Building Awareness and Overcoming Obstacles to Water Demand Management

Guideline for river basin and catchment management organisations

Abbreviations and acronyms

CMO	Catchment Management Organisation
FAO	Food and Agriculture Organization
NGO	Non-Governmental Organisation
SADC	Southern Africa Development Community
WDM	Water Demand Management

Preface

Table of contents

1 INTRODUCTION

1.1 Target readership

This guideline is aimed at the following:

- River basin and catchment management organisations (e.g. Catchment Councils, Zimbabwe; Zimbabwe National Water Authority; Catchment Management Agencies, South Africa);
- National and regional multi-national government water sector policy makers and legislators (e.g. Department for Water and Rural Affairs, Zimbabwe; Department for Water Affairs and Forestry, South Africa).

1.2 Objectives of this guideline

1.2.1 Primary objective

The primary objective of this guideline is to provide a framework for implementing integrated WDM programmes at a river basin or catchment level.

1.2.2 Secondary objectives

Secondary objectives include:

- Targeting and prioritising investment in WDM at a river basin or catchment level;
- Improving water use productivity and efficiency at the same level;
- Reducing capital investments in large-scale infrastructure projects;
- Improving the equity of water allocation and charges;
- Assisting in the provision of the basic water needs for all;
- Helping with conflict resolution;
- Improving the sustainability of water use.

2 BACKGROUND TO INTEGRATED WDM AT A RIVER BASIN SCALE

2.1 Introduction and definitions

River basins and catchment areas have long been recognised as a useful rational unit of analysis for water management. Recently the role of transboundary river management organisations has become increasing important. Examples of such organisations in the Southern African Development Community (SADC) include:

- The Limpopo River Commission (LIMCOM);
- The Okavango River Basin Commission (OKACOM);
- The Orange-Senqu River Basin Commission (ORASECOM);
- The Zambezi Watercourse Commission (ZAMCOM);
- The Tripartite Permanent Technical Committee (TPTC) formed by the Mozambique, South Africa and Swaziland to manage the Incomati and Usutu River Basins.

At a national level Catchment Management Agencies are being created in South Africa, and Catchment Councils have been set up in Zimbabwe. With recent developments in water management policy and legislation it is anticipated that such institutions will, in the foreseeable future, cover the entire SADC region.

Many of the current water management institutions in the SADC region tend to focus too narrowly on integrated water resource management without realising how integrated Water Demand Management (WDM) can assist them in their work. The purpose of this guideline is to provide a framework within which integrated WDM programmes can be implemented at a river basin or catchment management level to assist water management institutions with their work.

As competition for available water between different users increases, WDM needs to be approached in an integrated manner at a river basin level to be effective. Even before this stage is reached, integrated WDM can help free up water for additional users and thus significantly reduce the cost of supplying both domestic and productive water to those currently without.

Box 1 Definitions of a river basin and river catchment

River basin: An area bounded by a single watershed and a final saline water sink at its lowest point or, uncommonly, an area bounded by a single watershed without a final sink, including all the surface and groundwater resources contained therein.

River catchment: An area containing a river basin, or a portion of a river basin with a common outlet system, or an area containing a number of river basins. For administrative purposes, large river basins and multi-national river basins are often divided into a number of catchment areas whereas a number of small river basins may be combined into a single catchment area.

2.2 The WDM functions of river basin and catchment management organisations

As indicated in other guidelines in this series, all water supply institutions and end users can benefit from implementing WDM. To be effective river basin and catchment management organisations will have to encourage co-operation between stakeholders and many WDM functions need to be assigned to other more decentralised institutions. Thereafter, river basin and catchment management organisations will be able to add value to the WDM initiatives of these water services and user organisations by integrating information received from them and by being able to highlight where weaknesses and deficiencies exist. An overview of WDM functions relevant to catchment management organisations is given in Box 2. The content of the box is not meant to be definitive, rather it is intended to be a guide to encourage readers to consider what would best suite their regional circumstances.

Box 2 WDM functions of river basin and catchment management organisations

- Develop an integrated WDM implementation and monitoring strategy;
- Licence and regulate water use and wastewater discharges;
- Update water usage and effluent discharge regulations;
- Review licence conditions regularly and make amendments where necessary;
- Authorise the development of new resources in strict compliance with all the WDM related recommendations in the World Commission on Dams report (Reference 1), and all other regional agreements and National policies and legislation;
- Temporarily control, limit or prohibit the use of water during periods of water shortage;
- Monitor, audit and support the WDM and pollution control work of all water services institutions and relevant water users within its area of jurisdiction;
- Enforce licence operational and reporting conditions;
- Require water supply organisations and water users to invest in WDM and/or pollution control management systems and/or infrastructure;
- Where appropriate, support stakeholders in their quest for grants, subsidised loans, or operational subsidies to implement WDM initiatives or to support improved equity;
- Co-ordinate and promote WDM activities through hosting or attending water forums to be attended by politicians, water management and services delivery institutions, and community based organisations and water users;
- Be the guardian of a uniform and flexible information management system that contains ongoing historical and up-to-date information on the water management and financial performance of all water services institutions within the basin or catchment management area;
- Promote a greater understanding of the interaction between surface water and groundwater to enable the best conjunctive usage (Reference 2).

All the above functions should be carried out to conform to the aims of this guideline as set out in Section 1.2.

(Source: Adapted from Reference 3)

The functions in Box 2 cannot be implemented without the necessary financial and human resources. National legislation should ensure that an appropriate funding mechanism is in place for these organisations.

2.3 Potential responses to water shortages

As demand for water grows in a river basin, water shortages may occur. This prompts users, managers, and in some instances policy makers, to adjust their behaviours and strategies. These adjustments are extremely varied and come under the following categories:

- Augmentation of supply;
- Reallocation of water;
- Management of demand.

Figure 1 brings together some of these strategies as employed by the agricultural sector. It also distinguishes between those that are implemented by individuals and those that are implemented collectively by both user associations and public entities).

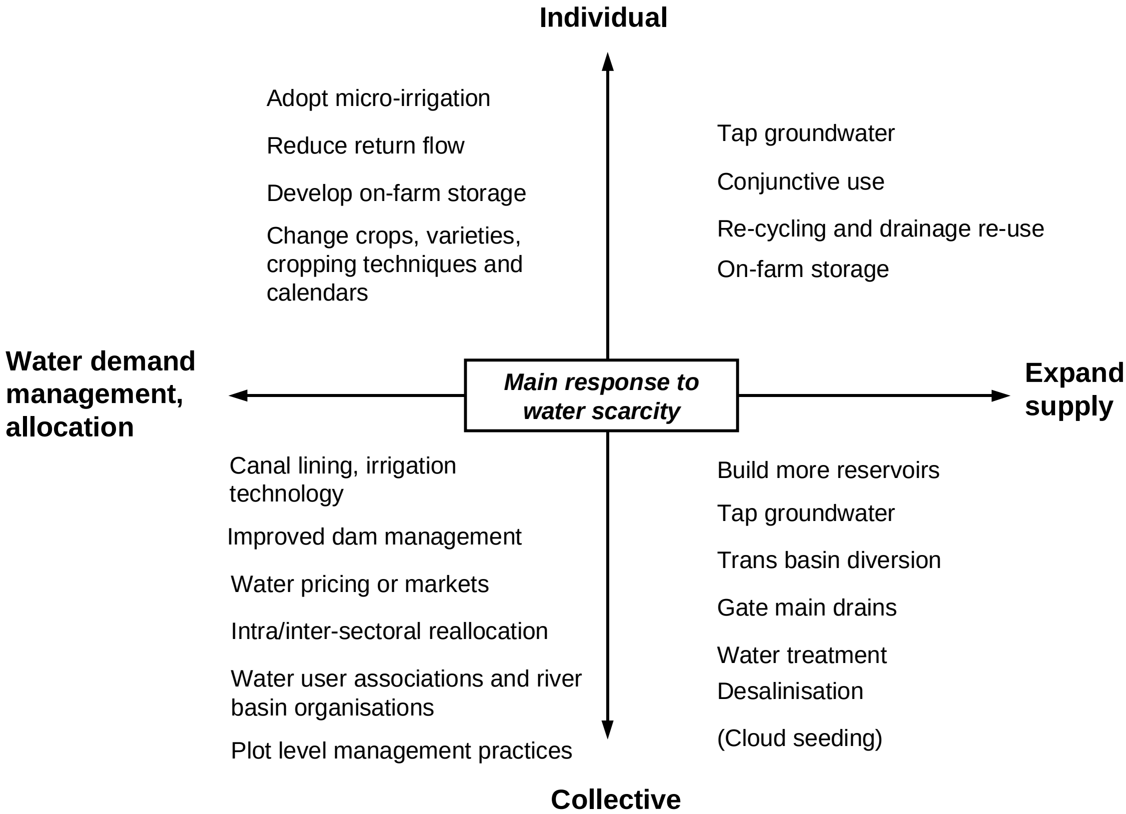


Figure 1 Responses in the agricultural sector to water scarcity and increases in demand

Often the collective and individual responses to water scarcity or increases in demand are supply side orientated. At a river basin level it is rare that water management organisations look to WDM strategies as a solution to their problems.

These Guidelines respond to the need to address WDM at a macro-level. The Guidelines assume the pre-existence of institutions, policies, strategies, legislative and economic instruments that can be employed to implement integrated WDM in a river basin. At the outset it is important to realise that there is no one integrated WDM programme that is universally applicable. Each river basin is unique and as such will require a specific solution. For integrated WDM to be successful, it is crucial that it becomes part of water management strategies that have previously focussed exclusively on water supply management.

2.4 Water losses at a river basin scale

Before an integrated WDM strategy is employed at a river basin level water managers should have an overview of the relationship between water sources and the demand centres within the basin.

A river basin can be considered to be made up of:

1. Sources e.g. rivers, reservoirs and aquifers;

2. Demand components including off-stream (e.g. irrigation schemes, municipal and industrial users) and in-stream (e.g. hydropower and the environment);
3. Intermediate components such as treatment plants and distribution systems.

River basins are inherently complex systems. The simplified relationship between the above components is shown in Figure 2.

The objective of an integrated WDM programme is to minimise water losses and to improve equity and water use efficiency. Water losses at a basin level can be categorised as follows:

- Loss of water to the atmosphere via evaporation from surfaces and the evapotranspiration of plants;
- Discharge of water to saline "sinks" such as oceans, inland seas and saline aquifers;
- Pollution of surface water and groundwater so that they become unusable;
- Loss of water to "economic sinks", where water percolates into the groundwater or other freshwater sinks, so it becomes uneconomic to recover;
- Incorporation of water into products e.g. inclusion of water into soft drinks or in plant tissues (irrigation) (Reference 4).

It is important to note that direct river and groundwater flows into oceans perform many important ecological functions in relation to protecting the environment and therefore need to be considered separately from unintended water losses.

2.5 Water use efficiency

Different definitions of efficiency can be used, depending on the objective to be achieved. The reason why efficiency is important is that water is a finite and often scarce resource. Generally, efficiency measures how much one can do with one unit of water. Economic efficiency or water productivity could measure the benefits derived from a unit volume of water used. Water use efficiency measures the proportion of water actually used for a given use.

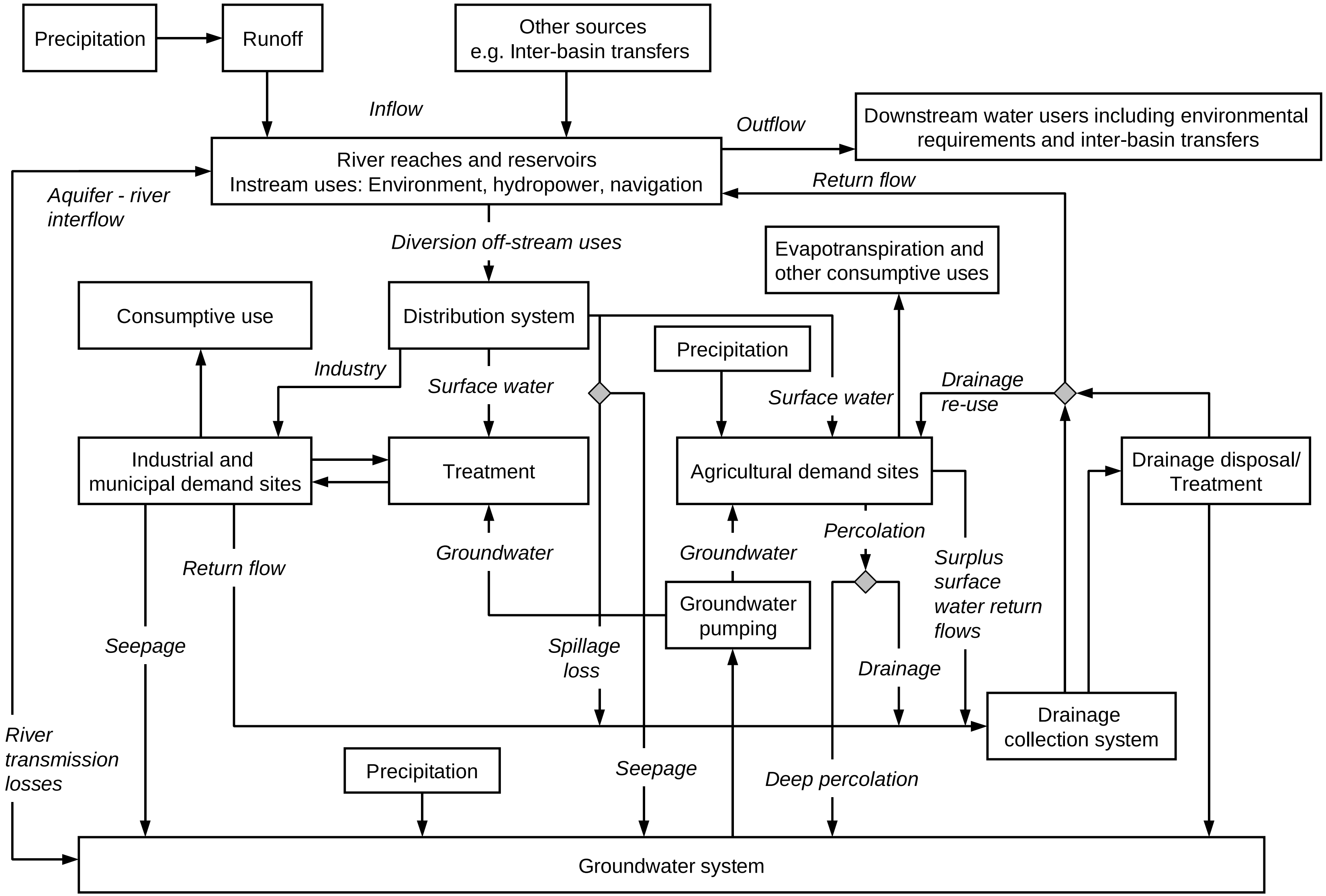
Box 3 Definitions of water use efficiency and water productivity

Water use efficiency may be defined as the ratio of the effective or useful output to the total input in a system. For example, in irrigated agriculture, the overall water use efficiency can be defined as the ratio of the crop water requirements (minus the precipitation) to the amount of water diverted from a river or reservoir to satisfy that need. Improvement in the efficiency of water use is related to WDM since it increases the fraction of water used beneficially.

Water productivity is generally defined as physical or economic output per unit of water application.

It is important to realise that water use efficiency is scale-dependent. In some river basins, where water is already fully allocated, efficiency gains from particular demand sectors may be limited. This is because the river basin water use efficiency may already be high owing to the re-cycling and re-use of drainage water, even though individual water users may be inefficient.

For example a river basin may contain several large irrigation schemes, each of which only achieves a water use efficiency of 50%, implying that half the water is "lost" from each scheme. However, part of this water may return to the river and be



(Adapted from Reference 4)

Figure 2 Schematic diagram of river basin processes

available to a downstream user. At the scale of the basin therefore, it is only the water transpirated by the crops that can be considered a loss. The overall efficiency of the basin may be as high as 80% to 90% owing to the re-cycling of irrigation return flows. For example, estimates of overall water use efficiencies for individual irrigation schemes in the Nile river basin in Egypt are as low as 30%, but the overall efficiency for the entire Nile system in that country is estimated at 80% (Reference 5). However, it must be recognised that that the re-use of water in this way may have important adverse effects. For example energy may need to be expended in pumping and the quality of the resource will normally be degraded.

Even if the river basin efficiency is greater than the efficiency of individual irrigation schemes, **the natural recycling of water within a river basin, which can be associated with a degradation in water quality, is not an alternative to implementing demand management measures.** This is because, in most cases, demand management measures will save money, improve the environment and the social equity of water distribution at both a sub-river basin and a river basin level.

Box 4 Definition of equity

Equity can be defined as providing everyone with a fair and equal opportunity in the utilisation of a resource according to one's needs. Equitable access does not necessarily mean access to equal quantities but rather equal opportunity to access water. Equity does, however, also deal decisively with the resultant distribution of wealth and resources among sectors and individuals of society. Hence it means that everyone must have access to sufficient water to cover their basic domestic and productive needs at a price they can afford.

2.6 Scale and boundary conditions

Reduction of water losses often has a high priority in attempts to balance demand with supply. However, because water use efficiency is scale-dependent, it is important that water losses should always be carefully and precisely defined. Whether water is considered a loss or not is dependent on the scales and boundary conditions. For example at the global scale no water is ever lost! (Reference 6).

In many situations, and especially in irrigated agriculture, a reduction of water losses may not free up the "saved" water. Even "real" water losses, such as transmission losses that occur when water is released from a dam and conveyed by a river to a downstream user, may provide an important service (e.g. recharge of aquifers and water for the environment). Once such services are recognised and formalised into permits (or in an "environmental reserve", as has been done in South Africa), the water manager may sometimes be able to find solutions that are advantageous to a number of different parties. In other cases this may not be possible. Analysis of water losses should therefore always:

- Clarify the scale and boundaries at which the analysis is done;
- Acknowledge both the consumptive and non-consumptive parts of the water use under consideration;
- Consider any other type of use (including the environment) that may benefit from the water "lost".

Any integrated WDM initiative that does not encompass the entire river basin runs the risk of being affected by upstream uses and in turn impacting on downstream uses. Since most river basins in southern Africa are large in extent, and often shared by more than one country, the water management initiatives are normally fragmented into sub-catchment areas which form part of the larger catchment. In such cases, both the allocation process and integrated WDM initiatives must include boundary conditions; i.e. a specification of water requirements at the inlet and at the outlet of the river basin area under consideration. Even for a river basin with an estuary as its downstream boundary, boundary conditions will be needed to minimise salt intrusion, and/or to ensure the health of the estuary for environmental, social and/or economic purposes (e.g. for mangrove forests and prawn fisheries) (Reference 7).

Box 5 Consumptive and non-consumptive water use

The distinction between **consumptive** and **non-consumptive** use of water is a critical aspect of effective water management. **Consumptive** use of water means that no water is returned to the water source from which it was withdrawn; the water is consumed and is not available for use by other water users downstream. **Non-consumptive** water use means that, after use, the water is returned to the source for use by others downstream.

The importance of the distinction between the two types of water use is their effect on downstream water users. Non-consumptive water use returns the water to a watercourse for renewed use by other water users downstream, provided it does not cause pollution that could further reduce the available water, though making existing water resources unfit for users downstream unless costly remedial treatment is undertaken.

Consumptive use means the water is not returned to the watercourse, reducing the water available to downstream water users.

2.7. Objectives of Integrated WDM at a river basin scale

The objectives of integrated WDM can be summarised as:

- Ensuring equity;
- Increasing output per unit of evaporative loss of water;
- Increasing the utilisation of water before it reaches salt sinks;
- Reducing water pollution;
- Reducing the loss of water to uneconomic sinks;
- Restoring the water in economic sinks to use.

Box 6 Overall objective of integrated WDM at a river basin scale

The overall objective of integrated WDM at a river basin level is to minimise water losses and to improve river basin water use equity and efficiency.

3. BACKGROUND TO THE MAJOR USER DEMAND SECTORS IN THE SADC REGION

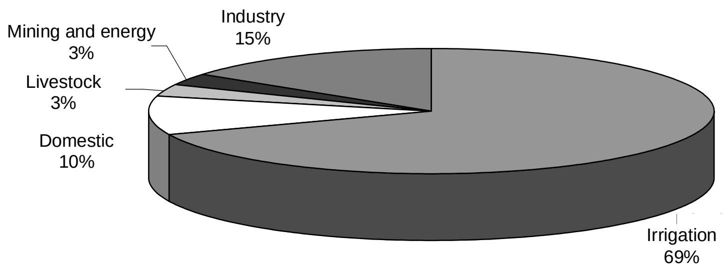
Before an integrated WDM programme is undertaken it is important that there is a good understanding of the major end users within the river basin. Figure 3 shows the estimated water use in southern Africa for the years 1995 and 2020. Irrigated agriculture is by far the largest user of water, followed by industry. The sections below provide background to the various demand sectors.

3.1 Large scale irrigated agriculture

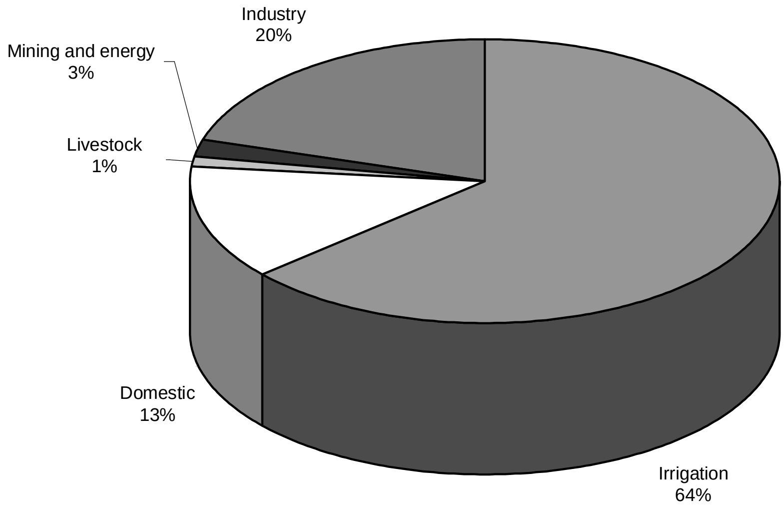
Large scale irrigated agriculture is an important activity in southern Africa in terms of food security, economic activity and water use. It plays an important role because it is generally two to three times more productive than rain-fed agriculture, and because irrigation uses approximately 70% of the region's water supplies. It has been estimated that about 1.8 million hectares in the SADC region are under irrigation. This is approximately 7% of arable land in the region. Irrigation is largely reserved for high value crops such as fruits and vegetables, however, irrigated sugar cane alone occupies 292,000 ha (Reference 7). The water use efficiencies of irrigation schemes in southern Africa are low ranging from 20% to 60%. Even without the land reform required in all the SADC countries, improved efficiency could make essential basic needs water available to existing poor subsistence farmers.

3.2 Domestic

The domestic demand sector can be spilt into urban and rural components. In many African cities, urban water demands are often non-homogeneous owing to a range of levels of service within the same urban area. Levels of service can vary from household connections to standpipes or to no service at all. Figure 4 shows the percentage of the population in African cities served by various water sources. This figure was produced from data collected from 43 African cities including the following urban areas in southern Africa: Dar Es Salaam, Gaborone, Harare, Luanda, Lusaka, Maseru, Maputo, Port Louis and Windhoek.



Estimated water consumption in the year 1995 32,120 million m^3



Estimated water consumption in the year 2020 81,545 million m^3

Source: Reference 7

Figure 3 Estimated water use for southern Africa

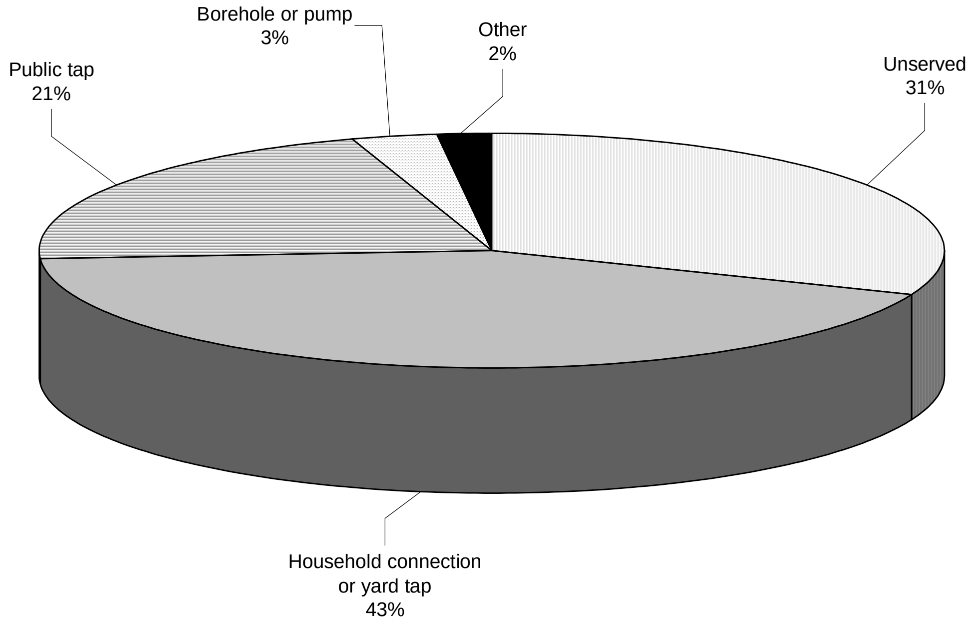


Figure 4 Source of water supply in large African cities

Many rural areas in the SADC region have no formal water supply schemes. They are typified by:

- Lack of physical infrastructure (i.e. a low level of service). There is often no piped water system or water borne sewerage. Water sources are commonly rivers, hand dug open wells or boreholes;
- Significant amounts of time are spent collecting water.

As a consequence, in many rural areas of the SADC region water use would increase considerably if the level of service were improved.

3.3 Industry

In most of the SADC region, relative to the primary sectors (i.e. domestic and the environment), water use by “wet” industries is economically efficient and quantitatively insignificant compared to other water demand sectors. However, effluent discharge from industries is significant. A levy on the discharge of industrial effluents could be a more beneficial means of achieving WDM in the manufacturing sector than increases in the water supply tariff.

3.4 Environment

The environment is increasingly being considered a legitimate water user in many SADC countries. As a consequence the water requirement of the environment needs to be estimated. The amount of water that will be allocated to the environment is a decision made by society, and is to some extent arbitrary. The quantity of water allocated to the environment will always be less than what would ideally be required to restore the natural, undisturbed, flow regime of a river. Society, therefore has to weigh the potential costs and benefits to the environment and to all other water users, of allocating (or not) a certain amount of water to the environment and of ensuring pollution is adequately managed.

3.5 Other uses

3.5.1 River transmission losses

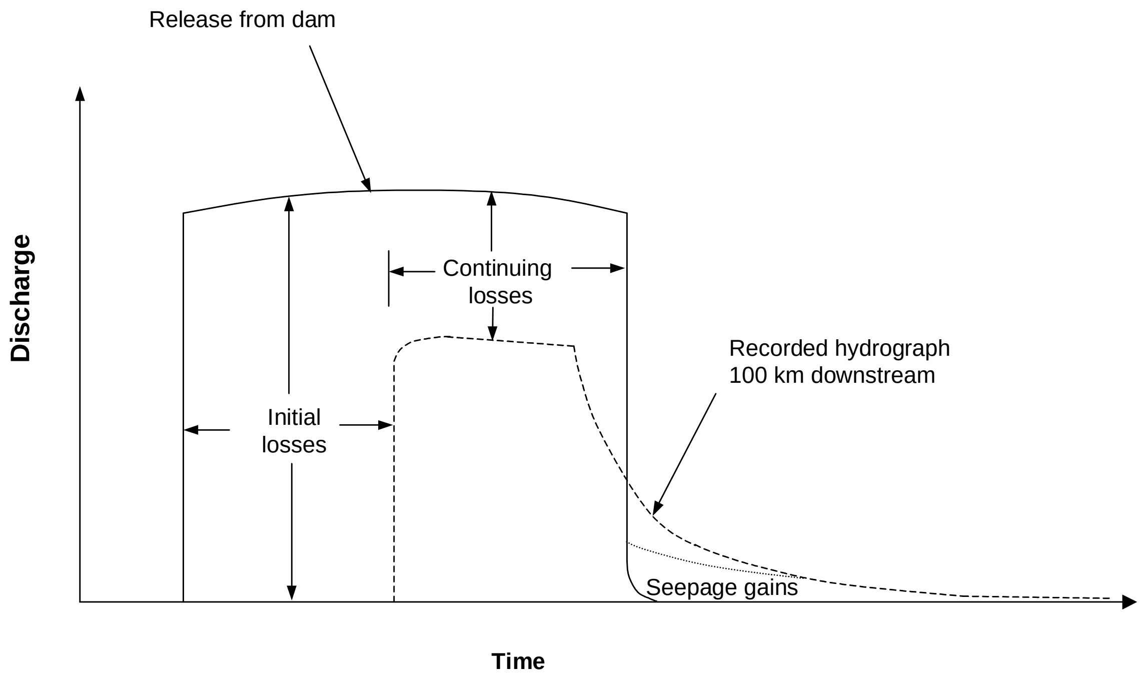
In southern Africa, to optimise the use of water resources, river flows are often regulated via dams, not only between seasons, but also often over periods of more than one year. Ideally, these dams are located close to the point of use. However, in many cases this is not possible for physical and economic reasons. Water often has to be conveyed over long distances via natural watercourses. This method of conveyance is inexpensive but it can result in significant losses, particularly in sandy rivers that do not have a perennial flow. When assessing water use at a river basin level these losses must be taken into account. The losses be categorised as follows:

- Natural losses:
  - Evaporation and transpiration;
  - Seepage from bed and bank storage;
- Artificial losses:
  - Domestic abstractions;
  - Industrial abstractions;
  - Agricultural abstractions.

Losses caused by evaporation from open water surfaces and by transpiration from riverine vegetation are often relatively small. The majority of transmission losses consist of two components shown in Figure 5. These are:

- Initial losses that occur at the front end of the release wave in filling up pools and saturating the river bed;
- Continuing losses, caused by evaporation and bed and bank seepage, that occur after the initial wetting of the bed has taken place and a steady flow has been established.

The river losses can, in some cases, be offset by "seepage gains" as water stored in the river banks seeps back into the river after the release wave has passed and the channel storage has been depleted.



Source: Reference 8

Figure 5 River transmission losses

3.5.2 Hydropower

Hydropower water use can be defined as the quantity of water used by a power plant where the turbines are driven by falling water. In most cases, the hydropower facility will be located in the channel of the watercourse, often at a dam (e.g. Kariba Dam in Zimbabwe). The water used by these types of facilities is considered to be an instream or non-consumptive use.

3.6 Priorities for water use within a river basin

When implementing an integrated WDM programme, it is important that the priorities for water use within the river basin are taken into account. Water laws often stipulate priorities for different types of water use, distinguishing between various sectors e.g. primary use (e.g. human consumption), environmental use, industrial use, agricultural use, water for hydropower.

In most countries, water use for primary purposes has priority over any other type of water use. Some countries also specify a priority for the remaining uses, whereby the most important economic use in that country normally receives a preferential supply. In other countries, all uses of water other than for primary (and sometimes environmental) purposes have equal standing. In times of water shortage, the amount of water allocated to all non-primary uses will be decreased proportionally, so that all these users share the shortage equally.

In some countries water laws may provide detailed stipulations that have a direct bearing on the allocation of water. For example the law may stipulate, for instance, that the allocation of water should be equitable. In other countries, in contrast, the law directs that water rights for particular sectors or abstractors have priority over others. In most cases, however, the legal framework does not provide a detailed "recipe" of how water should be allocated. Water managers may therefore have to interpret the more general rules for day-to-day allocation decisions. In many countries water managers may not be able to do this without consulting all the relevant stakeholders.

4. BENEFITS OF INTEGRATED WDM

In order to implement integrated WDM river basin managers must be able to quantify and establish the benefits of implementing an integrated WDM programme.

Box 7 Benefits of implementing an integrated WDM programme

- Postponement of capital investments;
- Improvements in the equity of water allocation;
- Increased water use efficiency and productivity;
- Conflict resolution;
- Improvements in the environment.

The establishment of a balance between water availability and demand, in the context of increasing water scarcity and the concurrent growth of multi-sectoral water requirements, cannot be achieved cost effectively, if at all, without WDM, especially in the irrigation sector. WDM should take account, not only of the technical aspects linked to the improvement of agricultural water use efficiency, but also of elements giving an incentive to better economic valuation and use of water. The results of failing to implement` an integrated WDM programme in river basins where water is fully allocated, population growth is high and water is unwisely managed are shown in Figure 6.

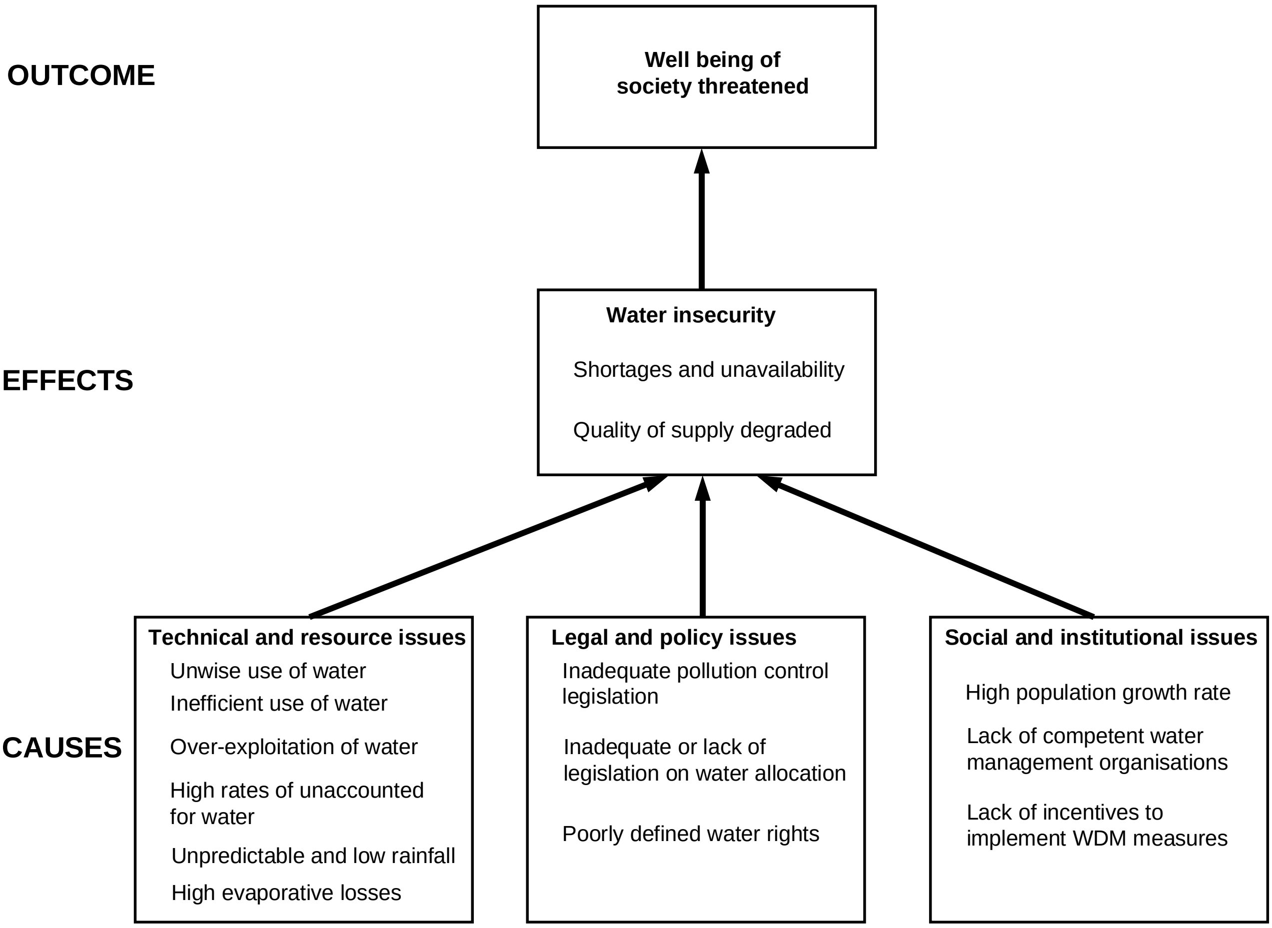


Figure 6 The effects of not implementing an integrated WDM programme

4.1 Postponement of capital investments

An integrated approach to WDM can lead to significant savings in capital investments. Figure 7 shows how the introduction of WDM measures can affect the timing of construction of new water supply infrastructure such as dams and boreholes, so delaying these capital investments. If, for example an integrated WDM programme resulted in a capital investment project being delayed by 12 years the resultant saving would be the difference in the net present values of building the infrastructure in 12 years, time rather than the present. However, the postponement of capital investments should not take place without sound demand forecasting. Such forecasting should be based on an understanding of the main components of the demand, rather than on the simple extrapolation of past records. In Namibia, the city of Windhoek was able to "produce" water through its WDM programme at a cost of US$0.10 per m^3 whereas the estimated cost of water from the proposed pipeline from the Okavango River is approximately US$1.80 per m^3 (Reference 9).

For Africa the average investment cost for medium and large-scale irrigation with full water control was estimated in 1992 to be US$8,300 per hectare. However, the average cost of irrigation systems in sub-Saharan Africa increases to US$18,300 per hectare if the typically high indirect costs of social infrastructure, including roads, houses, electrical grids, and public service facilities, are included (Reference 9). Hence any WDM that can postpone investment in irrigation infrastructure can result in considerable economic savings.

Box 8 Lesotho Highlands Water Project - Benefits of delaying investment in capital infrastructure

The Lesotho Highlands Water Project is designed to fully exploit the wet season rains in the mountains of Lesotho and redirect them to Gauteng in South Africa. The project comprises:

- The construction of five major dams;
- 200 km of transfer tunnels;
- 72 MW hydropower station.

The entire scheme has been estimated to cost $US8,000 million. Most of the funding has been raised within South Africa, with a large part coming from a levy on existing water users.

When the Lesotho Highlands Water Project was planned in the 1980s, WDM measures were not taken into account when the water demand projections for Gauteng were carried out. The implementation of effective WDM measures in the Gauteng area would have greatly delayed the implementation of the project and saved millions of dollars. It has been estimated that by reducing urban and agricultural consumption by 20% nearly 9,000 million m^3 of water would be saved per year. This is equivalent to ten times the expected combined yields of the two dams built to date. At the time the decision was made to implement the Lesotho Highlands Water Project, many political and social constraints existed in South Africa. This meant that any WDM programme implemented in Gauteng might not have been successful, leading to a shortfall in water supply and significant economic ramifications.

(Source: Reference 9)

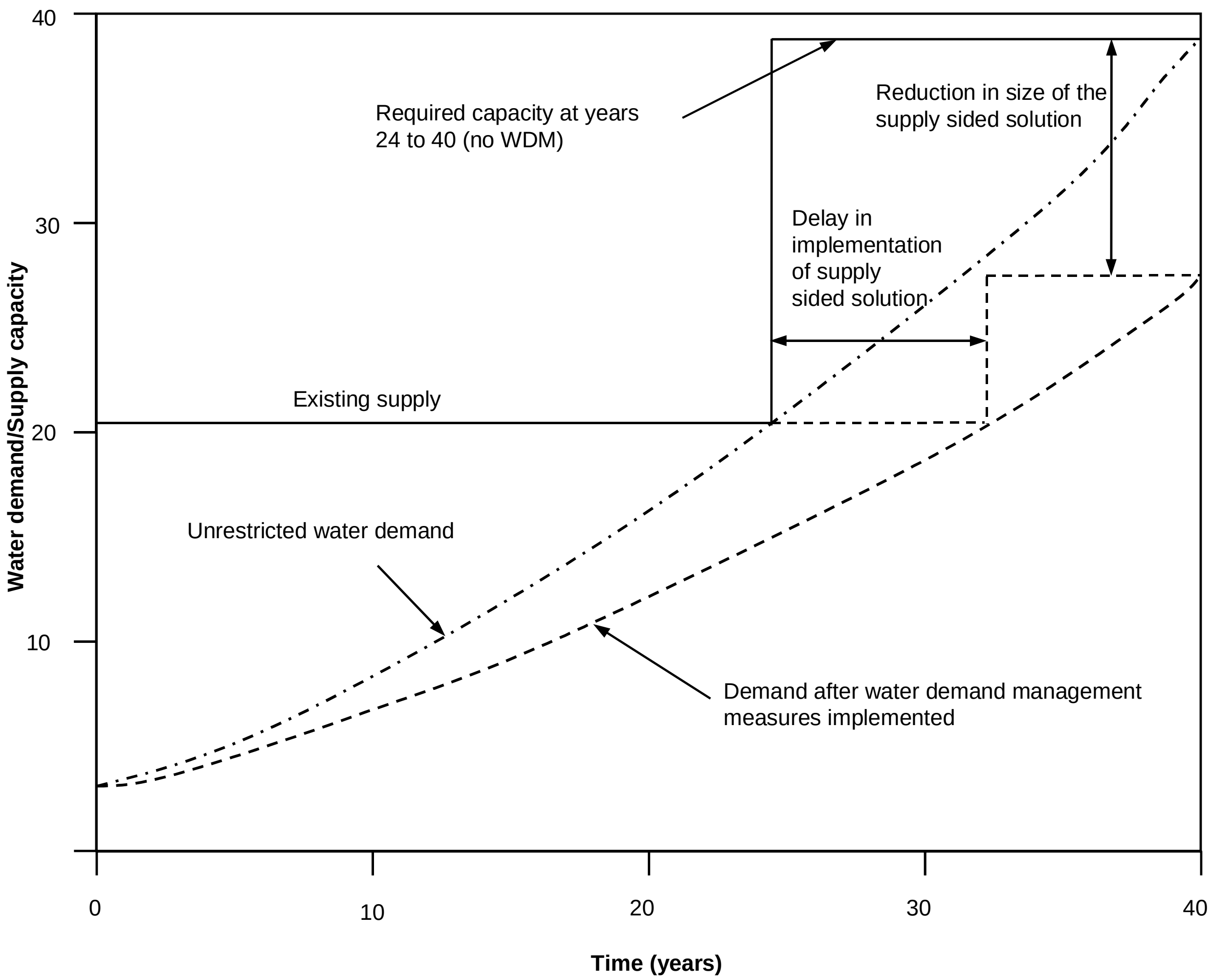


Figure 7 The effects of WDM on capital investments

4.2 Improvements in the equity of water allocation

Inequitable allocation of water and ill-defined water rights can pose a major obstacle to efficient management of water and limit the prospects of poverty reduction through economic growth. The introduction of an integrated WDM programme can assist in improving the equitability of water use within a basin encouraging improvements in the efficiency of large water users, such as large irrigation schemes so as to:

- Benefit communities who previously did not have access to water;
- Stimulate economic growth by allocating water to sectors producing high value goods.

Box 9 Improvements in water allocation resulting from integrated WDM

A new factory in Guanajuato in Mexico required 1 m^3/s in an already over-committed river basin. In order to "free up" this water, the factory paid for 100 farmers to invest in a drip irrigation system, saving 40% of the water that was previously used. The water that was saved provided sufficient water to supply the factory and employment for local communities.

Source: Reference 3

4.3 Increased water use efficiency and productivity

An integrated WDM programme can result in significant improvements both in the efficiency and productivity of water use. Opportunities for improving river basin water use efficiency are illustrated by the following examples.

Box 10 The effects of inefficient water use in southern Africa

- Nearly half the water in urban areas of South Africa is wasted through water loss or inefficiency;
- Irrigation represents 69% of total consumption in southern Africa but is estimated to be only 50% efficient;
- If irrigation practices were only 10% more efficient across the region, 2500 million m^3 of water could be saved a year
- If urban water use across the region could be made 10% more efficient more than 600 million m^3 of water could be saved per year;
- The above savings could supply every person in the region who is currently unserved with more than 100 litres per day.

Source: Reference 9

Box 11 Improved water use efficiency using drip irrigation in Cape Verde

In the early 1990s an FAO funded project sought to develop horticulture in Cape Verde. The project was a success but its extension was limited by the availability of water - average precipitation on the islands is about 230 mm/year, providing little more than 700 m^3/person/year. Drip irrigation was then introduced, first in experimental plots and then in farmers' fields. The new system increased production and saved water, allowing for an expansion of the irrigated land and cropping intensity. Convinced by the experiment, many farmers spontaneously adopted drip irrigation on their land. In 1999, six years after the first experiment the following had been achieved:

- 22% of the irrigated area of the country had been converted to drip irrigation;
- Many farmers had converted their crops from water-consuming sugar cane plantations to high-return horticultural crops such as potatoes, onions, peppers and tomatoes;
- Total horticultural production increased from 5,700 tonnes in 1991 to 17,000 tonnes in 1999;
- It is estimated that a plot of 0.2 hectares provides farmers with monthly revenue of US$1,000.

Source: Reference 10

4.4 Conflict resolution

Conflicts over water can occur for many reasons:

- Resource scarcity;
- Unmet expectations and needs;
- Differences in behaviour;
- Policy change.

An integrated WDM programme can promote strategies that assist in promoting societal, economic, and environmental security, thereby reducing the risk of conflict. Integrated WDM programmes should include participation by relevant stakeholders, not only to assist in establishing a consensus with regards to the measures to be implemented but also to promote more resource efficient and socially responsible water management that benefits all sections of society, especially the poor and marginalised.

4.5 Environmental improvements

An integrated WDM programme can have significant benefits for the environment. The wasteful use of water and the construction of unnecessary infrastructure can have an adverse effect on the environment. Water savings made at a river basin scale will require less water to be impounded and abstracted from river and groundwater systems, promoting greater bio-diversity and productivity in ecosystems. Public access to services, such as fish, recreation and clean water will potentially be improved. There will also be less public pressure on institutions caused by the deterioration of the environment.

5. OBSTACLES AND PRE-CONDITIONS TO INTEGRATED WDM

At a river basin scale there are numerous obstacles preventing integrated WDM from being implemented. These include:

- Allocation of water to end users irrespective of equity, economic value, efficiency or productivity of use;
- The relatively low cost of water especially in the agriculture sector;
- The disproportionate funding of supply sided measures at the expense of WDM measures;
- A lack of measured water use data for end users within the basin;
- A lack of a river basin management organisation
- A lack of regulatory mechanisms, that, regardless of increased prices, will be the main tool for WDM implementation in the agriculture sector for the foreseeable future.

Before carrying out integrated WDM at a basin level a number of pre-conditions need to be fulfilled including:

- Establishment of a rule of law;
- Establishment and implementation of a formalised system of water rights;
- Adoption of policies and priorities for water allocation;
- Adoption of policies on charging for water;
- Establishment of policies or sanctions for the misuse of water;
- Implementation of pro-poor policies;
- Agreed and transparent methods of assessment;
- Establishment of the instainfrastructure, and human and financial resources to undertake the assessment and ongoing monitoring and evaluation.

6. PRIORITISING WDM INITIATIVES AT A RIVER BASIN SCALE

6.1 Background

When prioritising WDM initiatives at a river basin level a simple approach would suggest that there are three main variables that need to be considered for each demand sector or end user:

- Volume of water used;
- Water user efficiency or productivity;
- Cost of water.

Prioritising an integrated WDM programme on this basis could lead to a water manager directing their efforts on sectors such as agricultural water use where volumes of water use are high and water use efficiency and the cost of water are generally low. This is shown in Figure 8. **However, is this the correct approach to take?** For some users, the reliability and quality of the supply is also key. It is also important to consider the non-monetary values that society puts on water in supplying for example: hospitals, poor communities and the environment.

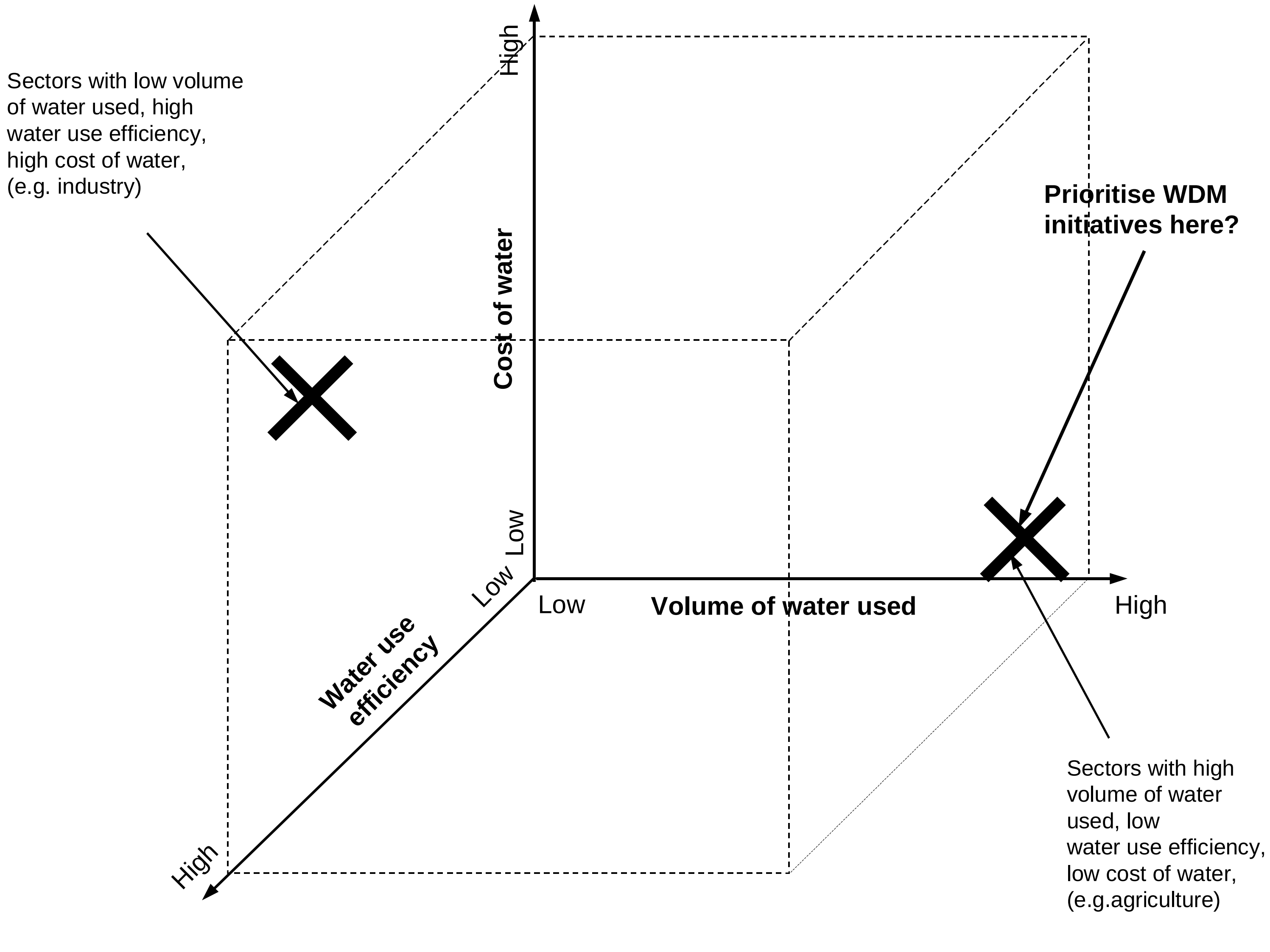


Figure 8 Simplistic basis by which to prioritise WDM initiatives at a river basin scale

6.2 The dangers of prioritising WDM measures based on the value of water

It is often advocated that WDM measures should be prioritised based on the value of water. Some types of water use add more value than other types. The classic example is the different values attained in the agricultural and urban sectors: the value attained in urban sectors is typically an order of magnitude higher than in agriculture. If water is currently used in the agricultural sector, the opportunity cost, i.e. the value of the best alternative use, may be ten times higher, subject of course, top constraints of "location and the hydraulic connections possible between users" (Reference 6). Thus, a shift towards the higher value use is often promoted as part of WDM initiatives.

Although the opportunity cost of water for domestic water use may be highest, the moment supply is higher than demand, the opportunity cost of the water will fall to the next best type of use. It is just not possible to consume all the water at the highest value use. The proper opportunity cost for irrigation water may therefore be only half, or less, than the best alternative use (Reference 6). Even then, the reliability of supply acceptable to irrigated agriculture is much lower than that for urban water supply. A storage dam yielding 1,000 m^3/day of water supplied to irrigation at 80% reliability, may yield only 500 m^3/day (or less, depending on hydrology) at 95% reliability to the urban sector. The effective opportunity cost of water used for irrigation should therefore again be halved at least. The resulting opportunity cost is thus only a fraction of the figure some neo-classical economists claim it to be (Reference 6).

Figure 9 shows the variation of supply and demand over a number of years for a typical river basin and the required reliability of supply ranging from 0% to 100%. It shows that, in general, primary (domestic) and industrial demands, with the highest ability and willingness to pay, require a high reliability of supply, which is normally achieved through relatively large storage provision. Environmental demands are also not the most demanding of the resource. Agricultural water requirements tend to be much higher, fluctuate strongly but also can tolerate a lower reliability of supply.

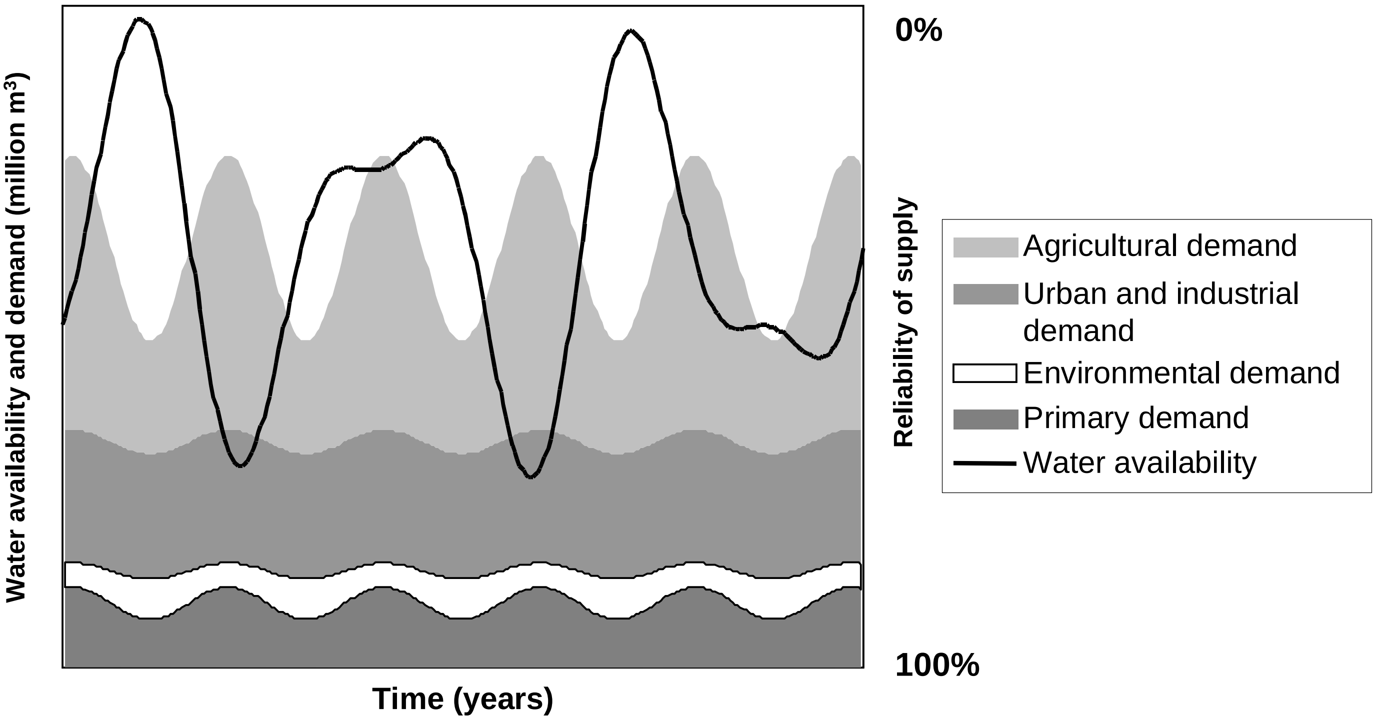


Figure 9 Variation of water availability and demand, and reliability of supply

The primary purpose of water management is to match or balance the demand for water with its availability, through suitable water allocation arrangements. The balancing of water demand with water availability is river basin specific and hence there is no one particular method that can be recommended. The balancing of supply with demand will often involve a process of decision making where difficult compromises have to be made. In all cases, the water allocation process requires a sound quantitative understanding of both water availability and water demand. Moreover, the following aspects should receive careful attention, and possible win-win combinations sought:

- The constitutional obligation to provide a basic amount of fresh water to all the population for both domestic and productive needs;
- The legal (or treaty) obligation to consider downstream requirements beyond the area being considered for water allocation;
- The legal obligation to provide for environmental water requirements;
- Analysis of water losses to consider different spatial scales, and the unintended functions these losses may serve;
- Allocation principles to include clear provisions for (extreme) drought situations;
- Allocation principles to promote water users' willingness to invest in water infrastructure to improve efficiencies;
- The ability of improved efficiency to make more water available to cover outstanding demands.

Box 12 Reliability of water supply

The reliability of supply is the percentage of time in any given period for which the daily water demand can be satisfied. For example, a level of reliability of 98% indicates that the design level of demand can be satisfied for 98% of the time or 98 days out of 100. On average, the supply will fail for approximately seven days per year, or for a total of 70 days in 10 years. An alternative or supplementary water supply must be available to make up the shortfall during times of water deficiency. Alternatively, the use of rationing when the supply falls below a given level will assist in the management of the shortfall. Typical reliability figures for domestic and industrial reliability of water supply are between 98% and 100%. For irrigated agriculture, a typical reliability figure is 80%.

Box 13 Research into water allocation in the Great Ruaha Basin in Tanzania

Tanzania's Great Ruaha River Basin has been the subject of a river basin management study. The Great Ruaha River covers nearly 20% of the country's area. The basin is a good example of a situation where allocation of water is required between irrigated agriculture, the environment and other sectors.

The study has investigated the prevailing theory that it is possible to generate win-win tradeoffs by raising irrigation efficiency and then delivering water savings to more needy sectors. However, the logic of reallocation based on spare irrigation water is by no means certain because the irrigation efficiency of the schemes is not known. Furthermore, even if water savings from the schemes were possible there may not be any actual "savings" because local irrigators may recapture "spare" water.

The initial results of the study have shown that irrigation efficiencies especially of schemes growing rice, are not as low as commonly believed and that savings are not likely to be significant. In addition, observations show that most water is divided between users during times of peak flow by natural river-based means. This outcome signals that inter-sectoral allocation of bulk volumes of water is a lower management priority than attending to the lifeline needs of domestic, livelihood and environmental sectors during the dry season, when small quantities of water are required that are well placed, timely and of high quality. The case study indicates that the efficacy of river basin management and integrated WDM might best be judged by an ability to attend to local and micro-scale issues that are normally below the "radar" when compared to perceived macro inequalities in supply.

The emerging picture is that the sectors with highest value uses should have access to water. In many SADC countries these sectors require only 20% to 50% of average water availabe, and these demands can easily be satisfied in all but the driest years. In most years, much more water will be available, and this water should be used beneficially, for instance for irrigation. There is therefore no need for permanent transfers from agriculture to other sectors, except in the most heavily committed catchment areas of the world. **What is needed is a legal and institutional context that allows temporary transfers of water between agriculture and urban areas in extremely dry years.** No market is required to cater for such exceptional situations. A simple legal provision would suffice, through which irrigators would be forced to surrender stored water for the benefit of urban centres against fair compensation of (all) benefits forgone. In those heavily committed catchment areas where permanent transfers of water out of the agricultural sector are required, normally voluntarily negotiated solutions can be agreed, provided the laws allow this to happen.

Box 14 The value of water and WDM initiatives

The various uses of water in the different sectors of an economy add value to these sectors. Some sectors may use little water but contribute significantly to the Gross National Product (GNP) of an economy. Other sectors may use a lot of water but contribute relatively little to that economy. For Namibia it has been estimated that:

- Industry and commerce use less than 3% of all water used in Namibia, but contribute 42% to the Namibian economy;
- Irrigated agriculture uses 43% of all water used, but contributes only 3% to the economy.

Care should be taken when interpreting the above data. For instance, it is well known that the agricultural sector typically has a high multiplier effect in the economy, since many activities in other sectors of the economy depend on agricultural output, or provide important input services. Hence the "real" value added by water may be underestimated. The added values of some uses of water are very difficult, if not impossible, to measure. For instance, the value of domestic use of water is very difficult to quantify. The value of irrigated use of water in general is at least a factor ten less than in other types of industrial and commercial use.

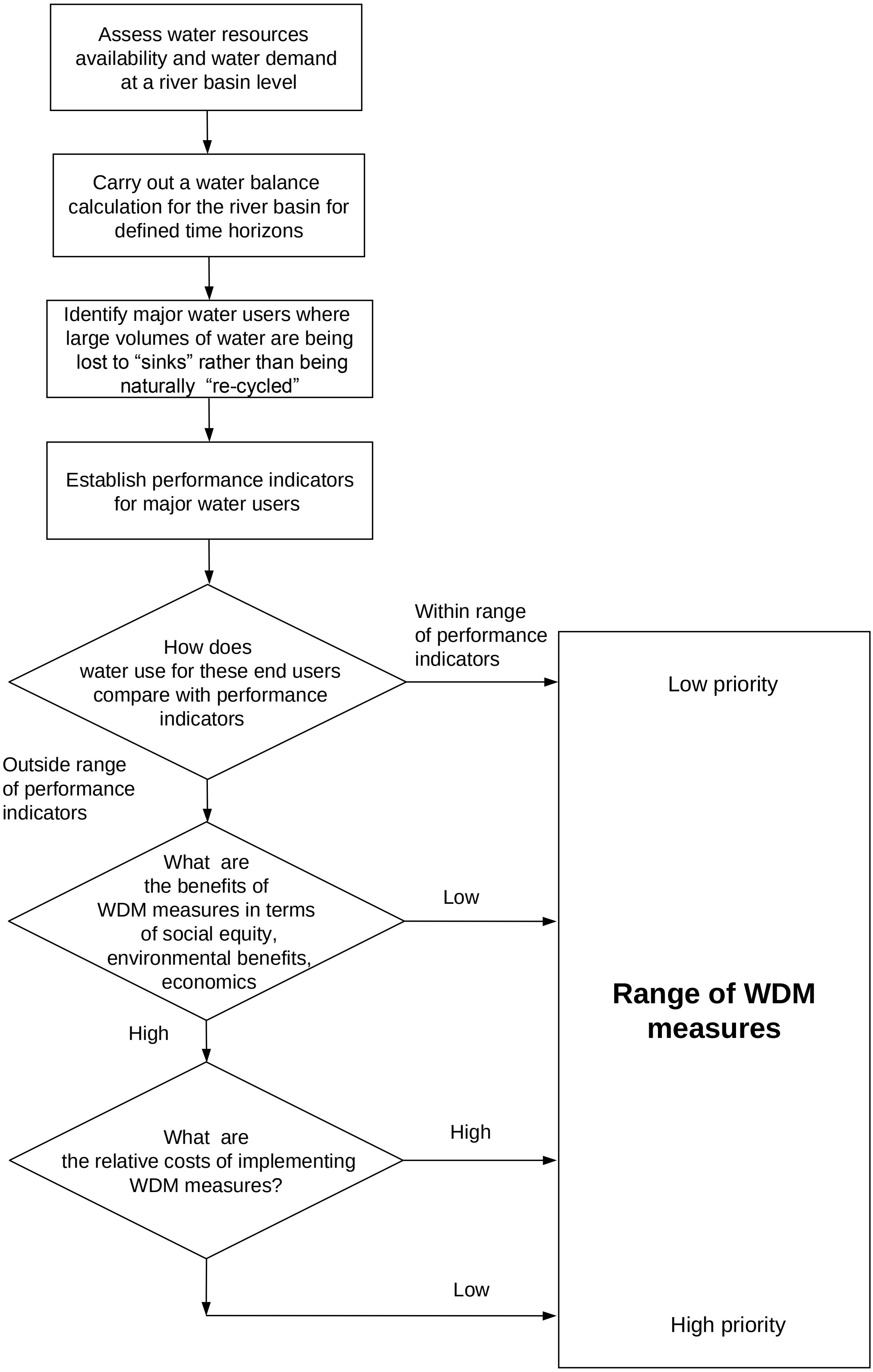
(Reference 6)

6.3 Framework for prioritising WDM measures at a river basin scale

Before adopting a framework for prioritising WDM measures it is important that the pre-conditions outlined in Section 4 of this document are in place. In order to prioritise the WDM measures that are needed at a river basin scale it is essential to:

1. Collect existing data to identify and quantify water availability and all the water used within the river basin.
2. Carry out a water balance for the river basin.
3. If necessary, identify gaps in the water balance and add required detail.
4. Identify major end users where large volumes of water are being lost to "sinks".
5. Investigate what practices and devices are appropriate to encourage water efficiency.
6. Estimate the human wellbeing and financial benefits, and costs, of implementing these measures.
7. Implement your programme of measures.

This framework for prioritising WDM measures is shown in Figure 10.



Note: This flowchart assumes the pre-conditions outlined in Section 4 are fulfilled

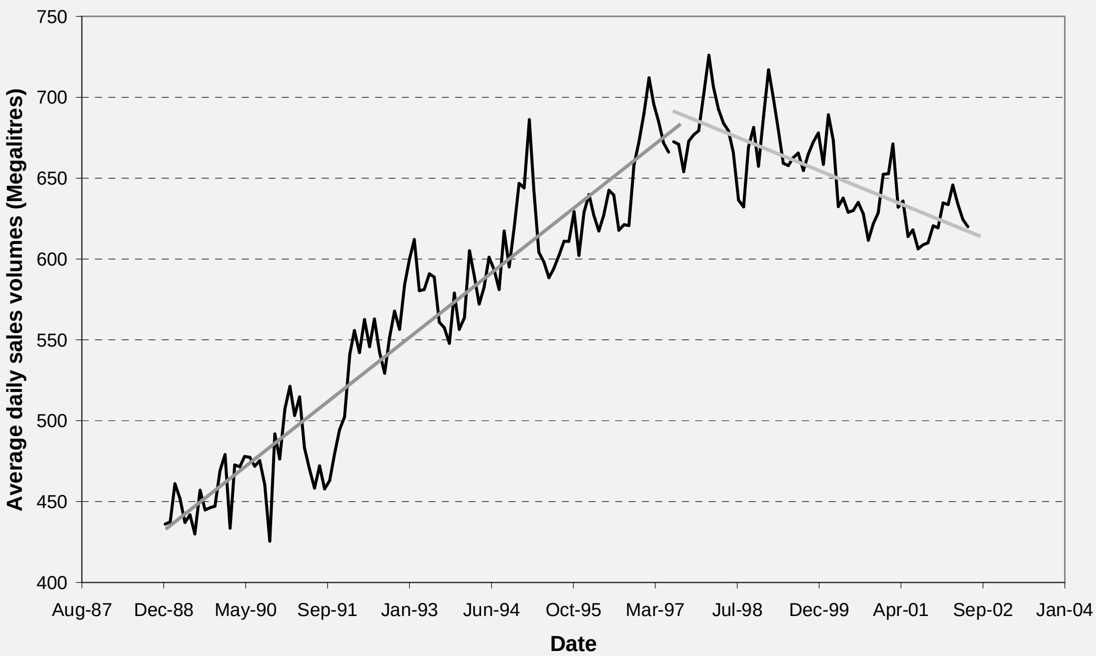
Figure 10 Simple flowchart for prioritising WDM measures at a river basin level

Box 15 Example of the prioritisation of WDM measures at a river basin

The Umgeni river basin in South Africa covers almost 4,500 km^2. The basin contains the two major urban centres of Pietermaritzburg and Durban, as well as large areas of irrigated agriculture. The Umgeni river basin provides a good example of how to prioritise WDM measures. The metropolis of Durban has a population of some 2.5 million people and is located on the coast. Over a nine year period between 1989 to 1998 there was a 5.5 % steady growth rate in water demand in Durban as shown in Figure 11. However, in 1998 a series of measures were introduced in an attempt to reduce this growth in demand, these included:

- **A stepped tariff structure** based on the assumption that the average domestic household used 30 kilolitres of water per month. The first 6 kilolitres are free, as long as this is not exceeded per month. When consumers use more than 6 kilolitres for the month they are billed a fixed charge to cover the first 6 kilolitres. The consumers, who used more than 30 kilolitres would be charged at a penalty tariff for the excess;
- **Replacement of deteriorated reticulation** in high water loss areas;
- **The development of a US$7.4 million wastewater purification plant** that converts partially treated effluent into water for industrial use. This water is sold to industrial clients for direct re-use in their processes. The project has allowed delay of capital expansion projects for five years, as it treats up to 10% of Durban's wastewater. It frees up drinking water for 300,000 people in and around the city.

These initiatives have assisted in reducing water demand in the Durban area by some 2.2% per year over the past five years. This reduction in demand is shown in Figure 11.



(Reference 10)

Figure 11 Water demand for Durban, South Africa 1988 to 2002

Before an integrated WDM programme is implemented it is important that key concepts are established. These may include:

- The ownership of water;
- Water use;
- Primary uses of water;
- Equity;
- Efficiency;
- The financial wellbeing of water services institutions;
- The precise rights and obligations conferred with a water permit.

A particularly important issue is the definition of water use, since this basically defines the point where water converts from a public to a private good. Lack of clarity about where exactly this conversion occurs will create confusion, which will directly impact on the effectiveness of the water allocation process. For instance, if a permit holder has lawfully stored water in their dam, has this water already been used and hence is owned by the permit holder or not yet? The South African Water Act (1998) defines water use as taking and storing water, activities which reduce stream flow, waste discharges and disposals, controlled activities (declared activities which impact detrimentally on a water resource), altering a watercourse, removing underground water for certain purposes, and recreation.

7 TOOLS FOR IMPLEMENTING INTEGRATED WDM AT A RIVER BASIN SCALE

There are numerous tools for implementing integrated WDM at a river basin scale. The most important of which are:

- Water resources assessment;
- Development of water management indicators;
- Pricing of water;
- Effluent tariffs;
- Tradable water rights.

7.1 Water resources assessment and river basin water balance

To implement an integrated WDM programme at a river basin scale it is essential that a water resources assessment is carried out. This would include:

- Hydrological assessment to establish the resource base at a river basin level;
- Demand assessment that would examine the competing uses of water and assess the demand for water, by different sectors for given charges.

A water resources assessment often needs to be carried out in several steps of increasing complexity. A rapid water resources assessment may assist in establishing the most important issues and priority areas in a river basin.

The water resources assessment should include a water balance. The estimates of water supply and demand for river basin are used to establish the water availability within the basin. These estimates are adjusted to take explicit account of return flows and water recycling, the importance of which is often neglected in studies of water scarcity.

7.2 Tradable water rights

Tradable water rights are water entitlements or allocations that can be bought or sold. The commodification of water in such a manner which allows water to be purchased by the highest bidder is generally not recommended in the SADC region where the power that can exerted by the rich is already excessive when compared to the weakness of the poor. Water should rather be freed up through carefully defined regulation and making funds available at concessionary rates when improved water usage efficiency would make water available for a new demand more cheaply than by exploiting new resources. Help with choosing crops that require less water is another possibility.

An exception to the above recommendations is less heavily committed catchments is to implement a legal and institutional framework that allows temporary transfer of water from agriculture to urban areas in extremely dry years. Irrigators would be forced to surrender stored water for the benefit of urban centres against fair compensation for all benefits foregone. Compensation should not be calculated in terms of market price since in dry years this price may be orders of magnitude higher than in a normal year.

7.3 Development of water management indicators

Water management indicators allow water mangers to establish the relative efficiency and productivity of a particular end user. The following water management indicators are often used:

- For irrigation schemes this may be the yield per cubic metre of water used i.e. "crop per drop";
- In industry, it is the Specific Water Consumption e.g. in steel production water use is measured as m^3/tonne of steel produced. For beer it is measured in m^3/m^3 of beer produced;
- For domestic water suppliers, the volumes of unaccounted for water.

Performance indicators make it possible to see how well large users of water are performing at the system, basin or national scale. As a tool for measuring the relative performance of water users, performance indicators can assist the following:

- Policy makers and planners to evaluate how productively land and water resources are being used by different sectors, and to make more informed strategic decisions regarding water resources management;
- Irrigation managers to identify long-term trends in performance, to set reasonable overall objectives and to measure progress;
- Researchers, to compare irrigation systems and identify factors that lead to better performance;
- Donor agencies, governments and NGOs to assess the impact of interventions in the irrigation sector and to design more effective interventions.

7.4 Pricing of water

Planners should be very clear about what they aim to achieve from increased pricing of water. Two objectives are commonly cited:

- Cost recovery;
- Demand management.

The two objectives are quite distinct and require quite different tariff levels. Since agriculture is the major user of water, it is the main focus of this section. To date, water use in agriculture has commonly been subsidised by governments. However, it is generally accepted that all sectors, including agriculture, need to be financially, as well as technically sustainable. That means, for agriculture, that the price set must result in collections to cover at least system operation and maintenance and often some part of capital costs. It is generally true that such expenditure on water forms only a relatively small part of farmers' overall costs and can be afforded. The limited exception to this conclusion applies to the poorest farmers in some of the least developed counties, where governments may need to make special arrangements to reduce real hardship.

On the other hand, it is a fact that no country in the world uses water pricing in agriculture as the principal mechanism to control demand. Even in Israel, quotas serve as the principal control mechanism. Below that level, a system of step tariff pricing helps to trim demand. The price a farmer will be prepared to pay for water depends very much on the crop and stage of the season. At crucial stages in the season, he/she may be willing to pay substantially more than at other times. It has been estimated that, in some circumstances, the price of water may need to approach the value of the output to exert substantial control over demand. Clearly, at this level agriculture is no longer a viable enterprise. That means that pricing for control of water demand in agriculture represents an extremely blunt instrument. Allocation should remain the principal method of control.

7.5 Effluent tariffs

For some sectors effluent tariffs may be the most effective WDM measures. This is often the case for industrial water users especially when it is combined with effective pollution control. Relative to southern Africa's primary sectors, water use by "wet" industries is economically efficient and quantitatively insignificant. Consumptive use is small. However, effluent discharge is significant. Often a levy on the discharge of industrial effluents is a more beneficial means of achieving water conservation in the manufacturing sector than water supply tariff increases. Overseas experience indicates that effluent levies are an effective WDM tool.

Box 16 The use of effluent tariffs as a WDM tool in South Africa

Often, appreciation of the advantages of improving water efficiency for an industrial plant requires a holistic examination of the facilities operations in terms not only of water use by various components used in the process, but also of effluent water quality. A good example of this is the Abakor Abattoir in Johannesburg, South Africa. This abattoir uses single cell protein to manufacture stock feed.

Improvements in the treatment of the effluent (through single cell protein recovery) produced the following results:

- Reduced chemical oxygen demand (COD) values from 9,000 mg/l to 200 mg/l;
- Industrial treatment charges reducing from R5 million to R300,000 per annum.

Owing to the improved quality of the effluent, further tertiary treatment was possible to produce water of a high enough quality to be reused in the abattoir. These system improvements reduced the water consumption and effluent discharge by 50%. At full capacity production, the cost of reclaimed water is 42% of the cost of the potable supply.

(Reference 11)

7 References

1. World Commission on Dams (2000) *Dams and development: A new framework for decision making* The report of the World Commission on Dams (http:/www.dams.org/)
2. Parsons, R. (2004) *Surface water – groundwater interaction in a South African contect: A geohydrological perspective* Water Research Commission, Pvt Bag, X03, Gezina 0031, South Africa
3. Department of Water Affairs and Forestry (2001) *The catchment management agency as an organisation* Guide 2 in the CMA/WUA guide series, Department of Water Affairs and Forestry, Pvt Bag X313, Pretoria 0001, South Africa
4. McKinney, D. Cai, X., Rosegrant M. Ringler, C and Scott, C. (1999) *Modeling water resources management at the basin level: Review and future directions* SWIM Paper 6, Colombo, Sri Lanka, International Water Management Institute (http://www.iwmi.cgiar.org/pubs/SWIM/SWIM06.PDF)
5. Keller, A. and Seckler, D. (1996)*. Integrated water resources systems: Theory and policy implication* Research Report No. 3. Colombo, Sri Lanka: International Water Management Institute.
6. HR Wallingford (2003) *Handbook for the assessment of catchment water demand and use* Department for International Development Knowledge and Research Project R7135
7. Food and Agriculture Organization (1995) *Irrigation in Africa in figures*, Food and Agriculture Organization, Rome, Italy
8. Kammer, D. (1998) *River transmission losses in Zimbabwe*, Department of Water Development Zimbabwe (Unpublished)
9. Rothert S., (2000) *Water conservation and demand management potential in southern Africa; An untapped river* (http://www.environmental-center.com/magazine/inderscience/ijw/art8.pdf
10. Food and Agriculture Organization (2000) *Crops and drops –Making the best use of water for agriculture*,

http://www.fao.org/DOCREP/005/Y3918E/y3918e00.htm#TopOfPage Food and Agriculture Organization, Rome, Italy
11. eThekwini Metro (2002) *Water demand management: the Durban Case* eThekwini Metro, Water Services, PO Box 1038, Durban 4000, South Africa (Unpublished)
12. Personal communication (1998) with Muller, J. General Manager of technology development Abakor, Pretoria
13. Cai, X., Rosegrant M., and Ringler C. (2003) *Physical and economic efficiency of water use in the river basin: Implications for efficient water management,* Water Resources Research Vol. 29 No. 1
14. Global Water Partnership (2003) *Integrated Water Resources Management ToolBox Version 2*, Global Water Partnership
15. Gumbo B. and van der Zaag (2001) *Principles of Integrated Water Resources Management*, Southern Africa Youth Forum
16. Savenije, H. and van der Zaag (2002) *Water as an Economic Good and Demand Management Paradigms and Pitfalls* Water International, Volume 27, pp98-104 March 2002
17. Badenhorst, J.W., de Lange M., Mokwena, M.E., and Rutherfoord, R.J. (2002) *Water Conservation and Water Demand Management in Agriculture: Development of Water Management Plans by Irrigation Water Suppliers in South Africa*, International Commission on Irrigation and Drainage (ICID) Eighteenth Congress, Montreal
18. Maddaus W., and Maddaus L (2001) *Water Demand Management within the Integrated Resource Planning Process* http://www.isf.uts.edu.au/whatsnew/Demand_Mgmt_IRP.pdf
19. Ashton P.J. and Haasbroek B. (2001) *Water Demand Management and Social Adaptive Capacity: A South African Case Study* African Water Issues Research Unit (AWIRU) and International Water Management Institute (IWMI), Pretoria, South Africa
20. Batchelor, C., Cain J. Farquharson, F. and Roberts J. (1998) *Improving Water Utilization from a Catchment Perspective* SWIM Paper 4. Colombo, Sri Lanka: International Water Management Institute
21. Bakir, H. (2001) *Water Demand Management and Pollution Control: Key to Securing and Safeguarding the Water Supplies of MENA in the 21st Century* World Health Organisation Eastern Mediterranean Regional Office Staff Technical Paper http://www.emro.who.int/Publications/CEHA-ESCWA.pdf
22. Louw D. and van Schalkwyk (2002) *Efficiency of water allocation in South Africa: Water markets as an alternative* World Bank report http://lnweb18.worldbank.org/ESSD/ardext.nsf/18ByDocName/EfficiencyofWaterAllocationinSouthAfricaWaterMarketsasanAlternativeLouwvanSchalkwyk/$FILE/Louw_Schalkwyk.pdf
23. Lévite, H., Sally, H., Cour J. (2002) *Water demand management scenarios in a water-stressed basin in South Africa* 3rd WaterNet/Warfsa Symposium Water Demand Management for Sustainable Development, October 2002
24. Molden, D. (1997) *Accounting for Water Use and Productivity* SWIM Paper 1, Colombo, Sri Lanka, International Water Management Institute