. However, further supply augmentation is becoming increasingly expensive as the country has to look further afield for water. Water demand management (WDM), implemented to reduce demand rather than continue to augment supply, and non-conventional supply schemes have become important components in Namibia's integrated water resources management (IWRM) programme. The recently approved Water Sector White Paper reflects this and concentrates more on managing water resources.

As more research is conducted there is an increasing number of feasible and potentially feasible projects to conserve water and augment supply cost effectively. Windhoek has been the forerunner in IWRM in Namibia. This paper describes IWRM supply and demand side initiatives that have been adopted and which are being investigated for Windhoek and how these have been developed by a partnership of Windhoek Municipality, NamWater and the Department of Water Affairs. It then discusses the implications of current and future IWRM for Windhoek and the progress made in some aspects of IWRM in the rest of the country.

A CASE STUDY: WINDHOEK

Introduction

Urban growth in the capital city, Windhoek is high. Due to urbanisation pressures it has a population growth rate of approximately 6% per annum. Economically, politically, culturally and socially it is the most important city in Namibia. The country's parliament is located there and it is the capital for trade, industry, commerce, culture and education. At the beginning of the 1980s average water consumption was 600-700litres/person/day (l/p/d) in the affluent areas of Windhoek. IWRM was introduced in the early 1990s as a concerted effort to both reduce the level of consumption and increase the safe yield of Windhoek's water resources to meet increased demand. Considerable progress has been made to date, the current average water consumption having reduced to 180l/p/d, although this is still above average for African cities.

Areas of intervention

The areas of intervention for Windhoek's water supply concentrates on both supply and demand side measures. The different approaches for Windhoek now and in the future are presented below.

Supply side

Current sources of supply for Windhoek

Traditional water supply to Windhoek has come from groundwater in the Windhoek locality. Whilst Windhoek still gets some of its yearly supply from groundwater its main source is from the 3 dam system north of Windhoek. Table 1 summarises Windhoek's supply sources.

Table 1. The Supply of Water to Windhoek (1999).

Operator	**Water Source**		**Capacity (Mm^3/a)**	**Safe Yield (Mm^3/a)**	**Amount supplied (Mm^3/a)**
NAMWATER	Ephemeral Rivers	Omatako Dam	43.5	} 20	13.180
		Swakopoort Dam	63.5		
		Von Bach Dam	48.6		
	Groundwater	Berg Auchas Mine	-	3*	2.177
MUNICIPALITY	Ephemeral	Avis Dam	2.4	1.2	
		Goreangab Dam	3.6		
	Groundwater	Municipal Boreholes	-	2.3	
	Reclamation	Goreangab Works	-	3.6	2.424
		TOTAL	**161.6**	**30.1**	**17**

Source: Ben van der Merwe and Ben Groom (1999)

- **Integrated three dam system**

The 3 dam system was developed between 1970 and 1982. Of the three dams, the Von Bach is the nearest to Windhoek and the most efficient[1]. Water from Swakoppoort Dam bypasses Von Bach Dam and is pumped straight to the water treatment plant and used directly for Windhoek. The Omatako Dam, the smallest of the 3 dams and also the least efficient, is intended to store only a minimum amount of water and is used primarily for surface water catchment[2] and replenishing the Von Bach Dam. By operating the dams on such an integrated basis the 95% assurance of supply is increased from 13.7Mm³/a to approximately 20Mm³/a, a 42% increase in efficiency.

- **Groundwater**

Groundwater is Windhoek's traditional source of water. When settlers first moved into what is now Windhoek, there were springs in a number of places. However the Windhoek Aquifer has been depleted to the point where there are no longer springs. Over the long term the aquifer can sustainably supply 2Mm³/a of Windhoek's total water consumption. However in the short term and with conjunctive use it can supply as much as 6Mm³/a.

- **Reclaimed and reused water**

Windhoek was the first city in the world to reclaim its water back to potable water quality for use in the reticulation system. The first pilot plant, commissioned in the 1959, was followed by a full scale plant in 1960. The treatment process includes flocculation, sedimentation, flotation, filtration, ozonation and treatment with activated carbon. As a cost effective way of augmenting supply, Windhoek Municipality is currently constructing a new reclamation plant to increase the capacity from 3.6Mm³ to 7.5Mm³ of water per annum. In addition to reclaiming water back to potable standards, approximately 1Mm³ of semi-purified water is distributed from Gamanns sewerage works in a separate reticulation system for use in parks, sports fields and a golf course.

- **Kavango River/Karst Aquifer Pipeline schemes**

Investigations into conventional groundwater and surface water supply augmentation has been done and focus on two main schemes, water transfer from the Karst Aquifer, north east of Windhoek and from the Kavango River. The Karst Aquifer is divided by a natural ridge. The south eastern section is already in production with water drawn from Kombat and Berg Aukas mines and transported along the Eastern National Water Carrier (ENWC) into the Windhoek supply system via the Omatako Dam. The north western section is currently under investigation and would follow the same route with little extra infrastructure required. The Kavango scheme would involve the construction of a 250km pipeline also feeding into the ENWC. Because of their geographical situation these two supply augmentation schemes complement each other. However both are seen as expensive options[3] in comparison to other IWRM options, involving water transfers over 350km and 600km respectively.

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[1] Efficiency is measured as a ratio between depth and surface area. The amount of evaporation relative to capacity is subject to this ratio.

[2] With the addition of the Omatako Dam, the 3 dams cover two river basins with a total catchment area of 16 800km². Planners anticipated that this should increase the surety of supply by splitting the risks of drought in different river basins. The success of this strategy has been disappointingly limited since drought patterns in southern Africa stretch over very large areas, minimising the advantage.

[3] See table 6

- **Congo River Transfer scheme**

Due to sensitivities regarding the use of water from the Kavango River and the potential environmental impact on the Okavango Delta, alternatives that avoid influencing water flow to the Delta are being investigated as well. Many Southern African Development Community (SADC) countries experience or at least anticipate a shortage of water. For this reason a desk study is underway to determine the feasibility to transfer water from the headwaters of the southernmost tributaries of the Congo River such as the Kasai or Lualaba to the headwaters of the Zambezi or Kwando Rivers, possibly in cooperation with hydropower projects e.g. Nzilo.

- **Artificial recharge**

Artificial groundwater recharge is considered a potentially important part of IWRM for Windhoek. To cancel the effects of evaporation, groundwater can be an efficient way of storing water. As an estimated 35Mm³ evaporates every year from the 3 dam system there could be great benefit in preventing evaporation of even some of the water that is stored. At present, research is being conducted into the financial feasibility of artificial recharge in the Windhoek locality and the suitability of certain aquifers for water storage. Initial results suggest that artificial recharge of the Windhoek Aquifer is a feasible alternative to storing water above ground. Further studies are due to start this year on aquifers in the 3 dam system area and to the south of Windhoek. Table 3 shows the estimated amount of water saved over three years through artificial recharge, depending on the amount of water stored. This alternative for water storage could certainly postpone alternative, more expensive supply augmentation schemes, some perhaps indefinitely.

Table 2. Artificial Recharge and Total Saving in Evaporation Loss

Artificial Injection in First Year only (Mm³)	Saving in Evaporation Loss over 3 years (Mm³)	Total Saving* in Surface Water over Three Years (Mm³)
10.00	3.95	11.95
15.00	5.70	17.70

An allowance of 20% was made for losses in the aquifer during storage
Source: Ben van der Merwe and Ben Groom (1999)

- **Reduction in unaccounted for water levels**

An additional water conservation measure on the supply side is to reduce unaccounted for water levels that have traditionally accounted for a disproportionately high level of the total water supply in Namibia. At present, Windhoek loses an estimated 10%, a loss of 1.7Mm³/a[4], of its total water supply through leakages and poor maintenance of its reticulation system. This is relatively low in comparison to other municipalities in Namibia but is still a cause for concern. A study is currently underway to look at implementing WDM related maintenance programmes in municipalities throughout Namibia to try to reduce the extent of this problem.

Conjunctive use of water

The very low safe yield of the individual surface water sources is a direct result of the low efficiency of storage due to evaporation and the variability of rainfall. By augmenting or ‘backing up’ these sources of supply with other sources that are more reliable like a perennial resource, or at least not as affected by drought, existing sources can be utilised at a much higher risk, increasing their effective and safe yield dramatically. Table 3 illustrates how the

[4] Although it could be as high as 15%, a loss of 2.55Mm³)

safe yield of the dams increase from 12Mm³ to 20Mm³ by operating them on an integrated basis, which increases to 30Mm³ when the Karstland groundwater is fully utilized, and finally 40Mm³ once water is supplied from the perennial Kavango River. Groundwater is also important. In times of good rain, surface water can be used before the water evaporates as the predominant water source whilst saving groundwater for years of low inflow into the dams due to low rainfall. The table also shows the effects of non-conventional water conservation and supply initiatives such as artificial recharge and the increase of capacity at the Goreangab reclamation facility. Conjunctive use of Windhoek's water supply system is one of the key components of IWRM for Windhoek.

Table 3: Conjunctive Use of Windhoek's supply side schemes

SOURCE	**SUPPLY POTENTIAL Mm3/a**				
Windhoek Boreholes	2	2	2	2	2
Artificial recharge			1.5	1.5	1.5
Windhoek Reclamation	4	4	4	4	4
Additional reclamation plant capacity			3.5	3.5	3.5
Individual Dams (95% assured yield)	13.7				
Dams on Integrated Basis		20	20		
Dams with Karstland Water				30	
Access to Okavango River					40
TOTAL	**19.7**	**26**	**31**	**41**	**51**

Source: Piet Heyns

Demand side

Water Demand Management

One of the main components of IWRM and an important consideration in terms of conjunctive use, is WDM. A WDM policy was introduced in Windhoek in July 1994. Windhoek has seen a growth in total water consumption of 1.28Mm³, an increase of just 7.7% over 9 years against a population growth of approximately 60% since 1991. WDM measures can be broadly split into two areas:

- Market mechanisms and
- Direct interventions.

Table 4: Water consumption in Windhoek

Financial Year	**Total Water Consumption (Mm³)**	**Growth in water consumption (%)**	**Daily/capita residential consumption (l/p/d)**	**Total daily/capita water consumption (l/p/d)**
1990/91	16.72	-	201	322
1991/92	15.59	-6.8	201	283
1992/93	14.58	-6.5	167	251
1994/95	17.50	20[1]	161	271
1995/96	14.41	-17.7	136	211
1996/97	12.36	-14.2	117	179
1997/98	15.24	23.3	130	201
1998/99	17.69	16.1		
1999/2000	18.00	1.8		

1. This is over the previous two years

Source: Windhoek Municipality

- **Market mechanisms: block tariff structure**

A block tariff structure based on a system of volumetric charges has been implemented in at least four municipalities throughout Namibia. Windhoek was the first to approve a block tariff structure in 1991. In conjunction with other WDM measures this has met with considerable success in promoting conversation and more efficient use of water. Table 5 shows Windhoek's block tariff structure.

Table 5. The Block Water Tariffs in Windhoek

Water Consumption (m^3/month)	**Tariff** (N$/$m^3$) (June 1998)	**Tariff** (N$/$m^3$) (Dec 2000)
0-6	2.65	3.51
7-15	3.70	4.89
16-36	4.75	6.28
37-45	6.25	8.26
45+	8.15	10.77

Source: Windhoek Municipality

There are two main benefits of a block tariff structure can have. Firstly a block tariff structure can achieve full cost recovery of the water supply yet still keep the cost of water affordable[5] for low income groups. It achieves this through the cross subsidisation of water from rich to poor. The wealthier part of the population are characterised more by those who have large gardens to water, swimming pools to maintain and more cars to keep clean. Therefore these will be people who demand more water. Secondly this pricing structure, as it increasingly punishes higher water consumption, encourages more efficient, careful use of water by consumers because the less water they use the less the average cost of each unit.

The structure of the block water tariff has a significant impact on water conservation. The more a unit of water costs, the less a rational customer will consume. The degree to which this is the case is dependant on the Price Elasticity of Demand[6] (PED) In terms of water conservation in conjunction with keeping the lowest block affordable but still achieve full cost recovery, this is very important. Block water tariffs have proven to be an important component of WDM. It is also a relatively flexible tool and works towards three policy objectives of WDM, namely full cost recovery, affordability, and water conservation. In addition the more efficient the use of water, the larger the population that Windhoek's water supply system can support, thus contributing to the conjunctive use of the supply system.

[5] Affordability is defined as the minimum amount of water required for human consumption not costing more than 5% of a person's income.

[6] $\text{PED} = \dfrac{\%\text{ change in quantity}}{\%\text{ change in price}}$

- **Direct interventions**

The main components of these measures are summarised in Box 1.

Box 1: Water Demand Management Direct Interventions

POLICY-policies approved and implemented in Windhoek
Maximum reuse of water: including semi-purified effluent for irrigating municipal areas and recycling of water to potable standards **Plot sizes**: reduced for new developments and higher density housing encouraged for existing developments **Urbanisation**: guidelines have been developed to efficiently supply water to growing population. **Reduction of municipal water use**: for public gardens etc. reduced by 50%. **Wet industries**: guidelines given to promote efficient water use in wet industries and re-use of water by new wet industries

LEGISLATION
Compulsory water efficient equipment: metering taps in hotels, taps outside non-residential building to be self closing or lockable, toilet cisterns must be dual flush units, automatic flushing devises prohibited; replacement of inefficient devices within 3 years. **Groundwater**: monitoring of abstraction and groundwater levels controlled. **Gardens**: watering prohibited between 10.00 and 16.00 **Swimming pools**: must be covered when not in use **Prevention of pollution**: regular testing of underwater tanks mandatory and all tanks to be registered
TECHNICAL MEASURES
Lowering of unaccounted for water: leakage detection carried out, repair programmes in place, water audits undertaken, proper management of meters, and systematic pipe replacement programme. **Efficient watering methods**: proper irrigation systems for municipal gardens, advice given on efficient watering methods
PUBLIC CAMPAIGNS AND AWARENESS
Education programmes: lectures in schools and other educational institutions, use of radio, television and local media, pamphlets on water saving ideas distributed with water bills. **Consumer advisory service**: advice on water related issues an information on leak detection. **Advice of efficient gardening methods**: including suitable flora and efficient watering techniques **Community empowerment in formerly neglected areas**: training of community based plumbers and gardeners

Source: Ben van der Merwe and Ben Groom (1999)

Comparison of financial implications of IWRM measures for Windhoek

Table 5 shows the difference in unit cost between some the schemes presented above. As can be clearly seen, traditional supply schemes and conventional supply augmentation are generally more expensive that alternatives supply sources and non-conventional supply augmentation. This provides the financial impetus for introducing IWRM in Windhoek and potentially the rest of Namibia.

The progress of WDM in other areas of Namibia

Block water tariffs have been implemented in other areas in Namibia. Table 7 shows the municipalities that had introduced a block water tariff system by 1998.

In a survey as part of the IUCN WDM country study, it was found that measures considered part of a WDM initiative have been introduced in 79% of municipalities surveyed. However, only 30% of the municipalities or towns have introduced 3 or more projects. As has been shown in Windhoek, for WDM measures to have significant effect, it is important to implement a range of different measures. But perhaps the most serious problem in many municipalities is the level of unaccounted for water. A level of 30%+ was recorded in 1998 in at least 5 municipalities and the majority of municipalities surveyed lose substantially more than 10% of their water supply.

Table 6: Comparison of supply costs between different schemes in Namibia

Water Schemes	**Cost per unit (N$/m³)**
Current water supply schemes	
NamWater cost recovery tariff	3.17
NamWater bulk tariff	2.40
Goreangab (existing plant)	2.35
Boreholes	1.15
Purified Effluent	1.57
Conventional supply augmentation	
Okavango pipeline scheme	8.50
Tsumeb Karst Aquifer	N/a
Congo River Pipeline Scheme	N/a
Unconventional supply augmentation	
Goreangab (new plant)	2.80
Artificial Recharge	1.25

Source: IUCN WDM Country Study, 1998

Table 7: Municipalities which have adopted a block water tariff structure (1998)

Town	**Municipal Block Tariff Range 1998** (N$/M³)
Windhoek	2.65 – 8.15
Henties Bay	2.60 – 3.20
Okahandja	1.95 – 5.00
Swakopmund	2.25 – 4.50
Tsumeb	2.25+
Walvis Bay	2.16 – 8.54

Source: IUCN WDM Country Study, 1998

CONCLUSION

As Namibia’s population grows and economy develops, IWRM initiatives are becoming more and more important in terms of conserving water, promoting efficient water use and cost effectively augmenting supply through the conjunctive use of water supply systems. This discussion on Windhoek’s IWRM policies and initiatives show the success these have had and could potentially have in meeting and managing the growing demand for water and enhancing Windhoek’s water supply system. The successes of using such IWRM initiatives as WDM and water reclamation measures are important lessons for the rest of Namibia. Whilst some progress has been made in implementing WDM measures and using reclaimed water in some municipalities there is considerably more that can be done to conserve water and use it more efficiently. This remains one of the many challenges for Namibia.

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