A study to determine water demand management in Southern Africa: the Zimbabwean experience

J. Ndamba, J.S. Sakupwanya, J. Makadho and P. Manamike

Institute of Water and Sanitation Development

IUCN
The World Conservation Union

Sida

List of Abbreviations

AFC	Agricultural Finance Corporation
Agritex	Agricultural Technical and Extension Services
ARDA	Agricultural and Rural Development Authority
BOOT	Build Operate Own and Transfer
BOT	Build Operate and Transfer
DDF	District Development Fund
DWD	Department of Water Development
FAO	Food and Agriculture Organization
ICA	Intensive Conservation Areas
IMC	Irrigation Management Committees
IWSD	Institute of Water and Sanitation Development
IUCN-ROSA	International Union for the Conservation of Nature - Regional Office for Southern Africa
MAR	Mean annual runoff
MCM	Million cubic metres
ML	Megalitres
MLA	Ministry of Lands and Agriculture
MLGNH	Ministry of Local Government and National Housing
MMET	Ministry of Mines, Environment and Tourism
MOHCW	Ministry of Health and Child Welfare
NGOs	Non-governmental Organisations
RWA	Regional Water Authority
SADC	Southern Africa Development Community
SIDA	Swedish International Development Agency
SSD	Sub-surface drip
UIM	Urban, industrial and mining
WDM	Water Demand Management
WRMS	Water Resources Management Strategy
WUA	Water Users Associations
ZAPF	Zimbabwe's Agricultural Policy Framework
ZESA	Zimbabwe Electricity Supply Authority
ZIMSCO	Zimbabwe Steel Company
ZINWA	Zimbabwe National Water Authority
ZISCO	Zimbabwe Iron and Steel Company

Chapter 1

Water resources in the Southern Africa region and the need for water demand management

In Africa a number of countries are already in a situation of absolute water scarcity where available water resources are less than $1000M^3$/head/year. This is against the background of regional food shortages while water resources are becoming scarce. Therefore new approaches to water development projects that move away from the large scale, top-down approaches of the 1970s with associated high costs and disappointing performance are now required. It is apparent that water demand management strategies are required given the finite nature of water resources. These are key to increased food production, economic development and to improve water use efficiency.

The fact that water is finite and its scarcity is on the increase means that the region needs to develop effective mechanisms of managing it. Sustainable water resource management is also an important element of regional security and internal stability. The conventional approaches to water management have been to construct elaborate dams to increase the supply in order to meet demands. In general water has been under-priced leading often to the abuse and inefficient use of the resource. Given that supply is likely to diminish, and the building of dams for most countries now is becoming an expensive option, a strong need has arisen to explore different water management strategies.

The Government of Zimbabwe recognises that water is a strategically important resource that is finite and should be managed in an efficient, sustainable and integrated manner with due regard to socio-economic and environmental needs. Thus, water of sufficient quantity and quality and at affordable prices should be available to meet current and future demands without compromising environmental integrity. In recent years the Government has been increasingly concerned about the lack of co-ordination among the many institutions active in water resources management and development. The absence of a policy framework for water resources management and consequent unco-ordinated sectoral planning and development of water resources together with the increasing frequency and severity of droughts in the country over the last few decades constitute a serious constraint on social and economic growth. Water has been described as the most valuable of Zimbabwe's natural resources. This is because without adequate and assured supplies of water the exploitation of the mineral wealth, the intensification of agricultural production, the establishment of industries and the expansion of towns are impossible. Indeed, water availability and the extent to which water can be exploited and controlled strictly limit the whole development of Zimbabwe and its capacity to support an increasing population. The problems highlighted are not unique to Zimbabwe but affect the whole of the Southern Africa region.

In appreciation of these problems, a project to assess water demand management activities currently taking place in the region has been initiated. Water demand management is of crucial concern to the countries of the region because of the increasing human population and associated demand for resources that require water, especially food. Some States are already water stressed due to prolonged droughts or low and unreliable rainfall while others will experience water scarcity in the not too distant future.

The current project was initiated by the International Union for the Conservation of Nature Regional Office for Southern Africa (IUCN-ROSA) with the financial support from the Swedish International Development Agency (Sida). The project aimed to identify and evaluate current policies and strategies for WDM in order to establish the benefits and impacts, as well as its effectiveness in meeting social and environmental needs in the Southern Africa region. The country study approach has been taken to illustrate the main policy lessons and issues that may be of relevance at the regional level. It is planned that the findings from these case studies will be useful in encouraging regional governments to adopt WDM strategies as a water resources management tool. In Zimbabwe, the team selected cases in the large and small scale agriculture as well as the urban, industrial and mining sectors due to the importance of these sectors to the country's economy. Since the agricultural sector accounts for 80% of the recorded water use in Zimbabwe, introduction of demand management in this sector is imperative. Unfortunately data is not readily available on the current water use practices in this sector as these tend to be individual farmer driven. On the other hand, the UIM sector is important in that it encompasses the most important water users in terms of priority of use.

Chapter 2

An overview of the water sector in Zimbabwe

2.1. Total water resources in Zimbabwe

Southern Africa is generally poor in terms of water resources given the conditions of unpredictable rainfall, very high evaporative losses, and low conversion of rainfall to runoff. Zimbabwe is a semi-arid country characterised by mid-season droughts during the rainy season and a dry winter season. The rainfall ranges from 450 mm to 650 mm in the low rainfall areas (Natural Regions IV and V), mainly in the south-west of the country and 750 mm to over 1 000 mm in the high rainfall areas (Natural Regions (I and III), located in the Eastern Highlands. The bulk of the rains are received in only four months of the year from November through to March. Most of the rain falls in heavy short storms, thereby giving rise to considerable runoff, especially in the low rainfall areas. The adverse climatic factors in Zimbabwe namely, large temporal and spatial variations of rainfall and even greater temporal variations of mean annual runoff necessitate the provision of large storage capacity to balance river flows throughout the year and over sequence of several years. This results in a decreased availability of water due to evaporation losses when water is held in storage over an extended period of time. Thus whereas some countries can aim at a total practical potential surface water resources that can be used of 80% of the mean annual runoff, the maximum that can be obtained in Zimbabwe is only about 50%.

Boreholes, which are mostly recharged by rain water, are also a source of water for the country. The ground water sources are generally scarce in the context of sustainable macro-irrigation development, but are however used mainly for potable water supply for the rural population, and rural service centres. It is estimated that surface water contributes 90% of the country's water supply while groundwater contributes only 10%. Therefore the country is heavily dependent on surface water.

2.2. Surface Water

Surface water resources in Zimbabwe have been calculated based on the estimates of mean annual runoff in six hydrological zones identified by letters A to F on the hydrological map of Zimbabwe (Figure 1). These are :-

Zone A : Most of this zone drains north-west into the Zambezi River. The remainder drains into Botswana via the Nata and Gwabazabuya Rivers. The mean annual runoff (MAR) of this Zone is 17 mm.

Zone B : The south-western catchment area of all rivers draining into the Limpopo in Zimbabwe. The MAR of the zone is 19 mm.

Zone C : The Mupfure, Munyati, Sanyati and Manyame catchment area. The MAR of the zone is 62 mm.

Zone D : The Mazowe and Ruenya catchment area. The MAR of the zone is 113 mm.

Zone E : The Save-Runde catchment area. The MAR of the zone is 70 mm.

Zone F : The eastern slopes of the eastern highlands which drains into Mozambique. The major rivers are the Pungwe, Gairezi and Budzi. The MAR of the zone is 174 mm.

The estimates show that the average total annual runoff in the country is 19 900 million cubic metres (MCM). Of this, the potential yield of surface water is estimated at 11 260 MCM. The yield that can actually be exploited is 75% of the potential, that is 8 500 MCM. Of the exploitable potential, about 4 900 MCM are currently committed. This leaves an estimated amount of 3 600 MCM for future use. Table 1 presents the surface water resources data on the basis of the 8 river basins, estimated as at 1991.

Table 1. Extent of surface water resources utilisation on a river basis (1991)

Basin	Area (km^2)	Sub-catchments	Total available water (MCM)	Committed Water (MCM)	Available for use (MCM)	Percentage that can be exploited
Gwayi-Shangani	86 121	25	410.92	137.00	273.92	33
Sanyati	62 945	14	1 249.70	323.20	926.50	26
Manyame-Dande	44 019	11	1 310.75	781.80	528.95	60
Mazowe	27 489	17	1 471.59	366.20	1 105.39	25
Ruenya-Pungwe	12 898	9	761.25	50.60	710.65	7
Save	47 114	24	1 966.12	881.40	1084.72	45
Bubi-Runde	63 955	27	1 076.95	823.30	255.65	77
Shashe	39 642	24	254.11	195.50	58.61	77
Total	384 183	151	8 501.39	3 559.00	4 908.39	

Figure 1: River basins of Zimbabwe

Zimbabwe is one of the few African countries where comprehensive water resources assessments have been made from the available river flow records. The records are of adequate duration and quality. At present, these assessments exclude water available from international rivers such as the Zambezi and Limpopo. As of 1991, a calculation was done in order to determine the commitment of the exploitable water in each river basin. This is presented in Table 1. The least exploited basin is the Ruenya-Pungwe with only 7% of the water having been exploited and the most exploited basins are the Shashi and Bubi-Runde with 77%. Most formal irrigation depends on water stored in more than 10 000 dams scattered throughout the country. Of these, approximately 5 700 are privately-owned dams which have been constructed by commercial farmers. The remainder are government dams.

2.3. Groundwater

It is estimated that surface water contributes about 90% of the country's water supply while groundwater contributes only 10%. Groundwater resources in Zimbabwe are scarce and are not expected to sustain macro-irrigation projects. However, there are some areas where groundwater can sustain medium and small-scale irrigation projects. The importance of the groundwater resources however is reflected by the fact that in rural areas of Zimbabwe, where about 70% of the population live, groundwater is the main source of reliable and potable water supplies. According to the National Action Committee on Rural Water Supply and Sanitation, a total of approximately 20 000 boreholes and 10 000 deep wells are used by rural communities throughout Zimbabwe. This suggests a total annual abstraction of the order of 27.7 - 34.6 cubic metres for rural water supply only (Interconsult, 1985). The assessment of groundwater resources was carried out in 1986. This assessment is considered generalised since it does not have an evaluation of the available resources in terms of recharge rates, groundwater dynamics, water usage and management. It is, however estimated to be in the region of 1 000 to 2 000 MCM. The low groundwater potential areas cover two thirds of the country while the higher potential areas only cover one third.

Chapter 3.

The Water using sectors in Zimbabwe

The three main sectors that use water in Zimbabwe are agriculture (80%), urban, industrial and mining (UIM) (15%) and rural/primary use (5%). It has also now been generally recognised by the government that the environment is a producer and also a legitimate user of water.

3.1. Rural areas

Water supply in the rural sector is mainly for domestic consumption, livestock and vegetable watering and small-scale irrigation. The emphasis has been to provide rural people with clean potable water for domestic and primary use. This is mainly abstracted from groundwater sources. The approach has been successful in providing access to reliable water from about 30% of the rural population in 1980 to about 80% in 1998. Improvements in access to clean potable water however, have been occurring within an environment of decreasing capacity for food production in these same areas. Arguments have therefore been put forward to strike a balance between the provision of what has been termed "social water" and the provision of "productive water" in the rural areas. There is little available data on specific use of groundwater by the rural sector but reports suggests a total annual groundwater abstraction of the order of 27.7 - 34.6 million cubic metres for rural water supply (Interconsult, 1985).

3.2. Agricultural sector profile

According to the statistics from the Department of Water Development, the committed water resources in the country are in the order of 4 900 million cubic metres (Table 1). This includes granted rights and ministerial water. The agricultural sector accounts for a total of 80% equivalent to 3 760 million cubic metres of water of the recorded water use in the country. The rest, (20%) amounting to 940 million cubic metres, account for the water use in the other sectors of the economy which cover urban, industrial and mining requirements.

At the present level of development in Zimbabwe, where agriculture is the mainstay of the economy, it is appropriate that the bulk of water is used by agriculture. However, as industry, mining and urban centres grow, a higher proportion of the water is expected to be used in these sectors. Therefore the rights system and the water pricing mechanisms should be designed to facilitate a smooth transfer between the sectors of the economy. Indeed the Water Bill (1998) has facilitated this by empowering Catchment Councils to manage water resources in their areas of jurisdiction and introducing the water permit system, where the water permits, instead of water rights, are reviewed periodically.

Agricultural water sectors are divided broadly into the irrigation of land, use of water for fish farming purposes and the operation of a feedlot in which twelve or more cubic metres of water are aggregated for each months or more months out of twelve consecutive months. The irrigation of land is by far the largest and most significant consumer among these users. While fish farming is practised in isolated cases but because of its no-withdrawal nature, its relative impact on competition with other sectors is not yet obvious, and is likely to be relatively insignificant. Livestock is practised in all areas of the country. In most cases, livestock watering is done using small dams and boreholes. They tend to compete with domestic use and small gardens supplied by those small dams in communal areas.

3.2.1. Main sectors consuming water in the agriculture sector

Although statistics are not readily available to confirm this, the irrigation sector consumers are known to utilise most of the 80% of the recorded water use in Zimbabwe. The irrigation sector comprises largely two major sub-sectors which competes for water. These are the large scale private commercial sector and ARDA on one hand and the small holder communal and resettlement sub-sector on the other. Table 2 shows the proportions of irrigated areas of the sub-sectors as well as the number of beneficiaries. It is estimated that a further 20 000 ha of small gardens, ranging in size from about 0.1 ha to 0.5 ha, is irrigated country-wide by communal farmers. These gardens, referred to as dambos, utilise shallow ground water normally found adjacent to rivers or in vleis.

The large-scale and small schemes differ a lot in their approaches to the operation and maintenance of their schemes and water management. The former operate as commercial farms with a well structured institutional management system and the latter utilises irrigation management committees, who heavily rely on persuasion when enforcing water management practices. Within the small holder group, there are two types of small holder irrigation schemes whose management is significantly different enough to affect their water use practices. These are the government-managed irrigation schemes and the farmer-managed small holder irrigation schemes. In the former, the operation and maintenance of the irrigation infrastructure is shared between central government and farmers. In the latter it is a preserve for the farmers themselves.

Since few of Zimbabwe's internal rivers are perennial, most formal irrigation depends on water stored in more than 10 000 dams. Of these, some 5 700 have been constructed privately by commercial farmers while the remainder are government dams. There are currently about 152 000 ha of land under formal irrigation in Zimbabwe in the four broad farming categories. These are 1 600 large-scale commercial farms (130 000 ha), 18 estates under parastatal management (11 000 ha), small-scale commercial farms (2 030 ha) and on 178 government developed communal and resettlement small holder schemes (8 580 ha) (Figure 2).

In addition to the above, there is a large area of land under irrigation in very small community or individually managed informal schemes and gardens in the communal lands throughout Zimbabwe. These typically range in size from about 100 sq. metres to about 2 ha. Although no reliable data exists, the total area of such schemes could be of the order of 5 000 - 10 000 ha.

Figure 2. Pie chart showing the major agriculture water users in Zimbabwe

It is clear from the pie chart that a large portion of the water is used by the large scale irrigators that use over 80% of the available water resources while the small scale farmers only use 1.3%. This disparity, in the benefit in utilising the country's water resources, are largely due to the three following factors;

(a) about 4 500 large scale farmers (the less than 1500 irrigators included) own a total of 11 million hectares of highly productive arable land in high rainfall potential areas while one million small holder farmers reside on 16.3 million ha. In addition there are 57 000 farm units in resettlement areas covering 3.3 million hectares and 8 500 small-scale commercial farms covering 1. 4 million hectares in extent. Productivity in the small scale commercial sector is low because it is constrained not only by the natural resource base, but also the historical imbalances of investment in land and water, among other causes. For the purpose of this discussion they will be considered as having the same requirements, in terms of access to agricultural water allocation, as small holder farmers.

(b) the large scale commercial farms are mainly located in high rainfall areas, typically Natural Regions I, II, in which 4.4 million hectares (40%) are located and the remaining 6.6 million hectares (60%) are in Natural Region III. Seventy five percent (75%) of the communal areas are located in marginal areas, Natural Regions IV and V, where mean annual rainfall is about 4000mm. This is also home to about 70% of Zimbabwe's population of 10.4 million people, (now unofficially reported as 12.5 million people), based on the 1992 census results

(CSO, 1992). Besides the communal areas being marginal, small holder irrigators have typical plot holdings of < 0.1ha to 2 ha or an average of 0.5-1 ha per family, mainly due to population pressure, lack of resources as well as the meagre water resources in their areas.

Table 2: Proportions of irrigated areas on a sector basis.

Irrigation Sector	Area Irrigated Area (ha)	 % age	Number of Units	Number of Beneficiaries
1)Large Scale Private Commercial Farmers	126 000	81	1 500 farms	< 1500 farmers
2) ARDA 3) Settler farmers (under ARDA)	13 500 3 600	9 2	26 farms	over 500 farmers Gvt
4)* Small holder communal and Resettlement Farmers	12 900	8	306 formal schemes	20 600 families
TOTAL	156 000	100		appr. 22 600

* comprises formal schemes and informal (private) schemes

(c) The priority date system has not narrowed the gap in access to water resources either. The large scale commercial farmers have managed to acquire water rights earlier and some of the rivers, especially in the high potential areas have almost been fully righted, the Manyame-Dande, Bubi-Runde and Shashe river basins being a case in point (Table 1).

3.4. The urban, industrial and mining sector profile

Zimbabwe has a three-tier structure of urban settlements, which include at the lowest level the growth points and the intermediary settlements and at the highest level the big cities. The main sectors consuming water in urban areas arise from the commercial, industrial, domestic, mining and institutional use. Institutional use includes schools, hospitals and other arrangements.

Commercial sector: The commercial sector on average seems to take about less than 10% of potable water distributed by most local authorities. The Commercial sector due to harsh-economic conditions seems to be decreasing and thus consumption has decreased significantly from 1994 upwards. Opportunities for WDM are there, since meters are installed in the entire sector. There will therefore be no need for large infrastructural investment except for mapping of water infrastructure.

Figure 3: Water use in the urban, industrial and mining sector in Zimbabwe

Industrial sector: The industrial sector in most towns and cities of Zimbabwe seem to take a major share of the water. In industry, water is an input in the manufacturing process or may facilitate the process through the generation of steam, cooling or product dilution and also disposal of waste. There are a number of wet industries with a high demand for water in the production process. These include the beverages industries and paper mills. The annual average consumption of industry ranges from 20% to 50% depending on the size of the urban area and the nature of industrial activities. During drought periods, local authorities have had to initiate water use restriction measures. For example, in Harare, in 1994 the industrial and commercial tariffs that were previously on a flat rate irrespective of level of consumption were banded into two bands with the higher band attracting heavy tariffs. As a result some industries have imposed some self-regulatory, public awareness campaigns aimed at saving water. A good example is the National Breweries which now uses the least volume of water per hectolitre of beer produced in the world! Added to this, other industries have had to drill boreholes in order to augment their supplies. But the use of ground water, although it relieves pressure on municipal supplies has tended to work against WDM principles as it is often viewed as private water. Although there is some legislation that requires availability of a permit before a borehole can be drilled in the municipal area, most local authorities do not have adequate resources and capacity to effectively enforce the legislation.

Mining sector: In the mining sector water is primarily used in the refinery processes of ores. The mining sector is complex in the sense that there is need to compile data from various urban centres. Other towns are mainly mining towns whilst others are not. Also some mines are water agencies on their own. The indications are that mines that get their water from the town's supply systems consume about 1% of the potable water. The low figure is due to the fact that mines tend to recycle groundwater from their mining activities and only use potable water for sanitation and refinery processes where clean water might be necessary.

Domestic sector: The domestic sector consumes on average from 5 to 18% of the annual average treated water. For domestic requirements, water use is related positively to the affluence of the household. The water use per household is also directly linked to the household size. The bigger the household the higher the quantity of water required to meet per capita needs. Furthermore, the average age of the household has a bearing on the actual amounts used. Children tend to need less water but waste more. The availability of taps within the household encourages frequent and unnecessary use, thus promoting excessive usage. Other important factors that influence household demand include the user's water using habits, the abundance and nature of water availability, regularity in the flow, universal metering, the residual pressure in the reticulation system and climatic conditions.

3.4.1. Availability of water in urban, industrial and mining (UIM) sector

To most urban, industrial and mining sectors in Zimbabwe, water is available as surface raw water stored in government, private, syndicate and local authority owned dams. The dams are scattered throughout the country in various catchment areas in the five major river systems of Zimbabwe. Groundwater is mainly used to augment water supply. Some individuals and industries drill boreholes to supplement their water supply especially during drought periods when they are hit by rationing and hefty water fines. One concept that has to be noted from the beginning is that the industrial sector is within the urban sector and to a small extent the mining sector as well.

The 21-month rule is a generally widely accepted rule for management of water supplies to urban centres in Zimbabwe. The rule states that if the volume of water in a reservoir (dam) at the end of March (approximately the end of the rainy season), cannot sustain the present demand on that reservoir for 21 months, through any assumed drought, then rationing should begin at once. Rationing should be at a level which assumes the supply will last to the beginning of the rain season after the next. Traditionally dams meant for UIM usage are designed for a 4% risk level unlike 10% for irrigation purposes. The 4% risk level means that out of 100 years there is a likelihood of failure of 4 years. However the drought experience in recent years, especially in 1992 indicate that there is higher risk of failure attached to urban water supplies than the agreed 4%. During drought very few urban centres in Zimbabwe can be considered to have secure supply (Table 3).

Table 3: Some major urban centres their source of supply, current demand and capacity of sources

City/ Town Population served	Harare & Chitungwiza 2 000 000	Bulawayo & centres 750 000	Mutare & Penhalonga 175 000	Gweru 16 000	Kwekwe Redcliff 130 000	Kadoma & mines 95 000	Masvingo & Renco 70 000	Chinhoyi & mines 65 000
Present Source	Manyame/ Chivero	Mzingwane/ others	Odzani Dam	Gwenoro White Waters	Sebakwe	Claw Dam	Mtirikwe	Manyame
4% yield present source $x10m^3$	155	45	20	17	45 exclude irrigation	20	20	17
Demand $X10^6m^3$	1 600	263	13	20	45	15	13	11
Present Available Balance	24	0	8	0	11	11	8	1

The data indicates that new sources of water for most centres need to be developed or water demand management strategies need to be urgently adopted.

Chapter 4

Competition and conflict among water using sectors in Zimbabwe.

4.1. Competition and conflict

There are three principal forces that conspire to create water scarcity and its potential to incite conflict or dispute. These are:-

1. The depletion or degradation of the resource, which shrinks the resource pie.

2. Population growth which forces the pie to be divided into smaller slices. Since 1931 the population of Zimbabwe has been doubling almost every 20 years.

3. Unequal distribution or access, which means that some get larger slices than others. In the agricultural sector, this issue has been exacerbated in the past by the concept of priority of application date as a basis for water allocation that seriously prejudiced new farmers and those who were being discriminated against before independence. As a result a situation had arisen where some water right holders had huge amounts of water when their neighbours had virtually nothing.

Although all three factors often play a part in inciting competition and conflict, it appears that unequal distribution or access often has the most important role. In some cases, dams and other development projects intended to improve conditions for agriculture or the economy can end up fuelling tensions. This is particularly so if newly created access to the scarce resources worsens existing inequalities, further marginalising the poor and creating opportunities for the rich to capture the resource. Numerous such cases have been reported in the local press. It has been reported that some people in some parts of Gutu and Buhera Districts who are the custodians of the Ruti Dam have not benefited from the largest water reservoir in their area because they do not have any rights to the water. The people from the Mutasa Communal Lands have no access to the Osborne Dam waters and this has fueled a lot of political discussions. Although the Mupfure River passes through Beatrice, the town cannot use Mupfure water except when the boreholes supplying the town run dry since all water rights are held by the surrounding commercial farmers. Mwenezi farmers cannot irrigate their crops although the Manyuchi Dam, the fifth largest inland dam in Zimbabwe is spilling only a mere 10 km away. The Zhove dam recently completed in Matebeleland South has only benefited four commercial farmers in a province which lies mostly in Region V. Large scale dam projects such as Lake Mtirikwe were constructed to supply water to large scale irrigation schemes of the lowveld hundreds of kilometres away but with very little benefits to the local people. As a result of the water rights system, communal farmers can only watch the water going downstream but with no access to it. All these stories highlight how in some cases existing inequalities have been worsened by new developments.

As conflicts over water worsen, many people wonder where water for the future will come from. Expanding the water supply to one user now means taking it away from another. Municipal authorities scream for more water while commercial farmers resist moves to reallocate the water. The key challenges now therefore are to establish priorities and policies for allocating water among competing uses and users, to encourage more efficient and productive use of water and to reshape institutions to better suit the new era of water constraints. It is within this context that demand management should be seriously considered as an option for stretching existing water supplies so as to help satisfy additional demand and relieve tension amongst users.

4.2. Competition for water resources

The major competing water users in Zimbabwe are the urban, industrial and mining sector and the agricultural sector, mainly the irrigation sector. Within the agricultural water sector the large scale commercial sub-sector and the small holder sub-sector are the major competitors. The competition between these sub-sectors is a result of historical imbalances which can not today be regarded as being ideal for fostering sustainable and equitable economic and social development.

Starting in the 1940's, the then government placed high priority on water development, particularly the construction of dams for large scale commercial farmers. This was done through the creation of Intensive Conservation Areas (ICAs), a mechanism through which these farmers received 50% financial subsidy for building dams as well as free technical designs and advice. Today, the farmers have 5 700 dams among them. They also have good access to water from government dams. As a result, the commercial farmers enjoy the benefit of this long term investment and are able to minimise the effects of droughts and improve their returns through the cultivation of high value crops, such as tobacco and horticultural crops. The development of infield irrigation infrastructure was however left to the individual commercial farmers. During the period 1930 to 1960, several small holder irrigation schemes were built in today's communal areas, mainly as social schemes for drought relief and also to resettle black farmers evicted from what became white large scale commercial farms. The operation and maintenance of these schemes was done by the government. Other policies which followed, such as financing arrangements continued to marginalise the small holder sector, until the change of government in 1980.

Despite this seemingly obvious accessibility by the large scale farmers, conflict often arises with the local authorities. The Urban Councils Act (1980) allows a local authority to forcibly abstract water from any reservoir if the need for drinking waster arises. It further states that if an owner of the premises fails to comply, then the council will go ahead and make the connections and charge all the costs of making such connections to the owner of the property. This has happened particularly during drought periods when water has been diverted from the commercial farms to urban dwellers. The clause has posed problems with some commercial farmers some of whom claim to have priority over some urban areas. A case in point is the Upper Manyame vs City of Harare case. In addition, the Act empowers the council to remove any obstruction, other than works constructed under the authority of any law, which interferes with the flow of a public stream. This has implications on some farmers who have constructed small dams, some of which are illegal, as these can be destroyed at any time without any form of compensation.

As mentioned earlier, the concept of priority date of application of water rights being used as a basis for water allocation has seriously prejudiced new entrants. The system benefited large scale commercial farmers at the expense of communal farmers and it is not uncommon to see water rights holders with huge amounts of water living next to their neighbours that have no water. These inequities mean that the re-allocation of water is increasing becoming more urgent by the day.

The new government, having realised the role of small holder development in Zimbabwe, as early as the mid-1980's, set out to construct new dams and irrigation schemes as well as rehabilitate old ones. Although some success was registered in this regard, as shown by the expansion from about 4 500 hectares in the mid 1980's to about 12 900 hectares in 1997 (Table 2), financial constraints have hampered speedier development. The policies that have been pursued by the government have been for the promotion of small holder irrigation development as commercial enterprises. These policies of late include the National Irrigation Policy and Strategy and the Water Bill (1998). Recently, the government awarded 10% of all water in existing dams to increase the water supply to small holder and small scale farmers. Prior to these policies, the policy environment for the large scale commercial sector has remained largely unchanged.

Chapter 5.

Current legal aspects that affect the water resources management

5.1. Legal and policy issues in relation to agriculture water

The current Water Act of 1976 vests all the water in the President who in turn delegates the Minister of Rural Resources and Water Development to manage it. The Act states that any farmer who needs public water for agricultural purposes must have a water right and in the case of water shortages, priority will be given to those who were issued with water rights first. The rights are issued in perpetuity. The fact that water management follows a priority date system during drought means that some users will not have access to water, unless a water shortage area is declared by the Minister. Once the Minister declares a water shortage area, all water rights in that area are suspended to allow for the redistribution of the available water to all users. However this process may take too long to complete while the situation is still critical. Some farmers have drilled boreholes on their own properties in order to beat water shortages. The provisions of the current water act relevant to agricultural water are discussed in more detail in the following sections.

5.2. Water Act (1976)

The Water Act (1927) stated that all water is vested in the state. Besides the inherent right for domestic and stock watering by mainly riparian water users, the use of water for any other purpose requires specific authority in terms of the Act. This law has been based on the "appropriation" doctrine, whereby water rights are allocated on a "first come, first served" basis as opposed to the riparian doctrine, whereby riparian users can enjoy varying degrees of inherent rights to use water. The Water Act (1976), which replaced that of 1927 broadened the scope of water development and utilisation in the country, as well as the establishment of water development advisory councils. The Act allows for the application of water rights for the use of public water, the control of water rights in some circumstances by the state, the declaration of public water shortage areas, the control of underground water, the prevention and control of pollution and the safety of dams among other changes. The Water Act (1976) defines P*rivate* and *Public* Water. *Private* water belongs to the owner of a piece of land on which that water falls or rises naturally without joining a public stream, underground water being excluded. *Public* water is defined as water found on or below the bed of a public stream, including marshes, springs, swamps or vleis, forming the source of or found on the course of a public stream. Public water is vested with the President. As such, it is laid down in the Act that public water may not be abstracted, apportioned, controlled, diverted or used other than in accordance with the provisions of the Act. Agricultural water belongs to this category and a water right should be applied for before water can be used for this purpose.

The Act defines agricultural use of water as the irrigation of land or, use of water for fish farming purposes or the operation of a feedlot in which twelve or more cubic metres of water, aggregated for each six months or more months out of twelve consecutive months in a year. The highlights of the Act which have a direct bearing on water demand management include *reservation and control of water for future use where the* Minister can reserve water for future potential use and to declare public water control areas, where the use of water is approaching the limit of the potential of its catchment area. In addition, there are no restrictions on the drilling of boreholes, sinking of wells and use of ground water. A landowner may, therefore, abstract underground water without any hindrance, except where an underground control or shortage area is declared. In that case, a permit should be applied for before any borehole or well of more than 15 m depth is sunk or water abstracted from it. The permit is issued by the Secretary of Rural Resources and Water Development, where no objections are raised by interested or affected parties and the Water Court after hearing the objections. As in the case of water rights, permits are attached to the land concerned and pass with it on transfer.

The new Act and the provisions that have been proposed in it embody the concept of the use of water as an economic good. The agricultural users, most of who hitherto did not pay for water, are now paying for the resource. However more work still needs to be done in order to implement water demand management tools in such a way as not to erode the economic viability of the agricultural sector, while at the same time maintaining the viability of water demand management institutions.

5.3. Legal setting in relation to water supply to the UIM sector

Urban Councils enter into abstraction agreements with the Department of Water Development to abstract raw water from the Department's dams. Each agreement has a stated quantity. An Urban Local Authority can also enter into a storage right agreement, which can be granted by the Administrative Water Court to build a dam/reservoir.

However, currently, there is an element of private ownership with water rights issued in perpetuity. But water management in urban areas is governed by the Urban Councils Act, Chapter 214 (1980). The Act, states that a council may enter into agreements for the purchase and sale of water and for any other thing necessary in connection with the maintenance and supply of water. Subject also to the provision of the Water Act of 1976, the Council may construct works inside or outside the Council area for the purpose of providing and maintaining a supply of water. This recognises an Urban Council as a water authority in terms of water supply.

The same Act mandates Urban Councils to increase their domestic water supply base by forcibly connecting premises to water supply if Council feels it is necessary to do so. It is stated in the Act that a council may, by notice in writing, require the owner of any premises within the council area which are not connected with the water supply system of the council to connect his premises to the limits of his property to that system for the purpose of taking a supply of water for drinking, domestic and sanitary purposes. The owner of the premises shall comply therewith within such reasonable time, being not less than thirty days, as is specified in the notice for the compliance. If an owner of premises fails to comply with the terms of the notice within the time specified therein or within such extension of time as the council may allow, the council may connect the premises to the water supply system on behalf of the owner and the owner shall be liable to pay the expenses incurred by the council in making such connection.

The Urban Councils' Act also protects the distribution reservoirs and pertinent structures by authorising Council to remove any obstructions. The distribution network is also protected by the Act by not allowing certain activities to take place within the servitude of the pipelines. The Urban Councils' Act provides for rationing during emergencies or restricted use of water (Urban Councils Act, 1980). This scheme provides for surcharges to be introduced to try and curtail the usage of water. This arrangement has to be initially advertised and eventually gazetted.

The Act allows the urban councils to institute emergency water rationing or any other water use restriction measures. The Act states that a council may, in case of emergency, establish by resolution a scheme for the rationing or restricted use of water. The water rationing scheme may provide for the payment of a surcharge for the use of water which is rationed or restricted and may provide that any person who contravenes any of the provisions of the scheme shall be guilty of an offence. It is however a requirement that where water rationing has been instituted, the council shall give notice thereof in a newspaper and in any other way which the council deems convenient to bring it to the notice of persons affected by it. This clause has been effectively used by local authorities as a way of cutting down on water use but only during the drought periods. In Mutare restrictions went as far as switching off water supply on alternate days of the week at the height of the 1991/92 drought. Harare reported a drop of 20% in water consumption in the low density suburbs while the same results were evident in Bulawayo.

Chapter 6

Main agencies involved in water management and supply in Zimbabwe

In Zimbabwe, several government ministries and their related parastatals are involved in the water sector activities. The division of responsibilities amongst the agencies is mainly based on historical events and expresses the establishment of different institutional units to deal with specific problems. The changes from the Water Act (1976) to the Water Bill (1998) necessitate a change or re-definition of the functions of some of the institutions currently dealing with the supply and management of water resources. It is therefore necessary to understand the present institutional set-up in order to appreciate the proposed changes to it. The major institutions that are involved in the water sector in Zimbabwe and their roles and responsibilities are outlined below.

6.1. The Department of Water Development (DWD)

The Ministry of Rural Resources and Water Development has under its charge, the Department of Water Development (DWD) and the District Development Fund (DDF). The DWD has the mandate for water resources management in Zimbabwe. It plans, implements and operates water projects as well as supervise the planning, implementation and operation where these functions are carried out by other organisations or individuals outlined in the Water Act of 1976. Water resources development activities comprise about 80% of the DWD’s current workload. The department is also responsible for maintenance of an up-to-date inventory of hydrological data on surface and underground water resources as well as information on availability and quality of water and pollution monitoring and control. Under the current arrangement the DWD depends on finances from the government for all its operations. The draft Water Act (1998) proposes a division of these responsibilities between the DWD and the parastatal, ZINWA, which has already been formed by an act of Parliament, to take over most of the current functions of the department. The planning of water resources development and utilisation will be done by catchment councils, in close liaison with ZINWA. Catchment Councils are still to be constituted. DWD’s role will be mainly facilitatory.

6.2. The District Development Fund (DDF)

DDF is the channel for funding most district level investment expenditures. It is established at each district and is responsible for developing and managing public works such as boreholes, small dams and water points, primarily in the communal and resettlement areas. Although DDF generates revenue which goes to treasury, through contract hiring out of its plant and equipment, it relies on government grants. Together with the DWD and the Ministry of Health and Child Welfare, it is responsible for provision of primary water supplies to communal and resettlement areas. It is also involved in the design and construction of small to medium size dams for water supply and irrigation.

6.3. The Regional Water Authority (RWA)

The RWA is responsible for managing and exploiting the water resources of the Middle Save and Lowveld area. As such it operates and maintains the water reservoirs and dams in the area. It also sells bulk water to farmers and a small quantity to local councils for domestic supply. Its role is the same as that of the water users' association (River Boards).

6.4. The Ministry of Local Government and National Housing (MLGNH*)*

As the parent ministry of all local authorities, it is responsible for water distribution in most of the major local authority areas. The Urban Council itself is a water authority and is the main agency in terms potable water supply. But most Urban Councils get their raw water from the Department of Water Development though other Urban Councils are already owning dams that supply raw water. In other smaller Local Authorities such as Gwanda and Hwange, the Department of Water Development supplies potable water to the urban centres but efforts are being made to change this.

6.5. The Ministry of Lands and Agriculture (MLA)

Within the Ministry of Lands and Agriculture, the Department of Agricultural Technical and Extension Services (Agritex) is the one that is directly involved in agricultural water supply and management, mainly through its role in small-scale irrigation development and management. It designs and constructs small and medium size dams as well as irrigation projects. The Ministry also has three parastatals which are directly involved in water resources development and management. These are, the Agricultural and Rural Development Authority (ARDA), the Regional Water Authority (RWA) and the Agricultural Finance Corporation (AFC). AFC is involved in agricultural water management mainly through the supply of credit facilities for agricultural development, such as irrigation and other inputs. A brief explanation of the roles of the more directly involved players is given below.

6.6. Agricultural Technical and Extension Services (Agritex)

The Department of Agricultural Technical and Extension Services (Agritex), within the Ministry of Lands and Agriculture has the mandate to provide agricultural technical and extension services in the country. To this end it is represented from national to ward level. The department also has a mandate to plan, develop, operate and maintain government-funded and managed formal small-scale irrigation schemes as well as plan and develop government-funded farmer-managed irrigation schemes. It also carries out irrigation research and technology development. In doing this, the department works in close liaison with Irrigation Management Committees (IMCs) in all aspects of irrigated agriculture and in respect of water utilisation, irrigation scheduling and efficient water use practices. Agritex also provides guidance to farmers in dam construction and water delivery systems.

6.7. Agricultural and Rural Development Authority (ARDA)

ARDA is a parastatal responsible for agricultural and rural development on behalf of the government. It is heavily involved in government planning of national water resources in irrigation. The parastatal is the largest single irrigator in the country. It also commands a sizeable number of settler irrigators around its core estates.

6.8. Water Users Associations (WUAs)

In agricultural water management water users are organised into either Water Users Associations (WUAs) or simply individuals who do not belong to any association at all. WAUs take a different form between the large scale commercial and small holder sub-sectors. In the large scale commercial areas and ARDA sub-sector, they take the form of River Boards while in the small holder sub-sector they take the form of IMCs. According to the national objectives and policies for the agricultural sector, embodied in "Zimbabwe's Agricultural Policy Framework 1995-2000 (ZAPF)",the IMCs will be strengthened and the Water Bill (1998) stipulates that communal and resettlement farmers will be represented in Catchment Councils. Therefore they will be an integral part of the decision-making process on water resources development and management at that level.

River boards are set up to monitor the utilisation of water on a particular section of a river system. They also articulate the views and concerns of the farmers operating in a specific river system to local authorities and central government. The farmers in River Boards endeavour to create a spirit of close co-operation and consultation and show willingness to compromise in times of water shortages. According to the new Act, River Boards will be succeeded by Catchment Councils. In the small holder sub-sector the farmers form IMCs whose purpose is to monitor that farmers perform their tasks in adherence to by-laws agreed among themselves. Their major function is the co-ordination of activities within the irrigation scheme as well as liaison with water supply authorities on water allocation and usage.

6.8. Others

MOHCW is responsible for well sinking activities and for health and hygiene education as part of the provision of domestic water supply for communal and resettlement areas. The Ministry is also responsible for monitoring of health related water quality parameters through the Government Analyst. On the other hand, the MMET through its Department of Natural Resources is empowered by the Natural Resources Act of 1986 to stop all operations where the use of natural resources is not consistent with appropriate and sustainable use. The other institutions include the IWSD (training, research and consultancy), the University of Zimbabwe (training, research and consultancy), the National University of Science and Technology (training and research), the Geological Survey (research). The Ministry of National Affairs and Employment Creation (community mobilisation), the Meteorological Department (planning), the National Economic Planning Commission, the Administrative Court (water right applications and dispute resolution) and Non-Governmental Organisations (training, research and development) also play a significant role.

Chapter 7

The current reforms in the water sector

The ever-growing scarcity of water, the recent severe and frequent droughts and the preliminary findings of the Poverty Alleviation Study, undertaken by the Government of Zimbabwe in 1995, have compelled the government to introduce changes in the water sector. Coupled to these problems has been the lack of a policy framework for water resources management and the resultant unco-ordinated sectoral planning and development in the sector. Such a system can no longer be sustainable, given the prevailing macro-economic environment in which fiscal austerity is a cornerstone of structural adjustment. Therefore changes in water resources development and management have been inevitable. However they are still to be implemented in order to address the requirements of water demand management. These changes are listed below;

7.1. Legal reforms

7.1.1. Changes to the Water Act of 1976

The main legislation in the water sector in Zimbabwe that is being repealed is the Water Act No. 41 of 1976, which is administered by the Department of Water Development on behalf of the Ministry of Rural Resources and Water Development. The Act generally provided a sound basis for managing the water resources of Zimbabwe. But it contained some shortcomings that had to be addressed to take into account the socio-political changes that have occurred since it was passed into law. This is in addition to the growing competition for the available water that now exists between and within sectors. The main objectives therefore to be achieved by repealing the old Water Act (1976) are to ensure equitable access to water for all Zimbabweans; improve the management of water resources; strengthen environmental protection and to simplify the Act and improve its administration. The changes to the Act also see the issue of WDM coming in as a principle especially in terms of trying to conserve the water resources and maximise the use of already existing water resources investment. It is hoped that this wil definitely force the water using sectors to change their management concept of their water supply systems. The major new aspects of the Bill which are related to water demand management are:

(a) the vestation of all water in the President, which removes the concept of private water,

(b) the removal of the concept of water rights being real rights issued in perpetuity and attached to land and in its place introducing permits for the use of water, which will be valid for a specified period and are subject to review as circumstances dictate,

(c) the removal of much of the differentiation in approach between groundwater and surface water,

(d) the removal of preferential rights currently held by riparian owners,

(e) the conferring on catchment councils set up to manage water in their respective catchment areas (river systems) with power to issue water permits, thus decentralising and removing this function from the Administartive Court, which will however be an appeals court in certain circumstances,

(f) ensuring that the catchment councils are representative of all water users, in order to promote representation of all stakeholders, communal and resettlement farmers included and

(g) introducing the Zimbabwe National Water Authority, established by the Zimbabwe National Water Bill (1998), a parastatal intended to perform some of the functions, hitherto performed by the Secretary of the Department of Water Development.

The Bill also builds onto the Water Act (1976) in respect of;

(a) introducing fees for the applications of permits for commercial use of water, the moneys from which will be used for the development of water resources,

(b) charges for permission to discharge effluent into streams or water bodies, which will be used for water quality control purposes,

(c) economic penalties which will be charged for contravening the provisions of the Act.

7.2. Institutional reforms

7.2.1. Formation of the Zimbabwe National Water Authority

On institutional reforms in the water sector, the formation of the Zimbabwe National Water Authority (ZINWA) is now at an advanced stage. It is a result of the amalgamation and rationalisation of the roles and functions of the Regional Water Authority and the Department of Water Development. ZINWA is necessary because at present there is no separation of Government statutory and regulatory functions from the provision of engineering and other water related services. Focus has been on constructing more dams, drilling more boreholes, while management and planning of water resources has not been given much attention. ZINWA's role is therefore to ensure better water resources management and equitable access to water by all Zimbabweans. This is to be done through the decentralised Catchment Councils that must fully represent all water users in a particular catchment.

7.2.2. Formulation of a National Water Policy

Currently, there is no documented national water policy for Zimbabwe. In line with the reforms in the water sector, the Ministry of Rural Resources and Water Development has also initiated a process of formulating and documenting a national water resources policy. The policy is intended to provide a framework and guide the development, management, utilisation and conservation of the country's water resources through a co-ordinated approach. The elements are:-

1. *Stakeholder involvement in water resources management*. To ensure that stakeholders' views, skills and knowledge are taken into account in the planning and management of the resource, a two way communication system and continuous dialogue between the technocrats and stakeholders should be promoted.

2. *Water conservation and demand management*. The character of demand management is multi-disciplinary. One cannot address demand management purely from a technical angle. Although it is possible to introduce water conservation by technical measures such as drip irrigation and leakage control, they always have financial and administrative implications, which introduce economic, legal, institutional and eventually political aspects. The national water resources policy will therefore promote technical, economic, administrative, legal, educational, operational and political measures to achieve the objective of water conservation and demand management.

3. *Water pricing*. Water pricing will be based on the user pays principle where the consumer pays the full cost of the water (capital and recurrent), including future development of water supplies. In view of the social value of water, targeted subsidies will be considered.

4. *Protection of the water resources*. The national water resources policy will utilise both economic and administrative instruments to control pollution and the approach is based on the principle that unaffected levels of water quality are not realistic and therefore certain levels of changes in the quality of water is unavoidable. It therefore becomes very important to define the water quality goals and standards as guidelines for the maintenance of the quality of water.

5. *Water resources allocation.* The proposed policy measures are aimed at promoting equal access to water through the equitable allocation and distribution of water among the different uses and users. Allocation of water shall take cognisance of the fact that water for primary purposes has priority over all other uses.

6. *Gender considerations*. The management of water resources will ensure that gender equity and gender balance are promoted.

7.2.3. The National Irrigation Policy and Strategy

The National Irrigation Policy and Strategy has been developed to provide broad policy guidelines to facilitate an expanded programme of action by Government and its partners in irrigation development. Some of the major policy issues spelt out in the document include water resources development, water demand and utilisation, irrigation technology and management systems. In addition, institutional support and capacity building, human resource development, water users associations, strengthening of irrigation management committees and River Boards, environmental sustainability, water allocation and equity, water legislation, land tenure, water pricing, economics of irrigation and cost recovery have also been dealt with. The strategy elaborates adopting a river basin approach to planning and development, as well as the need for stakeholder involvement at all stages. Other important aspects of the policy are the recommendations for the review of the Water Act (1976) and the formulation of a water pricing policy which would reflect the scarcity of water. These recommendations are being considered.

7.2.3. The Launching of the Water Resources Management Strategy (WRMS) project

WRMS has been tasked with the initiation of the Water Sector Reform Programme. Fundamentally, the strategy aims to achieve an equitable provision of adequate and quality water to all sectors. This is being done through the production of guidelines on how to attain equitable distribution and allocation of water, quantifying the total national water resources, and producing guidelines for the implementation of water demand management strategies aimed at promoting efficient use of water in all sectors. In addition, the project aims to ensure good environmental management and recommending policy changes in this area, provide guidelines for catchment planning and pricing policy to be adopted. To that end, WRMS is implemented through an inter-ministerial Steering Committee and three sub-committees comprising the agricultural, rural and urban, mining and industrial sectors. Active participation of stakeholders has been a pre-requisite to the development of the strategy.

Chapter 8

Current water demand management approaches in Zimbabwe

8.1. Application of water demand management

Water Demand Management activities in Zimbabwe are currently going on in an environment where there is no national policy on WDM. As a result of this, the WDM strategies currently being applied are not well co-ordinated and are mainly initiated by stakeholders in the water sector as a response to periodic water shortages. A draft document entitled "The Effects of Introducing Demand Management on Water Supply", produced in February 1998, by the Ministry of Rural Resources and Water Development seeks to produce guidelines on the management of all water resources within all the sector users in the country. The fundamental principles of the document are based on the idea of integrated water resources management, which is a new concept in the field of water resources engineering and management in Zimbabwe. The principles entail;

- a holistic approach to water management to take care of different users,
- a participatory approach to management in which planners, decision makers, developers and stakeholders all play a role in water resources development and management at the lowest possible level,
- recognition of the role played by women in water resources utilisation and therefore the role they should play in decision making,
- recognition of the principle that "water has an economic value in all its competing uses and should be treated as an economic good".

This is the latest draft policy document produced in order to incorporate water demand management, for all sector users, into the water resources management strategy. Therefore a National Strategy for Water Demand Management still has to be produced. It may also be necessary to produce a National Strategy for Agricultural Water Demand Management.

8.2. What is water demand management?

The terms “consumption” and “demand” are often confused. However, only a portion of the water demand is actually consumed and therefore lost from the water resource system. Water demand management is the focus on the consumer to achieve maximum efficient utilisation of water to meet the required demands while water conservation is purely saving water. Water conservation focuses on the environmentalists, conservationist and communication experts and may contradict some of the WDM principles, the best interest of the consumers and the water supply industry. In addition, it may not lead to the required efficient water management approach. The pertinent issue about demand management is the risk of adopting water conservation strategies.

Managed demand is a means of ensuring sustainability of water supplies. The requirements from water users are adequately treated water, easy accessibility, reliability of supply and low affordable cost. The only way to meet these requirements is to manage and control the demand. From the aforesaid, water demand management can therefore be defined as any beneficial strategy that improves the efficient and sustainable use of water resources taking into account economic, social, environmental, national and regional considerations. The elements of demand management vary depending on the water using sector. These range from technical, legal, policy and cost recovery measures some of which will be discussed in detail in the main paper. It is however important to point out that there is no universal definition of water demand management and that this varies with the prevailing sector, national and regional conditions.

8.3. Water demand management in the agriculture sector

Until recently, water management in the Zimbabwean agricultural sector has been supply oriented rather than demand oriented. This approach necessitated the continuation of dam building and borehole drilling programmes mostly to address the requirements of the marginalised smallholder irrigators. The following two examples illustrate the supply orientedness of the system as well as the desire of government to distribute water equitably;

(a) In 1995 the government undertook to build at least one medium size dam per district per year to supply water to communal farmers,

(b) at about the same time, the government also declared that 10% of the water held in all dams should be re-allocated to communal and resettlement farmers.

It is important to look at the water demand management tools that have been in place in order to appreciate why the management of water is currently supply oriented. In Zimbabwe, three major water management tools have only been partly used in order to manage water resources in the country. These tools have been applied on an ad hoc basis, hence the lack of effectiveness. These measures are: (a) technical measures, otherwise known as direct interventions, that is, infrastructural measures intended to alter the quantities of water used, (b) water pricing, based on blend pricing and (c) legislative measures. A number of technical measures have been namely (i) physical infrastructure (ii) water supply management and scheduling, and (iii) institutional support. On the other hand examples of legislative measures are: (i) water pricing (ii) priority date policy, (iii) declaration of water shortage areas. As a result of lack of legal framework and policy, individual farmers and other organisations, largely in response to periodic water shortages, initiate the few WDM activities currently being implemented.

8.3.1. Physical infrastructure

It is a requirement that water measuring devices should be installed at all irrigation schemes utilising surface water (from rivers and dams), in order to ensure adherence of water users to the amount of water stipulated on their water rights. This requirement was, however, not extended to ground water abstractions. The concept of efficient water utilisation, though not explicitly qualified in the Water Act (1976) has been adopted by both large scale and small holder farmers. The predominant irrigation technologies used in Zimbabwe are surface and sprinkler irrigation systems. Micro-irrigation is used mostly by large scale commercial farmers. Where surface irrigation methods are used in the country, all canals should be concrete-lined in order to minimise water loss to seepage and breeding of disease vectors. Proper land levelling is encouraged in order to improve on application efficiencies. This is not a national policy but a measure which has been adopted by the institutions involved. In the large-scale commercial sector, 70% of the irrigated area is under sprinkler, about 29% is under surface and the remaining area is under micro-irrigation technology. In the small holder sector, an estimated 89% of the area is under surface irrigation and 11% is under sprinkler irrigation. The government is contemplating to introduce drip irrigation in small holder areas in order to improve on irrigation efficiencies.

8.3.2. Water supply management and irrigation scheduling

Large-scale irrigation schemes are operated by a single proprietor, in the form of an individual, a private company or parastatal. They normally have a hierarchical management structure. Large scale commercial irrigators normally voluntarily constitute themselves into water users associations. Small holder irrigation schemes, on the other hand, are operated by a group of individual irrigators, with each member having a plot. They share a common irrigation infrastructure down to the plot level. The irrigation management committee (IMC) oversees all activities at the scheme, including water distribution and irrigation scheduling. However the IMC is not legally constituted into a water users association, and this is known to reduce its effectiveness.

Generally both small holder and large scale irrigators are familiar with and practise water scheduling in order to determine when and how much to apply to crops. In terms of water demand management at field level within the two systems, there are tendencies for lower irrigation efficiencies in small holder schemes. Small holder irrigation schemes are prone to problems of poor water distribution, if there is lack of group cohesiveness and proper training or by-laws governing water distribution within the irrigated area. This is especially so for surface irrigation systems such as Nyanyadzi, where as an example, tail end users are dogged by persistent water shortages. Such problems are rare for sprinkler systems. In order to address issues related to lack of accountability for communal equipment maintenance and use, the government shifted from semi-portable smallholder sprinkler systems to drag-hose smallholder sprinkler systems, in which each farmer is accountable for the equipment he/she uses at plot level.

There is not much work that has been done to determine the actual application efficiencies in both large scale and small holder irrigation schemes. The overall design efficiencies of the irrigation systems in Zimbabwe are, 45-50% for surface, 75% for sprinkler and 85-90% for micro-irrigation systems. As mentioned earlier, the annual gross irrigation requirements of a typical small holder irrigation scheme are however estimated to be 10 000-12 000 m^3/ha and 17 000-20 000 m^3/ha respectively for sprinkler and surface irrigation.

Large scale commercial farmers, with private dams in their properties are responsible for operating and maintaining their own water supply systems. The same applies to those farmers with abstraction points along rivers and their own supply infrastructure. Therefore they manage their own demand, but have to remain within the limits of their rights, to abstract or to store water. The rights specify the allowable storage capacity of dams or volumes or rate of abstraction as well as the period when that is allowed. As the law stands, those with boreholes and shallow wells on their properties also manage their own water unless an area is designated a water shortage area. This applies to both large-scale and small holder farmers. The exception is when DWD is responsible for water delivery from boreholes. Water management, in that case is done in a similar way to government dams. A third source of water is government water held in government constructed dams. These dams are operated and maintained by DWD. As a result DWD is responsible for the management of water in those dams. Most smallholder irrigators, 60 % of all small holder schemes, are supplied water by such means. A number of large scale irrigation schemes have allocations (agreement water for which they pay a bend price) from government dams.

There are two types of small holder irrigation projects, whose management is of great relevance to water demand management at field level. These are the government-managed schemes and the farmer, managed schemes. In government managed schemes, farmers pay a maintenance fee which covers all services supplied by government, through DWD and Agritex. DWD supplies water and operates and manages the supply system up to the field edge in most schemes, whether the water is from dams, rivers or boreholes. Agritex operates and maintains all infield irrigation infrastructure, with the farmers only attending to minor maintenance works. Water is supplied to these schemes after Agritex and the IMC make a request, stating the quantity they want. In the farmer-managed irrigation, the farmers request for water directly from DWD and they operate and manage the water supplies on their own, with expert advice being provided by Agritex. The farmers are responsible for all operation and maintenance costs of their projects.

8.3.3. Legislative measures

There are some legislative measures that have been used in Zimbabwe for the purpose of water demand management. The most widely used legislation is the priority date system. The system states that water right holders will not utilise any water until the prior rights are satisfied fully, and not in part. This policy has been used effectively in times of water shortage, to the disadvantage of other users, especially small holder irrigators. The exceptions have been mostly along rivers managed by River Boards as the boards preside over, to strike compromises among farmers. This, however, is mostly in commercial farms. Another piece of legislation, which has been utilised as a demand management tool, is the declaration of water shortage areas by the Minister. This was done on the Nyamandlovu aquifer, during the 1991/2 drought year. Presently, agricultural activities compete fiercely with urban and industrial water requirements of Bulawayo City.

The Water Act (1976) covers water pollution. Pesticide pollution of surface and ground water is an environmental issue. In Zimbabwe the only major occurrence of this problem was with regard to the use of DDT to eradicate tsetse flies in the Zambezi river. However data showing pesticide levels in natural water courses is not easily available, therefore the magnitude is not known.

8.3.4. Small and large scale dynamics in relation to WDM

According to the 1996 Water Pricing Options and Implications study document, produced after stakeholder consultation by Zimconsult, responses to questions dealing water pricing were greatly varied as typified by the following two responses. One response acknowledged the viability of irrigated agriculture and its capacity to pay for water and implored that the government should construct more dams in communal and resettlement areas "to instil stability". This was in apparent reference to the inequitable water distribution between small-scale, resettlement and communal farmers on one hand and commercial farmers on the other. In sharp contrast another view from some large scale commercial farmers, was that farmers should not pay for water since the revenue generated from their production was going to be taxed anywhere. Of course the latter view overlooks the inequities inherent in the current priority right system and the need for prices to reflect opportunity costs in order to achieve economic efficiency.

There has been a natural resistance by some people in the large scale irrigation sector to the removal of some provisions in the Water Act (1976) which bestowed unlimited privileges to them with regards to access and utilisation of the country's water resources. Typical thorny issues have been the removal of priority dates and replacement of water rights with permits. Permits are subject to periodic reviews. The water rights and priority dates have been a privilege which guaranteed water, whether it was used or not. The permits system is not only going to address the inequities of the past, but also encourage efficient use of water resources. The marginalised groups also see a window for redress.

As mentioned earlier the new changes in the water sector will need institutional re-organisation. This is the reason why ZINWA is being formed. The decentralisation of responsibilities and function to the catchment level will ensure that decisions are made at the lowest possible level. The representation of communal and resettlement farmers at catchment level will ensure that the small holder irrigators contribute to the decision making process on issues that affect their livelihood.

8.3.5. Water pricing as a water demand management

There are a number of grey areas in the pricing of water which are not consistent with proper water demand management. The pricing policy for raw water from government dams has been financially based to cover the operation and maintenance costs as well as the historical capital costs. The tariffs are determined by a blend price intended to achieve equity across the country by charging the same amount per unit volume (currently Z$185/1000 m^3). The payment of water charges is not yet uniformly applied across all agricultural sectors. It is important to note that in Zimbabwe, only large scale commercial farmers with agreement water have actually been paying for water. The rest of the large scale farmers and small holder farmers have not been paying for water. Commercial farmers, who get water from government dams have what is known as agreement water (water supplied by the dams which fall under DWD) for which they have been paying for a long time. It is only recently that the same tariffs were introduced in the communal and resettlement sector, only where the farmers get water from government dams. This means that communal and resettlement farmers who get water from dams built and managed by the District Development Fund (DDF) and those constructed by Agritex and NGOs do not pay for water, even though their counterparts who get water from DWD dams do pay.

According to the "Water Pricing Options and Implications" document, prepared by Zimconsult, the national blend prices pegged at Z$145/ML for agricultural users and Z$175/ML for UIM as of 1995 have benefited the large scale commercial sub-sector and the high income urban dwellers more than the small holder irrigators and low income urban dwellers. This is partly because new costly dam construction investments have been made mostly, in the agricultural sector, to benefit large scale irrigators while paying below-market prices for the water. The communal and resettlement farmers, with water supplies managed by DWD, have all along been paying a fixed maintenance fee to cover for the operation and maintenance of the whole irrigation infrastructure, prior to the introduction of water charges. In fact some of them still pay maintenance fees while paying for water charges. This shows the uncoordinated way in which water charges have been introduced within the smallholder sector.

However, there are no charges levied for water abstraction from rivers or privately constructed dams, other than nominal application fees for the administration of water rights. Borehole water is not levied unless if it is piped by the Department of Water Development. If borehole water is supplied to communal and resettlement farmers by DWD, then only operation and maintenance costs are paid. The present system is very much dependent on government treasury and as such, its sustainability is very much questionable given the current budget deficit that the government is facing.

8.3.6. Challenges of present pricing system

The challenges to the existing system are that: the use of blend price encourages supply oriented approach rather than the cost effective demand management where the user pays an economic cost for water. Yet the supply oriented approach is unsustainable since the constrained government financial resources can not cope with increasing demand and costs of exploiting new water resources. Even though the commercial farmers have been paying the blend price for agreement (Ministerial) water, it has not served as an incentive for the conservation of and efficient use of water. Rather the incentive for attaining higher water use efficiencies has been to conserve water in case of drought, minimise energy costs where pumping is necessary and to conserve the soil against degradation among other factors. The effect of the recent increase in water charges from Z$ 47/1000 m^3 to Z$ 185/1000 m^3 on improving water use efficiencies can not be quantified as yet.

This against the background where there has been a growing demand on agricultural water by the increasing population without access to that water. This has put pressure on the need for more efficient and effective ways of allocating the resource. As a result, government has been compelled to declare that 10% of the water in every dam should be allocated to communal, resettlement and small scale farmers. The principal agricultural water supply authority, DWD, is allocated an increasingly limited budget to meet the operation and maintenance requirements of the water supply systems, especially as regards the communal and resettlement small holder irrigation schemes. This has resulted in water shortages emanating from electricity disconnection to some irrigation schemes due to unpaid electricity bills (this being the responsibility of DWD which it is currently trying to offload to the smallholder farmers).

The shortcomings of the present system have illustrated the need for a new approach to the management of water resources. One of the important implications of this approach is the economic pricing of water. The pricing options should be based on:

(a) the promotion of efficient water utilisation and equitable water allocation,

(b) ensuring financial viability of water supply authorities,

(c) provision of targeted subsidies to vulnerable groups, who in the case of irrigation can be small holder irrigators with unreliable water supplies or prohibitively high operation and maintenance costs.

(d) promotion of environmentally sustainable development and utilisation of water resources.

8.3.7. Potential for implementing WDM in the agriculture sector

The potential of the agriculture water sector to implement water demand management exists. The best response has been on the use of efficient irrigation technology (infrastructure which promotes high water use efficiencies). This has been adopted by both sub-sectors although the small holder sector has been constrained in some cases where rehabilitation of old schemes has not yet been completed. The large-scale irrigation sub-sector has responded relatively better than the small holder sector in installing water measuring devices at their abstraction points. Although the statistics are not readily available, it is well known that the majority of small holder schemes do not have measuring devices, therefore they do not necessarily comply with the provisions of the Water Act. Another area where the response to management tools has been effective is when water is in short supply, but only in the large-scale commercial sector, where river boards would distribute water among its members equitably. The priority date has been followed but to the detriment of small holder farmers, who by and large are not members of river boards.

The response to water supply and management is also varied. Not much is known about the efficiencies of water application in both the large scale and small holder sub-sectors. However in the latter, some field observations by Agritex have revealed that farmer-managed schemes are generally more efficient than government-managed small holder schemes. The reason points squarely on lack of market-based tools for water demand management. Farmers in farmer-managed schemes have been paying for operation and maintenance costs of their irrigation infrastructure, but not water. However this was enough to encourage them to save electricity and fuel costs incurred by their pumping units, thereby saving on the water as well. Farmers at government-managed schemes have been paying a maintenance fee, currently set at a maximum of $185/ha/year, irrespective of the operation and maintenance costs, which however, are paid by government.

8.4. Water demand management in the UIM sector

Right now there is no institutional policy for water demand management in the UIM sector except as a drought mitigation measure provided for by the Urban Councils' Act. Therefore, because of lack of institutional policy, the UIM sector implements fragmented pieces of WDM principles. A number of WDM measures that include leak detection, technical measures, differential tariff-structures, pre-paid systems and mapping have been used. Leak detection is a systematic detection of pipeline leak designed to quickly detect leakeges in the transmission systems in order to avoid water loss and hence revenue loss. It involves pro-active maintenance, replacement of aged systems and retrofitting households and reducing unaccounted for water in the process. Block tariff structures are designed to ensure that everyone pays for an affordable cost of supply and the poor do not necessarily subsidise the rich and extravagant. In a good system, the basic cost of supply per cubic metre that include capital replacement and operation and maintenance costs, must be established. This becomes the assurance of supply which every consumer must pay for irrespective of income level. From the assurance of supply the tariffs then increase in block-form to ensure that those who drive the costs of water (that is, expansion to the infrastructure and the source) are now contributing a fair share towards that cost.

Prepaid metres are an efficient way of collecting revenue and ensuring sustainability and pro-active maintenance systems while mapping of water distribution network on computers ensures auditing and easy management. It is apparent that in urban centres, WDM defers major capital investment by delaying upgrading and investing in new dams. Some Urban Councils such as Harare, are now concentrating on replacing old-pipes and leak-detection. Others are concentrating on mapping of the water distribution network on the computer which help in terms of system management and leak detection but it is also not an entire package. Industries are simply reducing consumption to reduce operational costs. Unfortunately they do not always reduce consumption but may drill boreholes for abstraction putting pressure on the groundwater resources. Most mines do not have water demand management policies in place.

8.4.1. Potential for implementing WDM activities

With awareness campaigns the sector responds favourably to WDM. Drastic reductions in water consumption have been registered from cases where WDM strategies have been implemented. The infra-structural and institutional support exists for intensive and total demand management package to be installed. The primary objectives of demand management strategies are to contribute to more efficient and equitable provision of water and sanitation services. They accomplish this objective by the use of instruments aimed at (1) saving water and reduce pollution; (2) to reduce financial, economic, and environmental costs and (3) to obtain more benefits from given amounts of water. Each of these instruments has a set of costs associated with their implementation that should be weighed against the benefits. The relevant costs include those that have to be incurred by any of the stakeholders affected, including consumers, municipal authorities, as well as government.

Water conservation strategies require that consumers use less water. Industrial water saving requires that industrial water users have incentives to or are required to undertake conservation measures. Water pricing policy lies at the heart of incentives for demand management. Since water consumers respond to price, raising average price levels therefore, is clearly a means of conserving water. But the effects that this would have on equity in the distribution of water resources and efficiency of use should be carefully assessed. It is very easy to price the vulnerable groups like women and children and the poor out of the market for acceptable quality water.

Universal metering is a recommended instrument for demand management. However to the water-supplying agency, the cost of meter installation, maintenance, and regular reading and billing are costs which need to be weighed against benefits. It may turn out that if these costs are taken into account, volumetric pricing for low-income, small volume users is not an economically attractive option. Similarly, the benefits of introducing leak detection and control programmes in a distribution network should outweigh the costs.

In situations where mandatory controls are used, like switching off supplies on alternate days and banning the use of hose pipes, care should be taken to adequately take into account the legitimate interests of many stakeholders, particularly users, in order to avoid these being used to reinforce the decision-makers' preferences. The decision-maker's definition of wasteful and adequate consumption may differ quite markedly from that of consumers. These controls are also quite costly in terms of information requirements, staffing, and enforcement. These controls depend heavily on a high level of public compliance.

In summary, therefore, some of the elements of water demand management with potential for being applied in the UIM sector in Zimbabwe include leak-detection, tariff-structure, pre-paid systems and mapping**.** Leak detection is a systematic detection of pipeline leak designed to quickly detect them to avoid water loss, thus revenue loss. It involves pro-active maintenance, replacement of aged systems and retrofitting households. Tariff-structures are carefully designed and evaluated to cover the cost of supply for basic needs and the extravagant use of water that drive costs of upgrading of new treatment plants and distribution systems. Prepaid metres are an efficient way of collecting revenue and ensuring sustainability and pro-active maintenance systems. Mapping of water distribution network on computers is useful for water auditing and easy management. Individuals and institutions are already applying some of these WDM measures. It will therefore not be difficult to adopt some of these strategies nationally provided these are backed by appropriate legislation and policy. The strengths of WDM outweigh the weaknesses and there is an urgent need in the water sector to introduce it through the national water policy and strategy provisions. It is expected that WDM will become increasingly important as water becomes scarcer, the severity of the recurrent droughts increases, the financial resources for augmenting supply dwindle and water gets more polluted and costly.

Case studies

Chapter 10.

Case studies in the agriculture sector

9.1. Introduction

The irrigated agriculture sector which currently accounts for two thirds of the world's water use is increasingly required to produce more food from a limited land area using less water. Over the period, 1979-1984, population growth outstripped food production in 24 African countries (World Bank, 1994). The Food and Agriculture Organization (FAO, 1996) emphasised the importance of water for achieving food security. However, water resources are increasingly being exhausted and competition for the available water between agriculture and the municipality and industrial sectors is increasing each year. In 1990 the global irrigated area was estimated at 255 million hectares (Field, 1990) of which 200 million hectares were in low or middle-income economies.

In Zimbabwe 80% of all the available water resources are used for irrigated agriculture. However, of this, over 80% is used by commercial farmers with only a small percentage being available to the small scale and communal farmers. The water sector reform programme currently talking place will see a lot of changes in the way water resources management. It was therefore thought it appropriate to look at the large and small scale irrigation projects that are taking place in order to assess the sector dynamics that need to be considered. This is in addition to the fact that this is the main water using sector and the water management arrangement currently in place needs to be reviewed in order to allow corrective measures to be taken.

9.2. Case study methodology

The methods that were used to obtain information in this case study were structured questionnaires, review of relevant documented information and informal random surveys. For the large scale commercial sector, the irrigation engineers, the Zimbabwe Sugar Association and the Regional Water Authority management were interviewed. For smallholder irrigation projects, the questionnaires were administered to government officials from the Department of the Agricultural Technical and Extension Services (Agritex) and Department of Water Development (DWD) who work closely with or at the irrigation schemes concerned. These are the people who were expected to have technical information that included the quantities of water used by the projects. The information gaps that were identified were filled in using documents and informal interviews with the farmers at the irrigation projects, provincial government staff from DWD and Agritex as well as staff from the Zimbabwe Electricity Supply Authority. In the case of the Middle Sabi irrigation project, which is run by the Agricultural Rural Development Authority (ARDA), only structured questionnaires were used and they were administered to ARDA officials.

9.3. Large scale irrigation schemes

9.3.1. Description of the study area

The study was undertaken in Hippo Valley, Triangle and Mkwasine Sugar Estates, the largest sugar cane growing estates in Zimbabwe. Sugar cane is a tropical plant, a member of the grass family. It requires strong sunlight and abundant water. The lowveld of Zimbabwe, at an altitude of about 400 metres above sea level and with an average effective rainfall being close to 330 mm, is an ideal place to grow sugar cane enabling Zimbabwe to produce high quality sugar. Commercial irrigation in the lowveld started in 1923 (Saunders, 1989) when Thomas Murray MacDougall constructed the Jatala Weir on the Mutirikwi River. In 1958, Guy Hullet, the chairman of Triangle entered into an agreement with the government for the construction of Lake Kyle (now Mutirikwi) and the canal systems in return for cheaper water and priority in allocation. Completion of the lake in 1960 facilitated rapid expansion of large-scale commercial sugarcane production. At the time of completion, the lake was the largest inland water reservoir in Zimbabwe. Currently and due to the low rainfall the area receives, the lowveld relies almost entirely on water from 10 dams and weirs with a combined capacity of 2 352 010 megalitres that have been constructed in the Mtirikwi and Chiredzi river systems and managed by the Regional Water Authority. The available water in each of the reserviors is shown in Table 4 below.

Table 4: Available water in reservoirs that supply the lowveld sugar industry with water.

Reservior	Capacity (Megalitres)
Nyagena Weir	11 600
Lake Mutirikwi (Kyle)	1 378 000
Bangala Dam	130 370
Tokwe Weir	9 400
Manjirinji Dam	284 200
Muzhwi Dam	110 140
Tokwane Barrage	14 300
Jiri Dam	20 000
Manyuchi Dam	319 000
Mteri Dam	75 000
Total	**2 352 010**

The contribution of sugar in the overall economy is substantial. The growing of sugar cane is at the forefront of the agricultural development that has taken place in the lowveld. Sugar cane is grown at the two large sugar estates situated at Triangle and Hippo Valley by 50 commercial planters, by the consortium at Mkwasine Estate and by 191 small-scale planters. All sugar is delivered to two mills at Hippo Valley and Triangle. The mill at Hippo Valley with a rated capacity of 250 000 tonnes per season, is one of the largest mills in southern Africa and produces an average of 8 000 tonnes of sugar each week between April and November each year. The mills are powered from electricity generated by steam turbines in turn powered by the burning of dried sugar fibre.

The sugar industry covers about 45 000ha of fully irrigated lands producing over 5 million tonnes a year of sugar. With about 23 000 people directly employed by the sugar industry and after taking into account their families and dependants, together with the employees and families of auxiliary services in the area, it is estimated that some 200 000 people are reliant on the sugar industry. It is however important to highlight that sustainable water supply is the cornerstone of the survival of the industry. In 1980 the largest ethanol plant outside Brazil at the time was completed at Triangle. Utilising a molasses based feedstock, this plant produces 40 million litres of ethanol per annum, significantly reducing Zimbabwe's imported fuel bill.

The large scale irrigation development of the lowveld sugar industry was studied as a case representing large-scale irrigation schemes. Sugar cane is grown under both overhead and flood irrigation. A number of boreholes have also been drilled but the water from these is mainly used for domestic purposes. Before the drought of 1992 when some of the estates had to scale down their operations, water was not a big issue. However, since the drought, water management has become an issue and various water management strategies that include installation of drip and centre pivot irrigation systems have been initiated in both Hippo Valley and Triangle Sugar Estates (Clowes and Breakwell, 1998).

Figure 4: Water consumption pattern for the lowveld sugar estates from 1989 to 1998.

9.3.2. Drip irrigation

In the lowveld, and in appreciation of the fact that a plentiful supply of water is necessary for satisfactory growth of sugarcane, sub-surface drip irrigation (SSD) has been introduced. This precisely applies a pre-determined quantity of water and nutrients directly into the root zone. The system can increase yields of both cane and sugar per hectare, per m^3 of water applied, per unit of labour and per unit of power required. At the same time the dripper line is protected from the elements, mechanical damage and from rodents but can succumb to pest attack. During the study, it was highlighted that the advantages of using the SSD ranged from the highly efficient use of water, minimisation of crop water stress, the possibility of applying nutrients and chemicals through the system when needed and low labour and power requirements. Efficiency of water application under SSD can exceed 90%, has at least a 10% advantage over the next most efficient system, and up to 50% over a poorly managed and wasteful form of irrigation. On the other hand, its disadvantages were highlighted as being the need for the high initial set-up costs, the need for highly qualified expertise to design and maintain the system, and that the system is susceptible to damaged by the use of heavy in field machinery.

9.3.2. Centre pivot irrigation

Centre Pivot Irrigation on sugar can is a new concept in Zimbabwe. The advantages of the centre pivots irrigation systems were said to include the possibility of water application that can be matched with crop requirement. Light applications can be applied after planting into a good tilt to assist germination and ensure uniform crop emergence. As the crop grows, the system can be slowed down to apply more water on the basis of requirement. Installing pressure regulators on each sprinkler ensures uniform water application over the length of the system. A properly designed system will apply water at a rate suited to the infiltration rate of the soil, thus avoiding puddling, leaching and run-offs losses. The irrigation efficiency of the centre pivots is estimated to be 55%. Other advantages were given as the longevity of the systems, low maintenance and labour requirements as one operator can look after 5 or more systems.

The disadvantages of the centre pivots were said to be the high initial capital investment especially on small systems. But the bigger the system, however, the lower the capital cost per hectare becomes. In addition the need for a continuos power cost increases electricity costs. The main component of power cost is that of pumping the water to the system. This is generally 1/3 - 1/2 of that for sprinkler irrigation, and depending on system layout, can be lower than for drip irrigation.

However, the farmers highlighted that water demand management is very much influenced by the pricing policy and that this would encourage savings in water use. But this does not occur at present in the lowveld as water that is not used is also charged for. It was apparent from discussions with the RWA that the reason why unused water is still charged for is primarily to ensure the viability of the RWA. The director pointed out that by not charging for the unused water already allocated to specific farmers, then it would be very difficult for the RWA to meet its salary and other costs if farmers do not draw water from the RWA managed dams. Indeed cases where farmers have constructed their own water sources or draw water from those dams that are run by the Department of Water Development were reported. But in these cases, the farmers still pay for the water as if they are drawing it from the RWA dams. This, coupled with the blend pricing system, inevitably discourages the farmers from saving water and from even investing in new water development projects as there are no incentives and benefits do not directly accrue to them. The RWA pointed out that the farmers are paying for their allocation whether they use it or not. It was said that if the farmers do not want to pay then they should surrender the water and let the RWA re-allocate it. It was further pointed out that this was an added security for the farmer as water is always assured. This scenario is one of two business partners with different survival strategies.

Table 5: Water savings and financial benefits of implementing WDM

Flood irrigation	Drip irrigation	Water saved	Additional sugarcane area	Cost Benefit (Z$)
94 ML	**75.6 ML**	**18.4 ML**	**19.57 ha**	**a. 3 404** **b. 672 719**
Flood irrigation	Centre Pivot irrigation	Water saved	Additional sugarcane area	Cost Benefit (Z$)
94 ML	**83.7ML**	**10.3 ML**	**10.96 ha**	**a. 1 906** **b. 376 750**

a) the financial saving in the water bill
b) extra resources generated through increased acreage under irrigation

9.4. Small scale irrigation schemes

9.4.1. Description of study area

In order to be able to assess the water demand management issues set out in this case study, 5 irrigation schemes were selected for investigation. The schemes were Mushandike, Ngondoma, Murara, Principe and Middle Sabi irrigation schemes. The first three projects are gravity-fed smallholder surface irrigation while the last two are sprinkler irrigation projects that utilise pumps to supply water to the fields. Mushandike and Ngondoma are government-managed irrigation projects but Murara and Principe are farmer-managed schemes. Middle Sabi is a large scale irrigation scheme operated by ARDA. The following are brief descriptions of each of the projects.

9.4.1.1. Mushandike Irrigation Scheme

Mushandike irrigation scheme, located 20 kilometres south of Masvingo town in Masvingo District, is a resettlement irrigation scheme that was constructed between the mid 1980's and 1990, in what was originally a commercial farm. It is 624 hectares in extent. The project lies in agro-ecological zone IV, which receives an annual rainfall of about 650 mm per year. It derives its water from Mushandike dam. A 25 kilometre canal is used to supply water to the scheme by gravity. Out of the 25 kilometres of the canal, 17 kilometres are concrete-lined and 8 kilometres are unlined. All water users including, smallholder irrigators, pay water charges based on the volume discharged at the dam.

The dam and canal are operated and maintained by DWD. The infield irrigation facilities are jointly operated by the department of Agritex and the farmers, through their Irrigation Management Committees (IMC's). Mushandike irrigation scheme has a number of blocks, each of which is supplied by a calibrated intake structure. The responsibility of operating and maintaining the measuring structures and flow data in the main canal lie with DWD. However due to the shortage of project staff in both departments, Agritex staff also take readings from these structures in order to compliment the efforts of DWD who can not cover all areas adequately. While the official irrigated area is 624 hectares, there are a number of small gardens which were incorporated into the project area to allow farmers to grow vegetables, which should not be grown within the irrigation project. The average irrigated plot holding per family is 1.5 hectares. The irrigators at this scheme utilise rotational water supply to each irrigation block. Their major crops are cotton and grain maize in summer and wheat and beans in winter. A block consists of the same crop and is partitioned to accommodate every irrigator. This system is called block irrigation.

9.4.1.2. Ngondoma Irrigation Scheme

Ngondoma irrigation scheme, which is 44.5 hectares in extent, is located in the Zhombe Communal Lands of the Midlands Province. The project is in Natural Region III that receives an average of 650 to 800 mm per year. Ngondoma was initially established in 1968 as a 10-hectare project serving 12 families. It has since been expanded to 44.5 hectares on which 167 farmers have plots ranging from 0.1 to 0.8 hectares. The scheme gets its water by gravity from Ngondoma dam via a 5.8 kilometre concrete lined canal. Both the dam and main canal are operated and maintained by DWD. The infield irrigation infrastructure is operated and maintained by Agritex and farmers, through the IMC. The system of irrigation is similar to that utilised at Mushandike irrigation scheme. There are reports of illegal water abstractions along the canal and water losses due to overtopping of the canal.

The major crops currently grown at this scheme are green maize, beans and various types of vegetables. Ngondoma farmers pay for water charges. Although DWD allocates 900 000 cubic metres of water per year, it only charges farmers for 550 000 cubic metres per year.

9.4.1.3. Murara Irrigation Scheme

Murara irrigation scheme is an 18-hectare farmer-managed gravity-fed surface irrigation scheme, located in Mutoko district of Mashonaland East Province. It lies in Natural Region IV. The scheme was implemented in 1990, even though the Murara dam, which supplies water to the scheme, had been constructed in 1974. The District Development Fund (DDF) is responsible for operating and maintaining the dam. However over the years, farmers have gradually taken over this responsibility. In addition, the farmers, who number 36 and have 0.5 hectare per household, are responsible for operating and maintaining the main canal and the infield irrigation infrastructure. The system of irrigation is similar to that utilised at Mushandike and Ngondoma. The major crops grown by Murara farmers are grain maize, beans and a variety of vegetables. Murara farmers do not pay for water, since their dam does not belong to DWD.

9.4.1.4. Principe Irrigation Scheme

Principe irrigation scheme is located in a resettlement area in Shamva district, Mashonaland Central Province. It lies in Natural Region IIB which receives an average annual rainfall of 750 to 1 000 mm per year. The project consist of two blocks, A and B. Each block is 30 hectares and it serves 30 farmers having 1 hectare each. Block B, which is the subject of this case study, was implemented in 1993 and Block A was implemented a year later. Both blocks utilise water pumped from weirs that are fed by the Eben dam. Principe utilises the drag-hose sprinkler irrigation technology.

The Eben dam is operated and maintained by the DWD. The same department also maintains the weirs. The irrigators operate and maintain all the irrigation infrastructure from the pumps to the sprinklers. The scheme pays water charges to DWD. The charges are calculated based on the volume discharged at the dam outlet. The major crops grown at Principe are green maize, grain maize, beans, and a range of vegetables.

9.4.1.5. Middle Sabi Irrigation Scheme

This 3 000 hectare project, which is located in Manicaland Province in agro-ecological region V, is operated and maintained by ARDA. It is run on commercial basis just like any other privately owned commercial irrigation scheme. The project gets its water from Rusape dam. The main water supply system is operated and maintained by the Regional Water Authority (RWA). ARDA is responsible for its own abstraction system and all the irrigation infrastructure in the irrigation scheme. ARDA pays the RWA for water charges calculated based on the volume discharged at the dam outlet.

9.4.2. Issues

From the description of the irrigation projects above, a number of issues were raised regarding the running of the projects. The following main areas of concern to water demand management in smallholder and ARDA irrigation projects become pertinent:

- main water conservation drivers in smallholder irrigation schemes.
- water pricing regime in smallholder irrigated agriculture and existing strategies for protecting potential vulnerable groups, mainly communal irrigators, from excessive water charges.
- infra-structural support system for water demand management and the implications thereof. In this case, it was necessary to investigate the availability of measuring devices, their operational status and whether they are well maintained.
- whether the irrigation infrastructure supports efficient water utilisation.
- institutional set-up as regards who manages the water supply to irrigation schemes and the implications of this on demand water management. This aspect is important in order to establish to what extent the current and proposed institutional framework would affect the implementation of water demand management.
- the availability of water consumption information to farmers and how they subsequently used the information to promote more efficient use of water.

9.5. Approach to water demand management in the schemes studied

In Zimbabwe, there are three demand management tools that are currently being used in the agriculture sector, namely technical measures, water and energy pricing and legislative measures. This study has attempted to establish schemes where these tools are being used in irrigated agriculture. The following are examples of each of these measures.

(a) The Principe and Middle Sabi sprinkler irrigation projects were designed and implemented as sprinkler schemes based on the widely accepted premise, that sprinkler schemes are more efficient in water use than surface schemes, such as Mushandike and Ngondoma. This is an example of the use of technical measures that are aimed at reducing water demand.

(b) Water charges, which have all along been implemented in the commercial irrigation sector have now been extended to the small holder sector. However the water fee is still limited to irrigation schemes which get water from those government dams that are managed by the Department of Water Development. The evidence of this is that Principe, Mushandike and Ngondoma irrigation schemes are paying water charges to DWD while Murara is not. The reason is that the Murara dam was built by and is being managed by DDF.

(c) For irrigation schemes where water is pumped, the need to keep electricity costs down indirectly imposes good water management practices on farmers. This is clearly evident at Principe irrigation scheme, where farmers have had to reduce the number of days when they pump water, from 7 days per week to 4 days per week, more as a measure to cut down on energy costs rather than water use.

(d) The legislation states that primary water supply and the environment take precedence over irrigation in times of water shortages. From the case study, one evidence of this is at Mushandike irrigation scheme where 5 million cubic metres of water have to be reserved in the Mushandike dam for primary water supply to farmers, other settlements and the environment in cases of a water shortage. Indeed in the 1991/2 irrigation year, no water was allocated for irrigation primarily for this reason.

It is important to mention here that the current pricing policy structure is not yet market based. Consequently, the present price of water is a blend price covering the whole country, irrespective of the actual cost of constructing a particular dam. The new approach to water pricing as suggested in the new Water Bill (1998), is that the cost of water should be set by each Catchment Council and should take into account the economic cost of developing and managing water resources within that catchment. It is also important to note that the current agricultural water price was arrived at without stakeholder consultations. The introduction of water charges was initiated from the top and implemented without giving smallholder farmers any lead time to prepare for such charges. As a result, smallholder farmers do not understand how the cost of water was arrived at, why it had to be introduced only recently and why it should keep on increasing. In view of the fore-going, the major water conservation drivers are the type of irrigation technology, water pricing (although not yet market based), energy costs and the legislation.

9.5.1. Water measurement

Measuring devices are an important means of determining the amount of water a project, its sections or an individual plot uses over any given period of time. They can, therefore, be used in irrigation schemes to determine water losses and the points or sections of the irrigation schemes contributing to such losses. Besides the water use data obtained from the devices can be used to calculate water charges to the project as a whole, to sections of the project and even to individual users, where feasible.

Generally all the irrigation schemes which were investigated, except Murara, have measuring devices, at the water source, that is the dam or at the intake works. However all the schemes except Mushandike do not have measuring devices at the head of the project itself or along canals or pipelines leading to sections of the irrigated project. Generally, the devices at the dams or intake works are flumes for the surface irrigation projects and water meters for the pressurised irrigation schemes. However these devices are generally not well maintained as evidenced by Principe irrigation scheme, where the water meter has not been in operation for almost 3 years and Ngondoma irrigation project, where the flume is poorly maintained. It is not known at this stage how regularly these devices are re-calibrated.

9.5.1.1. Bulk water measuring devices

The measuring devices at the intake works are intended for measuring the total flow to the water users, including irrigation projects. Murara dam, constructed by DDF, does not have a measuring device at all. In general, whereas there are measuring devices at the outlets of dams constructed by DWD, those that are built by the District Development Fund, Agritex and Non-governmental organisations, do not always have measuring devices or if they have, the devices are rarely ever used to monitor water use. It is however, a requirement by law that measuring devices should be installed for purposes of monitoring compliance with water right provisions, whenever a dam is constructed.

9.5.1.2. Water measuring devices at section or plot level

As mentioned earlier, all smallholder irrigation schemes, save for Mushandike irrigation scheme, do not have water measuring devices for different sections of the scheme. The implication of this is that the water use and losses within each section and between sections can not be established and is therefore not quantifiable. All the irrigation schemes surveyed do not have measuring devices at plot level. As a result it is not possible to quantify the water used or the water losses at plot level.

In general, therefore, the current irrigation infrastructure does not adequately provide for the detection of water losses. As a result, the unaccounted-for-water is not known to any reasonable degree of accuracy. The Department of Water Development however, makes some estimates of water losses in the main supply system, in cases where there are no measuring devices at the head of the irrigation scheme. They then provide the volume of water from the dam that will include the estimated losses and charge the schemes on the basis of that volume released at the dam. None of the irrigation schemes surveyed had any knowledge of the water losses within the irrigation schemes themselves due to the lack of measuring devices within the irrigated areas.

9.5.2. Availability of water use information

The availability of water use information to water users is of paramount importance to the success of the implementation of water demand management. It provides the user with the necessary reference when it comes to planning the year's or season's cropping programmes and irrigation schedules and also helps in the identification of water losses and where such losses occur.

Figure 5: Water allocation and consumption pattern at Mushandike irrigation scheme.

All schemes that utilise agreement water submit to DWD annual estimated water requirements for the year at the beginning of every irrigation year. DWD then allocates the available water to users, based on the bids and the available water in the dams at the end of each rain season and informs the users accordingly. Figure 5 show water allocations and utilisation for Mushandike. The figure shows a typical variation in water allocations to Mushandike irrigation scheme from year to year. Middle Sabi also receives an annual allocation from the Regional Water Authority. The system of water allocation at the start of the irrigation season allows the irrigation projects to formulate their cropping programmes to match the available water for that year. Irrigation projects are regularly reminded, as the season progresses, about the balance of water remaining from their allocation. The irrigation schemes can request for extra water, beyond that which they are allocated, when there is a need and they are granted, the requests if the water is available.

The general absence of water measuring devices at project level means that the farmers themselves can not regularly take stock of their water consumption. Neither can they quantify the water losses for the project as a whole or in different sections of the project, let alone water losses attributable to individual plotholders. As a result of this, the irrigators do not have any records of the amounts of water they will have used be it at project, section or plot levels. Therefore they depend on DWD to know how much water they have used, despite the fact that there may be no means for determining the amount of water delivered at the head of the irrigation project.

9.5.3. Water charges

Until about two years ago, only commercial farmers utilising agreement water paid water charges. The smallholder irrigators did not pay for water, but did pay an irrigation maintenance fee which was meant to be a contribution towards the services rendered by the government on the operation and maintenance of those schemes. Presently some of the smallholder irrigation schemes have started paying for water from DWD dams but others still have not.

9.5.3.1. Non-uniform water charges

The case studies revealed that there is a lack of uniformity in the application of water charges to the smallholder irrigation sector and ARDA estates. This lack of uniformity depends on who manages the water source. The first scenario involves irrigation projects which are supplied "agreement water" by the Department of Water Development. These projects are charged Z$ 185 per 1 000 cubic metres of water. The second scenario concerns the Middle Sabi Estate which is supplied by the Regional Water Authority. The Authority currently charges Z$ 145 per 1 000 cubic metres of water and this charge is expected to rise to about Z$ 200 per 1 000 cubic metres soon. The third scenario concerns the irrigation projects which derive their water from small to medium size dams which are not maintained by DWD. Normally these are small dams built by DDF, Agritex, NGO's, Town Councils or individuals and the projects do not pay water charges.

9.5.3.1. Non-uniform enforcement of payment of water charges

The uniformity of application of water demand management measures helps to build an understanding and confidence in farmers to adopt such measures. The survey done among the smallholder irrigation schemes, however, shows that there has been a non-uniform enforcement of water charges and a general resentment by farmers to paying water charges. This has been exacerbated by the perceived steep rise in water charges from Z$ 47 to the current Z$ 185 per 1 000 cubic metres of water within a period of about 2 years. While the Ngondoma and Principe farmers are already paying Z$ 185 per 1 000 cubic metres, the farmers at Mushandike irrigation scheme are still paying for water at the old rate of Z$ 47 per 1 000 cubic metres although officially they should be paying the new rate. This is reportedly due to resistance against the new rate.

9.5.3.3. Water charges not based on actual water use

The fact that there are no water measurements taken at project site, means that the Department of Water Development has to use estimates for charging farmers instead of actual measurements. Even at Mushandike irrigation project, where all the water delivery data (at the dam site) is available, some of the water abstraction data showing the volumes of water delivered from the main canal to the different sections of the project is not available. Tables 6 and 7 present water delivery data from the dam site, as measured by DWD and water abstraction data from the main canal as measured by Agritex.

Table 6. Water delivery data from Mushandike Dam and water intake structures along main canal (year 1993)

Month	Irrigated area (ha)	Water to scheme as measured at dam wall (m^3)	Water to scheme measured at intakes on main canal (m^3)	% age unaccounted for water	*Bulk water use (in m^3/ha
Jan	198	276 948	-	-	-
Feb	198	261 792	151 200	42	763.6
Mar	198	285 120	250 164	12	1263.5
Apr	198	407 824	342 080	16	1727.7
May	198	618 624	181 183	71	915.1
Jun	198	747 792	433 296	42	2188.4
Jul	200	568 452	551 232	3	2756.2
Aug	200	842 400	431 436	49	2157.2
Sep	200	774 144	389 172	50	1945.9
Oct	200	350 784	260 000	26	1300
Nov	208	464 732	350 230	25	1683.9
Dec	208	167 616	-	-	-
Total		5 766 228	3 339 993	42	16 701.2

*Water measured at Intake Structures divide by Irrigated Area)

At Ngondoma farmers are reportedly allocated 900 000 cubic metres each year, but are actually charged for the use of 550 000 cubic metres, whether this is what they actually use or not.

Table 7. Water Delivery Data From Mushandike Dam and Water Intake Structures Along Main Canal (Year 1994)

Month	Irrigated Area (ha)	Water to scheme as measured at dam wall (m^3)	Water to scheme measured at intakes on main canal (m^3)	% age Unaccounted for Water	Bulk water use (m^3/ha
Jan	416	782 772	311 147	60	747.9
Feb	416	966 816	547 558	43	1316.2
Mar	367	1 092 670	671 103	39	1828.6
Apr	156	630 592	450 207	29	2885.9
May	156	507 168	411 264	19	2636.3
Jun	207	590 544	416 016	30	2009.7
Jul	207	633 600	431 568	32	2084.9
Aug	207	669 168	471 744	30	2279.0
Sep	207	694 656	409 106	41	1976.4
Total		6 965 426	4 119 713	41	17 765.0

*Water measured at Intake Structures divide by Irrigated Area)

9.6. Impact of irrigation technology (infrastructure) on water use efficiencies

The argument advanced in favour of adopting sprinkler irrigation is that this technology, if well designed and operated, can attain irrigation efficiencies of 75% or more while surface irrigation can be expected to achieve about 50% efficiency. This case study attempted to make a comparison between Mushandike surface irrigation scheme and Principe sprinkler irrigation scheme in order to determine broadly whether this could be the case. The comparison could not be extended to the other projects, due to the non-availability of data. Even then, this comparison is still limited, in terms of its accuracy. Therefore the results will just show the broader picture.

Based on the information that was available, from Mushandike irrigation scheme, it was only possible to estimate the water losses between the dam and the intake structures, along the main delivery canal. From the estimates (Tables 6 and 7 for the years 1993 and 1994 respectively), the water losses in the main canal amount to approximately 42% of the water measured at the dam. By dividing the total amount of the water measured at the intake point by the irrigated area, the water use was estimated to have been 16 701 and 17 765 cubic metres per hectare per year for the years 1993 and 1994 respectively. This means that these estimates include water conveyance losses to the fields (that is between the intake structure and the night storage dams at the head of each field), distribution losses and field water application losses. However these losses can not be measured due to lack of measurements in the field.

In the case of Principe, the total project water use was estimated between the pumping station, at the weir, and the field. This means that all losses, conveyance, distribution and application are included in the estimates. Due to the fact that the measuring device at the pumping station is not functional, electricity consumption data (in kilowatts) was used to compute the water used. The data, which was only available for the years 1995 and 1996 was used to estimate the water consumption figures . Based on the results and a total area of 30 hectares for the project, the annual water use for the scheme was calculated to be 9 667 and 8 067 cubic metres per hectare per year for the years 1995 and 1996 respectively.

Although the data used for this comparison is not for the same years, it can still be inferred that Mushandike irrigation scheme uses approximately two times as much water as Principe and the irrigation technology may be a contributing factor to this. Some of the major reasons for this are the fact that Mushandike irrigation scheme is located in a drier area than Principe and the crops that the schemes grow are not exactly the same, although a number of them are common. In addition to this, although the annual crop water requirements of Principe irrigation scheme was estimated to be 4 062 901 cubic metres (13 543 cubic metres per hectare per year) at planning stage, for these two years in question it only utilised less than 71 % of this estimate.

9.7. Discussion and conclusions

The case studies showed that irrigation technology, water pricing and legislative measures are the three main water demand management strategies which are currently being utilised in large and small scale irrigation schemes. However their application has not been uniform. Consequently it has been largely ineffective except in the large scale schemes where investment costs are carefully weighed against the accrued benefits of saving water. In the small scale sector, it was evident that the current policy and institutional set-up are responsible for the unintended selective application of water charges in smallholder irrigation and the application of different water charge rates for ARDA schemes depending on who manages the source of water. This anomaly has been taken into account by the provisions of the proposed Water Bill (1998), which requires that all water be priced at market value, and the fact that Catchment Councils will determine the prices of the water in their jurisdictions. This means that water prices do not have to be uniform across the country or even within a river basin.

The case study shows that there are a number of constraints related to water measurement which can militate against the effective implementation of demand driven water management in irrigated agriculture in Zimbabwe, especially the smallholder sector. Ideally, each individual irrigator should be able to know how much water he/she has used and should pay accordingly. This would shift the responsibility from communal responsibility for paying for water to individual responsibility, thereby ensuring that each individual can be held accountable for his/her water management practices. However it is almost impracticable from an economic and engineering point of view to supply a measuring device for each smallholder irrigator. Nevertheless, it is possible to install water measuring devices which can be used to measure water supplied to sections of irrigation schemes and at strategic points within the sections. These sections would comprise a small number of irrigators who would be jointly responsible for paying for water delivered to that section. All irrigation schemes surveyed in this case study require water measuring devices for different sections. There would still be a need for scheme members to agree on how to apportion the responsibility for the payment for water losses incurred in the main distribution and conveyance systems.

The lack of water flow measuring devices in irrigation schemes has is a major drawback to the promotion of efficient water utilisation. This has resulted in farmers not having information on water use, with the result that they can not adequately monitor water use patterns on their own. In addition, water charges are not applied uniformly as some projects do not actually pay for water at all, making water a cost or a free input depending on who supplied the water. The practice of estimating water use data does not provide an incentive to farmers to save water. This puts farmers in a compromising situation, since they can not contest the water consumption figures on which charges are based. This scenario can lead to the lack of trust between the water supply institution and the farmers, a situation which is undesirable for improved water management.

The introduction of water charges is expected to instil some discipline in the way farmers use water. It is expected that irrigation schemes will become more efficient. It was reported that at Mushandike Irrigation scheme farmers decided to exclude small gardens from irrigation in order to utilise the available water on the irrigated area. High water losses that were clearly visible in drainage channels are now a thing of the past. It has to be noted that when farmers are charged on a fixed volume of water, as is the case for Principe and Ngondoma, then water fees may not be a good enough incentive for saving water. This could be different in cases where farmers pay for water that they actually use.

Although charging for water is a welcome move in terms of demand management, there is a need to revisit the price of water in order to ensure that it does not render smallholder irrigation schemes non-viable, especially those projects which already have high energy costs. Using the 1995/6 estimated annual water consumption figure of 290 000 cubic metres or 9 667 cubic metres per hectare per year, the water charge introduces an extra cost of Z$ 1 788/ha/year on the operation costs of the project. Prior to the implementation of the current blend price, the maintenance charge was structured so as to cater for the reliability of the water supply system. This pricing structure took cognisance of the dependability of the water supply system as it impacted on the viability of the irrigation schemes. The current blend price of water does not take this aspect into account and yet it is an indicator of the potential ability of farmers in different areas of the country to pay for water. Areas with relatively unreliable sources of water may need some subsidies, therefore this is an aspect which needs further study. In addition, there is a need to assess scheme viability from the point of view of all operational costs (water included) and revenues which schemes can manage to raise. There may be a need to subsidise certain schemes, particularly those which have high energy costs.

Water, just like energy and other inputs required in irrigated agriculture is a cost to the farmers. Therefore it should be supplied in the right quantity, quality and at the right time. There are known cases especially in smallholder irrigated agriculture where water has been supplied but not on time, resulting in severe crop yield reduction or complete loss. In such cases, farmers have just lost their investments without any compensation or assistance regarding the loss. There is therefore a need to ensure that there is a mechanism by which farmers can be compensated for negligence on the part of the water supply institution.

It was apparent from the results of the case studies that surface irrigation utilises more water than sprinkler, drip and centre pivot systems. Therefore wherever possible, these technologies should be adopted, provided that the associated energy costs are not prohibitively high. The types of crops grown can also be re-considered. Measuring devices should be installed and maintained in a good state of operation. In order to be able to detect water losses, these devices should be located at all dams, water intake structures, night storage reservoirs, branch conveyance canals and pipelines. They should serve smaller sections of the irrigation scheme. It is however appreciated that this exercise could be costly. The need therefore for resources to be made available and for training programmes to targeted at both farmers and extension workers be initiated is apparent. Such training could focus on the operation and maintenance of measuring devices, use of the data obtained from measuring devices in determining water use and loss detection and irrigation scheduling.

The need to build up the capacity of the Catchment Council, so that it has enough qualified staff who can monitor water within each river basin including at the source of water of each irrigation scheme is appreciated. This will ensure that water use measurements are taken and farmers are charged on the actual amount of water they will have used. These staff will also need enough transport and finances, as well as equipment to monitor water use. In conclusion therefore and in light of the findings of this case study it is suggested that investigation on the impact of irrigation technology on water use efficiencies in Zimbabwe's irrigated agriculture be initiated. This research can take on board surface and sprinkler technology currently used in the country as well as drip irrigation used in the lowveld and which the government is contemplating to introduce in the smallholder sector. Water pricing and scheme viability in the light of the changing macro-economic environment in Zimbabwe need to systematically assessed.

Chapter 10

Case studies in the urban, industrial and mining sector

10.1. Introduction

During the 1992 drought, there was a nation wide water shortage. Many local authorities, introduced water rationing in their respective areas in an effort to conserve water. At the moment, most urban centres are in the process of developing new sources of water. This is particular so in the four cities of Kwekwe, Mutare, Harare and Bulawayo. But the most pertinent questions are whether investment projects are being tied closely to more accurate demand forecasts and whether local authorities are not rushing to implement infrastructure projects that could have been delayed had other water resources management strategies, such as water demand management, been adopted. The previous supply-oriented approach has become untenable. Alternatives to bringing new supplies to urban centres have to be considered. These include demand management, optimisation of existing water and recycling. Rationing is probably the only method applied in Zimbabwe during times of severe water shortages. In the four major centres, public awareness campaigns through the national media have been used with encouraging results. Harare reported a drop of 20% in water consumption in the low-density suburbs and negligible change for the high-density areas, a fact that seemed to emphasise that demand is rigid in the later and elastic in the former. The same results were obtained in Bulawayo and Mutare.

Kwekwe is one of the cities where a number of WDM initiatives were started and with very encouraging results. Different pricing structures to discourage high water consumption and restriction of flow through insertion of pressure reduction disks reduced water consumption by 50%. Even to date water demand is still being managed through the banning of hose pipes, fitting of pressure reducing valves and restriction to 10 cubic metres of water per households per month. A fine is imposed for any excess consumption in the form of a two-tier block tariff. The household is charged the normal fee for the first 10 cubic metres and then a high rate for any excess usage. It was therefore decided that this experience that has been very well documented with data available from 1990 to date would form a very good case study.

10.2. Methods

The study aimed to assess the efficiency of the Water Demand Management activities that were initiated in order to mitigate the effects of the drought periods experienced throughout the country. The impact of the various WDM activities that were applied, opportunities and constraints in implementing WDM principles were assessed through the examination of the available historical data. In addition, structured interviews and focal group discussions were held with key staff, other employees and stakeholders. Information pertaining to the water use, knowledge about WDM principles, possible constraints and other views were obtained during these interviews.

In the case of industries, the production managers were extensively interviewed in addition to other members of staff. A tour of the factories was undertaken in order for the researchers to have an in-depth understanding of the manufacturing processes and how these impact on WDM.

10.3. City of Kwekwe

Kwekwe City is the fifth city in Zimbabwe after Harare, Bulawayo, Gweru and Mutare. It is situated on the main highway from Harare to Bulawayo some 215 kilometres either way making it strategically located at the heart of the country. Altitudes within the city range from approximately 1 400m to 1 500m above sea level. The City of Kwekwe was originally established as a gold mine and to date it is still surrounded by gold mines. Kwekwe currently draws water from the Sabakwe Dam constructed by the DWD and with a capacity of 262 000ML and pays Z$200 per ML for the raw water to the DWD. The total yield of the impoundment, at 4% risk, is some 99 000ML. The dam was constructed in the sixties and raised in 1981 with the aim of providing water for both domestic and industrial use. Water is released from the dam into the Sebakwe river from where it is pumped to Dutchman Pool treatment works at Ducthman Pool Weir that was constructed by the DWD. The treatment works has the capacity to treat 90 ML a day and is the second largest treatment works in the country after Morton Jeffrey that supplies treated water to Harare.

According to Central Statistical Office, Kwekwe has the highest per capita income in the country at the moment. It is the second largest urban centre in terms of water supply averaging in 1998 45ML to 50ML per day. On average, 63% of the water treated by Kwekwe is consumed by ZISCO who in turn supply it to Redcliff Municipality. The most recent data-source for the population of Kwekwe is the 1992 census which enumerated the population to be 120 000 and that of Redcliff to be 30 000. The combined supplied population is therefo re 150 000 although it is difficult to prove the accuracy of the census data. The long-term annual average population growth rate for Kwekwe is 6.4% which is significantly higher than the national average population growth rate of 3.5%. This is explained by the pronounced rural-urban migration that took place in the post independence period.

10.4. Water demand for Kwekwe

The water demand for Kwekwe over a period of 7 years is shown in Figure 6. Detailed analysis of the 1991 – 1997 water consumption records of the City of Kwekwe gave individual residential consumption rates as follows:-

Higher density	35M^3 per month
Medium density	47M^3 per month
Low density	60M^3 per month

Figure 6: Water consumption pattern for the City of Kwekwe from 1991 to 1997.

10.5. Water demand management in Kwekwe

10.5.1. Water-loss management

Unaccounted for water in the City of Kwekwe ranged from 10 to 30% with an average of 20% before the initiation of the leak detection programme. To reduce unaccounted for water, the City is carrying out a leak detection programme using as a leak detector. This is an electronic instrument that magnifies the sound of leaking water making it possible to identify underground leaks without water coming to the surface thereby minimising water loss and optimising water utilisation. This system has problems in that the frequency of travessing the water lines is not strictly adhered to due to lack of adequate manpower resources and poor mapping of the existing water lines. Figure 7 represents the unaccounted for water from 1992 to 1997. It is apparent that there is a general decrease (from 30% to 14% in 1996) in the amount of unaccounted for water during this period that is attributed to the programmes put in place to manage water losses.

Figure 7: Unaccounted for water for the City of Kwekwe from 1991 to 1997.

Although water audits ensures value for money, unfortunately no proper water audit system has been put in place resulting in significant losses in water and revenue. This makes it difficult to manage demand. There has been a general decrease in amount of unaccounted for water from 1992 to 1997 as a result of programmes put in place to manage water losses. Basically the indications are that there is increased saving of water which normally is unaccounted for. At a constant demand from the consumer, the value of the water to consumers is optimised due to saving of this water.

10.5.2. Block Tariffs

The tariff structure is an integral component of a good WDM system. In a good system, the basic cost of supply per cubic metre must be established (including capital replacement values, operation and maintenance). This becomes the assurance of supply which every consumer must pay for irrespective of income level. From the assurance of supply the tariffs then increase in block-form to ensure that those who drive the costs of water (that is, expansion to the infrastructure and the source) are now contributing a fair share towards that cost.

In Kwekwe, the closest period during which a block-tariff structure was reached was during the water rationing programme of 1992 and 1995. These schemes meant the city had to manage the water resource in a manner never done before. In both schemes the water demand of different consumers was categorised. The idea of introducing these schemes was purely for water conservation. This resulted in a change from supply oriented type of management to demand oriented management. The maximum water consumption for domestic households was limited to 400 litres per day and most industries and institutions were limited to 50% of the last six-months average. In 1995, the domestic high density consumption was limited to 500 litres per day and low density to 667 litres per day. The industries and institutions were limited to 70% of their last six months' average.

In both cases, the fear was that the industries would be severely curtailed to the extent of closing down especially in 1992 but no noticeable effect was recorded in terms of loss in production. The industrial consumer reacted by optimising use such that water became an input cost resulting in its efficient utilisation. In some instances, heavy industries like ZIMSCO drilled boreholes to augment water supply but the general trend was good water management. The rationing schemes provided for offending industrialists to be summoned to the council offices for counselling.

10.5.3. Awareness creation

Any water demand management measures taken are bound to fail if there is no stakeholder participation in the overall programme. Political ward meetings were used to disseminate information on the water rationing schemes in addition to the print and the electronic media. In the 1992 scheme, flow restriction discs were installed for repeated offenders reducing the water flow to only a trickle. Although retrofitting particularly of low volume toilet flushes in the homes and shower caps is an important WDM activity, the programme has not been put in place except in terms of awareness campaign especially on the use of shower caps.

10.6. Impact of WDM on consumption pattern

The consumption pattern for 1991 indicate that the average monthly consumption was 1 500ML. In 1992 it started decreasing in October when measures were introduced and the average monthly consumption decreased to 1 000ML. In 1993 with the measures still in force, there was no increase and the average consumption was still around 1 000ML per month. In 1994 the average increased slightly to 1 200ML per month after the lifting of the rationing exercise but it was way below the average before rationing. In 1995, the water consumption per month averaged 1 300ML but started decreasing again after the reintroduction of water rationing in September. The result of the scheme can best be described by the graphs of monthly consumption of water (Figures 6 and 7). In 1997 the figure still averaged 1300ML per month. It is important to note that an engineering consultant study prior to the rationing scheme had indicated that the City of Kwekwe would need to increase the treatment capacity of the plant from 90ML per day to 120ML by 1995 (Burrow and Gibb, 1992). However, even though the study was undertaken in 1992, the current average daily consumption is about 48ML, some 2ML below the 1991 average yet the treatment capacity of the plant has not been upgraded and is unlikely to be for sometime.

10. 7. Sable Chemical Industries Limited as a case study in industry

10. 7.1. Introduction

The existence of an independent nitrogen industry in Zimbabwe is a situation which is taken for granted these days but in the late 1940's it was something of a dream in the eyes of the Southern Rhodesian Government. It would be seen even then that the need for a supply of nitrogen fertilizers would be a continual drain on the foreign currency earnings of the country, increasing each year with the expansion of the agricultural industry. As well as this, the country would always be at the mercy of overseas supplier's prices when material was in short supply throughout the world. There are several routes by which ammonia, the starting point for nitrogenous fertilizer can be made. Hydrogen, which is the most elusive and expensive element to produce, is an essential element for ammonia production. It can be obtained as a by-product from the tail gases of an oil refinery; by cracking of oil products; from natural gas; from coal or coke gasification process or from the electrolysis of water. In Zimbabwe's circumstances, particularly after 1965, the use of imported raw materials for the production of nitrogen fertilizer could not really be considered as a sound proposition and, therefore the use of coal or electrolysis of water were the only alternative available.

Coke oven gas is not available in sufficient quantities and the modern technology of coal gasification is still too much in its infancy for application. Electrolysis of water is, therefore the most logical route for an industry where only air, water and hydro-electric power which, at the time Sable Chemicals was established, were in abundant supply.

In the process of manufacturing ammonia, water is taken from the Sebakwe River and after purification, it is electrolyzed to produce the basic elements of hydrogen and oxygen. Air is reduced to temperatures at which it becomes liquid and its main components, nitrogen and oxygen are distilled off separately. The hydrogen from the water and nitrogen from the air are reacted together at high pressures and temperatures, in the presence of catalyst, to make ammonia - the basic raw material required to produce ammonium nitrate.

10.7.2. The factory

The factory is sited 16km north of Kwekwe on the main Harare-Bulawayo road. Although not an ideal spot for distribution to the main agricultural market, the site chosen has major benefits from an industrial point of view. There is a plentiful supply of water, it is near the country's main electricity distribution centre and it enables the supply of oxygen directly to the nearby Zimbabwe Iron and Steel Company (ZISCO) from the factory. A total number of approximately 650 personnel are employed, 270 of these being shift workers as the factory operates around-the-clock, on a 4 shift cycle. All employees and their families live in the town of Kwekwe and commute to and from the factory by bus. The design and actual annual production output of the factory is 65 000 tonnes ammonium and 220 000 tonnes of 34,5% nitrogen content ammonium nitrate fertilisers. The oxygen produced as a by product is sold to the ferri-chrome industry of ZIMSCO, and ferrous industry ZISCO.

10.7.3. Water supply to Sable Chemicals

Sable Chemicals abstracts water from the Sebakwe River. This abstraction agreement is for Sebakwe Dam from where the City of Kwekwe and other surrounding farmers also get their water. This water is released from the dam and flows using the natural river course. The water is then abstracted at a weir that was constructed by Sable Chemicals. Raw water is abstracted from the Sebakwe River and released in the plant's upgraded treatment plant on site. The total average raw water abstraction is 4.32 ML/day of which 0.304 ML/day is lost as waste during treatment and 4,016ML/day is available for various uses in the plant. The water consumption pattern for Sable Chemicals is shown in Figure 8. The industry treats an average of 15 million cubic metres per annum. The treated water is used for both domestic and industrial use. The water is distributed into offices, public conveniences and the electrolytic plant. The total pumping mains and distribution network is about 8 kilometres excluding the industrial pipe-tubing fittings. Meters are strategically located to account for all the water consumed at every step of the fertiliser manufacturing process. The water for industrial use is demineralised to easy the electrolysis.

Figure 8: Water supply to Sable Chemicals for the period 1992 to 1998

10.7.4. Water uses at Sable Chemicals

10.7.4.1. Domestic

Domestic use of water entails, toilets, human consumption, watering of gardens and the automatic fire-sprinkling system. This system altogether consumes 0.393ML/day which is % of the total water consumption at the factory.

10.7.4.2. Industrial use

Almost all chemical reactions at Sable Chemicals are exothermic (producing heat). This therefore means that they need cooling or lowering of temperatures. Water is used as the medium for lowering temperatures from the heat of reactions. Water is also a raw material for hydrogen and oxygen through a process of electrolysis.

10.7.4.3. The fertiliser manufacturing process

To appreciate the usage of water and WDM principles at the industry, it is necessary to describe the fertiliser manufacturing processes that use water. Sable Chemicals produces or manufactures ammonium nitrate fertilisers. The Sable Chemical Industry is the only industry of its nature in the Sub-Saharan Region. The activity of the industry can also be gauged from the fact that it is the largest single industrial consumer of electricity, using 6% of the national power consumption in Zimbabwe. In other words, electrical power is considered as a raw material together with the water that is required for the electrolysis process. The company owns the largest private sub-station in the country receiving load directly from ZESA at 88 000 volts.

4.3.1. Ammonia synthesis

In the ammonia synthesis plant, gaseous hydrogen from electrolysis and gaseous nitrogen from air separation are chemically reacted over an activated iron catalyst to form ammonia. The two gases, hydrogen and nitrogen, are mixed in a ratio of 3:1 by volume. The *'synthesis gas'*, as it is called, passes to the suction of two multi-service positive displacement compressors. The gas pressure is raised to approx. 300 bars, the normal operating pressure of the plant. The gas is then heated and passed over the activated iron catalyst. It is not possible to obtain complete conversion in one passage, only about 12-17% of the gases being converted on each occasion. The ammonia produced in each passage through the converter is separated from the unconverted gases by condensation in an ammonia cooler. The unconverted 'syngas' is returned to the converter with fresh make-up gas which continually replaces the condensed ammonia gas at it is removed from the system. Circulation of the gas is achieved by the multi-service compressor.

The reaction in the converter is exothermic and produces temperatures of up to 560°C. This heat of reaction is utilized in a waste heat boiler to produce steam, which is exported to the steam manifold and utilized throughout the factory. The liquid ammonia produced on the plant is exported to the two spheres at the Ammonia Storage Plant. The capacity of the Plant is approximately 220 tons of ammonia per day.

10.7.5. The electrolysis of water

The major water consumer at Sable Chemicals is the electrolysis plant. The main function of the electrolysis plant is to produce hydrogen gas of a high purity (99,8%) which is used as a feedstock for the ammonia synthesis plant. The hydrogen is produced by the dissociation of water by electricity, (electrolysis). Oxygen is also produced at half the rate of hydrogen. About 0.538 ML/day of water is further treated by removing mineral impurities through a process of deminerailized and 0.056ML/day is left to waste during this process. The remainder estimated to be 0.378ML is pumped through the electrolytic plant where hydrogen and oxygen are separated electrolytically. It was said that

0.104ML of the remainder is used to react with Ammonia to form nitrate acid. The oxygen, 99,5% purity, is further purified in a de-hydro unit to 99,99% before being piped away to Zisco where it is used in the manufacture of steel.

The dissociation of water is achieved in 14 electrolytor pairs, each pair consisting of 8 cell blocks, 4 gas separators, 2 electrolyte circulation pumps and 2 electrolyte filters. The unit is filled with an electrolyte solution of potassium hydroxide. This solution is continuously circulated through the cell blocks, into the gas separators, through the electrolyte filter and then back into the cell block. About 1100 V DC is applied to the unit and passes through the 1112 cell plates of the 8 blocks. At each cell plate hydrogen and oxygen gas is produced from water and then flows with the electrolyte solution into the respective gas separators.

The gases separate from water and is drawn off to either the ammonia synthesis plant (H_2) or the de-hydro unit (O_2). As the levels in the electrolytors drop due to dissociation, fresh demineralised water is fed in under level control. The electrolysis plant uses a large quantity of power, about 85% of the Works' 110 MW off peak and 100 MW on-peak load. This process also uses ML of water per day. To optimize this power usage, a power control computer has been installed to control plant usage as close as possible to the maximum permitted limit. Maximum gas production of the plant is 21 000 NM^3 hydrogen and 10500 NM^3 oxygen per hour.

10.7.6. Air separation system

In this system nitrogen and oxygen are separated from the air through a physical process of compression to liquify air and then fractional distillation. the process of compression generates a lot of heat which is absorbed through the water in the water turbines, the water then loses the heat in cooling tower when it showers down and re-circulated again. The same tower is also used to cool water that absorbs heat from the electrolysis plant. The tower is supplied with 0.059ML/day and 0.245ml/day is lost due to blow down.

10.7.7. West cooling tower

The hydrogen from electrolysis of water and nitrogen from the air is then reacted over an iron catalyst at more than 560^0c to form ammonia. The reaction is highly exothermic and requires cooling. Water is used as the heat exchange medium through various piping passing through the system where the chemical reaction is actually going through. the heat so gained is lost through blow down in the cooling tower. The same tower is also used to cool water that would have been used in cooling reaction or formulation of acid gas where ammonium and oxygen are reacted to form the gas. A total of 1.730ml/day are used in this cooling tower and 0.494ML are lost during blow-down. In addition, 0.496ML/day are further used in the water softening plant where they are lost to waste.

10.7.8. Approach to WDM at Sable Chemicals

10.7.8.1. Recycling

Sable Chemicals recycles water from the heat exchange systems. Water is used to cool-down chemical reactions on the plant and the hot water goes through the cooling tower where it is cooled before recycling for the cooling process again.

10.7.8.2. Water loss management

Bulk meters are strategically located for the purpose of water-audit which are read on a regular basis. Leaks once identified are urgently repaired. Suspect sections of the pipelines are repaired and/or replaced before bursts occur. This is complemented by the retrofitting programmes that involves the replacement of corroded tubing and valves that are not functional. The industry spends an average of Z$2 873,00 per day on water demand related costs on the 8 kilometre pipeline.

10.8. Discussion and conclusion

In most urban centre in Zimbabwe, WDM strategies are only put into place in response to the drought periods only to be lifted after the reservoirs are full again. For example, Harare reported a drop of 20% in water consumption in the low density suburbs and negligible change for the high density areas as a result of a water conservation campaign implemented during the drought of 1992. However, in Kwekwe, it would appear that the WDM strategies have been sustainable as currently, there is no form of water restrictions and yet the increase in consumption has not been significant. Further, no serious repercussions were felt by both industrial or institutional consumers during the rationing period. The droughts imposed a forced demand management that was highly successful and that resulted in people improving their water management practises. The tariff structure, fines and awareness campaign could have contributed to the modified consumption pattern. Whilst the number of burst pipes have increased**,** the percentage of unaccounted for water has decreased over the years. This could be attributed to the water loss management that has been put in place and is being effected. The upgrading of the treatment works at a cost of $40million (that is, 39ML/day plant, 14km of 675mm diameter pumping mains and a 25ML reservoir) has been deferred from 1995 for an indefinite period of time. The consumption pattern still averages below the pre-rationing period of 1991 despite an increase in the population size.

Most local authorities always aim at developing new sources of water without necessarily looking at ways of maximising current sources. In most cases the benefits derived from delaying new water infrastructure projects by adopting WDM strategies are not apparent to many because of the considerable misunderstanding that the costs of the projects are bound to rise if they are delayed. This is apparent in the case of the City of Harare where frantic efforts are now underway to raise funds for the construction of the Kunzwi Dam that was estimated to cost Z$119 400 000 in September 1993. But, such cost increases are only in nominal terms as the projected price increases are purely due to inflation. The immediate benefit of delaying projects is that the resources which would have to go into the project can now be used for more productive purposes generating an income until it is needed for the delayed project. This way the water users are not unnecessarily burdened by unrealistic tariff structures in an attempt to recover capital and operation and maintenance costs as will happen in the case of Harare and Mutare.

Although the local authorities generate high revenues from high water sales, they are increasingly realising that water is a finite resource which must be conserved. It has been reported that Harare loses 116ML or 25% of water through leakages and mishandling during transmission that translates to about $180 million worth of revenue. This led to the Director of Works for the City of Harare, pointing out that it would not help much if the multi-million dollar Kunzwi Dam project was to start while there were a lot of leaks in the production, storage and distribution system.

It is apparent that although most urban councils have embarked on some WDM programmes, the approaches are not comprehensive and are very much unco-ordinated. There is a lack of policy on matters like the location of wet industries and on the consumption of water in the municipal parks and fountains. The legislation is outdated and most Departments of Works do not have adequate resources and capacity to effectively enforce even the outdated legislation. For example, the requirement to have a permit before a borehole can be drilled in the municipal area has not been systematically enforced such that even if WDM is initiated, some organisations and private individuals can simply drill boreholes on their properties and abstract as much water as they want freely. This practice has been seen in a number of cases such as ZIMSCO in Kwekwe. The use of ground water, although it relieves pressure on municipal supplies has tended to work against WDM programmes as it is often viewed as private water.

The mandatory measures that have often been implemented, have only been during water shortage periods like the severe drought of 1992. For instance, in Harare, water rationing is in place apparently only because of inadequate pumping capacity at Warren Pump Station which the City is now upgrading. No incentives have been provided to industry to conserve water by encouraging recycling. Those industries that have done so, have done so from their own initiative as water conservation made economic sense to them. The National Breweries in Harare, for example, now has one of the lowest levels of water use per hectolitre of beer produced in the world, not just in the region purely because of the initiative by management.

Chapter 11

Constraints and opportunities for implementing WDM principles in Zimbabwe

11.1.Constraints

Despite the remarkable achievements that have been made in trying to implement WDM principles, there are constraints that have contributed to the failure to implement the total WDM package and these are discussed below.

11.1.1. Legal

The main constraint for demand management is the legal system currently in force. Even the new Act does not specifically address WDM as an issue. The conflicts that exists between farmers and Urban Councils is a problem that needs to be addressed. This is in addition to lack of incentives being available to save water apart from the availability of more water that can be used for other activities. In the large scale irrigation schemes farmers are charged whether they use the allocated water or not. In the small scale sector some farmers pay for water while others do not depending on who constructed the dam.

In Urban Councils, tariffs for water are now a variable in a Council budgetary equation. The tariffs are not related to the demands in the water sector but it balances off the remainder of income Council envisaged. The Urban Council's Act itself should allow for a setting up for a different water-supply budget for efficient management of the water supplies. In general, the main constraints facing both the urban and the industrial sector in terms of water demand management is detailed information on what WDM is and the benefits of initiating the programme. The problem is compounded by the fact that in Zimbabwe, the cost of raw water has always been marginal and the input cost of water is considered negligible causing less emphasis on the optimisation of its utilisation. It is however unfortunate that, except for Kwekwe, there was no systematic collection of data prior to the implementation of some these WDM initiatives to allow a proper assessment of the benefits of implementing WDM strategies.

11.1.2. Policy

There is need to have a policy framework for demand management in the water sector that could also be simplified to a strategy if WDM is to make an impact at all. The fact that the WRMS project has already started drafting a policy document that also makes reference to WDM is an initiative that might see this being adopted in all sub-sectors. It is expected that ZINWA and Catchment Councils will be largely self financing. The water demand management policy options answer to a particularly important area for government, that of reduced subsidies from the already constrained fiscus. The levies directed towards new projects will also give impetus to development, although central government will still play its role as custodian of development. Secondly, the options address what is potentially a socio-economic problem to government, by way of redressing the historical imbalances. The previously marginalised groups are expected to get a fairer share of the national water resource. In line with government's policy on resettlement of previously disadvantaged groups, this will go a long way in bringing stability to communal and resettlement areas.

11.1.3. Economic

Economic consideration remains one of the stumbling blocks especially considering retrofitting programmes of urban utilities. Yet the economic situation in the country is such that it is difficult to convince the policy makers that an investment in a WDM programme is necessary and important. The need to retrofit households with water metres and other technical measures means that a lot of money will be spent initially. Economic constraints do not exist in the large scale agriculture, mining and industrial sectors, as the financial resources are available but what is lacking is the understanding of the water demand management principles. But unlike in local authority managed urban centres, in agriculture estates, industrial and mining areas, the population is not an electoral society where leaders are chosen through an election process. Therefore, the society accept management directives without questioning them. Instead, the directives induce a change in the social behaviour towards water management. Cooking, bathing and washing patterns are modified. In the urban sector, the social acceptability of demand management has to be over extensive education and awareness campaign. In Zimbabwe, the basic rate for payment of water is not economic except during the drought periods. It means people are not paying the economic value of water. Introducing block tariffs will mean the basic unit of payment will be economical, whilst it is readily accepted during crisis the idea of economic rates can be a potential socio-political problem.

The other constraints will come in terms of financing the changes to the infrastructure. As water demand management is implemented the more the inadequacy of the infrastructure is realised. There is need to put certain infrastructure in place especially mapping of water distribution systems, valves for water audits and other pertinent infrastructure. In the agriculture sector, the installation of drip irrigation and other systems can be a costly exercise that some farmers, particularly those in the small scale sector are unlikely to afford. On the other hand the strength of most infrastructure in the UIM sector is that metres already exist. Most houses in urban areas are metered.

The costs of implementing Water Demand Management in the industrial and mining sector are affordable. The costs to Local Authorities are on the high side. Costs to Kwekwe for a complete programme of water-loss management, retrofitting, prepaid metres is about Z$20million. Council always find it easier in this situation to plough this money into a capital project where one sees it "physically" rather than into a system which one can only understand the benefits. A Council sometimes would rather build a water structure than avoid it thorough initiating water demand management.

11.1.4. Political considerations

On the political front, the will to implement a WDM programme that will have financial implication on people might not exist. Such political decisions are normally based on individual political gains and the implications such decisions would have on the voters. Political shifts also make it very difficult to have standard strategies for a long time to realise the benefits of such a strategy.

11.1.5. Institutional

In the urban environment, institutional culture is the only thing that needs to be changed. In industries, the farming and mining sectors, there is no bureaucratic constraints in changing culture. Understanding of the demand management principle results in implementation as there are no institutional regulations governing how water supplies should be run. Large mines and large scale farming estates run their water supplies differently enabling them to propose changes in water management strategies without any major problems.

11.2.Opportunities

11.2.1. Economic structural adjustment programme

On the other hand a number of opportunities that can assist the implementation of WDM principles are available. The water sector has been characterized by a high degree of natural monopoly, which made it impossible to rely on market forces for the efficient provision of the related services at competitive prices. Extensive evidence from all over the world shows that water developed by government departments and local authorities often end up charging subsidized water tariffs across the board which do little to help the poor. Most countries in the region are implementing economic reforms as a way of reviving the ailing economies characterised by high budget deficits, high inflation, and low economic growth. These problems have led to a drastic reduction in the budget allocated for infrastructure development hence the need now for new and more innovative ways for financing the development of infrastructure. The current drive for economic performance in the water sector means everybody appreciates the fact that the sector has to be managed properly including instituting a demand management orientation rather than the previous supply oriented management. The thrust towards the commercialization of most services is likely to result in effective management of water resources. The future development of capital investment in the water sector is likely to involve visible private sector participation through the BOT or BOOT) systems. Thus the private sector driver will call for economic efficient operations of the water management system. But the need for a high level political commitment and decisiveness about the preferred private participation options is apparent. Any major reforms are politically driven and the need for a clear leadership and political vision is therefore paramount.

11.2.2. Water sector reform programme

In relation to the above, another opportunity exists on the management of the national water resources largely due to government initiated changes. The Water Sector Reform Programme with its changes to Water Act and formation of the ZINWA provides another conducive environment and opportunity for demand management. The new Act mentions demand management with the possibilities of incentives for efficiently managed system in the Statutory Regulations. The involvement of stake-holders in administering catchment councils will mean that urban councils will have a say in the distribution of the water resources.

11.2.3. Desire for change

Most local authorities accept the WDM principles and are ready to implement them despite the limited financial resources. The use of meters to ensure that each household pay for what the use is one method which some local authorities have effectively used to manage the block tariffs. These including shower caps, and low volume toilet cisterns are instruments which can easily be retrofitted and would become handy in the event of a fully fledged demand management. One important lesson learnt is that local councils should not base projections on water use on extrapolation of current use. The demand for the water must be taken into account especially if new capital investment have to increase the cost of water. Unlike in Harare where plans to construct the Kunzwi Dam are advanced, had the City of Kwekwe went ahead to upgrade the treatment works then the City would have been saddled with costs but without the demand for the water. The two years consultant deadline for upgrading the treatment works has since passed and yet the City is only consuming about half of water treated. Leak Detection Programmes need to be more extensive than what Kwekwe has at the moment.

11.3. Poverty and gender issues

Water Demand Management has a long-term impact of reduction of costs of water to the consumer. From a socio-economic point of view, there will be both positive and negative effects of water demand measures. The positive aspects in the agriculture sector are the equitable distribution of water which will bring some dryland farmers into the mainstream of irrigation, and therefore be able to earn more income. The short-term negative aspects could be the erosion of incomes of families who for years were used to subsidies. In this group are the schemes which will be able to stand the extra costs and those that may not be able to pay for all costs. The latter group is likely to be in those small holder irrigation projects which have high pumping costs and those schemes with unreliable water supply. Any erosion of incomes will impact on women (who are estimated to contribute about 70 % of the labour force in agriculture) negatively. This is most likely going to affect women more as most of the schemes are managed by women.

In the urban areas, the costs reduction might be in the long term but they imply the poor will continue to afford water at the assurance of supply cost. The deferred costs due to demand management programmes imply deferred increases. A sustainable cost to the poor can be assured for sometime. Demand Management in both sectors will reduce load on women. Costs deferring means channelling of money towards extension of the reticulation network reducing the distance between house and stand-pipes thus distance which women have to carry water.

The consumers who live in the fringes of poverty datum line can continue affording the commodity. The differential tariffs will mean the rich pay for themselves without receiving any subsidy from the poor. When the water becomes affordable the issue of communal water standpipes is made redundant as more areas are reticulated. The burden on women of fetching water some distance on their heads is drastically reduced.

11.4. Drivers of WDM

The implementation of the national water resources policy is the responsibility of the Minister responsible for Water Resources. The Minister through the Department of Water Development is therefore identified as the key driver of WDM. Working closely with the Department of Water Development will be other government ministries, local authorities and other water using agencies. For the WDM programme to be sustainable there will be a need to involve the major stakeholders, particularly the users and to introduce a public awareness campaign. Therefore with the new Act coming into place Government will drive WDM. So far WDM is being driven by individual organisation only after a realisation of their water crisis.

Chapter 12

The regional implications of water demand management based on the Zimbabwean case studies

The SADC Protocol on Shared Water Course Systems within the region affirms the need for equitable and sustainable use of shared water. According to the Helsinki Rules of 1966 on shared waters, each basin state is entitled, within its territory, to a reasonable and equitable share of the water of an international river basin. The Rules however cannot be enforced, but depend on their acceptance by the basin states in arriving at a just and reasonable allocation of water resources. The problem of water scarcity in the Southern Africa region has become more acute in the recent past because of the severe and persistent droughts in the region, mismanagement of the available water resources, and economic and population pressures on the resources (World Resources Institute, 1994). Droughts occurred in 1992, 1994 and 1995, severely restricting water supplies for agriculture, mining, industry and domestic consumption. Demands on water resources are increasing dramatically and yet water available in the region per capita has been declining since 1950. Currently water consumption is low compared to world standards but this is likely to increase with standards of living. The SADC population is expected to grow from 140 million in 1995 to 292.5 million in 2025. Current levels of industrial development and hydro-electric power generation in the region is small. This can be expected to increase dramatically requiring treated water (Sichingabula, (1996). International disputes over water from the Zambezi and Limpopo rivers are increasingly likely as regional water demand grows. At the same time water wastage at every stage in its management by different uses only emphasises these problems. Due to these pressures the crucial issue in the region is therefore how to manage water resources so as to ensure adequate and sustainable supply to all users**.** This has inevitably led to competition for water resources within the region which will only get worse in the future unless a co-ordinated trans-boundary integrated water allocation, utilisation and management strategy is put in place by the Governments of the region of which WDM is one of them. A major constraint to the successful implementation of WDM in the region is the lack of accurate knowledge with respect to the state of the water resources of the region and the social expectation with respect to the strategic behaviour of the regional governments of the region. Technological uncertainties exist with respect to quantities of water available, possible alternative water sources and the proper weight to give to a Government's policy objectives. The problems associated with the management of the Zambezi River water will be used to illustrated some of the problems encountered in trying to manage international river systems.

For Botswana, the National Water Master Plan (NWMP) requires implementation of the North-South Carrier by the year 2013. On this basis, it would appear that Botswana will not require use of the Zambezi waters, except in the extreme north of the country, before the year 2020. However, should the proposed

Matebeleland Zambezi Water Project in Zimbabwe go ahead, then there is a strong likelihood that Botswana will review its NWMP to determine the potential benefits of a joint Botswana - Zimbabwe project being implemented. The effect of such co-operation would be to advance Botswana's need to access the waters of the Zambezi.

The Namibia Water Master Plan suggests that those areas of Namibia that are located along perennial river borders should obtain water locally. Where necessary water must be transported into the interior to meet demand. It is clear that in the Eastern Caprivi which has access to the perennial Zambezi River, Namibia will turn to the Zambezi for meeting its water needs.

In Zambia, water use and development had been dominated by hydropower and water supply for domestic and mining purposes. However, with the downturn in copper prices and the unarrestable urban migration which resulted in a drop in food production, the Zambia Government instituted an economic recovery programme with a strong emphasis on ensuring self-sufficiency in food production. This policy has resulted in a proliferation of irrigation schemes that have increased water use particularly in the Kafue River Basin which occupies 17% of the Zambezi River Basin and contributes an estimated 12% of basin flow at its confluence with the Zambezi River. Plans are also underway to revive and expand the large irrigation schemes such as the Gwembe Development Company which plans to irrigate 21 000 ha. The total irrigation potential in the Zambezi Basin in Zambia is estimated to be 112 000 ha. If this irrigation potential is fully developed by Zambia, then the downstream Basin States will certainly be at risk with regard to their water security since they are turning to the Zambezi waters to meet their future water requirements.

According to the Department of Water Development in Zimbabwe, the current Urban, Industrial and Mining (UIM) water use from tributaries of the Zambezi is 400 million cubic metres per annum and according to demand projections this will have increased to 2 000 million cubic metres per year by the year 2030. When projected irrigation water requirements are included, the total will rise to about 4 000 million cubic metres per year. This represents about 35% of the water which flows into the Zambezi from Zimbabwe.

Even though South Africa is a non-basin state as far as the waters of the Zambezi are concerned, it has expressed interest in importing water from the Zambezi in the reach around the Caprivi Strip without having to provide storage on the Zambezi and to convey it by pipeline and/or canal through Botswana into South Africa. It is clearly recognized within the region that South Africa is not entitled to any of this water and an agreement would have to be reached among basin states whether to allow such a scheme to ahead taking into account their future water requirements and those of the environment.

It is now generally accepted world-wide that the environment is a water user and this is also the case within the Zambezi Basin. Wetland ecosystems constitute a very important sub-system of the Zambezi Basin ecosystem. The Zambezi River and its tributaries constitute a riverine wetland system. Other wetlands found within the basin include swamps, marshes, flood plains and littoral zones of Lake Kariba and Caborra Bassa Dam. In allocating the water resources of the Zambezi Basin these ecosystems should be taken into consideration. Other environmental issues that should be considered include wildlife habitats, fisheries, forestry resources, water quality and land use.

The Protocol on Shared Watercourse Systems in the Southern African Development Community (SADC) Region was signed by the SADC Heads of State and Government on 16 May 1995 in Maseru, Lesotho. The Protocol is a general framework agreement on transboundary waters containing seventeen articles. Article 2, General Principles, is the core of the Protocol. Within the General Principles is Item No. 6 which is perhaps the Protocol's most important provision. It states that "Member States shall utilize a shared watercourse system in an equitable manner ..... " This item sets forth what many regard as the cornerstone of the law of shared watercourse systems. This requires that a member state must use an international watercourse in a manner that is equitable taking into account the needs of other states sharing the same watercourse. On the other hand member states have a right to an equitable share of the uses and benefits of an international watercourse. Equitable is used here in terms of fairness and not necessarily equal amounts. An argument can therefore be extended that any basin state that uses its water resources wastefully, is not utilising the resource in an equitable manner. Thus WDM should be viewed as a measure for promoting equitable utilisation of water resources within the region. But the key question is how to ensure that each member state manages its share of the shared watercourse efficiently in order not to disadvantage other riparian states.

However, the problem is how riparian states whether its use of the shared water is equitable compared to other basin states. Item 7 of the General Principles sets forth a non-exhaustive list of relevant factors and circumstances to be taken into account in making the determination on what is equitable. These include the "geographical, hydrological, climatic and other factors; the social and economic needs of member states concerned; the effects of the use of shared watercourse system on other watercourse states; existing and potential uses of shared watercourse system and guidelines and agreed standards". Item 5 requires the member states to exchange available information and data regarding the hydrological, hydrogeological, water quality, meteorological and ecological condition of the watercourse system. Indeed, it would be nearly impossible for a member state to ensure that its use of the watercourse system is equitable without data and information from other riparian states as is required in item 5. But the principle of equitable utilization is much better suited to implementation through very close co-operation between the basin states concerned.

The importance therefore of co-operation amongst riparian states with a view to achieving a regime of equitable utilisation for a shared watercourse system as a whole cannot be overemphasised. Thus Item 6 goes on to lay down a general obligation by member States to co-operate “with a view to attaining optimum utilisation thereof and obtaining benefits therefrom consistent with adequate protection of the watercourse system”.

Item 3 is the most controversial provision of the entire Protocol. The obligation by member states to “maintain a proper balance between resource development for a higher standard of living for their peoples and conservation and enhancement of the environment to promote sustainable development”. It would seem obvious that one state should not cause significant harm to another state, whether through its use of a watercourse or otherwise. But in the case of shared watercourse systems, it not so simple. The fundamental issue, however, is that countries of the region must accept the principle of equitable and sustainable use of water resources as a key guiding principle in their water resources management strategies. Upstream and downstream states must acknowledge each other’s rights to use water resources for national development, as well as each nation’s responsibility to conserve water and prevent the pollution and degradation of the resources. Once these steps are taken, potential relationships exist that will yield benefits for the region.

Although these joint commissions are being considered, a major constraint to the successful implementation of WDM in the region is the lack of accurate knowledge with respect to the water utilisation within the basin and the social expectation with respect to the strategic behaviour of the governments of the basin states. Technological uncertainties also exist with respect to quantities of water available, possible alternative water sources and the proper weight to give to a basin state’s policy objectives such as achieving self-reliance in food production. The basin state’s sincerity in revealing true preferences as far as WDM measures are concerned, commitment to an agreement and disclosing all private information are questioned. The basin states must develop a trust in each other and allow for information acquisition and sharing as set forth in Article 2 of the SADC Protocol on Shared Watercourse Systems. Without the correct information, the basin states will remain extremely nervous about threats to sovereignty, especially when another basin state (particularly, but not necessarily upstream) is deemed to have that information and is therefore perceived as being powerful.

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