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TOOLS FOR WATER USE AND DEMAND MANAGEMENT IN SOUTH AFRICA

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SUMMARY

This WMO Technical Report draws on the case studies and feedback produced at the 'Tools for Water Use and Demand Management' workshop held in Harare, Zimbabwe, from 19-21 October 1999, supported by the Hydrology and Water Resources Programme of WMO, the UK Department for International Development (DFID), and UNESCO. The workshop was attended by 59 participants from twelve countries, representing various sectors including industry, agriculture, municipalities, research, government, NGOs, and SADC Water Resources Technical Committee.

This technical report aims to highlight those elements required to manage water use and demand effectively, not only in the SADC region, but hopefully to be of practical application in other regions with an approaching water resources crisis. In this way, the lessons learned from workshops such as this may be used not only to help cope with crisis situations in water resources management, but, preferably, to mitigate *potential* water resource management problems. The objectives of the workshop were to:

- Raise the awareness of water resources specialists towards water demand management (WDM) policies;
- Identify best practice and case studies for implementing WDM in water resources planning;
- Demonstrate tools and methodologies for accounting for water use and demand in water resources; and
- Provide material for this WMO Technical Report for use by operational hydrological services and those involved at many stages in the implementation of WDM, particularly in Southern Africa.

It is now widely recognised that a paradigm shift from the traditional supply orientated mind set towards one of water conservation and demand management is essential for the sustainability of water resources and the environment, as well as economic efficiency and social development. However, the move towards this integrated approach takes a great deal of time, effort and commitment on behalf of key players at many levels in the institutional and political spectra. In support of this, the wheels of change are beginning to turn, and with this gathering momentum the process of implementation of the integrated approach becomes easier.

The layout of this report is as follows: Chapter 2 gives a general introduction to the Hydrology and Water Resources Programmes of WMO and UNESCO. Chapter 3 gives an overview of integrated water resources planning and management, followed by a discussion in Chapter 4 of the paradigm shift from supply development towards demand management. Chapter 5 presents the situation with regard to water resources and demand management in Southern Africa, via a summary of the key points from the papers presented at the workshop. Chapter 6 presents examples of the integration of water demand management policies into water resources planning, and emphasises the needs that emerged from workshop presentations and discussions, whilst Chapter 7 similarly presents examples and needs with regard to the tools and skills necessary for water demand management. Each of Chapters 6 and 7 are supported by tables of examples and needs, by sector, under three key headings. In an effort to give a balanced and justified view of water demand management, some of the benefits and risks of its application are given in Chapter 8. Finally, Chapter 9 presents recommendations to many and various groups, institutions and projects for the best way for WDM to proceed in Southern Africa. Annexes 1 and 2 contain the workshop programme and the list of workshop participants, respectively, Annex 3 contains references from the main body of the report, Annex 4 is a dictionary of definitions and acronyms, and Annex 5 contains a directory of web sites containing useful data and information on water use and demand in Southern Africa.

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1. WMO AND UNESCO WATER RESOURCES PROGRAMMES

There are at least nine UN agencies that are significantly involved in various aspects of water management. Two agencies have a world-wide brief for water resources assessment and management. The World Meteorological Organisation takes a lead role in measuring the hydrological cycle, by assisting national operational hydrological services. UNESCO leads in scientific hydrology and research. These two organisations plan their long term programmes for water resources together. They are both committed to integrated water resources development and management.

WMO and UNESCO are also both committed to the guiding principles of the 1992 Dublin Statement, including the fourth which states:

"Water has an economic value in all its competing uses and should be recognised as an economic good."

The Dublin Statement goes on to say that the role of water as an economic and life sustaining good should be reflected in demand management policies, implemented through water conservation, efficient use, recycling and reuse, resource assessment and financial instruments.

WMO and UNESCO have produced a handbook on Water Resources Assessment titled *'Water Resources Assessment: Handbook for Review of National Capabilities'* (WMO/UNESCO, 1997). WMO has published a Technical Report on: '*Methods for assessing trends in water demand and use for hydrological services*.' (WMO/TD – No. 915)

Water use and demand management is one of the specialist topic areas that WMO seeks to develop and share its knowledge and experience.

The aims of the workshop are to:

- Raise awareness of what demand management is and how it can be integrated into water resource planning.
- Identify best practices from the papers presented and the two workshop discussion sessions.
- Demonstrate the specific tools and methodologies which are needed to plan and implement water demand management.
- Produce a summary Technical Report for publication by WMO, based on the contributions to the workshop.

The workshop has been designed to build upon the foundations laid by the IUCN programme and conference on developing effective water demand management strategies for Southern Africa. A summary of this work is given in Paper 3 by Mr Saliem Fakir. One of the significant comments of the IUCN conference in May 1999 in Johannesburg was the following statement by the IUCN Regional Director, Dr Katarere:

"Water demand management is not an intrinsic part of water resources planning and management at the national and regional levels in Southern Africa."

This is the particular gap which this workshop seeks to address.

Two other joint programmes by WMO and UNESCO are relevant to the development of water use and demand management in water resources planning.

WMO leads the World Hydrological Cycle Observing System (WHYCOS) programme. Adequate information is essential for wise management of water resources, but globally, the status of data collection networks is declining. WHYCOS was developed to assist WMO Members in maintaining and improving their water resources information systems. Modelled on WMO’s World Weather Watch (WWW), WHYCOS provides a vehicle not only for disseminating high quality information, but also for promoting international collaboration. WHYCOS consists of regional systems, such as is under implementation in Southern Africa (SADC-HYCOS). Each HYCOS has two main components: a support component, which strengthens co-operative links among participating countries; and an operational component, which achieves ‘on the ground’ implementation at regional and international river basin levels.

UNESCO leads the joint initiative HELP – Hydrology for the Environment, Life and Policy. HELP is a new initiative to establish a global network of catchments to improve the links between hydrology and the needs of society. The goal of HELP is to deliver social, economic and environmental benefits to stakeholders through sustainable and appropriate use of water, by deploying hydrological science in support of improved integrated catchment management

2. INTEGRATED WATER RESOURCES PLANNING AND MANAGEMENT

At the 1992 UNCED Earth Summit in Rio, Agenda 21 stated that *'By the year 2000 all states should have national action programmes for water management, based on catchment basins or sub-basins, and efficient water use programmes. These could include integration of water use and other resource planning development and conservation, demand management through pricing, regulation, conservation, re-use and recycling of water.'* Water demand management is a key component of integrated water resources planning, which is in turn the pre-requisite for sustainable water management.

To fully understand integrated water resources planning and management, it is essential to first understand what the terms involve. A distorted picture of the water balance can arise through misunderstandings of the mechanisms at work in the catchment. A common misunderstanding can be cleared up through careful differentiation between consumptive use of water - which does not return to the water resources system - and that which is diverted but from which a proportion is returned to the system in a short period of time. It has been said that this is the difference between water that is *used*, and that which is *used up*. This is of particular importance for the agricultural sector, which is often cited as "using" vast amounts of the available water resource. However, a large proportion of the water abstracted in irrigation systems will return to the system.

After a clear understanding is obtained regarding how much water goes where, the issues which then become important are the timing and the quality of the return flows. These return flows cannot be considered as water available for use downstream unless the quality of the water is suitable for the next application. Irrigation systems, and more notoriously industrial users, often return polluted water to the system - effectively meaning that the water is not available for further use. In this case, an improvement in irrigation efficiency - whereby a smaller volume of water is abstracted and an even smaller volume returned - will mean a better quality of water is available for the next downstream user. Timing is important since such systems of abstraction and return flows tend to upset the hydrology of the river or water resource, with short time periods between abstraction and return being the least disruptive.

Consumptive use by irrigated agriculture has two main components: water which transpires from the plant's leaves; and water which evaporates directly from the soil surface. The largest savings can be made by reducing the latter through such mechanisms as closer row spacing, mulching, correct timing of irrigation at different stages of a crop's life cycle, and well-designed sub-surface drip irrigation that does not wet the soil surface. Transpiration cannot easily be reduced without affecting crop yield. However, some crop types benefit from correctly timed periods of water stress that actually serve to increase crop productivity and quality.

A final important point on agricultural water use is the relevance of location. In Southern Africa, the opportunity cost of water used for agriculture is often low because there are no viable competing uses in the vicinity.

3. SUPPLY DEVELOPMENT VERSUS DEMAND MANAGEMENT: *THE PARADIGM SHIFT*

There are many variations on the definition of water demand management, but a good general description is: '*The management of the total quantity of water abstracted from a source of supply using measures to control waste and undue consumption*.'

The traditional approach of hydrologists and water resources engineers has been to focus on the supply side and the assessment of available water resources. Forecasts of water demands have often been provided by other departments, ministries or consultants, with a wide range of uncertainty because of the:

- Limited data on historic actual water use
- High levels of uncertainty in establishing efficiency of water use, with significant losses likely in irrigation, urban and industrial water use
- Uncertainties in the basic economic, social and demographic assumptions required for water demand forecasts.

As a result, there is a high degree of uncertainty in current forecasts of the supply-demand balance at national, regional and global levels. There are large variations in local availability - both in space and time.

Thus, it is increasingly being recognised that supply and demand can only be balanced if water resources and water supply engineers address *both* sides of the balance. Donor agencies, such as the World Bank, have long advocated demand side management, and now national and local government agencies in Southern Africa are participating in a number of programmes that implement these policies. For instance, SADC has played an important role in agreeing on key strategic objectives and defining an Action Plan of 31 priority projects - which includes one on the Economic Accounting of Water Use. However, water resource policy makers and professionals are now challenged to work out the practical implications of water demand management within *integrated* water resource planning, development and management. New approaches to water management are also beginning to focus on the way in which water is needed and used (efficiency, effectiveness and demand management) in each user sector, rather than simply predicting, planning and providing all its water demands.

Reasons for promoting WDM include:

- Excessive water use leads to over capitalisation of infrastructure;
- Additional infrastructure brings high debt and high fixed water costs;
- WDM measures often have benefit to cost ratios in excess of 10:1 in urban situations;
- WDM measures can be introduced flexibly and incrementally;
- WDM can be a vehicle for socio-political objectives such as equity and gender issues;
- WDM only succeeds with community participation;
- Water saving technologies are not usually capital intensive or high technology;
- WDM requires measurement of all components of the water cycle and good management;
- Realistic water charges support sustainable water services.

Finally, to enable this paradigm shift towards demand management, the importance of political intervention cannot be over-emphasised. This can give major impetus to the campaign – and without this kind of open and proactive political support, the wheels of change are almost certain to grind to a halt.

Studies have indicated that within the next ten to thirty years, Lesotho, Tanzania, Zimbabwe, Mozambique and Mauritius will join Malawi, South Africa and Namibia as countries where water is very scarce. By 2000, more than half of Southern Africa’s population will live in urban areas, further increasing the demand for clean water.

4. WATER RESOURCES AND DEMAND MANAGEMENT IN SOUTHERN AFRICA

Introduction

Southern Africa is considered by much of the rest of the world to be a 'water scarce' region. Yet, within the region water is not traditionally a high profile subject in the development process. A paradigm shift is required in the Southern African region, to recognise the need to work against a tradition of supply management, and to concentrate on demand management instead. There is the need to foster a culture of caring for the resource, of knowing *how* to save water, and for politicians to realise that water can play an essential role in developing a country.

Several countries in the region are undergoing, or are about to undergo, a period of great change in the way their water resources are managed. There is a trend towards the decentralisation of responsibility to a catchment level, such as the Water Resources Management Strategy in Zimbabwe where stakeholders elect catchment-based water management groups. The Strategy recognizes the importance of incorporating the concerns of poor and disadvantaged stakeholders.

In this chapter we look at the messages coming from the papers presented at the Workshop, under the headings: Awareness; Country Overviews; Best Practice Case Studies; Tools and Skills. One of the main messages to be taken from the workshop is that it is beneficial to regionalize standards to make use of facilities and equipment that already exist. As the region already has a large resource of indigenous knowledge it is neither good to be too prescriptive, nor to re-invent the wheel.

Recognising the growing interest in water use and demand management in Southern Africa, the workshop aimed to develop skills through raising awareness on water demand management policies - identifying examples of best practice and demonstrating tools and methodologies used for accounting for water use and demand. The workshop was sponsored through the Water Resources Programme of WMO, with additional funding from the UK Department for International Development (DFID).

General needs and recommendations

An integrated, sustainable, comprehensive and long-term approach is needed since WDM implies changes in society's attitudes and behaviour. Policy should be put into practice, supported by improved evaluation. This in turn needs to be effected at the grassroots level through capacity building. There is currently inadequate capacity to enforce the new, decentralised water acts being formulated in the region. It is generally acknowledged that any gaps in the policy of these water acts can be filled by community action. The region needs low cost, community manageable solutions, and horizontally integrated cross-sectoral planning. Models and definitions of the above are required to enable the various governments and institutions in the region to understand good demand management and appreciate IWRM at its best.

Awareness

The workshop took place during the consultation period for the *Vision for Water, Life and the Environment in the 21st Century*. This global programme is being run within a framework organised by the World Water Commission, the World Water Council and the Global Water Partnership. The opening workshop paper (1) looked at the possible impacts on water demand in attaining Key Vision goals, such as economic growth, wider access to and ownership of water, new financing mechanisms for water supply, policy and institutional changes, improved waste disposal, better food security, energy conservation and defining environmental use of water. Key recommendations to fulfil the vision are:

- better co-ordination and integration of regional and national organisations dealing with water;
- priority focus on information management systems for water use;
- development of local information tools such as databases and GIS.

The *Southern African Development Community (SADC) Water Sector* is currently introducing a newly ratified Protocol on Shared Water Course Systems[(2)]. Water use and demand management in the region is seen as one of the most important issues between riparian states for the successful management of shared resources. Partners need to demonstrate equally efficient use of scarce water resources. The SADC Regional Strategic Action Plan consists of 31 project concept notes which will form a bidding document to donor agencies. Water use and demand management is included in a project on economic accounting for water use and another on assessment of surface water availability using agreed common methodologies.

From a *SADC perspective, the two major factors affecting the future of water use and demand*[(25)] are seen to be human consumption and irrigation. The key uncertainties in forecasting the growth in domestic demand include:

- Rising per capita consumption with improved socio-economic conditions
- Population growth from high birth rates
- Demographic effect of HIV/AIDS
- Patterns of irrigation from rural to urban areas

The demand for irrigation water will be influenced by:

- National legislation on water pricing and rights
- Market forces arising from greater economic integration between SADC countries
- Progress in water efficiency

A long term, regional approach is advocated to ensure equitable utilisation of water within the SADC region.

A comprehensive study by IUCN has reported on *WDM case studies in five Southern Africa countries*: South Africa, Botswana, Namibia, Mozambique and Zimbabwe[(3)]. The case studies highlight successes, lessons learnt and future issues.

Successes include:

- Block tariffs, retrofitting, awareness and effluent re-use (Namibia)
- Legislative changes and institutional reforms (Zimbabwe, South Africa)
- Water Conservation and Demand Management National Strategy (South Africa)
- Water charges, restrictions and education campaigns (Botswana)

A full account of these case studies is published by IUCN (South African Country Office), Pretoria.

Country Overviews

The *National Water Conservation and Demand Management Strategy for South Africa*[(4)] is one outcome of two recent pieces of legislation: The Water Services Act (1997) for treated water; and the National Water Act (1998) which addresses water governance and water resources management. Key features of the acts include:

- Water rights invested in the custodianship of the Minister, with fixed term licences for use
- A new water governance regime based on river catchments, with local participation and governance

- Water conservation and water demand management (WC/WDM) as the key driver towards efficient water use

The new democratic South Africa is a developing country that is water scarce and water stressed. In contrast to traditional approaches to only developing new supplies, the implementation of a paradigm shift to WC/WDM is seen as essential for the sustainability of water resources and the environment, as well as economic efficiency and social development.

South Africa's Department of Water Affairs published a comprehensive assessment of water use and demand titled "*Management of Water Resources of the Republic of South Africa*", in 1986. This has now been updated[10] by the publication "*Overview of Water Resources Availability and Utilisation in South Africa*", 1997. Comparing the 1986 forecast for 1996 with actual use for that year shows remarkably accurate forecasting with actual only 5% below total forecast water use as given in the following table:

Water use sector in South Africa	**Water use in 1996 (Mm^3/a)**	
	1986 Forecast	**Actual**
Urban/domestic	2,608	2,171
Mining/industrial	2,131	1,598
Irrigation/afforestation	12,689	12,344
Environmental	3,652	3,932
Total	**21,080**	**20,045**

For the last three years *Zimbabwe* has been developing a *National Water Resources Management Strategy* (*WRMS*)[5] . Ten key organisational stakeholders from government and industry were identified in a wide ranging consultation process. A key outcome is the devolution of catchment planning and management to locally appointed Catchment Councils. WRMS have carried out over a dozen specific studies of water management issues, many of which investigate demand management topics (e.g. pricing, effects of WDM, price subsidies, water allocation priorities, etc.).

A review of water availability and use in Zimbabwe[9] points out that most runoff is in the form of storm flows, so that reservoir storage is the key to water conservation. However, there are a few river basins where 200-400% of Mean Annual Runoff has already been committed to water rights holders. Most water is utilised by large scale irrigated agriculture, where irrigation efficiencies are very low. Demand management should be targeted at the large-scale irrigation sector given the fact that more water is lost when water is released from reservoirs for downstream irrigation. A small saving in the irrigation sector makes a big contribution to other sectors - such as municipal use.

As the driest sub-Saharan African country, *Namibia has considerable experience of WDM*, particularly in Windhoek[6], where integrated Water Resources Management has been used to promote a holistic approach to both supply side development and demand side efficiency measures. Treated effluent is used through a dual pipe system for municipal irrigation ($1.14Mm^3$ in 1997). Water reclamation for potable use was pioneered in 1968 and currently supplies 8,000 m^3/day - 19% of the daily potable supply. The success of integrated WDM measures resulted in zero overall growth in water consumption over the period 1990-97, despite a 35% population increase.

The main components of water use in Swaziland[11] include:

Sectoral water use in Swaziland	Mm^3/annum
Irrigated agriculture	629.0
Manufacturing (citrus, sugar, pulp)	
Municipal and industrial	11.4
Rural domestic	2.6
Livestock	9.2
River basin transfers to South Africa	344.0

With responsibilities for water management shared between a number of government organisations there is an urgent need to implement integrated water resources management, through the enactment of the draft Water Bill of 1998 and the establishment of a National Water Authority. A Water Master Plan would be implemented to address a water demand survey, a catchment based assessment of surface and ground water resources, balancing of supply and demands, and the development of major resource development proposals, with reviews of the inter-river basin transfers to South Africa.

Best Practice Case Studies

A summary of water demand management experience in Zimbabwe[12] identifies the principal forces that have led to conflicts in Zimbabwe's water sector as the:

- Depletion/degradation of the resource through inefficient use
- Doubling of the population approximately every twenty years
- Unequal distribution or access to the resource

Rationing measures applied in the city of Bulawayo had important effects on levels of consumption in high and low density areas as given in the following table:

Period	Type of urban area	Consumption (litres/capita/day)
Normal period	Low density	300
	High density	100
Rationing period	Low density	80-150
	High density	60-85

Most major urban areas in Zimbabwe still have a supply-orientated approach. To co-ordinate nation-wide WDM approaches, satisfy additional demand and relieve tension amongst users, WDM needs to be introduced through the national water policy and strategy provisions.

The Kafue flats in the middle of the *Kafue River Basin, Zam*bia is an area of increasing water demand for irrigated agriculture, industry and hydropower. *Water allocation*[14] is the responsibility of the National Water Board, as water rights are vested in the President. Growing competition between users has led to the introduction of demand management techniques. Historic water allocations were $70m^3$/day/hectare throughout the year. Presently, water rights have been revised to match actual monthly crop water requirements. The original fixed lump sum tariff has been replaced by an actual use tariff with rising blocks, and this has brought improved water efficiencies. Small scale farmers are protected by a flat fee for up to $500m^3$/day.

In order to resolve the problems associated with new water allocation strategies, the *Zambian Water Board* promoted an education campaign for farming communities - as a result of which a number of *Catchment Management Associations* were set up[19]. Their primary objective is to regulate water abstractions while striking a balance between the needs of the environment and farmers. They are registered with the Water Board and operate as a co-operative society.

Recent successes include:

- Detecting leakage to reduce losses to below 30%
- Shifting to sprinkler/drip irrigation
- Implementing water rationing during drought
- Promoting compulsory metering of abstractions
- Explaining increases in water rights fees
- Reviewing water rights applications
- Disconnecting those who waste water
- Carrying out irrigation maintenance programmes
- Determining seasonal water allocations to farmers

Water allocation in Zimbabwe will be the responsibility of new catchment councils. The Ministry of Water is developing an *allocation algorithm*[(15)] for use by the Catchment Councils. Seven uses that have been identified are:

Water use sectors in Zimbabwe catchments	**Typical catchment Allocation (%)**
Primary and environmental	5
Urban, industrial and mining (UIM)	5
Not accessible (with present state of resource development)	25
Reserve for future use	5
Downstream	10
Power generation and tourism	5
Agriculture	45
Total use of available water (mean annual runoff)	**100**

Guidance is given on the iterative process of estimation and allocation of water use by catchment.

The environmental and economic regulatory regimes for British water companies provides an example[(16)] of explicitly *integrating demand management options into water resources plans* and long-term operational and investment plans. The regulatory planning framework requires the 28 water companies to submit detailed component forecasts of water use for some 150 water resource zones in England and Wales. These include the costs and benefits of demand management options which must be assessed on the same economic basis as supply development options where supply and demand are out of balance. Data submission is by standard spreadsheets and a relational database stores data nationally with GIS outputs.

Water use accounting has been used in the Olifants River Basin, South Africa[(17)] to assess the impacts of irrigated agriculture. Similar studies are being conducted simultaneously by IWMI in Mexico, Morocco and Turkey. The approach constructs a water balance for an identified domain of water interest, specifying spatial and temporal boundaries. Components of the balance are:

- Water depletion - *process depletion*, to produce a good, e.g. industrial water use and evapotranspiration.
  - *non-process depletion*, losses but not for a human purpose, e.g. reservoir evaporation (non-beneficial) and grassland transpiration (beneficial).
- Committee outflow - from the domain for other uses.
- Non-depletive uses - e.g. fisheries.

Olifants River Basin Level Accounting

	Mm^3/annum	
Gross inflow		34,637
Uses		
Depletive uses		
Process depletion		2,364
Irrigation (surface and groundwater)	510	
Domestic and industrial	90	
Mining	80	
Power generation	200	
Exotic plantations	56	
Stock watering	28	
ET from non-irrigated crops	1,400	
Non process depletion		31,023
Flows to sinks		
Evaporation from open water	168	
ET from natural vegetation	14,000	
Exotic plantations	56	
Evaporation from bare ground	16,799	
Total water use		33,387
Outflow		
Total outflow		1,250
Surface outflow from rivers	1,235	
Surface outflow from drains	0	
Sub-surface outflow	0	
Committed outflow		15
Navigation	0	
Environment	*0	
Trans-basin diversions	15	
Uncommitted outflow		1,235
Unaccounted for		**0

* to be determined
** inflow - uses - outflow

Deficit irrigation of sugar cane in Zimbabwe[18] demonstrates that there are increases in marginal gains and efficiencies with *decreased* watering. The study used the ACRU agro-hydrological computer model to simulate crop water supply and irrigation operating strategies. Model outputs have been transferred into simple charts and tables for optimum operation use.

Tools and Skills
Papers under the general theme of tools and skills covered information management, models, databases and use of geographical information systems (GIS). An innovative *Data Archiving System* (DAS) has been developed for the Romwe catchment in Zimbabwe by the Institute of Hydrology, UK[20]. The system uses standard PC-based relational database software to develop an object oriented data storage architecture which reflects the approach used in the GIS to which it is linked. Data items are referenced using three co-ordinates:

- Features – physical features such as households, weirs, villages, fields
- Attributes – which describe features, e.g. a village may have a population attribute
- Time data – for feature/attribute pairings, e.g. the date of the village population census

The DAS was developed using a database in MS Access 95 and a GIS developed in ESRI's ArcView Software. The two packages were linked using Dynamic Data Exchange (DDE), within

Windows 95. The system is easy to use and allows users to quickly add new data items without specialist knowledge of the complex data model.

A very sophisticated *national GIS programme for water use and associated data* has been developed by the Department of Water Affairs in South Africa[(21)], to support the strategic development of water services. The purpose of the GIS management tool is to facilitate:

- Development of a proper information system
- Transformation of data into knowledge data
- Execution of querying and communication
- Programme integration and communication
- Effective planning
- Decision-making
- Empowerment and training
- Monitoring and evaluation

The products produced so far in electronic format include:

- Guide to all communities: location, population, water services, with national, provincial and regional perspectives
- Guide to groundwater resources by communities: location, potential and quality
- Guide to community water projects: population served, costs and progress
- Guide to community water infrastructure

Other products in the course of development include:

- Surface water
- Institutional arrangements
- Management issues

These products can be delivered as paper guides, maps and as CDs.

The University of Natal, South Africa, has developed two tools to help hydrological practitioners move from *national to local scale water use and demand management*[(22)]. It is recognised that hydrologists and catchment managers have to respond to the significant paradigm shifts taking place within water resources management such as from:

- Functional engineering systems to environmental issues
- Water resources development to sustainable resource management
- Top-down political decision-making to bottom-up public participation

The ACRU hydrological simulation model is a deterministic multi-purpose modelling system which can output daily run-off, irrigation demand, soil moisture and seasonal crop yield estimates. The model is currently set up to cover the entire region of South Africa, Lesotho and Swaziland through 1,946 interlinked Quaternary Catchments, as identified by the Department of Water Affairs and Forestry.

A complementary spatial and temporal database stores the relevant catchment data for the Quaternary Catchment. This includes soils, crops, vegetation spatially and a set of 45 year rainfall records at 1,300 stations. The database is linked to the ACRU model by GIS.

Four case studies demonstrate the application of these tools:

- Land use impacts on water quantity and quality
- Conflict resolution from competing land uses

- Assessing streamflow reduction by different activities
- Water use efficiency for irrigated sugar cane

A strategic approach to information management for water use and demand was presented by HR Wallingford[23]. The information cycle provides a useful conceptual framework on:

- Information utilisation
- Information needs
- Information strategy
- Data collection
- Data analysis

This approach is applied to develop *a pilot concept for an Integrated Water Information Management (IWIM) System* to provide information on water use and demand in Zimbabwe[24]. Current use, available supplies and forecast demands can be stored for a large number of key sectors and sub-sectors. The information is also stored at different nested areal levels for mapping purposes, with IWIM providing algorithms for aggregating and disaggregating up and down these levels.

Typical levels include:

- Political and administrative boundaries
- River catchments
- Water supply areas

Information requests can be across sectors, levels and time.

Hydrologists are recognising the need for *integrating water use and demand management into catchment hydrology*[26] through the Southern African contribution to HELP (Hydrology for Environment, Life and Policy). The proposed new long-term global research programme, being promoted by UNESCO and WMO, aims to utilise the skills of scientific hydrologists in real world issues on integrated water resources management at the river basin level.

Workshop Papers

(1) Demand management implications in Southern Africa of the Vision for water, life and the environment in the 21st Century; GWP/WWVision: Andy Bullock
(2) Water use and demand management in the SADC water resources programme; SADC WRTC: Edward Mokuoane
(3) Water demand management in Southern Africa; IUCN Southern Africa: Saliem Fakir
(4) A national water conservation and demand management strategy for South Africa; DWAF South Africa: Dhesigen Naidoo
(5) Putting policy into practice – developing water resources management strategy (WRMS) for Zimbabwe; WRMS Zimbabwe: Simon Pazvakavambwa
(6) Water demand management and water re-use in Windhoek, Namibia; DWA Namibia: Ben Groom and Ben van der Merwe
(9) Availability and intensity of water utilisation in Zimbabwe; University of Zimbabwe: Dominic Mazvimavi
(10) A brief overview of the Republic of South Africa's water situation and its recent water use figures; DWAF South Africa: Dr Pieter Pansegrouw
(11) Overview of water use and demand in Swaziland; Ministry of Natural Resources, Swaziland: Solami Mavimbela
(12) Water demand management experience in Zimbabwe; WRMS Zimbabwe: Dr Jefter Sakupwanya
(14) Water allocation in Zambia – managing the water demand in Kafue river basin; DWA Zambia: Jonathan Kampata and Andrew Mondoka
(15) Allocation of water resources in Zimbabwe; Dept. of Water, Zimbabwe: Dr Hugh Williams
(16) Planning for water use assessment and demand management with British water companies; NWDMC, UK: Peter Herbertson
(17) Olifants river basin water accounting; IWMI South Africa: Marna de Lange and Herb Blank
(18) Deficit irrigation of sugar cane: from theory to practice; Zimbabwe Sugar Association: Neil Lecler
(19) Community participation in water demand management for agricultural use in Zambia; DWA Zambia: Peter Chola
(20) New tools for holistic water resource management; IH Zimbabwe: Patrick Moriarty, Jeremy Cain and Chris Lovell
(21) GIS for water use and associated data; DWAF South Africa: Fred van Zyl
(22) Tools for national to local scale water use and demand management in South Africa; University of Natal: Professor Roland Schulze
(23) Information and its role in water use and demand management; HR Wallingford: Tim Hannan
(24) A pilot concept for an Integrated Water Information Management (IWIM) System to provide information on water demand and use; HR Wallingford: Adam Dickinson
(25) Some factors affecting the future of water use and demand in a SADC perspective; DWAF South Africa: Ruhiza Boroto
(26) HELP - integrating water use and demand into catchment hydrology; WRMS, Zimbabwe: Simon Pazvakavambwa

(N.B. Papers No. 7, 8 and 13 were withdrawn.)

5. INTEGRATING WATER DEMAND MANAGEMENT POLICIES INTO WATER RESOURCES PLANNING

Policies giving special regard to water demand management are currently few in the Southern African region. However, governments are increasingly recognising the need for consideration and implementation of WDM, and one way to initiate this is through the development of new policies. To put these policies into action, at a water resources planning level, is not always easy. The workshop aimed to identify good examples of *existing* water use and demand management policies and practices being included in integrated water resources planning and management; and moreover, to identify and prioritise the need for *new* policies and practices for WDM, and the best ways of implementing them.

In this chapter the main needs, and recommendations for tools to support them, highlighted at the workshop, with regard to the integration of water demand management policies into water resources planning, are grouped according to the following three subject areas: Legislation and policy; Institutions and administration; Promotion, communications and education. Summaries of the key issues within each subject area are supported by tables containing examples and needs for each of the following categories/sectors: Integrated Water Resources Planning (IWRP), Agriculture, Industry, and Municipal. The examples of best practice refer to specific countries in which they are carried out, but are not intended to cite every instance of best practice, rather to provide a point of reference for an interested reader to find out more. In some cases, boxed examples of case studies have been inserted into the text to help explain the topics being discussed.

Legislation and policy

Several Southern African countries are leading the way with the development of new legislation and policy that pays specific regard to WDM, perhaps most notably the National Water Act from South Africa (DWAF, 1998). Being the most arid sub-Saharan African country, Namibia has also developed holistic policies targeted towards effective WDM, particularly in and around the capital city of Windhoek. Much can be learned from these existing policies, which have been proven to make massive savings in water despite continually high levels of population growth and water demand. See Table 5.1 for a summary of examples and needs.

Stakeholder participation

It is notable that norms, standards and regulations should be "implementable" if they are to be useful tools for managing demand. With many countries decentralising responsibility for water management to a catchment level, this means involving stakeholders in the development of such policies. In turn, this necessitates legal documents which are written clearly, and widely disseminated within the public domain. In such a manner, what may have traditionally been terse, jargon-filled documents become not only workable but enforceable. Moreover, they represent policies that people using the water consider relevant, since they actually helped to formulate the ideas. As a result these stakeholders become more keen to work within legal frameworks. But it does not end there, the power to apply WDM measures is also being devolved to a local level, to community-based organisations like catchment management associations, and with local political support, the likelihood of a sustainable situation is made much more realistic. It is notable that community management of development projects helps them to succeed. In practice however, stakeholders are not always willing or capable of being involved in such a process. To encourage the willingness of stakeholders to embark on community managed projects can require an approach involving sociologists, churches and local leaders. Capacity building may also be required in many situations.

In the past, policies of subsidised water schemes have encouraged inefficient water use, particularly in the agricultural sector, whilst obstructing social equity by giving insufficient consideration to the rights of new consumers and future generations (Naidoo, 1999). Stakeholders and consumers are tending to take a higher profile in policy development.

International water transfers
Policies for WDM need to be applicable at many different levels, whilst remaining both integrated and co-ordinated across the various water sectors. On an international scale, fifteen of the larger rivers in the region cross international boundaries, highlighting the need for regional policies and co-operation to manage these resources, *e.g*. the SADC Protocol on Shared Water Courses, which has been ratified by South Africa, Lesotho, Botswana and Mauritius. The Protocol says that use of the resource is open to each riparian state, provided that there is a proper *balance* between resource development, and the shared water course is used in an *equitable* manner. Such international resources provide either a catalyst for conflict or the potential for neighbouring countries to develop resources and work together in harmony, depending on how the situation is managed, and on the policies of the riparian states. Inter-basin transfers between neighbouring countries already take place in the region, but should ideally only go ahead if the receiver can prove that it is already performing demand management and not wasting water. The timing of the Lesotho Highlands Water Project has recently been under review, since South Africa has been making progress with effective demand management and the need for additional water from Lesotho is being reassessed; demand management has been shown to bring significant water savings even in situations of extreme water stress.

The regulatory approach
A strong regulatory approach is advocated by the World Bank, which may well be the best model for some countries in the Southern African region. Privatisation is beginning to take place in South Africa, but it doesn't automatically improve water services to the poor. However, privatisation can be made to work as long as it is tightly regulated by governments and is prescribed by specific contracts. Privatisation can become a useful tool as long as governments effectively regulate the private sector. In the UK, for example, all water suppliers are regulated by two regulatory bodies made up of the Office of Water Services (OFWAT) and the Environment Agency (EA). These two regulators benchmark and publish the performance of the water companies in the economic and environmental fields.

Sectoral targeting
Targeting specific sectors is important, since WDM policies can be tailored to be more effective in specific circumstances. For example, agriculture accounts for around two-thirds of the volume of abstracted water in Southern Africa. Traditionally, water abstraction permits for agriculture have been issued but the amount of water actually abstracted under those permits remains unknown. In some countries, the abstractor is required by law to return records of the abstraction made, but this law is not sufficiently enforced. Until these volumes are more accurately estimated it will be difficult to manage the resource or to gauge the real level of demand. In Zimbabwe, for example, ownership of water is changing from the tradition of privately owned water rights - whereby riparian owners were able to take as much as they required - to public ownership of trade-able permits of a limited life-span. Under-utilised permits are being reduced or even revoked, in an approach described as 'use it or lose it!'

Environmental considerations
When coidering each sector's demand for water, the natural environment is increasingly being recognised as a 'user' in water legislation. Under South Africa's new National Water Act there has emerged the concept of an 'environmental reserve'. The Act states that '*after providing for the basic needs of citizens, the only other water that is provided as a right, is the Environmental Reserve – to protect the ecosystems that underpin our water resources, now and into the future…It is the duty of national Government…to assess the needs of the Environmental Reserve and to make sure that this amount of water, of an appropriate quality, is set aside*' (DWAF, 1997). Hence, the environment is considered a user of water, and new policies need to recognise the significant impact this demand will have on the balance of water use. In many Southern African countries, the natural environment is precious for its capacity as a tourist attraction. The Okavango delta, for

example, provides much of the GDP of Botswana via tourism; the significance of the environment when new policies relating to WDM are being developed cannot be over emphasised, particularly since it is inextricably linked to the welfare of many countries in Southern Africa.

Institutions and administration

With the trend towards decentralisation of responsibility for water resources management in Southern Africa comes the need for revised institutional structures and responsibilities. With this, in turn, comes the need for capacity building of staff for these new institutions, to enable them to cope with their new roles and responsibilities. Along with the appointment and training of staff able to fill these roles comes the need to clarify what those roles are, and what responsibilities they incur. Such clarity will mean that WDM is carried out as effectively as possible, with a minimum of confusion over whose responsibility lies where.

Institutions need the power to uphold and enforce policy and legislation not only within each sector, but also in a manner that promotes integrated water management. Institutional structures benefit from local backing, particularly that of user associations and local politicians. An integrated reference framework, with a reference and monitoring system or advisory service, is a valuable institutional resource. See Table 5.2 for a summary of examples and needs.

Stakeholder participation
A good example of a newly revised institutional structure comes from Zimbabwe. This new structure emphasises how stakeholders can be usefully involved in the *whole* WDM process, from the development of new legislation through to the hands-on management of water. Stakeholders are traditionally seen to be men, and women are often neglected in such management spheres. However, they have long played a key role in planning and decision-making regarding water management in a domestic setting, and have valuable contributions to make in the stakeholder participation process. It is in everyone’s best interests that all the existing, intrinsic knowledge of water management is employed, and the recognition of gender issues is an action that could be of great benefit to WDM institutions in all Southern African countries.

Management
Democratic methods of managing resources have been proved succesful. For example, the Councils and Sub-Catchment Councils in Zimbabwe are semi-democratically elected. Each council has a catchment manager who is paid by the Zimbabwe National Water Authority (ZINWA), but who expresses the needs of the council, in a process known as ‘matrix management’. With regard to the capacity building of effective water managers, it was cited in the workshop that the best managers are those people who are capable of empathy and of listening to users’ needs. Effective capacity building gives managers the key skills required to turn the WDM policies, described in Section 6.1 above, into a reality.

Promotion, communications and education

Many needs but few examples have been cited with regard to the issues of promotion, communications and education. This serves to highlight the current low profile but the high perceived value of such mechanisms in WDM in Southern Africa. Boxed case studies, primarily from the United States, have been inserted into the text to help explain the topics being discussed. See Table 5.3 for a summary of examples and needs.

Promotion
The profile and perceived value of water is currently very low at all levels from consumer to government. Promotion in this context consists of taking good ideas and reinforcing them through techniques such as the dissemination of best practice. It involves raising people’s awareness of the most appropriate ways to perform WDM. By raising community awareness of sustainable water

management, as performed by the Catchment Councils of Zimbabwe for example, it is possible to create a culture of water conservation and demand management in suppliers and users. The ‘culture of caring’ is one of the most effective ways to instil consumers with the core ideas behind WDM, but such changes can take much time.

To promote the ideas behind managing water demand, the National Water Demand Management Centre of the UK Environment Agency publishes a regular Demand Management Bulletin, which reports on aspects of WDM primarily in the UK, but also on major developments overseas (NWDMC, bi-monthly). Dissemination of best demand management practices has already begun on a national scale, with the Southern African Regional Water Demand Management project funded by SIDA and IDRC, summarised in a paper given at this workshop (Fakir, 1999). Similarly, but on a smaller scale, through publishing the results of efficiency campaigns, water companies can raise the awareness of the value of WDM practices. The UNCHS (Habitat) and UNEP joint initiative entitled ‘Managing Water for African Cities’, described as the *‘first comprehensive initiative to support African countries to effectively manage the growing urban water crisis and protect the continent’s threatened water resources and aquatic ecosystems…’* aims to put in place an effective WDM strategy in ten African cities. Further information is given on the UNCHS web site at http://www.unchs.org.

Communication

In terms of communication, appropriate presentational levels of information are required for different users, to take account of their different capacities to assimilate and handle information in specific formats. A different approach is needed to communicate the problem and its solutions to policy and decision makers.

Figure 6.1: The water use ‘hand’

To begin with, perceptions of decisions makers regarding the value of the water may differ markedly from those of the consumers. There are some good communication techniques that effectively communicate the ideas behind *caring* for water resources to consumers, such as the icon of a hand used in water conservation awareness campaigns in South Africa, where one drop of rain water falls whilst four drops of water are potentially evaporated (Figure 6.1).

The needs of different sectors and sub-sectors differ, so that they should preferably be targeted individually - a procedure known as ‘discrete targeting’ - but without losing the view of an *integrated* management of the resource.

In the United States, the town of Cary, north Carolina, recently held a six month long **water awareness campaign**, whose goal was to significantly reduce Cary's peak water demand by promoting wise water use, especially outdoors. The specific goals were to reduce the Town's average per capita water use by 20 percent by the year 2014; support the high quality of life in Cary by providing safe, reliable water service, while reducing per capita use of water; conserve a limited natural resource; and reduce costs of infrastructure expansion.

The campaign involved a multifaceted approach to informing and educating citizens on a variety of water-related topics through several different information media. In 1999, having produced significant water savings, the Cary campaign won an Environmental Protection Agency Award for the Most Effective and Innovative Education Program. The plan had four major components:

- A 'Tuna Can Plan' which encouraged people to water their lawns only when needed, but no more than one inch, once a week, and only in the mornings. To achieve this goal, the Town distributed door-to-door to Cary homeowners. These one-inch deep tuna cans were accompanied by a flyer telling citizens how to use the can to know when their lawns have had enough water.
- A monthly Town publication focusing on different landscaping topics that promote good water practices. Topics included planting drought-resistant trees and shrubs, choosing the best type of grass for the area, water wise irrigation methods and tools, proper soil preparation, and water wise landscaping planning and design.
- A 'When-to-Water Website' designed to give people important information about water use and usage. By accessing 'When to Water', citizens can also know the current weather conditions and learn how these factors should impact their watering decisions. 'When to Water' also tracks daily water demand on the local water plant so that the community as a whole can see how it is doing in the total conservation effort.
- A Block Leader Program, the grassroots communications effort between the Town and neighbourhoods designed to give residents the latest information on important issues facing their community. Block Leaders spend between three and five hours a month learning about specific Town programs and sharing what they've learned with their neighbours. Subjects included water conservation, recycling, and other environmental topics.

The **Greater Hermanus Water Conservation Programme** was the first water demand programme in South Africa. The objective was to conserve the natural water resource as it faces increased demand using a comprehensive long-term water conservation programme. It was based on twelve scientifically and socially sound principles which are as follows:

- Clearing alien vegetation with high water consumption.
- Water loss management, dealing with the water not accounted for such as unmetered and illegal connections and leakage.
- Retro-fit programme, aimed at supplying existing homes and buildings with water saving devices. Owners were fined if devices are not installed after a certain period of time.
- School Audits, aimed at finding out what activities consume the most water, and why.
- Communication
- Security meter, installed in some of the homes with a pre-pay system and panic buttons for emergencies.
- Assurance of supply, a fixed amount levied every month, forming the basis of the authority's pledge to provide water to every house as long as it is available.
- Escalating block-rate tariffs
- Instituting initiatives to save water in the home
- Water-wise gardening methods
- Utilising 'grey' water for food production
- Water regulations and building by-laws

Education

Education and marketing are essential tools for enabling policy to be implemented, particularly when they are integral parts of a larger plan. The training of communities in simple, practical WDM skills is a cost-effective way to ensure sustainable, well-maintained systems; for example, skilled plumbers ensure water-efficient distribution networks with minimum leakage. In South Africa, plumbers have been trained and sent into consumer's homes to fix leaks free of charge, in situations which should theoretically have been the consumer's responsibility. An appropriate toolbox of skills necessary to understand and apply water demand management can be used in parallel with long and short-term training and support.

In 1992, the Department of Water Affairs and Forestry in South Africa announced a National Water Week Campaign. This annual date coincides with the official date for International Water Day on 22nd March. Holding National Water Week in the middle of March is an excellent time of the year in South Africa as the weather is usually good, which allows for outdoor activities. Through a national campaign such as Water Week, individuals are provided with an opportunity to create an awareness of the importance of water and the need to protect and manage this precious resource correctly.

The best efforts at managing water demand are known to take place in crisis situations, such as during periods of drought, when consumers can see for themselves the importance of managing water resources effectively. Lessons can be learned through understanding the mechanisms that make water usage drop during emergency situations but rise again when the emergency is over. This knowledge could be usefully employed to manage demand under normal resource conditions.

Teaching children about water conservation not only creates the 'culture of caring' in young consumers, but also, indirectly, teaches their parents. Several countries now teach water conservation via school syllabuses. Such lessons can be made more exciting and accessible for children using accessories such as posters, stickers and stamps. The techniques described in the Blue Thumb Project, and provided by their web site, could easily be used in Southern African schools and communities as teaching aids.

The **Blue Thumb Project**, based in the United States, is an ongoing campaign to raise public awareness and understanding of drinking water issues and to motivate individuals, communities, and companies to make water-responsible choices. The Blue Thumb Project began in 1992, to commemorate Drinking Water Week, seven days in May when individuals, communities and companies hold educational water events in libraries, schools, water treatment plants, shopping malls and city halls. Since then the Blue Thumb Project has generated an ever-growing movement towards water responsible actions. Now, the Blue Thumb Project is used to 'Celebrate Water' not only during Drinking Water Week but any day throughout the year. The idea behind the Blue Thumb Project is to make people realise that they have a hand in making something better; through using their Blue Thumb they can do their part to preserve and protect water.

The Blue Thumb Alliance is a group of non-profit and government organisations who share the goal of increasing water awareness and water education. The Blue Thumb Alliance provides the leadership for all Blue Thumb Project efforts. The associated web site provides news releases, camera-ready advertisements and logos, educational fact sheets, posters, educational catalogues, tips and tricks, and quizzes, at the web site http://www.awwa.org/bluethumb99/bluethum.htm.

Table 5.1 Integrating demand management into water resources planning: Legislation and policy

	Examples	**Needs**
IWRP	• Constitution that includes sustainable water use, & promotes a holistic approach to WDM (both supply side development & demand side efficiency measures). Resulted in no overall growth in water consumption from 1990-7 despite 35% population increase. (Namibia) • The Water Services Act (1997) & National Water Act (1998) (South Africa), & forthcoming Master Water Plan (Swaziland) cover such items as equity to water services access; sustainable & optimal water use; protection of resources; regulation of licence conditions. • Integrated approach effected through no differentiation between ground water & surface water (Zimbabwe) • Catchment Councils are empowered to issue permits (Zimbabwe) • Protocol on Shared Watercourse Systems for international river basin management (SADC Water Sector) • WDM upheld in water laws & policies (South Africa, Zimbabwe, Zambia)	• *National*, comprehensive, integrated policies for WDM (*e.g*. demand reduction targets, water use prioritisation, choice of tools to achieve targets) • Adoption of WDM into *regional* policies for planning, managing & sharing water resources, particularly international river basins • Recognition, approval & government by international bodies • Co-ordination of policy & legislation both *within* & *outside* water sector • Legislation to balance sustainability, efficiency & equity • Legislation to give authorities the power to apply WDM measures, & the adequate capacity to enforce water laws, with a strong, regulatory approach • Local political support, with stakeholder involvement at all stages • Development of *integrated* planning for water supply & efficient discharge • Specific groundwater policy to enable control over the resource • Better management of water abstraction permits • Recognition of the natural environment as a ‘user’
Agriculture	• No concept of ‘private water’ or water rights; all water is now owned by the President. Riparian owners have lost their preferential rights (Zimbabwe) • Primary water supply & environment take precedence over irrigation in times of water shortages (Zimbabwe)	• Legislative policies to support WDM, related specifically to agriculture • Stakeholder involvement in policy development & enforcement, with capacity building as necessary • Tighter control over water use permits so that volumes abstracted are known • Inclusion of women in planning & decision making regarding water management, especially in a rural setting
Industry	• Water efficiency carried out in commercial buildings (Namibia) • Water companies have a legal duty to promote water efficiency to industrial customers (UK)	• National, co-ordinated policies with a legal framework for WDM • Regulations, controls & intervention policies that can be implemented & enforced with suitable penalties • Effective tariff policy for effluent discharge • Inclusion of water efficiency in water use regulations
Municipal	• Water supply regulations refer to undue consumption (Namibia) • Sewerage & drainage regulations cover pollution (Namibia) • Urban Councils Act of 1980 allows emergency water rationing (Zimbabwe) • Widespread effluent re-use performed in the capital city (Namibia)	• Inclusion of WDM in water & sanitation sector policy • Policies specifically formulated for rural water supply • Strong, regulatory approaches, with specific contracts to ensure that private water companies deliver water services to the poor

Table 5.2 Integrating demand management into water resources planning: Institutions and administration

	Examples	**Needs**
IWRP	• Introduction of National Water Authority (ZINWA) to prepare water development plans, & supervise & fund catchment councils (Zimbabwe) • Decentralisation to Catchment Councils & Sub Catchment Councils, representing all water users (Zimbabwe) • Implementation of Water Resources Management Strategy, developed through stakeholder consultation, to address policy & development requirements of the water sector (Zimbabwe) • Catchment management associations established to regulate water abstractions – also reduces leakage, prosecutes water wasters, formulates/helps to implement catchment development plans (Zambia) • Water accounting, a procedure for analysing the uses, depletion & productivity of water, provides a broad picture of water use & depletion in a basin (IWMI's Water Balance Framework, Perry, 1996) • Decentralisation: DWAF challenged to move from a central to a regional structure (South Africa)	• Institutional changes with *local* political support • Networking within both *countries* & *regions* • Practical strategies capable of meeting stakeholder expectations – preferably involving stakeholders & interest groups in process of development • Addressing of geographic, demographic & gender issues affecting water use in a consistent & informed manner • Clarification of roles & responsibilities of new institutional staff • Revolving fund, from revenue, to manage WDM projects & research • Capacity building: properly trained institutions to carry out WDM activities • Management information systems to assist institutions to manage increasing volumes of data & information • Institutions accountable for their performance to reduce financial losses and regulate levels of service between communities • Clarification of roles for environmental NGOs
Agriculture	• Reforms in National Irrigation Policy & Strategy to aid WDM (Zimbabwe) • Use of national commissions & boards to research & disseminate WDM approaches, *e.g.* Water Research Commission, Agricultural Research Council, Irrigation Institute Training, Ground Water Schemes (South Africa); the Sugar Association Experimental Station, the Agricultural Research Fund, & the Irrigation Association (Zimbabwe)	• Inclusion of women in planning & decision making regarding water management, especially in a rural setting; such useful, intrinsic skills should not be overlooked • Duty-free water saving equipment for irrigation
Industry	• Trade associations for specific industrial sectors, such as the Tobacco Board (Zimbabwe), provide a good vehicle for education in water efficiency.	• Institutional power to uphold existing industrial legislation & policy • Integration of industrial monitoring & evaluation systems
Municipal	• Rand Water, a private enterprise bulk water supplier which is DM conscious, has no direct influence over distribution by municipalities (South Africa)	• Water supply tariffs related to economic price of water whilst recognising the need for social welfare.

Table 5.3 Integrating demand management into water resources planning: Promotion, communications and education

	Examples	**Needs**
IWRP	• Intensive communication campaigns & billing to spread WDM ideas (South Africa), with dissemination via both print & electronic media (Zimbabwe) • Political ward meetings keep local people & government in communication (Zimbabwe) • Country studies, demonstrating case studies of best practice from 5 Southern African countries, promoted via international conferences published in a widely disseminated document (Southern African Regional WDM project) • 'Water weeks' aimed at schools & at rural areas. Children can do a good job of teaching their parents, thus school campaigns educate parents via children, with water included in school syllabuses. Poster campaigns, competitions, stamps & stickers provide fun methods for teaching children (South Africa) • DM Bulletin provides a focus for expertise on promoting the efficient use of water both in the UK and internationally (NWDMC, UK)	• Raised awareness of benefits of WDM, for water managers & policy makers. Education of more technocrats to overcome lack of implementation capacity, especially with decentralisation to catchment management • Direct, appropriate levels of communication to (& between): Policy makers; Users; Schools; NGOs; Catchment Boards; Municipal authorities. • Training required to overcome the lack of expertise (*e.g*. plumbing) • More resources for promoting demand management (*e.g.* financial, human) • Published results of efficiency campaigns – both positive & negative aspects (overcome resistance to release of information by regulators), with documentation & dissemination of best practices • Improved scientific methodologies for water resources assessment • Use of window of opportunity provided by drought – finding ways to extend water awareness during wetter years • Promotion of a culture of social awareness/consultation/communication
Agriculture	• Educational campaigning in farming communities to manage water sustainably (Zambia)	• Education of farmers on efficient irrigated agriculture • Promotion of high value, rather than low value, crops • Encouraging the concept of food security • Research into efficient water management, such as irrigation techniques • Concentration on agriculture as one of the major impactors
Industry	• Targeted education of key industries having the biggest impacts to be made on WDM, such as brewing (Namibia)	• Environmental & social factors incorporated into cost of water supply management • Proper motivation for industry, to encourage increased co-operation • 'Discrete targeting': concentration on selected industries (*e.g.* mining) as some of the major impactors
Municipal	• Public awareness campaigns teach how to save water in the home, & how to maintain low water gardens (Namibia) • Schools liaison & school water audits, encourage a culture of awareness from an early age, & teach parents via their children (South Africa) • Educational campaigns & restrictions during droughts teach the public the value of their domestic water supply (Botswana) • National Water Conservation Campaign (DWAF, South Africa)	• Development of regional public awareness & communications programmes to increase community awareness on sustainable water management. • Raised institutional awareness of cultural issues (*e.g*. relating to effluent re-use for drinking water) • Involving community leaders in applying WDM in their own homes & farms – teaching by example & raising awareness among leaders • Community participation in Water User Associations to help control demand

6. DEVELOPING TOOLS AND SKILLS FOR WATER DEMAND MANAGEMENT

The identification of tools and skills to enable the implementation of WDM was the main aim of this workshop. In Chapter 6, WDM policy needs were identified, with the institutional needs to support those policies, and the ways to educate people and raise their awareness of demand management issues.

This chapter aims to identify the tools and skills required for practical implementation of demand management by water resources specialists, planners and managers. The three subject areas studied in this chapter are: Technical standards, methodologies and guidelines; Information management; and Economic methods. These summaries are supported by tables containing key examples and needs for each of the subject areas, by category/sector: Integrated Water Resources Planning (IWRP), Agriculture, Industry, and Municipal.

Technical standards, methodologies and guidelines

Technical standards, methodologies and guidelines should all be considered as useful tools when implementing water use and demand management strategies at all levels. This section presents a brief summary description of each of the three categories, followed by a table of examples of guidance and standards in the field of WDM from the UK and USA (Table 6.4). See Table 6.1 for a summary of examples and needs.

Technical standards
Technical standards are related to a very specific topic, and produced by nationally, or internationally, recognised organisations such as the International Standards Organisation (ISO). ISO promotes the development of standardisation and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing co-operation in the spheres of intellectual, scientific, technological and economic activity. ISO's work results in international agreements which are published as International Standards. In most countries, standards can be purchased from the standards organisation in that country. If standards are not available in a particular country, they can be ordered from ISO directly. Their address is: ISO Central Secretariat, PO Box 56, CH-1211 Geneva, Switzerland.

Within the SADC region, the South African Bureau of Standards (SABS) also produces many standards related to the water supply industry.

Methodologies
Methodologies tend to apply to quite specific technical procedures, and can include such tools as manuals, models, databases and Geographic Information Systems (GISs). There already exist in some countries, particularly South Africa and Namibia, many examples of best practice in the development and use of methodologies from which other SADC countries might learn.

The use of computer controlled management systems is increasing; for example, in the municipal sector, the use of water meter management systems helps to combat fraudulent meter bypassing. However, such systems can be expensive, and the benefits of operating these systems, such as for leak detection, should outweigh the costs. This illustrates the fact that economics has a pivotal role to play in any of the WDM measures employed, as discussed further in Chapter 7.3.

The agricultural sector is the region's largest water abstractor, taking around two-thirds of the total volume abstracted in Southern Africa, combined with some extraordinarily low levels of water use efficiency. Demand management measures have most to achieve in this sector (further discussion of agricultural water use issues can be found in Chapter 3). Deficit irrigation was cited at the workshop as having great potential as a water management strategy; the ACRU model (Smithers and Schulze, 1995) looks at balancing irrigation water versus crop yields, and thus helps to maximise economic returns. It optimises yields according to how much water a farmer has in relation to land area, and assists with deciding how to manage irrigation rotas, by deciding on a good 'dry-off' period between irrigating; it is easy to over-water crops and so waste lots of water to evaporation and deep percolation.

Water use performance can be optimised by changing crop types to those of higher value. Major savings can also be made through the use of more efficient irrigation techniques, such as drip and sprinkler irrigation, rather than inefficient methods such as furrow irrigation. Furthermore, savings can be made through the use of water efficient irrigation equipment. To be most effective, the water management system should motivate people to save water; in Zimbabwe there are pseudo 'reservoirs' within reservoirs, so that a farmer who saves water will have that resource available later, whilst a farmer who does not save water will not have extra resources to rely upon.

Computer models are becoming useful tools in areas such as decision making, where they are known as Decision Support Systems (DSSs). To enable consistency, decisions on which modelling tool to use ideally need to be made at a national level, and not changed too frequently. Software packages using the 'object oriented' approach allow great flexibility and can avoid the need for complex data models. They lend themselves naturally to the support of multi-disciplinary and sectoral analysis. The most useful tools are those which are based upon standard, commercially available software such as Microsoft Access or ESRI's ArcView. The Geographical Information System is a powerful tool for handling large amounts of spatially referenced data and information (such as population or land use data) and presenting them in a clear visual manner.

The IWMI water balance framework (Perry, 1996), based upon Microsoft's Excel spreadsheet software, is an easy-to-use computer model for analysing the utilisation of water from surface irrigation and rainfall within an irrigation project. The framework 'allows explicit definition of losses to seepage, operational losses, and efficiency of field application' to give a picture of the water balance in an irrigation project, but requires a good data set. The analysis is aimed at use by designers and managers of irrigation projects, for interpreting such issues as water use efficiency and water imbalances.

Guidelines

Guidelines are the most generic of the three types of tool discussed here, and as such offer the most flexibility and the greatest scope for employment. They relate to the interpretation and communication of policy in a technical area. Guidelines express intent, and can be used to steer people in the desired direction. For example, in the UK, policy guidelines are developed in the public domain; this is a consultative process, whereby a minister will produce draft guidelines with advice from specialists in the field, and will revise the guidelines in an iterative, democratic process.

Technical guidelines, such as those provided to UK water companies by the Environment Agency, could become a useful tool in the SADC region. They include such features as water industry definitions and terms; water industry agreed methodologies for demand forecasting, economic analysis, and headroom; a common set of assumptions and planning scenarios; a common spreadsheet format for electronic transfer of data tables. The WMO Technical Report (1998) entitled 'Methods for assessing trends in water demands and use for hydrological services' provides standards and guidelines for measuring, estimating, collecting, compiling and analysing water use data.

Summary

Technical standards, methodologies and guidelines are distinctly different tools; of the three, methodologies were by far the most commonly discussed tools at the workshop. Few examples of guidelines were mentioned, implying that there is a lack of clear, official guidance for water demand management in the SADC region, or that it is not widely known about. Examples of technical standards, methodologies and guidelines from the UK and USA are given in Table 6.4.

Examples from the UK are taken from the UK Water Industry Research Limited (UKWIR) web site (http://www.ukwir.co.uk/). UKWIR places research contracts on behalf of the UK water industry, and research programmes are developed against the industry's strategic business needs.

Examples from the USA are taken from the WaterWiser web site (http://www.waterwiser.org/) and the IWR-Main web site (http://www.pmcl.com/wdms/). WaterWiser is a water efficiency clearinghouse, a program of the American Water Works Association operated in co-operation with the U.S. Environmental Protection Agency and the U.S. Bureau of Reclamation, offering directories of water efficiency products and services, with an on-line listing of water conservation references and links. The IWR-Main Water Demand Management Suite can facilitate decision-making through such techniques as water demand forecasting, drought planning, rate analysis, watershed planning; and integrated resource planning.

Information management

Information management is one of the most important technical issues for water use and demand, and especially for integrated water resources planning, since water wastage and inefficiency are highlighted by good information management. A good information management system is an invaluable tool, succinctly upheld by the maxim: *'to measure is to know'*, and can be used to support WDM policies. Without the relevant information on current and historical water use and demand, it is very difficult to perform demand analysis, or to understand the drivers of future demand.

Typical information management tools include databases, bespoke computer models, and general strategies for managing data and information. There follows a summary of the main information management tools available, or required, with examples from the workshop. See Table 6.2 for a summary of examples and needs.

Databases

The best databases are those with greatest flexibility, where all data have been subjected to stringent quality checks and then clearly archived. This means that database development must be iterative and incremental, and involve the maximum possible interaction with potential users. In this way, the product will be user-friendly, and easy to maintain and update. This is important since the types of data needing to be stored will almost always change with time. For example, the National Water Balance Study carried out in South Africa is updating and transforming the data behind the 'Red Book' (a comprehensive summary of water use, and predicted water use, data for South Africa (DWAF, 1986)) into electronic format, thereby providing an easily updated, on-line summary of the best information on South Africa's national water usage figures. Thus databases can be used to assist with planning, through the forecasting of water availability and demand. Such forecasting requires a good understanding of demographics; for example population increases, the change in size of particular age groups, the proportion of the population living in urban/rural areas, and the effects of HIV/AIDS, etc. All these factors are important to truly understand water use patterns and must be well comprehended to enable realistic forecasts of water use and demand to be made.

Improved levels of hydrometric monitoring and the measurement and creation of databases on water consumption would enable more detailed assessments of surface and ground water resources, both qualitatively and quantitatively, and would also enable a much needed study of the seasonality of flow. Such procedures require a homogeneous methodology at the SADC regional level; improvements in stream flow monitoring are currently under way due to the Southern Africa Development Community (SADC) HYCOS project, part of the World Hydrological Cycle Observation System (WHYCOS), a World Meteorological Organisation (WMO) programme that is installing hydrological and meteorological measuring equipment at fifty sites across the SADC region (Andrews *et al.*, 1999). The data are transmitted by satellite and made available in near real-time to linked databases in each SADC country, enabling real-time planning procedures, as well as databases of hydrological data to be available internationally in the region. Such a system could realistically be extended to include measurement of water quality, making it of even greater use to water resources managers in the region.

Not only is a database of water use information important, but this can be supported by a 'knowledge base' of what is happening in a region, country, catchment or sector (industry and agriculture are especially lacking in good databases of water use and efficiency data) and what databases and tools are available. A good knowledge base is:

data – information – knowledge – ownership.

Information strategies

A flexible strategy for collecting and processing the most appropriate data should ideally be developed early in a project, when the best strategies are the simplest. The 'Information Cycle' (Figure 7.1) provides a framework for planning and implementing programmes to ensure that all information necessary for water management activities is available. With the trend towards a catchment council style approach, planners and water resource managers must give careful thought to how their data will be used, and stakeholder participation in the information process is of the utmost importance. It is advisable to periodically reassess information needs and update them; once again the idea of an iterative process emerges. Information needs in water management change when a resource/supply orientation changes to a demand and use one.

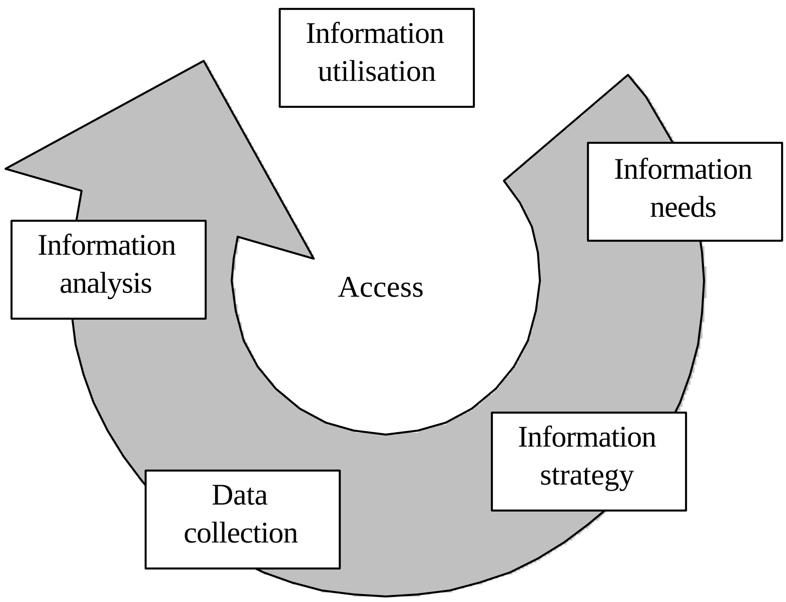

Figure 7.1 The Information Cycle (Hannan, 1999)

Since irrigation is the biggest water user in the Southern African region, it should be seen as having a great potential for efficiency measures; this means that information strategies can be sectorally targeted. For example, the accounting of irrigation use in a basin should be refined and include the analysis of return flows. The volume of water diverted for various types of irrigation and the amount of water consumed by various crops and plant species should be better quantified.

The Internet contains large amounts of information, not only on levels of water use and demand, but also water use standards and results of studies, from a wide variety of sources, and is becoming increasingly accessible across the region, *e.g.* the African Water Page which contains links to over eighty relevant sites (see Annex 5 for a summary of useful web sites for information on water use and demand management).

A good outline for the development process of Information Management Tool includes the following steps:

- Create a conceptual design with a team of people
- Establish the management requirements
- Collate the data and validate their quality
- Turn the data into information
- Put the data into the database
- Design a user-friendly interface
- Design the metadata
- Choose the hardware and software
- Make a maintenance design

A well-designed water resources computer model can have great potential for use in managing water use and demand data, and for turning them into useful information. This enables further analysis and added value to be gained, and can consider the effects of scenarios such as climate change and land use change. However, before beginning to set up a model of a water resources system, a good product specification is essential. Desired model attributes include:

- A deterministic basis
- A sound physical and conceptual structure
- The ability to mimic non-linear processes well
- Non-reliance on external calibration
- Short time steps; daily is considered good since it is natural, whereas a monthly time step is not meaningful nor natural for most parameters.
- The ability to work at scales where conflicts can be resolved and not at larger scales, *e.g.* the quaternary catchments used in South Africa.

Indices

Indicators of the state of a region's water resources (such as the Falkenmark index) should be tightly controlled to ensure they remain meaningful, for example by applying them to smaller areas such as the catchment instead of nationally. Conversely, there is a need for a broader picture, perhaps using health and education indicators in combination with standard physical indicators. Such indicators are often used as a marketing tool, and it should be ensured that the index is meaningful, but not so complex that it becomes unusable.

Summary

The best information management strategies, models and databases are the flexible ones, since in the real world, nothing is ever static. Information needs change, and need to be regularly monitored and updated in an iterative process. Finally, a reasonable rule to follow is (Hannan, 1999):

start small - be inventive - keep it simple.

Economic methods and approaches

Recognition of the pivotal importance of economics in the management of water use and demand is escalating. Economists use a narrower definition of demand management than that used by hydrologists and water resources managers, whereby the control of consumption of a service is via a price mechanism. The mention of 'control' indicates the magnitude of the part that economics has to play in managing water use and demand.

However, the economics of a situation are usually inseparable from other aspects; for example, computer-aided leakage detection management systems may seem to be prohibitively expensive unless measured against the savings that such tools can make (leading to the concept of 'economic levels of leakage'); strategies for managing irrigation rotas can mean that the balancing of irrigation water versus crop yields helps to maximise economic returns. Economics can therefore be seen as not only implicit in many water use and demand management situations, but perhaps even the controlling factor. Efforts towards gaining an understanding of the effects of economics used as a tool in managing the demand for water are gaining momentum in Southern Africa, perhaps more so than in many parts of the developed world. Yet the semantics of economics, and the perceived complexity of the subject, can form barriers to the understanding of how to use economics effectively. In this section, some of the main terms used by economists, and their potential applicability for managing water use and demand, are presented. See Table 6.3 for a summary of examples and needs.

Appropriate pricing strategies
Economists insist that an *appropriate* pricing structure must be put in place, taking account of price elasticity, to enable different users and sectors to respond to water demand management plans as required; that which is applicable in industry may not be a suitable strategy elsewhere. Thus different incentive mechanisms are required, whilst keeping equity in mind. Water pricing is a key tool, but has traditionally only been given secondary consideration.

Demand management should be practised with a particular social awareness of the poor. For instance, in South Africa, DWAF believes that water is a basic human right, and therefore considers cross-subsidisation by the more affluent members of society. Similarly, the Water Resources Management Strategy (WRMS), in Zimbabwe, proposes a 'user pays' approach to water pricing, but with targeted subsidiaries for the poor, although there should be no 'free' water. Demand management needs to identify the areas where the largest savings can be made, to enable re-allocation of water to other sectors and improve equity; for example, in Zimbabwe large-scale farmers have 94% of the irrigated land area and use approximately 70% of the developed water resources. In South Africa, industry and mining use less water and produce significantly more Gross Domestic Product (GDP) than agriculture.

Block tariff structures
Block tariff structures are a way of charging different consumer groups different, and appropriate, prices for water, an approach that was widely proven to work well in Southern Africa. For example, in Windhoek, Namibia, a system of Increasing Block Tariffs has the dual purpose of punishing high levels of water consumption and cross-subsidising access to minimum levels of water consumption through a 'lifeline' tariff. The approach used in Durban, South Africa, is to offer consumers a variable tariff structure, whereby various levels of service exist from which customers can select their preference.

Long run marginal costing
The price of water will not reflect the true cost of producing it unless the long-run marginal cost of water has been calculated. In addition to the short-run marginal costs (day to day expenditure on energy, chemicals and labour), the long-run marginal cost takes into account the capital investment needed to provide extra water. Where sources are fully utilised, the cost of a new source has to be included.

Cost-benefit accounting
A full understanding of the costs versus benefits of a water resources network leads to the correct application of pricing and subsidies.

Least cost planning
It is not always possible to reliably estimate all the costs and benefits from a scheme -particularly when some may be intangible. For example, it may be difficult to evaluate the cost of losing a wetland habitat to a resource development scheme. An alternative approach is to compare the financial costs of alternative projects, selecting those that have the least overall cost.

Price elasticity
Pricing measures can be targeted towards affluent housing areas, where more water is used for non-essential, or luxury, applications such as car washing. Here demand is more 'elastic', meaning that as price increases, consumption decreases. In less affluent areas metered water supplies are more likely to be used entirely for essential domestic purposes, with less scope for water savings, even if the price is raised.

Virtual water
'Virtual water' is that water which is imported as an inherent part of the crops that a country imports, rather than a country importing the water and growing the crops itself. In this way, crops could be grown in more suitable climates and exported to countries where water is more scarce. This concept prompts debate about most efficient water use across regional and national boundaries.

Full cost recovery
A range of monetary incentives (rebates, special funds, tax credits) and disincentives (real costs, penalties, fines) help to convey to users the true value of water. Realistic water pricing means that water users should pay in proportion to their use of water services and that the charges should cover the full cost of establishing and maintaining services - a technique known as "full cost recovery".

It is widely agreed that the full economic value of water should be charged and full cost recovery performed to enable the application of successful WDM. This gives the bulk supplier and the municipality greater knowledge of the strength of demand for water, whilst reducing the volume of water demanded.

Effluent fees
With particular relevance for the industrial sector, water charges should include the capital and operating charges along with the costs of treating the effluent and monitoring the streams. Full metering and monitoring of water use and wastewater discharge has been widely seen to increase industrial efficiency. In Namibia, such fees are linked not only to the volume but also to the strength of the effluent.

Perceptions of value
At many levels of society in Southern Africa, and in the various sectors, there exist problems of perception of the value of water as a resource. For example, farmers will often see the cost of electricity for pumping water as much more important than the abstraction charges for the water being pumped. Such perceptions can be altered, gradually, through appropriate pricing measures described above. Culture and socio-economics, or affordability, also affect perceptions of the *value* of water, and whether, for instance, consumers will use water efficient products. A prime objective of public awareness campaigns for water conservation is to increase understanding of the true cost of water to society.

Environmental evaluations
The environment is increasingly being recognised as a water user, implying that environmental evaluations will become more commonplace. For example, despite its huge importance to sectors such as tourism and hence the income of Botswana, delegates were not aware of a major economic evaluation study of the Okavango Delta wetlands. However, a useful wetlands economic valuation study for the Zambezi Basin Wetlands Conservation and Resource Utilisation Project was recently carried out by the Directorate of Environmental Affairs, Namibia. The huge study area included

the Barotse Flood Plain in Zambia, the Chobe-Caprivi area, the Lower Shire Wetlands of Malawi and the Zambezi Delta in Mozambique.

Summary
There are still many gaps in understanding the role of economics in controlling the demand for water. This was the topic area that delegates felt needed most attention within the community of water resources planners and managers. Economic principles are just as important to demand management as engineering or environmental principles.

More data needs to be gathered to enable cost benefit analyses and discounted investment analyses of WDM; this is not an easy task and, thus, has traditionally been overlooked by water resources planners. However, both water managers and economists need to know the strength of demand; they need to know *who* wants the water, and *how much* they want.

Table 6.1 Developing tools and skills for water demand management: Technical standards, methodologies and guidelines

	Examples	Needs
IWRP	• Guidelines for artificial aquifer recharge procedures to prevent huge evaporation losses from stored surface water resources (Namibia). • Reservoir operation guidelines – the '21 month rule'; by 31st March, present demand must be sustainable for 21 months, or rationing begins (Zimbabwe) • A national forecasting framework, with reporting guidelines, monitoring & reporting ensure consistency of approach between water companies (UK) • IIMI's Water Balance Framework: a standardised methodology & terminology for water accounting analyses (Perry, 1996) • The World Commission on Large Dams guidelines & criteria for future water resource development	• Standards to ensure that rivers & water resources are not over-abstracted • More detailed analyses, including methods for temporal supply & demand in sub-catchments • Investigations into long-term interactions between streamflow, irrigation strategies, water demand & available storage • Diversity of strategies in harmony with each country's political system & proportion of potential developed • Promotion of professionalism by affiliation to professional Institutions • Recognition of international standards when developing national standards
Agriculture	• Water-wise food production, with closed irrigation channels to save water losses (South Africa) • Use of wastewater for irrigation (Botswana) • Minimum tillage, intercropping, mulching & supplementary irrigation, with allocation of irrigated land to more productive crops (Mozambique) • Use of efficient irrigation methods (drip irrigation: 90% efficient) (Namibia) • Issuing of abstraction permits that consider actual monthly crop water requirements, not just a fixed amount (Zambia) • Trials indicating low gains & efficiencies with more watering (Zimbabwe)	• Devices to regulate & measure the withdrawal & consumption of water (at each secondary or tertiary canal) • More efficient structures with higher water use efficiencies • Promotion of water-efficient irrigation techniques • Infrastructure to detect water losses • Refined methodologies for crop water requirement estimation • Promotion & marketing of irrigation testing facilities & systems • Production of design operation & maintenance manuals, irrigation works & construction manuals
Industry	• Water rationing & recycling (*e.g*. for cooling) (Zimbabwe, Namibia) • Saving water via retro-fitting, leak detection, metering, water audits, reverse osmosis, effluent re-use & filter backwash water recovery (Zimbabwe, Namibia, Botswana) • Computerised networks to detect leaks & illegal connections (Namibia)	• Specific water intakes for industry • Industrial water audits to monitor water use • Water balancing & financial water balancing • Effluent standards & water quality control/guidelines • Proactive planning & incentives, to avoid crisis management
Municipal	• Water efficiency practised in residential, commercial & government buildings, where retro-fitting low volume toilet flushes & showerheads reduces consumption. Municipal water audits work! (Zimbabwe, Namibia) • Effluent re-use, potable re-use, use of seawater & grey water (Namibia) • Guides on saving water in the home, & water-wise gardening (South Africa) • Domestic water rationing reduces consumption (Zimbabwe)	• Improved distribution maintenance • Co-ordinated universal metering • Improved levels of access to, & reliability of, water supplies • Software & programs for effective billing systems • Metering management & process control systems

Table 6.2 Developing tools and skills for water demand management*: *Information management

	Examples	**Needs**
IWRP	• Good information management enables accurate predictions of future water needs. The National Water Balance Study of South Africa, in electronic format, & the 'Overview of Water Resources availability & utilisation in South Africa' supply up-to-date water use figures (South Africa) • Consideration of all possible DM options before supply development options saves water (UK) • Water companies submit water resource plans detailing components of water use for their region (UK) • Computer models/Decision Support Systems, using common software for flexible information management (*e.g*. Access, ArcView) • Spatial/temporal databases linked to hydrological simulation models can manage vast amounts of information in a user-friendly & accessible manner (South Africa) • GIS used as a powerful management tool for water services (South Africa)	• Knowledge of volumes of available water resources – especially an understanding of groundwater recharge – level of usage of resource is commonly unknown • Databases to support WDM policies • Understanding of the demographic effects of the spread of HIV/AIDS, the rate of rural exodus & ability to pay for increased water supplies • Estimates of present & future *sectoral* water use, then use of estimates to re-allocate water wherever there is a predicted shortfall • More open flows of information, with free international access to hydrological & water resources data, within SADC region • Solid 'knowledge base' including current demand data. The 'information strategy' should allow updating of information needs in the future • Dedicated communicators to help 'translate' & transfer messages & feedback
Agriculture	• National database of water rights held at Department of Water Development assists with law enforcement & understanding of how much water is being used (Zimbabwe) • Software such as ACRU model helps manage irrigation water efficiently; a simplified method for implementing WDM strategies & scheduling irrigation, using computer simulations to produce simple, easy-to-use charts (Zimbabwe)	• Assessment of quality (*e.g*. salinity) of irrigation water in different seasons & its effects on crop productivity • Data on actual amounts of water abstracted by farmers from rivers or their own storage works
Industry	• Management Guidelines for Water Service Institutions. Palmer Development Group of the WRC (South Africa)	• Price elasticity of demand for industry, *i.e.* how industries respond to price increases in water • Compilation of water losses data from leakage detection • Documentation of case studies of demand • Demand forecasting
Municipal	• Internet has vast amounts of information, *e.g*. WaterWiser (AWWA) giving tips on how to save water in the home, how to detect & fix leaks, how to irrigate gardens efficiently, etc.	• Planning information, such as population movement/migration. • Information systems on water & sewage schemes

Table 6.3 Developing tools and skills for water demand management*: *Economic methods

	Examples	**Needs**
IWRP	• National Water Act's pricing strategy involves social awareness factors (South Africa) • Charges for effluent discharge into streams & water bodies helps to control pollution (Zimbabwe) • Heavy reliance upon water charges controls demand (Botswana) • Differential pricing policies can target different sectors in different ways (Botswana)	• Better co-ordinated tariff setting • Stronger budget control • Clear tariff guidelines • Cost-benefit analysis of WDM measures • Consideration of equity issues when pricing water • Presentation of information on economic impacts to politicians • Phased introduction of water pricing towards full cost recovery • Subsidies, rebates & tax exemptions • Transparency & political intervention
Agriculture	• Water abstraction permits must now be bought, & are valid for a specified period only (no more free water) (Zimbabwe) • Trading of irrigated plots (a form of renting, with water rates paid by tenant) (Mozambique) • Investment costs incorporated into water rates mean that the real cost of water is appreciated (Mozambique)	• Better pricing structure for poor farmers & by crop type, with special rates for night-time irrigation • Fixed water rate/ha reflecting value of infrastructure & service provided • Charges to provide incentive to save water, with seasonal pricing connected to water risk • Understanding of local pricing structures for irrigation water & the effects of greater economic integration within SADC, which might favour agricultural development in wetter regions
Industry	• Block tariffs reduce consumption & target specific groups (Namibia, Zimbabwe) • Fees must be paid for permits for commercial water use, & these are valid for a specified period only (Zimbabwe) • Effluent fees promote efficient water use & control pollution (Namibia)	• Block tariff structure – charges curb demand for small consumers but not for large industrial consumers • Coherent tariff structure - full cost recovery for industrial water • Understanding of how water pricing controls demand • Long-run marginal cost pricing (include environmental costs for industry) • Financial planning & management (specific water budgets) • Effluent fees to control water pollution
Municipal	• Cross-subsidies between rich & poor provide a socially aware approach to charging for water, since many poor people cannot pay, & water is considered a basic human right (Namibia, South Africa) • Block tariffs reduce consumption (Namibia, Zimbabwe, South Africa) • Price & income elasticity are the most realistic approach (Namibia) • Fixed monthly assurance of supply tariffs (South Africa)	• Information systems • Cost-benefit & financial analysis tools • Understanding of social implications of pricing mechanisms • Performance assessment, with monitoring & evaluation • Social & environmental costing

Table 6.4: Examples of guidance and standards in the field of WDM from the UK and USA

UK	USA
• UKWIR/NRA Demand Forecasting Methodology – Report in two volumes: Vol. 1 (Main Report) and Vol. 2 (Spreadsheets & User Manual) • Sufficiency of Water - Methodology for Assessing the Supply/Demand Balance • Forecasting Water Demand Components – Best Practice Manual • Evaluating the Impact of Demand Restrictions, Main Report, Software User Guide and Input Data Guidelines • Effects of Climate Change on River Flows and Groundwater Recharge: Guidelines for Resource Assessment • Specification of Performance Requirements and Test Methods for Electronic Outputs of Water Meters • On-line Instrumentation Standards and Practices • Best Practice for Unmeasured Per Capita Consumption Monitors	• Water Management: A Comprehensive Approach for Facility Managers • Water Efficiency Guide for Business Managers and Facility Engineers • Customer Incentives for Water Conservation: A Guide; EPA 230-R-94-001 • Water Conservation Guidebook for Small and Medium-Sized Utilities • A Consumer's Guide to Water Conservation: Dozens of Ways to Save Water, the Environment, and a Lot of Money • A Guidebook for Preparing Water Conservation Plans by Agricultural Water Districts • Guidelines to Conduct Cost-Effectiveness Analysis of Best Management Practices for Urban Water Conservation • Step-By-Step: How to Deliver Conservation Services Using Community Organizations • How to Save Water at Home: A Step-By-Step Manual for the Do-It-Yourselfer • IWR-Main WDM suite

7. BENEFITS AND RISKS OF APPLYING WATER DEMAND MANAGEMENT

Water demand management can offer many benefits, but also some risks, to almost all areas of society and the environment.

One of the biggest developments in the Southern African region is the trend towards decentralisation of responsibility for water management to catchment level, and the involvement of stakeholders at all levels in the development and implementation of water resources policies. This is, at least in theory, a great step towards ensuring that policies can be implemented, with the support and co-operation of the people who actually use the water, and can give the opportunity for women to be heard. The risk is that stakeholders are not always willing, nor indeed able, to be involved in these procedures. The latter problem can be resolved through effective capacity building, but the former is more difficult to overcome. To encourage willingness is a slower process, tied up with the need for a general change in attitude and awareness of the value of water. It requires education and awareness campaigns, as discussed in Chapter 6.

On an international scale, fifteen of the larger rivers in the region cross international boundaries, highlighting the need for regional policies and co-operation to manage these resources. The SADC Protocol on Shared Water Courses says that the use of the resource is open to each riparian state, provided that there is a proper *balance* between resource development, and the shared water course is used in an *equitable* manner. Such international resources provide either a catalyst for conflict or the potential for neighbouring countries to develop resources and work together in harmony, depending on how the situation is managed, and on the policies of the riparian states.

Water Demand Management calls for a good understanding of *who* is making the demand, and *how much* they are demanding. Improvements in resource monitoring and in databases of water use information are therefore required. In turn, these valuable new resources can be used to make improved forecasts of water demand so that planning procedures are able to assure water supplies to more people - especially the poorest members of society who are traditionally hardest hit by water shortages.

With the trend towards policies that take account of the need for demand management, comes recognition of the environment as a user. Traditionally, the environment has been neglected, but with the new National Water Act in South Africa for example, comes the concept of an ‘environmental reserve’, to protect the ecosystems that underpin water resources, now and into the future. The Act also states that it is the duty of national the Government to assess the needs of the environmental reserve and to make sure that this amount of water, of an appropriate quality, is set aside. This approach has immense impacts on water resources management in South Africa, but raises the difficult question of how much environmental reserve a river or water resource requires.

A small saving through demand management in the agricultural sector, the largest water consumer, can make a big contribution to other sectors, such as municipal water use. There are great savings to be made in irrigation through simple practices such as the lining of trunk canals with concrete (this has been estimated to improve the efficiency of irrigation systems from around 40-60% up to around 80-90%). Improved technologies such as sprinklers, sub-surface irrigation, and drip irrigation, which also stimulate higher crop yields, are known to improve savings in irrigation systems. Sprinkler irrigation uses a system of pipes - so that there are no losses along irrigation canals - and only provides water when it is needed, thereby reducing salinisation, losses to evaporation and deep percolation. Mist irrigation, a relatively new development, works by regulating the climate of the plant and can reduce the specific water requirements for irrigation by more than 50% whilst increasing crop yields. Drip irrigation applies water directly to the base of the plant through pipes and has excellent rates of efficiency, with water savings of up to 90% over traditional surface irrigation techniques (Shiklomanov, 1997).

Some of the figures illustrating the benefits of water demand management are startling. In Namibia, for example, there was no overall growth in water consumption from 1990-7 despite a 35% population increase. Another illustration of the huge impact that demand management can have is taken from the Lesotho Highlands Water Project (LHWP). Phase 1A of the four phase scheme to export water from Lesotho to the Vaal region, the semi-arid industrial heartland of South Africa, has been completed, and Phase 1B is already underway. However, Phase 1B has been criticised by many non-governmental organisations (NGOs) who argue that further development is not needed, since they believe that the region has enough water for the near future if effective demand management measures are implemented. They believe that Phase 1A will provide enough water for the region until the year 2006 and beyond. Since the project treaty was signed in 1986, South Africa has suffered from periods of drought and low rainfall, forcing the implementation of water demand management measures and reducing the pattern of demand from that which was originally predicted. The South African Department of Water Affairs and Forestry (DWAF), believes that it is best to delay subsequent phases of the project for economic reasons. It was finally agreed to go ahead with Phase 1B, due to economic, social and political arguments, particularly since South Africa has an inescapable responsibility to pay Lesotho royalties for the scheme, and wants to maintain good relations with its neighbours. This complicated scenario highlights the significant effects that demand management can have on a water resources system. In South Africa, water demand management has been given special impetus by the National Water Act of 1998 and has meant that in some areas demand for water has actually fallen. DWAF believes that WDM initiatives in the Vaal region can delay further phases of LHWP by many years or even remove the need for such projects.

Finally, there is one big risk associated with the drive towards Water Demand Management in Southern Africa. Many countries are showing their commitment to demand management through the development of new policies relating specifically to the subject. However, as this workshop has highlighted, new policies are just the beginning of the story. To implement such policies takes a great deal of time, effort and commitment on behalf of key players at many levels. It needs political intervention to start the ball rolling. It needs water resources managers and stakeholders with vision who believe in the possibilities for demand management. It also requires a paradigm shift which takes time to come into effect. Practical workshops such as this will help to spread the word to these key players, and point out through case studies that the end can justify the means.

8. RECOMMENDATIONS

The key needs within the various sectors involved in water demand management have been summarised in this synthesis technical report. However, a number of more general issues were highlighted at the workshop. There is already considerable experience of WDM within the SADC region, where countries such as Namibia, as the driest sub-Saharan African country, and South Africa have been practising certain effective WDM measures for some time already. Hence this is not a question of starting from scratch but of building on existing foundations.

Perhaps one of the most important points is that communication is key to effective implementation of WDM. From talking to politicians, through to the setting up of catchment councils, effective communication gets the WDM ball rolling. Workshops such as this help to bring people together from all aspects of water demand management, to share experiences and learn from one another. Moreover, the workshop outputs, such as this WMO Technical Report, will hopefully help to spread the word to a wider audience.

Specific regional programmes will further the implementation of WDM. For example, in the past, projects such as Southern African FRIEND (Flow Regimes from International Experimental and Network Data) (UNESCO, 1997), a contribution to the Fourth International Hydrological Programme of UNESCO, have targeted the application of regional hydrological data sets for the sustainable utilisation of water resources. A new initiative called HELP (Hydrology for Environment, Life and Policy) (UNESCO, 1999) is currently being set up following a request for UNESCO and WMO to consider a conceptual framework focused on experimental hydrology linked with policy and development issues. HELP will build on FRIEND and hopefully assist policy makers and practitioners to develop implementation strategies in a truly integrated manner. It is hoped that water use and demand management will be given due consideration in such initiatives.

Information management is becoming more important, as increasing volumes of data on water use and demand are collected. It is agreed that in several countries much data on water use and demand already exist, but they are often neither generally available nor in a format that is useful to water resources planners. Tools, such as information management systems, using GIS, are beginning to emerge, and will become more widely adopted. National Hydrological Agencies in each of the SADC countries have an important role to play, particularly with regard to maintaining good databases and information management systems. Such agencies should be encouraged to share data between countries, to enable sensible management strategies for the large number of important, international river basins in Southern Africa.

With regard to improved information management, various sections of the WMO's System for Technology Transfer in Operational Hydrology (HOMS) could be updated to incorporate more information on practical WDM. It already deals with some aspects of WDM in Section A on policy planning and organisation with an option looking at 'assessment of water resources', which mentions water use for industry and agriculture and analysis of the balance between water supply and demand. Options for development include, for example, Section K: 'Hydrological analysis for the planning and design of engineering structures and water resource systems. Models and procedures whose main purpose is hydrological analysis for planning, development, design, and management of water-resource systems, including studies of climatic change and man's influence' could be expanded to include evaluation of water use and demand in a country. Also, Section G, on data storage, retrieval and dissemination, could give advice on how to manage water use and demand data and information. Sections H and I on data processing could be expanded to mention water use and demand data.

There is much room for improved water use efficiency in agriculture, which abstracts by far the largest volume of water of any sector in Southern Africa. However, the lack of data on abstraction and return flow volumes is currently restricting the extent to which demand is understood or can be managed. The creation of policies specifically to enforce measurement and reporting would be a step in the right direction. The whole water balance of agricultural systems needs to be better understood, including the water use of various crop types in order to maximise economic returns, and the relative merits of different irrigation practices.

It is generally felt that economics have a pivotal role to play in demand management, and that more emphasis needs to be placed on understanding the role economics has to play. Addressing the need for further application of cost-benefit analysis tools will help countries to manage water demand more effectively. There is a need to put a coherent framework on the economic skills required in practice.

Demand management is becoming rapidly more important to countries, not only in Southern Africa, where water resources are already stretched. It is crucial to raise awareness, among all members of society, of the value of this often limited resource. Lessons can be learnt from drought situations. If the mechanisms that cause demand to fall during such water stressed situations are better understood, they can be applied during routine system operation. It is recommended that bodies such as the WMO Commission for Hydrology, DFID and UNESCO disseminate the outcomes of the workshop so that they can be effectively used as tools for water resource planners and managers. Similar workshops would be beneficial in other water stressed regions of the world, such as southern Asia and the Middle East. Translation of the technical reports and case studies into other languages would also be beneficial.

Through summarising the workshop in a synthesis technical report, and through discussions with some of the delegates, it was felt that a number of the case studies merit further development, and should be disseminated in some manner to practitioners and politicians alike. These case studies would serve to reinforce the messages emanating from the workshop, and form guidance and promote understanding of the issues most crucial to such demand management spheres.

In 1999, the Minister of Water Affairs and Forestry in South Africa, Professor Kader Asmal, who opened the Southern African WDM conference, stressed that co-operation was not only vital to regional security both in terms of food and peace, but also in terms of alleviating poverty and the gender imbalance.

Annex 1: Workshop programme

Tues 19th 13:30		Welcome to delegates	Department of Water, Zimbabwe: David Durham/Gilbert Mawere
		Aims of the Workshop	WMO/UNESCO: Peter Herbertson
13:45		**Session 1 : Awareness**	
14:00	1.	WDM and World Water Vision	GWP/WWVision: Andy Bullock
14:20	2.	Water use and demand management in the SADC water resources programme	SADC WRTC: Edward Mokuoane
14:40	3.	Progress with WDM programmes in Southern Africa	IUCN Southern Africa: Saliem Fakir
15:00	4.	Development of the national water conservation and demand management strategy for South Africa	DWAF: Dhesigen Naidoo
15:20		Questions to authors	
15:40		**TEA**	
16:10		**Session 2 : Country Overviews (Part 1)**	
16:10		Introduction to Country Overviews	
16:20	5.	Putting policy into practice in Zimbabwe	WRMS, Zimbabwe: Simon Pazvakavambwa
16:40	25.	Future use of water and demand in a SADC perspective	DWAF South Africa: R Boroto
17:00	6.	The role of water demand management and water resources planning for the future in Windhoek, Namibia	MAWRD, Namibia: Ben Groom
17:20	7.	~~Water demand management in Zambia – opportunities and constraints~~ (Cancelled)	~~University of Zambia: Dr Phiri~~
17:40		Questions to authors	
18:00		**CLOSE**	
18:30-20:00		Delegates' reception	
Wed 20th 08:30		**Session 3 : Country Overviews (Part 2)**	
08:30	9.	Availability and intensity of water utilisation within the river basins of Zimbabwe	University of Zimbabwe: Mr Mazvimavi
08:50	10.	Overview of South Africa's water situation and a more detailed analysis of its recent water use figures	DWAF South Africa: Dr Pieter Pansegrouw
09:10	11.	Water use and demand in Swaziland	Ministry of Natural Resources, Swaziland: Mr Mavimbela
09:30		Questions to authors	
09:45		**Session 4 : Workshop A. "Integrating water use and demand management policies into water resources planning"**	
09:45		Introduction to workshop	Dr Jefter Sakupwanya
10:00		**COFFEE**	
10:20		Discussion groups	
11:20		Plenary Session : Feedback from groups	
12:00		**LUNCH**	
Wed 20th 13:15		**Session 5 : Best Practice (Part 1)**	
13:15	12.	Demand management experience in Zimbabwe	WRMS Zimbabwe: Dr Jefter Sakupwanya
13:35	14.	Water allocation in Zambia – managing the demand on the Kafue river basin	DWA Zambia: Mondoka, Nundwe and Kampata

13:55	15.	Allocation of water resources in Zimbabwe	Department of Water, Zimbabwe: Dr Hugh Williams
14:15	16.	Planning for water use assessment and demand management with British water companies	NWDMC, UK: Peter Herbertson
14:35		Questions to Authors	
15:00		**TEA**	
15:30		**Session 6 : Best Practice (Part 2)**	
15:30	17.	Accounting for agricultural water use: the Olifants river project	IWMI South Africa: Marna de Lange /Herb Blank
15:50	18.	Deficit irrigation: from theory to practice	Zimbabwe Sugar Association: Neil Lecler
16:10	19.	Community participation in water demand management for agriculture in Zambia	Department of Water Affairs, Zambia: Peter Chola
16:30		Questions to Authors	
16:50		**Session 7 : Tools and Skills (Part 1)**	
16:50		Introduction to tools and skills	
17:00	20.	Decision tools for rural water use	IOH Zimbabwe: Patrick Moriarty
17:20	22.	GIS for river catchment management	University of Natal: Prof. Roland Schulze
17:40		Questions to authors	
18:00		**CLOSE**	
Thurs 21st 08:30		**Session 8 : Tools and Skills (Part 2)**	
08:30	21.	GIS for water use and associated data	DWAF South Africa: Fred van Zyl
08:50	23.	Information and its role in water use and demand management	HR Wallingford: Tim Hannan
09:10		Questions to authors	
09:20		**Session 9 : Workshop B. "Developing Tools and Skills for WDM"**	
09:20		Introduction to workshop	Prof. Roland Schulze
09:35		Discussion groups	
10:35		**COFFEE**	
11:00		Plenary session: Feedback from groups	
11:45		Session 10 : Feedback and conclusions	
11:45		Water use sector feedback for input to World Water Vision regional consultation	GWP: Andy Bullock
12:15		Conclusions from workshop for input to WMO Technical Report	Peter Herbertson/Emma Tate
12:45		**CLOSE of Workshop and LUNCH**	
14:00-16:00		Informal demonstration of software Water Resources Plans database, UK Concept for integrated water resources management system and others.	

Annex 2: Workshop participants

Surname	Title	Forename	Company	Country
Blank	Mr	Herb	IWMI, Olifants River Project	Sri Lanka
Boroto	Mr	R	Department of Water Affairs and Forestry	South Africa
Buckle	Mr	Hannes	Rand Water	South Africa
Bullock	Dr	Andy	C/O IUCN ROSA	Zimbabwe
Cambula	Mr	P. F. F.	National Directorate of Water	Mozambique
Chipeta	Mr	W.P.C	Ministry of Water Development	Malawi
Chola	Mr	Peter	Department of Water Affairs	Zambia
de Lange	Ms	Marna	Socio-Technical Interfacing	South Africa
Dickinson	Mr	Adam	HR Wallingford Ltd	UK
Durham	Mr	David	Ministry of Rural Resources and Water Dev	Zimbabwe
Fakir	Mr	Saliem	IUCN	South Africa
Gillham	Mr	Steve	Umgeni Water	South Africa
Groom	Mr	Ben	Department of Water Affairs	Namibia
Hannan	Mr	Tim	Leeds Environment Centre	UK
Harlim	Mr	Joachim	Department of Water Development	Zimbabwe
Kafatia	Mr	K	Central Region Water Board	Malawi
Kambanda	Ms	Kaliki	Namibia Water Resources Management Review	Namibia
Kampata	Mr	J M	Department of Water Affairs	Zambia
Kaseke	Dr	E	University of Zimbabwe	Zimbabwe
Kayawe	Mr	T T	Botswana Institute for Development Policy Analysis	Botswana
Lecler	Mr	Neil	Zimbabwe Sugar Association	Zimbabwe
Luxembourg	Mr	William	Department of Water Development	Zimbabwe
Malkiewicz	Mr	T	DWAF	South Africa
Mangue	Mr	T. B. E.	National Directorate of Water	Mozambique
Matiza-Chiuta	Mrs	Tabeth	C/o IUCN Regional Office for SA	Zimbabwe
Matola	Mr	Jose R	National Directorate of Water (DNA)	Mozambique
Matondo	Dr	Jonathan	University of Swaziland	Swaziland
Mavimbela	Mr	Solami	Ministry of Natural Resources, Env & Energy	Swaziland
Mawere	Mr	G	Department of Water Development	Zimbabwe
Mazvimavi	Mr	Dominic	University of Zimbabwe	Zimbabwe
Mhlanga	Mr	S	Zambezi River Authority	Zimbabwe
Mndzebele	Mr	D.H.	National Water Monitoring Agency	Swaziland
Mokuoane	Mr	Edward	SADC	Lesotho
Mondoka	Mr	Andrew	Water Development Board	Zambia
Moriarty	Dr	Patrick	Institute of Hydrology	Zimbabwe
Mpasa	Mr	M.G.	Northern Region Water Board	Malawi
Mphande	Mr	C.U.	Ministry of Agriculture and Irrigation	Malawi
Munikasu	Mr	C.K.	MAWRD	Namibia
Mutede	Mr	Edward	Department of Water Development	Zimbabwe
Mwiinga	Mr	P.C.	Zambezi River Authority	Zambia
Naidoo	Mr	Dhesigen	Department of Water Affairs and Forestry	South Africa
Naketo	Mr	D.V.L.	Ministry of Water Development	Malawi
Ndamba	Dr	J	Inst. Of Water & Sanitation Development	Zimbabwe
Ndiwemi	Ms	B	Department of Water Development	Zimbabwe
Neto	Mr	Felix	National Directorate of Water	Angola
Nhira	Dr	Calvin	IDRC	South Africa
Novele	Mr	Bernardino	ARA-Centro	Mozambique
Nundwe	Mr	Cecil D	Ministry of Energy and Water Development	Zambia
Pansegrouw	Dr	Pieter	Department of Water Affairs & Forestry	South Africa
Pazvakavambwa	Mr	Simon	Ministry of Water and Land Resources	Zimbabwe
Roux	Mr	A.S.	Dept of Agricultural Engineering	South Africa
Sakupwanya	Dr	Jefter	WRMS Project	Zimbabwe
Schulze	Prof	Roland	University of Natal	South Africa
Sibanda	Mr	C	Inst. Of Water & Sanitation Development	Zimbabwe
Steward	Ms	Helen	DFID-CA	Zimbabwe
Stoop	Mr	Johan	Rand Water	South Africa
Van Zyl	Mr	Fred	Department of Water Affairs & Forestry	South Africa
Walmsley	Mr	Nigel	HR Wallingford	UK
Williams	Dr	Hugh	Ministry of Water	Zimbabwe
Herbertson	Mr	Peter	Environment Agency (Workshop Convenor)	UK
Tate	Ms	Emma	Institute of Hydrology (Workshop Co-ordinator)	UK

Annex 3: References

Andrews, A.J., Pieyns, S. and Servat, E. (1999); *The design of an international real time data collection system: SADC-HYCOS;* Water Resources Management **13**, 253-270.

DWAF (1986); *Management of the Water Resources of the Republic of South Africa;* Department of Water Affairs and Forestry; Republic of South Africa.

DWAF (1997); *The Water Services Act, Act 108 of 1997;* Department of Water Affairs and Forestry, Republic of South Africa.

DWAF (1997); *White paper on a National Water Policy for South Africa;* Department of Water Affairs and Forestry; Republic of South Africa.

DWAF (1998); *The National Water Act, Act 36 of 1998;* Department of Water Affairs and Forestry; Republic of South Africa.

Fakir, S. (1999); Water Demand Management in Southern Africa; *WMO/DFID workshop proceedings;* 19-21 October 1999, Harare, Zimbabwe.

Hannan, T. (1999); Information and its role in water use and demand management; *WMO/DFID workshop proceedings*, 19-21 October 1999, Harare, Zimbabwe.

IUCN (2000); *Towards developing effective water demand management strategies for Southern Africa.* Proceedings of the Regional Water Demand Management Conference; 23-25 March, 1999, Johannesburg, Republic of South Africa.

NWDMC (bi-monthly); *Demand Management Bulletin*; External newsletter of the National Water Demand Management Centre, Environment Agency; Worthing, UK.

Perry, C.J. (1996); *The IWMI water balance framework: A model for project level analysis.* Research Report 5; Colombo, Sri Lanka; International Water Management Institute (IWMI).

Smithers, J.C. and Schulze, R.E. (1995); *ACRU Agrohydrological Modelling System: User Manual Version 3.00;* Technology Transfer Report, TT70/95. pp372; Water Research Commission; Pretoria, Republic of South Africa.

Shiklomanov, I.A. (1997); *Assessment of water resources and water availability in the world:* Comprehensive Assessment of the freshwater resources of the world; WMO, Geneva, Switzerland.

UNESCO (1997); *Southern African FRIEND;* Technical Documents in Hydrology No. 15; UNESCO, Paris.

UNESCO (1999); *Expert group meeting to consider the need for a new experimental hydrology decade;* A report on the UNESCO sponsored meeting held at Wallingford, UK, 30th Nov to 1st Dec, 1998.

WMO (1998); *Methods for assessing trends in water demands and use for hydrological services;* Technical Reports in Hydrology and Water Resources No. 63, WMO/TD-No.915; Geneva, Switzerland.

Annex 4: cronyms

ACRU	Agricultural Catchment Research Unit rainfall-runoff model
BMP	Best Management Practice
CC	Catchment Council
DFID	UK Department for International Development
DWAF	Department of Water Affairs and Forestry
EA	Environment Agency (UK)
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GNP	Gross National Product
GIS	Geographical Information System
IIMI	International Irrigation Management Institute (Sri Lanka)
ISO	International Standards Organisation
IUCN	World Conservation Union
IWM	Integrated Water Management
IWRM	Integrated Water Resources Management
LHWP	Lesotho Highlands Water Project
MAR	Mean Annual Runoff
NGO	Non-Governmental Organisation
NWDMC	National Water Demand Management Centre (UK)
OFWAT	Office of Water Services (UK)
SADC	Southern African Development Community
SCC	Sub-Catchment Council
UKWIR	United Kingdom Water Industry Research
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WDM	Water Demand Management
WHO	World Health Organisation
WM	Water Management
WMO	World Meteorological Organisation
WRC	Water Research Commission
WRMS	Water Resources Management Strategy (Zimbabwe)
ZINWA	Zimbabwe National Water Authority

Annex 5: Directory of water use and demand information for Southern Africa

- Africa Water Page (http://web.sn.apc.org/afwater)

Written and maintained by Len Abrams. Had over 200 000 requests in the 2 years since it started. This is a page dedicated to the water sector in Africa. Issues addressed include water policy, water resource management, water supply and environmental sanitation, water conservation and demand management, and a variety of other issues. A primary objective of the page is information dissemination on water issues in Africa and to exchange views and ideas on water on the continent.

- AQUASTAT (http://www.fao.org/waicent/faoinfo/agricult/agl/AGLW/AQUASTAT/Aquastat.htm)

From the Food and Agriculture Organisation. This is an information system on water in agriculture and rural development. It produces regional analyses and country profiles on water resources development, with emphasis on irrigation and drainage. AQUASTAT has been launched by the Land and Water Development Division of FAO.

The types of data available: Tables of regional distribution of water withdrawals (agriculture, communities, industries, as percentage of internal resources); Regional distribution of water management methods; Regional distribution of main irrigated crops (partial information); Population, land use and Irrigation potential (by country); Water resources (by country) (includes average annual precipitation, annual renewable water resources, dependency ratio); Annual water withdrawal (by country, by agriculture, domestic, industrial, as % renewable resources, and per capita, in million m^3), Full or partial control irrigation techniques (by country, by surface, sprinkler, micro), Irrigated crops (by country).

- CGIAR (http://www.cgiar.org/iwmi/swim.htm#swim)

CGIAR (Consultative Group on International Agricultural Research) based at IWMI (International Water Management Institute), Sri Lanka. The Systemwide Initiative on Water Management (SWIM) is a program designed to address the critical need to increase water productivity, to generate a methodology on the measurement of water productivity that will be widely adopted by researchers, and to build the research capacity of the CGIAR, the NARS, and the NGOs in water management. Research is being conducted into:

- Measuring the Productivity of Water
- Productivity and Prevention of Resource Degradation in Irrigated Agriculture
- Water-Efficient Irrigation for Rice-Based Systems
- Alternatives for Improving On-farm Water Use Efficiency in Water-Scarce Areas
- Inter-sectoral Water Allocation in River Basins: Impact on Agricultural Growth and Environmental Sustainability
- Multiple Uses of Water in Irrigated Areas at the Local Level
- Improved Water Utilisation in a Watershed Perspective

- CGIAR (http://www.cgiar.org/ifpri/divs/eptd/dp/papers/dp28.pdf)

Contains a paper entitled 'Water resources development in Africa: a review and synthesis of issues, potentials, and strategies for the future' from the Environment and Production Technology Division of the International Food Policy Research Institute, Washington, U.S.A. The paper 'analyses how water resources development and water policy reform can be deployed to address the twin problems of food insecurity and water scarcity in Africa and, in particular, Sub-Saharan Africa. The paper reviews the current status of water supply and demand, and the existing and potential irrigated land base in Africa; reviews the performance of existing irrigation systems and assesses the magnitude of the potential contribution and cost-effectiveness of new irrigation development to future food production in Africa; and explores the potential for water conservation through demand management…'. Full paper can be viewed from its pdf format using Adobe Acrobat.

- CIA World Factbook (http://www.odci.gov/cia/publications/factbook)

From the United States Central Intelligence Agency. The types of data available: Current population levels at 1998 (broken down into age and ethnic groups), birth rates, land use figures (as percentages of total land area), irrigated land (as an area in square kilometres). The data are listed directly on the Web page, with no analysis undertaken.

- CROPWAT (http://www.fao.org/waicent/faoinfo/agricult/agl/AGLW/CROPWAT.HTM)

From the Food and Agriculture Organisation. The types of data available: CROPWAT is a decision support system developed by the Land and Water Development Division of FAO. It is a computer program for irrigation planning and management. CROPWAT is meant as a practical tool to help agro-meteorologists, agronomists and irrigation engineers to carry out standard calculations for evapotranspiration and crop water use studies, and more specifically the design and management of irrigation schemes. It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rain-fed conditions or deficit irrigation. CROPWAT version 7.0 can be downloaded as a zip file from the FAO's FTP server. The downloaded data is in compressed format, requiring a zip reader, such as WinZip or pkzip.

- DWAF Vaal River system (http://www.metsi.com/dwaf/demand13/demand13.html#MARCH 1997 WATER REQUIREMENT PROJECTIONS)

Future projections of water demand form an important part in the planning of the Integrated Vaal River system, since the phasing-in of new augmentation schemes is based upon it. The site has various tables, including one of water requirement projection growth rates graphs of projected demand in the basin.

- ESRI (http://www.esri.com/data/online/index.html)

From the Environmental Research Systems Institute, USA. ArcData Online is ESRI's Internet Mapping and Data Site. The site contains a wide assortment of geographic information that users can access to create map images and download data. ADOL is powered by ESRI Internet Mapping technology hosted in both the USA and Europe. ESRI are the producers of ArcInfo GIS software, along with ArcView, but users can download ArcExplorer, the free software for viewing GIS images, from the ESRI Web site. Data can be downloaded in shapefile format, able to be viewed by ArcInfo, ArcView and ArcExplorer.

The types of data able to be downloaded are DTM models of the SADC countries, base-maps showing rivers and administrative boundaries for each of the SADC countries, a population density map for the whole African continent, and a precipitation map for the whole of the African continent (mm/year).

- FAO (http://www.fao.org)

The Food and Agriculture Organisation. This Web site contains a very relevant and easy-to-use statistical database called FAOSTAT. Some of the data it contains are listed below:

Population data: Annual time-series (1961-1997), of gender, rural, urban, agricultural and non-agricultural, economically active and economically active in agriculture, (taken from UN Population Division and ILO); Long-term Series (quinquennial) (1950-2050) (Total/Rural/Urban population); Decennial series (1950-2010) of agricultural and non-agricultural population, total economically active population by sex, economically active population in agriculture by sex.

Agricultural data (1000ha) (1961-1997): Land Use: total, land, agricultural, arable and permanent crops, arable land, permanent crops, permanent pasture, forests and woodland, all other land, non-arable and permanent crops. Irrigated Area: Data on irrigation relate to areas equipped to provide water to the crops. These include areas equipped for full and partial control irrigation, spate irrigation areas, and equipped wetland or inland valley bottoms.

Non-subscribers can download up to 25 lines of data. On-line subscription gives access to extended query and download capabilities, with reduced rates for developing countries.

Each search of the statistical database gives results either in a table or downloadable csv file, also available on CD-ROM (US$600 – less 35% for developing countries, or free to new subscribers). Population projections have been undertaken (up to the year 2050) (taken from UN Population Division and ILO). Basic statistical analyses have also been carried out on the various data (mean, weighted average, standard deviation, 3-year average).

No special skills are necessary to download the data. A computer's browser can be configured to associate the file type `text/comma-separated-values` with its spreadsheet software, then it will be started automatically when the file is downloaded.

- FAO Land and Water Development Division

(http://www.fao.org/waicent/faoinfo/agricult/agl/lwris.HTM)
Includes links to AQUASTAT and CROPWAT.

- IDRC (http://www.idrc.ca/books/focus/804/chap8.html)

From the International Development Research Centre. This site presents several interesting papers containing facts and figures on water use and demand. It also lists of publications on-line about water demand management *etc*., and Africa.

- IDRC (http://www.idrc.ca/waterdemand/)

Contains links to a number of other useful Web sites.

- IUCN (http://www.iucnrosa.org.zw/water.htm)

From the World Conservation Union. There is a brief description of the five country studies, but no actual data.

- IWRMS (http://www.iwrms.uni-jena.de/watres_sa.html)

Integrated Water Resources Management System – a multi-disciplinary modelling approach. The Web site includes general descriptions of the population, geography and water resources of South Africa, Swaziland and Zimbabwe. Water resources includes water withdrawals, wastewater volumes treated, irrigation and drainage.

- Southern African Metadata consortium (http://www.gims.com/metadata/default.htm)

Says that 'there has been a strong need for some time now to establish a meta database of information available in Southern Africa. The levels of duplication in data capture are reaching exorbitant levels and the time required to obtain or trace data for project working is far in excess of what it could be. To try and alleviate some of these problems for the people of Southern Africa, and to encourage a true spirit of enhancing data sharing and increasing efficiencies and productivity in our country, a consortium comprising GIMS [Geographic Information Management Systems], CSIR and ISS decided to put some resources together and get the ball rolling. This meta data site is the result of this effort and we hope and trust that others will see the tremendous value in sharing their information in order to add to the common good of all'.

- UEA – IPCC Data Distribution Centre (http://ipcc-ddc.cru.uea.ac.uk/)

From the Intergovernmental Panel on Climate Change's Data Distribution Centre located at the University of East Anglia (United Kingdom). The DDC was established 'to facilitate the timely distribution of a consistent set of up-to-date scenarios of changes in climate and related environmental and socio-economic factors for use in climate impacts assessments'. The available scenarios are listed below. Full details of each modelling scenario are available on the website. Climate change scenario results are available for 30-year time-slices and an observed climate data set can also be downloaded. All data are in zipped format. Monthly data are available by contacting the DDC directly. Results are available for:

1. The UK Hadley Centre for Climate Prediction and Research (HadCM2)
2. The German Climate Research Centre (ECHAM4)
3. The Canadian Centre for Climate Modelling and Analysis (CGCM1)
4. The US Geophysical Fluid Dynamics Laboratory (GFDL-R15)
5. The Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO-Mk2)
6. The National Centre for Atmospheric Research (NCAR-DOE)
7. The Japanese Centre for Climate System Research (CCSR)

- U.S. Census Bureau, International Data Base USAID (http://www.census.gov/ftp/pub/ipc/www/idbprint.html)

From the U.S. Bureau of the Census, International Data Base. The site contains quite a thorough database of population data (various categories, for total, urban or rural values, for every year from 1950 to 2050), for every country in Southern Africa. The data can be viewed on screen, downloaded into a spreadsheet, or user-configurable.

- USGS Africa data dissemination service (http://edcintl.cr.usgs.gov/adds/data/data.html)

From the United States Geological Survey. Contains maps of the Southern Africa region's cropland use intensity. Data are also available by country (dekadal - 10-daily - data). The type of data available is as follows:

Satellite/image data (AVHRR/NDVI): Vegetation indices derived from the (NOAA) Advanced Very High Resolution Radiometer (AVHRR) sensor have been employed for both qualitative and quantitative studies. The Normalised Difference Vegetation Index (NDVI) is a measure of the amount and vigour of vegetation at the Earth's surface. Objectively determined 10 day African rainfall estimates were created for famine early warning systems (FEWS). Dekadal data are available for the whole of Africa, for the Southern African region, and for many individual countries. A technique for estimation of precipitation over Africa was developed to augment the rainfall data available from the relatively sparse observational network of rain gauge stations over this region. The method utilises METEOSAT 5 satellite data, Global Telecommunication System (GTS) rain gauge reports, model analyses of wind and relative humidity, and orography for the computation of estimates of accumulated rainfall. Work on this project has been performed for the United States Agency for International Development (USAID), Famine Early Warning System (FEWS) to assist in drought monitoring efforts for the African continent.

Digital map data: Administrative boundaries, Agro-climatic zones, Cropland Use Intensity, Digital Elevation Model, Hydrology, Railways, Rain gauges, Reference maps (GIF files of country maps), Roads, Vegetation. These data are variously available as maps of the whole African continent, Southern African region, or individual countries. One of the more relevant maps is of Cropland Use Intensity (CUI). This is a geographic parameter that represents an estimate of the amount of land under cultivation for a given area (or map polygon). It is directly related to the percentage of cultivated land by area. CUI was developed to prepare maps of the degree to which land is being used for cultivation, and thus can be reported in both tabular and map formats. Cultivated land includes a variety of cropland types, such as dry-land or rain-fed, irrigated, recessional, food and cash crops. However, CUI generally excludes tree plantations and orchards unless otherwise stated. Available for Southern African region, or various individual countries. From this Web site it is possible to access various other land use maps for Africa.

Tabular data/statistics: The more relevant ones available are: agricultural management statistics (in AGMAN format) AGMAN is an agricultural database manager. It is designed to facilitate the archiving, analysis, and presentation of agricultural production data; precipitation (in RAINMAN format) RAINMAN is a software package used to compile, update and manage a dekadal (10-day) rainfall database.

To download the data requires the use of WinDisp3: a software package for displaying and analysing time-series satellite images. The software is tailored specifically for monitoring vegetation and weather via satellite images for early warning of droughts, crop failures, and fire danger. It is downloadable from the Web site in compressed form (pkzip for PC format, gzip for UNIX format). Instructions are given for the use of metadata prior to viewing images. Digital map data can be viewed on the screen or downloaded in compressed format.

- USGS Hydrologic data via the internet site

(http://civil.ce.utexas.edu/prof/maidment/GISHydro/docs/websites/webtoc.htm)
Contains links to sites with downloadable Digital Elevation Models of the whole world. A Digital Elevation Model (DEM) consists of a sampled array of elevations for ground positions that are normally at regularly spaced intervals. The Digital Chart of the World (DCW) DEM data provide 30-by-30 arc-second digital elevation data produced from the Defense Mapping Agency's (DMA) 1:1,000,000-scale DCW contour and hydrology data. The EROS Data Center's DCW DEM project includes generation of 30 arc-second data for the entire world to be distributed on CD-ROM as major geographic regions are completed. As of January 15, 1995, Europe, Asia, Africa, Japan, Madagascar, and Haiti, are complete and available for distribution. The data can be downloaded as a compressed TAR file. Lines graphs are available for use in ArcInfo.

- UNEP/GRID Clearinghouse (http://grid2.cr.usgs.gov/)

From the United Nations Environment Programme / Global Resource Information Database. The types of data available are: Population / Population Density (the Africa Population Distribution Database – for 1960, 1970, 1980, 1990), Topographic, Climate, Soils, and Vegetation.

To access the data it is necessary to enter your name, email address and a description of your intended use for the data. The data can be downloaded in TIF or BIL format, in compressed form (either for PC or UNIX platform), or a map can be viewed on the screen.

- WaterWiser, of the American Water Works Association (http://www.waterwiser.org/)

Offers advice on how to save water and detect leaks in the home, how to irrigate gardens most efficiently, harvesting rainwater, buy efficient fixtures for the home, etc.

- World Bank data on water (http://www.worldbank.org/data/wdi/pdfs/tab3_5.pdf)

The types of data available are: (By country):Freshwater resources (m^3 per capita), annual freshwater withdrawals in Bm^3 (industrial, domestic, agricultural, as % total resources), proportion of urban and rural populations with access to safe water, land use statistics. The data can be viewed in tables on the screen.

- World Resources Institute 1996-1997 data query (http://data.wri.org:1996/)

The types of data available are: Access to safe drinking water and sanitation (by country or for whole of African continent), urban or rural situation, given as a percentage of the population. The data can be viewed on the screen only.