Strain, Water Demand, and Supply Direction in the Most Stressed Water Systems of Lesotho, Namibia, South Africa, and Swaziland

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Introduction

This paper addresses the sources of stress (including conflicts among uses and users of water) and the effects of this stress on the availability, accessibility, and quality of water in Lesotho, Namibia, South Africa, and Swaziland. In addition, water-demand–management strategies aimed at resource conservation and alternative water-supply sources and mechanisms are considered.

The approach taken in this study was to collate all available literature on the water situation in each country and then to follow up with visits to the countries to interview government staff, academics, consultants, and non-governmental organizations (NGOs). To preserve the confidentiality of the discussions, we do not identify the sources of the views and opinions presented. Data were collected mainly from government sources, with some inputs from consultants.

Lesotho

Water supply and demand

Water availability

The surface-water resources of Lesotho are substantial and far exceed the present and future needs of the nation. However, the high runoff is often rapid and occurs in inaccessible mountainous terrain. Major capital-intensive engineering works (unaffordable to Lesotho) would be required to harness this water for use by people.

Less than 9% of the land is arable. There is an acute shortage of land for settlement, overgrazing is severe, little fuelwood remains, and the annual rate of population growth is 2.6–2.9%. The result in many areas is acute environmental

2. Develop technology for studying and recovering groundwater, including that in contaminated wells.

3. Study the problems related to the operation and maintenance of water-supply schemes, with a view to making them sustainable and operational.

4. Develop mechanisms, tools, and models for updating information in the water sector.

5. Examine country-level institutions.

6. Work out a cooperation framework for the management of common water resources.

degradation, manifested by soil erosion and silting of rivers and dams. One reason for this degradation is that the Basotho people have only lived in the area for the past 140 years, and although their stock-management practices were well suited to the sparse settlement patterns of the flat Orange Free State and Transvaal, these practices have not been sufficiently adapted to the mountainous terrain of Lesotho.

The sedimentation of Lesotho's surface-water resources has serious implications for South Africa and Namibia as well, because the headwaters of the largest drainage system in South Africa, the Orange River, are located in Lesotho. About half the total flow of the Orange River is provided by the Senqu River.

Despite the high availability of surface water, there are problems with its suitability for community water supply. Untreated surface water is generally not considered potable because of Lesotho's high livestock levels, and water is rarely boiled because of the scarcity of fuelwood.

Although the total potential yield of Lesotho's groundwater resources is unknown, this source currently accounts for about 70% of the water used in Lesotho and is derived primarily from a large number of low-yield springs. People in the highlands use mainly spring water, whereas in the lowlands the rural communities are provided with water from both springs and boreholes. Groundwater availability is erratic, and aquifers are generally discontinuous along doleritic dikes. This makes drilling of boreholes unpredictable and expensive. Most boreholes yield less than 0.5 L/s. Recharge is extremely slow, and boreholes are frequently pumped dry.

Water demand

Water demand in Lesotho centres primarily around domestic and stock-watering needs. Annual demand is projected to increase from 26.7×10^6 m^3 in 1994 to 46.2×10^6 m^3 in 2020. Most towns rely on a mix of surface water and groundwater, although groundwater represents only 10% of total urban water consumption. Two urban settlements, Morija and Mapoteng, with a combined population of about 9 000, rely solely on groundwater.

There has been no long-term monitoring of changes in the yield of springs, but anecdotal evidence suggests many springs are drying up because of the loss of protective vegetation and soil. In turn, this loss promotes rapid surface runoff, as opposed to infiltration.

Water-management systems

Lesotho's Department of Water Affairs is responsible for hydrological services, resource management, development of a water-resource master plan, and water-

quality monitoring. Coordination with other agencies addressing water resources is poor. Management of soil erosion falls under the Department of Agriculture. Rural water supply falls under the Village Water Supply Section (VWSS) of the Ministry of the Interior; urban water supply, under a commercialized parastatal. No master plan or national water-supply strategy exists.

Rural water supply

Of Lesotho's 1.8 million people, 1.53 million (85%) live in rural settlements. Of these, 890 000 (58%) have access to improved water-supply systems, and the remaining 640 000 draw water from unprotected rivers, springs, and earth dams.

Rural water supply is the responsibility of VWSS. VWSS operates at three main levels: district, regional, and national. Communication among these levels is generally good, but with other government departments it is unstructured and informal and, between VWSS and villagers, limited. There is very little evaluation of projects, either before construction commences or after commissioning.

Government officials generally have less faith in the success of local water management than do the NGOs working in close contact with village committees. The head of VWSS believes that voluntary community structures don't work without cash incentives and maintains that if the government doesn't provide all the necessary resources, there will be a further breakdown. However, the government lacks the staff and resources to take full control of rural water supply. In contrast to this view, a recent report by consultants indicated that the rural water-supply system is starting to work relatively well, with local villagers managing basic maintenance and repairs fairly competently. Table 1, which is based on a mid-1994 survey of the Maseru region (regarded as typical of the mountainous areas), illustrates this point.

Water-improvement projects in Lesotho's rural areas are initiated at the village level. Villagers are required to form a village water committee (VWC) and start collecting funds toward construction and future maintenance. They approach VWSS through village leadership structures; in due course (this can take several years), VWSS provides a technical team of masons, engineers, and whatever else is needed. The major task of the VWC is to coordinate the inputs of local residents during the construction and installation of an improved water system. This includes free labour and accommodation for VWSS personnel. A major effort is required from local residents: trenches, often many kilometres long, have to be dug to lay pipes, and stones have to be cut for the construction of siltboxes and water tanks. Average construction time is 170 d, but some schemes can take more than 2 years to complete. Women carry out the bulk of this work because many men are absent as migrant labourers and because women tend to be the primary

Table 1. Survey findings from 209 water projects in the Maseru region of Lesotho.

	Proportion (%)
Systems that are handpumps	36
Systems that are gravity fed from springs	27
Systems that are a combination of handpumps and protected springs	37
Villages that have fully functional water-collection points	75
Villages that have a VWC	90
VWCs that have a bank account for repairs	69
VWCs that have a tool box	33
Villages that have a water minder	49
Villages that have a water minder who can undertake repairs	29

Note: VWC, village water committee.

beneficiaries of water schemes, through reduced time spent collecting water and reduced risk of family illness from contaminated water.

Once the project is complete, the VWC tends to become inactive until a problem arises. Residents are supposed to try to fix the problem themselves, and when they can't, they notify the district VWSS office. In due course, a technician is sent out. VWSS can barely cope with breakdown maintenance and does not undertake preventive maintenance. VWSS tries to recover 50% of the cost of repair from local residents, in instalments over 3 years if necessary. It seldom achieves this.

The distinction between VWCs and village development committees (VDCs) is breaking down. In the past, VDCs were regarded as the local arm of the ruling political party, and thus separate water committees were introduced in the 1970s to ensure that water development was not derailed by political posturing. This need for separate structures seems to have fallen away now, and there is talk of merging the two bodies.

Mistakes are inevitable in any rapid-development initiative. Lesotho's most serious mistake seems to be that in VWSS's eagerness to meet water demand and its own goals, it installed new water schemes faster than its ability to service them or train users to maintain and manage them. Its aim has been to achieve full coverage of rural areas by 2005, and it is well ahead of schedule. However, the

sustainability of these systems is questionable. Maintenance is a major problem, and it is estimated that only 40% of Lesotho's boreholes are operational.

Since 1992 VWSS has been trying to reformulate policy, determine strategies, and collect supporting data. The first regional report on coverage, condition of water systems, demographic trends, and local organizational capacity was completed in August 1994. Field inspections are now generating the kind of detailed data VWSS needs to begin to assess current capacity and evaluate strengths and shortcomings.

Urban water supply

The Water and Sewerage Authority (WASA), a parastatal set up by the Ministry of Natural Resources, relies on surface water for 90% of the water it supplies to urban settlements. The largest urban settlement is Maseru, with a population of 90 000. The next largest town in Lesotho has a population of less than 10 000. Most urban water is taken directly from local rivers and stored in reservoirs. However, the silting of both the rivers and the reservoirs supplying urban areas is a major problem.

Although the coverage of the water supply is adequate, WASA has management problems. It needs to spend more on upgrading its infrastructure to reduce water wastage and losses. Moreover, because of high connection costs for individual households, many people, most of whom could afford to pay regularly for water if the connection fee was lower, are drawing water free from public standpipes.

The Lesotho Highlands Water Project

If fully developed, the Lesotho Highlands Water Project (LHWP) could see the diversion of 2.2×10^9 m^3 of water per year from the headwaters of the Orange River to the Vaal River, making it available under gravity to Gauteng Province, South Africa's industrial heartland. The scheme is highly capital intensive.

Although Lesotho residents will not be supplied with water from the two dams that will be built as part of the LHWP, there are significant indirect benefits. For example, the development of infrastructure includes rural roads, health centres, schools, and a few village water-supply systems. There are also the royalties from the diversion of the water, self-sufficiency in electricity generation, and revenue from Lesotho's participation in the Southern African Customs Union Pool, which has received a boost from the importation of construction equipment and materials. The indirect costs of the scheme will be some environmental damage and the loss of some agricultural land through inundation.

Given the acute shortage of arable land in Lesotho, the loss of even a small percentage of agricultural land has serious implications for subsistence agriculture. Elaborate and sometimes controversial schemes have been instituted to compensate farmers for the loss of productive land.

Some doubt has, therefore, been cast on the merits of the LHWP. If it is fully completed, water transfers from the Orange River's headwaters into the Vaal River could jeopardize the assurance of supply to South African irrigation schemes lower down in the Orange River and in the Fish–Sundays catchment of the Eastern Cape, which receives water transferred from the Orange River. However, the benefits of an assured water supply to Gauteng are believed to exceed the negative impacts.

Major constraints and recommended research

Erosion and silting

PROBLEM — Overgrazing on the fragile soils of Lesotho's steep slopes is causing serious sedimentation of rivers and water-supply reservoirs, as well as reduced recharge of water-supply aquifers.

RESPONSE — Piecemeal soil conservation techniques are employed by the Department of Agriculture, but these do not address the complex underlying socio-economic problem of overgrazing and dense settlement on vulnerable soils.

RESEARCH — A multidisciplinary approach to soil conservation, focusing on community-based socioeconomic incentives, needs to be investigated.

Rural water supply

PROBLEM — Of rural households, 43% do not have access to clean water; most of these people live in remote areas. VWSS has overemphasized installation and construction of boreholes at the expense of developing maintenance capacity. Although VWSS has only a limited capacity to repair breakdowns, there are no private-sector borehole-repair teams. In addition, village water minders do not always have the skills they require to do preventive maintenance on handpumps.

RESPONSE — Despite a profound awareness of the problem, VWSS does not have the capacity to remedy the situation.

RESEARCH — Investigations need to be carried out to ascertain the best ways to ensure both the adequate transfer of maintenance skills to local people and the retention and effective use of these skills by the community.

Coordination and planning

PROBLEM — No overall picture of national demand and supply exists, water management objectives are imprecise, and interagency communication is poor.

RESPONSE — Academics at the University of Lesotho have been commissioned to investigate demographic trends and projected urban water demand. This will feed into a Water Resources Action Plan project, which began in December 1994. Lesotho urgently needs a water-management master plan and is currently looking for funds to commission this.

Legislation

PROBLEM — Lesotho's *Water Act* of 1978 has deficiencies and is largely ignored. It does not provide government agencies with the powers they need to resolve water disputes, nor does it provide for effective resource management and pollution control.

RESPONSE — The *Water Act* is being revised, but no completion date has been set.

Revenue

PROBLEM — The revenue from water connections and sales in urban areas needs to be increased if infrastructure upgrades are to be self-funding.

RESPONSE — WASA has recruited (with overseas assistance) the necessary skills to review tariff policies. Whether this will lead to a reduction in connection fees to ensure more paying customers is uncertain.

Namibia

Water supply and demand

Water availability

Namibia is the driest country in sub-Saharan Africa. It is estimated that 83% of all rain evaporates soon after it falls, leaving just 17% available as surface runoff. Of this runoff, 1% recharges groundwater sources, and 14% is lost through evapotranspiration. Only 2% of the total rainfall can be captured by surface-water-storage facilities.

There are no perennial rivers within Namibia, only ephemeral ones. Perennial rivers are found on Namibia's borders: the Orange in the south; the Cunene in the northwest; and the Okavango, Kwando-Chobe-Linyati, and Zambezi in the northeast. Namibia currently has access to an agreed 180×10^6 m^3/year from the Cunene River and at least 500×10^6 m^3/year from the Orange River. No

formal agreements have yet been reached on abstracting water from the Okavango River. However, the completion of the last stage of the Eastern National Water Carrier, the largest state water project in Namibia, will lead to the importation of 100×10^6 m^3/year from the Okavango River to augment supplies to the central, eastern, and western areas of the country.

The flow in the ephemeral rivers in the interior is irregular and unreliable, limiting both the potential for utilizing surface-water sources and the recharge of aquifers from river courses. The estimated safe yield of the surface-water works that could be developed on the ephemeral rivers is at least 200×10^6 m^3/year, or 40% of the total surface-water resources available in the interior. Ten large dams have been constructed on these ephemeral rivers, with a combined safe yield of 87.3×10^6 m^3/year.

Groundwater plays a major role in water supply in Namibia. The safe annual yield from groundwater sources is estimated at 300×10^6 m^3/year. However, overabstraction of groundwater is already a serious problem in some areas. In the karst (limestone) areas, excessive pumping from boreholes can result in the deeper lime-rich water being exposed to oxygen and thereby causing the lime to precipitate and block the borehole. The borehole then has to be abandoned or redrilled.

A more serious problem is the depletion of the aquifer itself. There are various examples that illustrate this issue:

- The Kuiseb River alluvial aquifer in the central Namib area has already been overused, and the water table has dropped significantly. The aquifer can no longer meet the needs of the coastal towns of Swakopmund and Walvis Bay or of the Rossing uranium mine, and the lowered water table has seriously undermined the dependence of the local Topnaar people on hand-dug wells for water.
- In the Kuiseb and Omaruru catchments, the combination of bad farming practices and prolonged droughts has reduced the vegetation cover, leading to considerable topsoil removal during intense rainstorms and the subsequent sedimentation of the Kuiseb and Omaruru rivers. This soil often forms a thin layer of fine material on the riverbed, which seals the surface of the sand and prevents groundwater recharge.
- The fossil water from the aquifer under the Koichab River is being mined to support the town of Luderitz and the industry at Elizabeth Bay. The aquifer will probably never be recharged under present climatic conditions.

- In some parts of the Stampriet artesian aquifer, saline water overlies the freshwater and poses a contamination threat to the freshwater. Farmers in this area are now required to use a specially designed borehole that seals off the overlying salty water.

Thus, in many areas, the abstraction of groundwater and the impoundment of surface water have upset the delicate balance sustaining highly vulnerable ecosystems.

Water supply

Namibia's total population is about 1.5 million. About 1 million people, or 65% of the population, live in the underdeveloped northern regions, mostly in rural settlements. The northern population is further concentrated in the centre of what used to be called Owamboland. Here 400 000 people live in an ephemeral wetland system of pans called the *oshanas*. Much of the groundwater in this area is too saline for human consumption. In addition, because of the extreme aridity of much of Namibia, most rivers and aquifers within the country may be regarded as under stress. However, extensive investments in pipelines, canals, interbasin transfers, and improved abstraction technology have made relatively dense human settlements viable in areas that previously could not have supported close settlement on this scale.

The *oshanas* run from north to south, whereas the pipelines, canals, and main roads run from west to east, obstructing the *oshanas*' normal flow and increasing evaporative loss. This, in turn, reduces groundwater recharge, which then threatens the water supply in those traditional settlements not serviced by the pipelines and canals. One quarter of Namibia's population live in the *oshana* area, and this is expected to double in the next 20 years.

Depending on the water region, rural people draw water directly from rivers and natural springs, dig for water in dry riverbeds, or use hand-dug wells.

In the *oshana* water region, groundwater takes two forms: a deep saline aquifer underlies most of the area; above this are perched aquifers, pockets of freshwater (rainwater) trapped between the surface and the saline water. Rural people dig into the fresh groundwater aquifer by hand, making round wells called *omifimas*. Water is abstracted with buckets.

Surface water is available during the summer months, when there is sufficient rainfall to make the *omifimas* flow and fill hand-dug earth dams. Initially, the quality of the fresh surface water is good, but as the water evaporates its salinity increases. Traditionally, rural communities would then move on to other water sources in the dry months. Rapid population growth, dense settlement, and environmental degradation are making this migratory lifestyle more difficult.

The United Nations Development Programme planned to set up pilot schemes in 1995 to investigate combining traditional hand-dug wells with infiltration galleries to provide low-technology filtration systems.

Nonconventional water sources

DESALINATION — A pilot desalination plant using seawater is being established on the west coast of Namibia, but the cost will be high, roughly 6.50 ZAR/m^3 (in 1996, 4.34 Namibian dollars [ZAR] = 1 United States dollar [USD]), including capital costs, if used locally. Pumping desalinated water inland to Windhoek is not economically feasible at present because of prohibitive pumping costs.

Most of the groundwater in the far north is saline. Desalination schemes for groundwater have been tested, but major investment in desalination schemes is unlikely because the groundwater is a limited resource.

Water recycling is practiced in some areas. Windhoek recycles about 12% of its water, and the Rossing uranium mine recycles about 76%. However, it is widely acknowledged that recycling could be greatly improved in other centres.

ASSISTED RECHARGE — To conserve Omaruru River floodwater from being lost to the sea, a dam has been built on the lower Omaruru River, near Walvis Bay, to trap silt-laden water during floods. The silt settles out behind the dam wall, and the clear water is then pumped downstream to sand-filled basins, where it rapidly infiltrates, recharging the aquifer. This water is later pumped out via boreholes. Earth dams are used for assisted recharge in some areas, but high evaporation rates reduce their effectiveness.

DROUGHT MANAGEMENT — Given Namibia's aridity, drought should not be regarded as exceptional. However, before independence, water tankers were extensively used in rural areas during droughts. This practice was revived during the 1992 Emergency Drought Relief Program, at a cost of about 50 ZAR/m^3, to augment other relief measures. However, given the logistics and cost of transporting water over long distances, the new government considered this an inappropriate response. Current drought-relief strategies focus on improving borehole reliability.

OTHER OPTIONS — Large-scale rainwater harvesting, weather modifications, and fog-harvesting systems have been investigated by the government but rejected, as they were shown to be uneconomic. Of course, rainwater harvesting at household level can prove feasible and is often practiced in areas where groundwater has a high salt content and where precipitation is sufficient.

Water demand

Groundwater meets 57% of Namibia's current water demand, and surface water meets the remainder. Settlements in the far north are aggregating along the network of pipelines and canals that connect the major rural villages with the Cunene River and supply water to about 30% of the northern population. Livestock are believed to account for 80% of all water demand in northern Namibia; much of this demanded is being met by the pipeline. Moreover, livestock that previously were moved from one water point to another are now settled in fixed areas, leading to overgrazing and overstocking. Fixed human settlement is also denuding vegetation as trees and bushes are used for fuel and buildings.

Because Namibia relies heavily on major interbasin water-transfer schemes, demand statistics expressed in terms of surface-water catchment are not particularly useful. Furthermore, aquifers are seldom contiguous with catchment boundaries and can even be subject to interregional transfer, as in the case of the Karstveld area around Grootfontein, where groundwater is exported southward to Windhoek. Therefore, sectoral demand is best compared with water availability on the basis of existing abstraction patterns, as shown in Table 2, which shows current demands and demands projected to 2005.

Table 2. Current and projected demand in Namibia by sector.

	Demand ($\times 10^6$ m^3)					
	Perennial rivers		Ephemeral surface water		Groundwater	
Sector	1990	2005	1990	2005	1990	2005
Urban [a]	12.6	40.0	13.4	45.0	41.0	45.0
Irrigation	39.7	95.0	34.8	30.0	31.5	30.0
Stock	3.7	10.0	0.0	65.0	60.3	65.0
Mining	2.0	10.0	2.5	10.0	7.5	10.0
Tourism and environment	0.0	2.0	0.3	2.0	0.7	2.0

[a] Includes domestic and industrial demand.

Only 49% of total estimated ephemeral surface- and groundwater sources will be used by 2005, but demand on perennial rivers is expected to increase by 270%. Irrigation demand is unlikely to increase dramatically because of generally poor soil quality. Any additional irrigation demand will probably be met from the perennial border rivers.

Reconciling future supply and demand

Unfortunately, much of the potential water resources available to Namibia are not located close to where they are required. For example, there is abundant water in the Fish River, but it is far from any human settlement. Therefore, as the surface drainage system experiences such high losses, the future utilization of perennial rivers will entail large, capital-intensive engineering projects. However, such schemes may not be affordable or internationally acceptable. Moreover, the diversion of water from internationally shared perennial rivers will require extensive negotiations with Namibia's neighbours.

Water-management systems

Rural water supply

Despite significant problems, rural domestic water-supply coverage is generally good (around 55%) and well within the United Nations International Children's Emergency Fund target for 2000. However, it is estimated that at least half the existing water points in rural areas are faulty.

Responsibility for rural water administration in Namibia has been reassigned three times since independence in 1990. Before independence, rural water supply was the responsibility of the eight ethnic regional administrations, with limited funding and capacity. The result was a massive backlog of communities with inadequate water supplies. Failure to involve and train local users led to a high number of system breakdowns, which was compounded further by the lack of routine-maintenance capacity during the war of liberation.

In early 1993, responsibility for rural water supply was transferred to the Directorate of Rural Water Supply (DRWS) in the Namibian Department of Water Affairs (DWA). With external assistance, a new model of water administration, designed to change the role of DRWS from that of provider to that of facilitator, is being introduced. Because of the lack of capacity within rural communities, the role of DRWS extends well beyond facilitation. Much of the work of DRWS focuses on developing institutional capacity. However, at this stage, only half the posts in DRWS are filled, and few of the existing personnel are appropriately trained. The success of DRWS depends on whether it can recruit and train sufficient staff members and enlist the cooperation of the rural communities with which it works.

Namibia has been divided into 10 water-supply regions, each with a chain of water committees from local water-supply points up to district level. DRWS asks communities to sign a contract giving the communities ownership of their local infrastructure and requiring them to undertake and fund routine maintenance. Each water committee will have a caretaker trained in preventive maintenance. For every 20 or so water-supply points (depending on distances between points or

terrain), there will be one rural water extension officer resident in the area. This person will be able to summon help for breakdowns and maintenance from DRWS's regional maintenance section. On paper, the scheme looks impressive, but it has not yet been implemented widely, so it is too soon for a critical evaluation.

With major donor and NGO assistance, DRWS has prepared a range of educational materials to improve understanding of the hydrological cycle and of the importance of appropriate resource and stock management. Booklets have been designed to assist in promoting literacy and to be used in conjunction with radio broadcasts. Caretaker manuals for diesel and handpumps, with logbooks (printed on water-resistant paper!) to chart daily abstractions, are being distributed to water-point committees. DRWS will feed all data gathered into a central database to monitor consumption and abstraction. Booklets are being distributed with guidelines on how to set up and run water committees. Participation by women varies, but they are generally underrepresented in water structures, despite their contribution to the development of schemes.

During South Africa's war with Angola and, at the time of the liberation movements in Namibia, water was supplied to rural communities at no charge in an attempt to win the hearts and minds of local residents. The provision of free water by the central government entrenched the idea that water is a free and abundant resource provided by government. Attempts to change this perception are now under way. Given low affordability levels in many areas, the government is not aiming at full cost recovery. However, payment may lessen wastage. Water tariffs are being introduced throughout the country, and with modest regular increases, full cost recovery on rudimentary schemes might be achieved by 2007.

Urban water supply

Most centres with populations in excess of 2 000 are supplied from a state water scheme, managed by DWA, which draws water from ground and surface resources. DWA sells bulk water to local authorities, where these exist.

Urban water supplies are likely to be placed under the most stress because of rapidly increasing population densities, higher per capita consumption levels, remoteness of most towns from perennial rivers, and high evaporation rates in urban water-supply dams.

At current rates of annual increase, Windhoek could start to run short of water by 1998. Water tariffs were recently raised by 30%, and water consumption exceeding 60 m^3/month per household or enterprise is billed at 5.30 ZAR/m^3. In response, average consumption has dropped by 25%, although it is unclear whether this reduction is in response to price cuts or moral obligation. Anticipated demand increases are such that, within the next 10–15 years, Windhoek will

probably need access to the nearest perennial water source, the Okavango River, 800 km away. The final stage of the Eastern National Water Carrier would then have to be constructed to convey the water.

Construction of the Okavango link could also be postponed if groundwater resources north of Tsumeb prove to be as abundant as are currently anticipated. However, the longer Namibia delays abstraction from the Okavango, the more likely it is there will be competition for this water source from other users, as well as objections from interest groups.

Inadequate maintenance of water mains and distribution schemes is a major problem in Namibia and leads to significant wastage. Again, tariff increases may resolve this to some extent. Infrastructure maintenance is expected to improve after commercialization in late 1995 of the bulk water-supply section of DWA. This will also improve management, cost-effectiveness, and planning flexibility.

As a commercial utility operating a capital-intensive system, DWA will probably seek to maximize the sale of water, even though such sales could undermine long-term strategies to conserve water. By the same token, maximizing revenue by increasing tariffs would curb demand increases, though by how much is not clear.

Role of NGOs

Relations between the NGO sector and government are generally very good. Representatives meet monthly in water and sanitation forums in both Windhoek and Cuvelai to discuss priorities and coordinate development. Because DRWS has extremely few people on the ground, it is imperative that it maintain good relations with the NGO sector, whose role at present is crucial in setting up and maintaining local water schemes.

Major constraints and recommended research

Population and environment

PROBLEM — The two key resource issues facing Namibia are population growth and environmental degradation. Complementing these are a range of subsidiary issues, such as overstocking, denudation, erosion, and desertification. Stock-reduction schemes are a major issue.

RESPONSE — Public education campaigns are being developed by the government.

RESEARCH — Community-based socioeconomic incentive systems that match livestock levels to the carrying capacity of the land need are a priority.

Technical skills

PROBLEM — Government capacity to implement its policies is limited by staff constraints. Namibians with the necessary technical skills are leaving the public sector for the private sector, where salaries are up to 50% higher. Some of these posts have been filled with expatriates on contract, who are supposed to train local personnel, but few local personnel are available in the public sector to be trained. The result is a growing dependence on expatriate technical personnel on short-term contracts and an increasing use of private consultants. Commercialization of the bulk-water sector will exacerbate the technical-skills shortage in the public service.

RESPONSE — None.

Local skills

PROBLEM — The rural water-supply sector will require time for training people for the posts currently being created, but relatively few posts call for high technical training.

RESPONSE — A major recruitment and training program is under way.

Urbanization

PROBLEM — Namibia's urban areas are growing at a rate of 5–11% per year. Water consumption in urban centres is far higher than that in rural areas because of individual household connections. This poses a particular problem because few Namibian towns have sustainable local water sources.

RESPONSE — Raised water tariffs were introduced in 1995, and alternative supply sources are being explored and developed.

RESEARCH — The demand–price elasticity characteristics of urban water consumers need to be better understood so that tariff policies that control demand increases more effectively can be designed.

Cost recovery

PROBLEM — Urban water tariffs do not achieve full cost recovery and barely cover operation and maintenance (O&M) costs. The result is a decaying water infrastructure that leaks and wastes water. Water tariffs need to be trebled to cover the full cost of current delivery.

RESPONSE — The government sanctioned a 30% tariff hike shortly after the first postindependence election, in December 1994.

Bulk infrastructure provision

PROBLEM — Management and development of bulk water supply are underfunded and constrained by bureaucracy.

RESPONSE — Privatization of bulk water supply was scheduled for late 1995.

Complacency over water availability

PROBLEM — The government's ability to provide high-technology solutions to many of Namibia's water problems has lulled most residents into believing that the water shortage can be overcome. Urgent public-education campaigns are necessary to promote awareness of the need for water conservation and better resource management.

RESPONSE — Public-education campaigns have been designed and will be launched soon.

RESEARCH — To prioritize user sectors and to improve the targeting of drought restrictions and scarcity-education campaigns, a better understanding is required of the intrinsic value that the various user sectors attach to water.

Rural water-supply infrastructure

PROBLEM — Water-supply equipment in rural areas is too heavy and complex for its primary users (rural women) to maintain. Water committees are unlikely to be able to develop the technical and managerial skills that DRWS requires of them.

RESPONSE — A very ambitious plan to train a corps of local water minders, assisted by local rural water extension officers, is being developed.

Planning

PROBLEM — No detailed master plan exists, and there is little coordination among government departments. Furthermore, no government department is taking responsibility for coordinating and implementing policy around sanitation.

RESPONSE — A Water and Sanitation Committee, representing all stakeholders, has been suggested. Its role would be to improve coordination and advise cabinet.

Legislation

PROBLEM — Namibia's *Water Act* is based on South Africa's *Water Act* and is clearly inappropriate to Namibia's needs.

RESPONSE — A draft revision exists but has not been finalized.

South Africa

Water supply and demand

Water availability

The greater part of South Africa is semi-arid and subject to variable rainfall, droughts, floods, and high evaporation. The mean annual rainfall is only 500 mm, which is 60% of the world average. In addition, this rainfall is poorly distributed relative to areas experiencing economic growth. Only a comparatively narrow region along the eastern and southern coastline is moderately well watered, whereas the greater part of the interior is arid or semi-arid. Given that 65% of the country receives less than 500 mm of rainfall annually (the level regarded as the minimum for successful dryland farming) and 21% receives less than 200 mm, South Africa's existing and future development depends to a large extent on the state's ability to move water in bulk from the well-watered regions to the centres of settlement and industry in the drier regions.

Water supply

Under the apartheid regime, the Department of Water Affairs and Forestry (DWAF) practiced the art of large-scale interbasin transfer, to the acclaim of the international water industry. However, DWAF performed this role exclusively on behalf of white South Africa and those nonwhite population groups that were allowed to reside outside the Bantustans. The supply of water in the so-called independent and self-governing homelands was the responsibility of the individual Bantustan administrations, which undertook the task with varying degrees of success.

Today, an estimated 16 million people in South Africa, 40% of the population, do not have adequate supplies of safe drinking water. This uneven situation is the result of a number of factors:

- the poor performance of Bantustan administrations, especially in maintaining existing infrastructure;
- limited state development capital;

- rapid urban settlement, which is outpacing the development of new water-supply infrastructure;
- inappropriate water allocations to commercial agriculture, often at the expense of primary users; and
- poor control over the abstraction and pollution of water resources.

To meet minimum needs in rural areas, an extra 120×10^6 m^3 of potable water must be made available each year. Relative to total demand, this is a small amount, but a significant portion of this new demand will have to be supplied in semi-arid areas, where very little surface water is available, infrastructure is poor, and population density is low.

Nonconventional sources of water

South Africa's relative abundance of first-world technology and skills has led to the investigation and development of several nonconventional ways to augment water supplies. None of these can be said to have been motivated by actual water stress. The achievement of first-world water-supply and treatment standards seems to have been the main driving force. The two most notable areas of research and development were in rainfall stimulation (cloud seeding) and ultrafiltration technology (desalination).

CLOUD SEEDING — Cloud seeding was practiced in the Bethlehem area of the southern Orange Free State, where it was found to benefit the yield of farm dams but not the runoff from the Vaal catchment. The program has since been moved to the escarpment area of the eastern Cape, where some measure of success is being experienced in increasing the rainfall over commercial tree plantations. This has been an expensive project, and there have been recent investigations to determine whether the money could have been better spent on improving water conservation.

DESALINATION — Ultrafiltration technology was largely developed in South Africa to deal with the wide range of industrial and mining pollutants. By law these have to be returned to the channel of origin, but there is usually insufficient dilution potential there to render the effluent harmless. Although there is great potential for augmenting South Africa's water supply by desalinating seawater and brackish groundwater, the costs are still prohibitive. As such, this state-of-the-art technology has not yet been applied to domestic water supply, except in exceptional circumstances.

Water demand

Out of 22 main drainage basins in South Africa, six are already experiencing deficits anywhere from 1×10^6 to 122×10^6 m^3/year. depending on the severity of localized drought conditions. Another six have surpluses ranging from more than 1×10^9 to 4×10^9 m^3/year. At the projected rate of water-demand increase, several basins will experience deficits of more than 1 000 m^3/year by 2010, but a larger number will still continue to have healthy surpluses of that same volume.

In April 1994, the new Government of National Unity, led by the African National Congress, came to power with a clear set of policy objectives to address the gross distortions of the apartheid era. The Reconstruction and Development Programme (RDP), for example, devotes special attention to rural and urban water supply and outlines a number of specific targets, with clear deadlines. Within the short term, generally understood as being by 1997 (although this now seems unlikely), the new government aims to provide all rural households with a clean, safe water supply of 20–30 L/person per day within 200 m and an adequate sanitation facility for each household. By roughly 2002, it aims to achieve an on-site water supply of at least 50 L/person per day. It is imperative that these objectives are met as soon as possible, yet capacity and logistic and financial constraints suggest that meeting them on schedule will be a major challenge. It should be noted that, within the first 6 months of office, the new government announced plans to construct projects that will improve the supply of water to 1.2 million people, many of whom are rural dwellers. Existing and projected sectoral water demand for South Africa is shown in Table 3.

The bulk of the nation's available water resources is assigned to commercial irrigation. Although the land-reform debate is starting to acquire substance in South Africa, many rural people are realizing that water is the primary limiting factor governing the allocation of land to emerging small-scale farmers. Because existing rural water supplies are largely fully utilized, water for rural domestic use and new agricultural development will have to be reallocated from large-scale commercial farming operations. This will entail some combination of the expropriation of water rights, which could prove costly and controversial; the development of more storage, which is expensive and not always possible; and some sort of differential water-pricing strategy that will force commercial agriculture to improve efficiency and stop irrigating low-value crops.

WATER-DEMAND MANAGEMENT — The commercial irrigators of South Africa are not the only water users that should be considered for cost-effectiveness or efficiency improvements. Indeed, by international standards, these irrigators are

Table 3. Current and projected demand in South Africa by sector.

Sector	Demand ($\times 10^6$ m^3) 1993	2010
Domestic	1 516	3 000
Industry	1 031	2 500
Municipal use	90	200
Urban losses	280	500
Power generation	224	400[a]
Mining	466	600
Irrigation	8 254	11 500
Stock watering	264	350
Forestry	1 284	1 700
Nature conservation	2 994	5 000

[a] Losses to evaporation in cooling systems, plus water used in ash-disposal systems.

among the more efficient in the world. The trend of the last 12 years toward drip and microirrigation systems, which was prompted by the shortage of water rather than by price, has resulted in leaching fractions of less than 15% in many areas. However, bulk delivery of water to irrigators still incurs losses in excess of 30%.

The other major user sector that needs to consider its consumption levels is the urban domestic one. Recent surveys conducted in South Africa's middle-class suburbs revealed that the conservation-threshold price of water (that is, the price at which householders would implement conservation measures) could not be determined with any accuracy because it was too much in excess of what was currently being paid for respondents to identify a specific price. This suggests that there may be considerable scope for raising revenue in South Africa by means of levies on urban water sales.

Clearly, there is the potential to curb South Africa's thirst for more water by introducing demand-management strategies. Furthermore, there is also some urgency to do this, given the new government's intention to expand the economy at a rate of around 5% per year. Unfortunately, there is little indication that policymakers are thinking along these lines.

Water-management systems

National overview

Responsibility for water supply in South Africa is divided among central, regional, and local authorities and nonprofit bulk-supply authorities (water boards), with the central government's DWAF managing the overall policy framework. DWAF is responsible for operating many of the country's major dams, setting policy, issuing forestry permits (based on estimated water use and runoff reduction), and coordinating long-term water-resource development. In the past, DWAF worked closely with provincial and ethnic homeland governments but had no jurisdiction over the four nominally independent homelands.

The former homeland governments are currently being reabsorbed into central and regional administrations. Nine new provincial governments have been established in place of the former provincial and homeland administrations. Despite the detailed wording of the new constitution, there is still uncertainty concerning the division of responsibility between central and regional governments, especially because the new regional governments are keen to assert their independence of central government. Water management is a responsibility of the central government, whereas provincial and local services are the responsibility of regional governments.

The anticipated lack of capacity at the provincial level, coupled with the rigid service-level targets of the RDP, has forced the central government to consider the establishment of water utilities (that is, nonprofit, democratically controlled water boards) to implement water-supply and sanitation works at the subprovincial level. Although these new utilities have still to be formed, it is widely recognized that the needs of rural communities will only be met with a collective and concerted effort from government, parastatals, NGOs, the private sector, and the communities themselves. Moreover, to benefit from the RDP, the communities must demonstrate both consensus and determination regarding these issues. The backlog in water-supply and sanitation services, the rapid urbanization rate, and rural population-growth rates of more than 3% per year present too great a problem for any single agency to assume total responsibility.

Rural water supply

Because of the policy of separate development, rural water supply in white South Africa, as administered by DWAF, focused on water supply for commercial agriculture, whereas water supply for the inhabitants of the ethnic Bantustans was allocated to homeland governments. In general, the latter lacked the resources,

capacity, and motivation to introduce and maintain sustainable water-delivery systems, although there were isolated success stories.

More than half of all rural people rely on unimproved water sources: streams, rivers, and unprotected springs. This direct dependence on natural water sources has made many communities highly vulnerable to droughts, to increases in water-abstraction patterns, to upstream land-use changes, and to effluent discharges. Current water conflicts and detailed catchment analyses are starting to indicate that rural water resources may have been overallocated, going beyond the safe yield of catchments and dams. Furthermore, nearly all of South Africa's surface water is unsuitable for human consumption in an untreated state, largely because of contamination by human, animal, and industrial waste. This water must be treated if any reduction in rural waterborne diseases is to be achieved.

In response to this problem, DWAF is setting up the Directorate of Rural Water Supply and Sanitation to support rural communities. The new directorate will strive to facilitate, rather than implement, water management. NGOs, local authorities, water boards, the private sector, and regional authorities will take primary responsibility for implementation. Local water committees will coordinate the rural water supply. It is anticipated that the current mapping of groundwater potential throughout the country will assist in satisfying rural water demand.

Urban water supply

South Africa's urban areas were historically segregated into white, Asian, coloured, and black areas. Water supply in white areas is generally excellent. Because African urbanization was forcibly discouraged, black townships outside the homelands were not designed to accommodate large populations. Since the lifting of influx controls in 1986 there has been a dramatic shift away from covert settlement in overcrowded township houses and back yards toward shack settlement on the urban periphery. Existing township infrastructure is proving inadequate to meet the demands now being placed on it. Politically motivated rent and service boycotts have deprived many local authorities of the revenue needed for maintaining and upgrading systems, and maintenance capacity has been deteriorating steadily for some time. Nearly 50% of the water supplied to Soweto is lost through leakage. The new political dispensation does not seem to have defused the crisis in many local authorities as residents grow impatient at the state's failure to deliver widespread civic improvements. Local government elections held in November 1995 give more legitimacy to the local councils that levy tariffs, but the perception that urban services can be had for free is now deeply entrenched in many black townships.

In the last 5 years, dense, informal settlements have sprung up around the periphery of towns and cities, such as Johannesburg, Durban, and Cape Town.

Growth is extremely rapid. In the space of a month, shack settlements of several thousand people can develop on vacant land, and local authorities are battling to provide even rudimentary services. Most residents rely on public standpipes in adjacent settlements or on water tankers. Sanitation is often nonexistent, and already there have been several outbreaks of typhoid and other waterborne diseases.

The involvement of the residents of informal settlements in water management or local administration was initially discouraged by the last government for fear of bestowing some form of legitimacy on such settlement practices, as they are perceived to be an illegal activity. The new government has adopted the policy of encouraging dialogue with informal community leaders and encouraging the provincial governments to give priority to their needs.

Cost recovery

The majority of rural users regard water as a free good that the government must provide in abundance. Government makes little attempt to recover the real costs of rural water supply from the beneficiaries, and rural consumers are required to pay a nominal tariff that is seldom consumption related, and then only if the water provided is close by. Very few people actually pay even this nominal tariff, and government agencies lack the capacity to enforce payment. In urban areas, mounting debt from long-standing rent and service boycotts in many areas is being covered by government through interdepartmental cash transfers, which depletes funds for new services and housing.

Payment for sanitation in rural areas has generally entailed the repayment of loans on a small scale for voluntary, owner-built pit latrines. However, disposable income is extremely limited in the impoverished rural areas, and other priority needs, such as water supply, food purchases, health, and education, are often considered more important. Service-payment schemes for RDP sanitation systems have yet to be developed and implemented.

The nonrecovery of even the O&M costs of water-supply and sanitation services has all the ramifications that have been experienced elsewhere in the world, such as

- failure by the community to identify with the scheme so long as it is state owned;
- lack of respect for the scheme, leading to abuse, theft, and vandalism, thereby raising maintenance costs;
- inappropriate system design resulting from lack of effort to reconcile the needs of the community with its levels of affordability and its capacity for managing sophisticated systems;

- increasing national O&M cost burden, which reduces available funds for new schemes and leads to a preoccupation within government with cost cutting; and
- wastage of water.

Homeland governments lacked the legitimacy and political will either to introduce or to enforce better cost recovery. Often, zero-cost-recovery water-supply schemes were seen as a way to foster rural political support, something that took on greater importance in the run-up to the 1994 elections. Today, in some large-scale rural reticulation schemes, the inherited policy of zero cost recovery completely undermines the reliability of the service, as people are not motivated to turn off yard taps and prefer, instead, to run the water continuously on vegetable gardens and lawns. This practice leads to pipeline-pressure reductions, with the result that many villages farther down the line do not receive water and have to rely on tanker deliveries.

The task of achieving a partial cost recovery, sufficient to meet at least O&M costs, now falls on the new government. The policy on this has been advanced in RDP documentation, where it was indicated that service charges would have to be levied on RDP infrastructure projects. However, the implementation of this policy in the existing environment, where service delivery has been highly politicized and welfare expectations run high, has still to take place.

DWAF plans to entrench the principle that all water consumed has a price. A low-level "lifeline" tariff has been suggested for low-income consumers, and higher tariffs on a sliding scale for other consumers could help finance a more equitable and sustainable water supply to all. Higher water tariffs for irrigators are also possible.

On payment, the achievements of a number of independently minded rural communities deserve recognition. Either as a result of objections to incorporation in homeland states or because of disfavour with homeland politicians, a number of rural communities in South Africa were left to fend for themselves during the 1980s and early 1990s. To survive, they established the foundations of an interim local authority, often with strong inputs from women. This authority collected funds within the community and approached NGOs for assistance with basic-service provision. In some instances, this new-found capacity has led to the development of rural industries and enterprises. The interesting feature of the many water schemes originated by the community is the reportedly high level of assurance of supply. This assurance is due essentially to an absence of government intervention in the development of the schemes. In such cases, it is not uncommon to find the local vehicle mechanic maintaining the village water pump.

Catchment management

Historically, natural-resource management has tended to focus on "separatist conservation," rather than viewing humans as an integral part of the natural environment. Hence, no catchment-management plans that can be implemented exist beyond statements of general intent. For example, dense settlements, overgrazing, and overburning have led to severe erosion, particularly in the former homeland areas. Diminished infiltration is affecting local groundwater supplies, flooding is increasing in frequency and severity, and the silting of rivers and estuaries is widespread. The impact of this degradation not only affects people in the immediate vicinity (the rural areas), but also will, in a short space of time, affect water supplies to the main metropolitan areas.

Broad policy statements are difficult to implement on the ground, and neither the Department of Agriculture nor DWAF has the power or resources to ensure better resource management in the important water-supply catchments. In the former homelands, environmental management was largely ignored. Instead, the focus tended to be on tourism-related conservation, rather than on veld rehabilitation and community education. Effective public-awareness campaigns are an urgent priority. However, in the absence of feasible management policies and the necessary development to alleviate rural poverty, progress is likely to be limited.

Major constraints and recommended research

Top-down development practices

PROBLEM — The historical approach by government agencies has been top down and paternalistic, with the emphasis on technical rather than institutional development. *Community participation* tended to mean "consulting the chief or headman about the siting of a borehole." Communication was generally one way and addressed exclusively to men.

RESPONSE — The new minister of DWAF has committed the department to the principle of bottom-up development, involving consultation with all stakeholders, particularly women. Extensive staff recruitment and management reeducation programs will be necessary to achieve this, as DWAF has tended to be white, male, and technocratic. Policies are being put in place to address this.

Poorly developed capacity in rural areas

PROBLEM — The existing rural water-supply system has fostered dependence and stifled initiative, without being able to meet community expectations. Organizational capacity at the local level is generally poorly developed, and if local committees are to play the role outlined for them by the new government,

considerable training will be required in organizational development, basic administration, bookkeeping, and rudimentary maintenance skills.

RESPONSE — In conjunction with NGOs, the government is formulating strategies to address training and organizational development. Also, in response to the realization that well-developed technical skills often exist in rural communities and merely require reorientation toward water-system O&M, there are moves to help establish small-scale water and sanitation entrepreneurs in rural areas.

Pollution of water-supply aquifers

PROBLEM — Contamination of water sources and aquifers has become a very serious problem, in part because of the rapid growth of dense settlements with poor sanitation infrastructure. Considerable contamination of groundwater has already occurred in many places, and it will be some time before government and community agencies have the resources to introduce better sanitation techniques and alternative water supplies.

RESPONSE — Improved sanitation is one of the RDP's priorities, and DWAF has assumed some measure of responsibility for ensuring improvements do occur.

Overstocking of grazing veld

PROBLEM — In the past, tribal chiefs were responsible for ensuring that lands under their jurisdiction were well managed. However, the erosion of their legitimacy in some parts of the country, coupled with incentives that encourage chiefs to maximize the number of households (with livestock) in the communities, has greatly reduced their enthusiasm to introduce new patterns of stock management. Government attempts to reduce stock numbers in tribal areas and forcibly introduce different stock-management regimes have often been politicized and have generally failed, although there have been documented successes in controlling the stocking rates of white farmers.

RESPONSE — Politicians have shied away from tackling this problem, both because of the cultural importance of cattle to many African people and because it tends to raise questions about land distribution in South Africa. It is one of the most pressing problems facing sustainable water management.

RESEARCH — There is a need to develop community-based socioeconomic-incentive systems that will match livestock levels to the carrying capacity of the

land. This may entail developing closer links between livestock farmers in tribal areas and the meat-products processing and marketing industry.

Water for the environment

PROBLEM — As a result of weak enforcement of environmental-conservation policies and a poorly coordinated environmental lobby, when water stress does occur, the natural environment invariably suffers. The water needs of wetlands, riverine habitats, and even conservation areas, such as Kruger National Park, have generally been overlooked.

RESPONSE — The Water Research Commission, in conjunction with the Foundation for Research Development, embarked on a program to determine the water needs of the natural environment in the mid-1980s. It remains to be seen whether the state will adopt the recommendations of this research, in view of the stiff competition for water from rural communities, although it is likely that the state will accept the concept of the aquatic environment being the resource from which water can be drawn, up to a certain point. In other words, the natural environment would no longer be viewed as a user but as the source of water and thus would be entitled to a reserve beyond which further abstractions would not be allowed.

RESEARCH — The contribution of freshwater systems to the economic performance of various sectors, such as agriculture and tourism, needs to be better quantified.

Legislation

PROBLEM — Responsibility for implementing the *Water Act* is dispersed amongst a myriad of authorities operating at various levels of government within South Africa and the independent and self-governing states. Moreover, South African water law is derived from European law and presupposes an abundant supply of water. Thus, the emphasis is on allocation, rather than on integrated scarce-resource management.

RESPONSE — Under the new government, DWAF is drafting legislation to consolidate and rationalize water legislation into one uniform body of law. From there, the nation's water law itself will be revised to meet current conditions.

Drought management

PROBLEM — Droughts are still seen as exceptional, rather than inevitable and predictable. Drought-relief schemes during the 1992–93 period raised awareness

among government officials that, in most places, the major problem was not that assured water was absent but that existing infrastructure had broken down, which forced communities to revert to traditional sources, which were soon exhausted.

RESPONSE — Better awareness of the need for ongoing maintenance programs involving local users exists, but few initiatives are under way.

Coordinating the activities of NGOs

PROBLEM — NGOs have played a pivotal role in installing improved water supplies in areas inadequately addressed by government. However, the rapid proliferation of NGOs in the late 1980s and early 1990s resulted in poor coordination and communication between organizations.

RESPONSE — A new NGO, the Mvula Trust, has been established to fund rural water and sanitation schemes and to coordinate their funding and implementation.

Swaziland

Water supply and demand

Water availability

The water resources of Swaziland may be described in terms of the four main geographical areas, each stretching from north to south. From west to east, they may be described as follows:

- Highveld has rainfall of 1 000 – 1 200 mm/year and abundant surface and groundwater.
- Middleveld has rainfall of 600–800 mm/year and good groundwater, but its surface water is unreliable.
- Lowveld has rainfall of less than 600 mm/year, little surface water, and few successful boreholes.
- Lebombo Plateau is relatively wet in the northeast, which has rainfall of 650 mm/year. Most rivers in the northeast have small irrigation dams for sugar, citrus, and other crops. The southeast is in a rain shadow and receives rainfall of only 400–500 mm/year. Domestic supply relies on boreholes and a little surface water.

Water supply

The traditional sources of water are springs and rivers, which are shared with livestock. The three main river systems affecting Swaziland are the Komati River,

the Usutu River, and the Ngwempisi River, all of which flow east from South Africa through Swaziland toward Mozambique.

The Komati River hosts a number of impoundments on the upstream South African side. These are used for supply of cooling water for coal-fired power stations and water for irrigation. Commercial timber plantations in both South Africa and Swaziland further reduce the runoff from this catchment. Historical agreements with South Africa have allocated a portion of the Komati River flow to Swaziland. This allocation has generally been more than could be used by Swaziland. However, the droughts of the 1980s and 1990s, coupled with increased irrigation abstractions upstream of Swaziland, have greatly reduced the flow in the Komati River as it returns to South Africa. This has partly been the motivating force behind the construction of the Driekoppies Dam on the Lomati River (a main tributary of the Komati River), on Swaziland's eastern border.

A second dam in the Komati catchment, at Maguga, has been proposed. If it goes ahead, it is to be funded 40% by Swaziland and 60% by South Africa. However, Swaziland has been slow to initiate the processes necessary to keep project negotiations on schedule. Maguga will have virtually no impact on domestic water consumption, as its primary purpose will be hydroelectric-power generation and irrigation, especially of sugar, citrus, and other crops.

Water demand

Swaziland's current and projected water demands are shown in Table 4. Official estimates are set at 1.2×10^9 m^3/year for irrigation, based on the register of permits allocated for irrigation. However, actual use is estimated to be far less, at around 0.4×10^9 m^3/year; no precise figures exist.

Table 4. Current and projected demand in Swaziland by sector.

	Demand ($\times 10^6$ m^3)	
Sector	1994	2016
Urban domestic	5.77	16.35
Rural domestic (estimated)	4.60	10.00
Industrial	5.71	13.94
Irrigation	400.00[a]	500.00
Forestry	120.00	130.00

[a] Official estimates are set at 1.2×10^9 m^3/year for irrigation, based on the register of permits allocated for irrigation. However, no precise figures exist for actual utilization, which is estimated to be far less, at around 400×10^6 m^3/year.

Nearly 30% of the population of Swaziland lives in urban areas, and this proportion is increasing rapidly as people leave the rural areas in search of work. Political change in South Africa has led to a measure of disinvestment from Swaziland in preference to its more developed neighbour. This is expected to place greater pressure on the commercial agricultural sector to generate jobs and wealth, which in turn will probably increase the demand for irrigation water.

Water-management systems

National overview

Swaziland is a constitutional monarchy, and the royal palace strongly influences decision-making. There is no single institution outside the monarchy with the power to coordinate water policy in Swaziland. Authority is dispersed among several government departments, each of which seems eager to cede responsibility. Despite much discussion and an agreement in principle taken 6 years ago, the proposed National Water Authority, with the powers to gather information, formulate policy, plan development, and oversee implementation, has still not been set up. Development planning falls primarily under the Ministry of Economic Planning, whose priorities do not necessarily address resource management and sustainable water delivery.

There is no comprehensive national water-development strategy or master plan in Swaziland, and rhetorical commitments to water-resource development have not been matched by the necessary financial and human-resource commitments. For example, until mid-1995, the Rural Water Supply Board depended entirely on external donors for its existence. The Government of Swaziland has now made a formal commitment to partially fund the Rural Water Supply Board (now renamed the Rural Water Supply Branch [RWSB]). Although this limited government funding will lessen uncertainty about the future of RWSB, there are no guarantees about the size of the annual budgetary allocation from government from year to year. Consequently, RWSB will remain dependent on the donor community for much of its activities.

Part of the reason for this complacency is that Swaziland is well provided with surface water. However, much of this water is unsafe for human consumption, largely because of human and animal fecal contamination, and the failure to invest in sustainable rural water infrastructure is reflected in high infant-mortality rates, widespread diarrhea, and a range of other waterborne illnesses.

Estimates of safe water-supply coverage vary widely. Between 20 and 40% of the urban and peri-urban population and between 45 and 55% of the rural population do not have access to potable water. Given that 70% of people live in

rural areas, this imbalance in water access reflects a bias toward higher quality service provision in urban centres.

Swaziland has three main water institutions, described as follows:

- The Water Department, within the Ministry of Natural Resources and the Environment, has few powers and resources. Its main activity is managing water for irrigation.
- RWSB falls under the Ministry of Natural Resources and the Environment but relies heavily on external funding. It was set up with donor funding and NGO support during the United Nations Decade of Water and Sanitation.
- The Water Services Corporation was privatized in August 1994 to facilitate better planning, budgeting, and overall management of urban water supplies. It remains answerable to the Ministry of Housing and Urban Development.

The Rural Water Supply Board (now Branch)

For many years the Government of Swaziland regarded RWSB as a temporary parastatal institution. Short-term and uncertain funding severely undermined its effectiveness. Most of its staff were in temporary positions and received little training, and training in community development was largely neglected. In mid-1995, the Rural Water Supply Board was formally reconstituted as a department of government and renamed as a branch (as mentioned earlier). It is too soon to tell what impact this change will have on the internal workings of the branch.

RWSB emphasizes low-cost, community-initiated water projects. People wanting an improved water supply are required to form a water committee and to collect contributions for O&M. When RWSB is satisfied the committee has shown sufficient commitment, it applies for donor funding. Funding, however, can take several years to secure. RWSB technicians install gravity-fed systems from reliable springs, wherever feasible, and sink boreholes where necessary. Where the depth is too great for handpumps, RWSB installs electric pumps wherever possible. Diesel pumps are rarely installed now because of theft of the pump and fuel. The use of electricity has raised the cost, and affordability is a major problem for many households.

A major factor complicating rural water provision is the entrenched cultural preference for scattered homesteads, rather than close rural settlements and villages. Among other factors, this raises the cost and difficulty of rural water supply. Once a water scheme is installed, many water committees lapse. Of those

that remain, only half maintain an ongoing water fund. People in rural areas are supposed to contribute a monthly flat rate, usually 6 or 7 ZAR, for O&M to the local water committee, but payment and collection rates vary. In theory, nonpayers are not allowed to take water, but in practice such water theft is hard to police. Vandalism by those excluded and the health costs of reverting to traditional water sources are far more expensive. Maintenance capacity is, therefore, limited. Although 45% of rural villages are serviced by improved water schemes, not all of these schemes are in working order, because of problems with communication, transport, and the shortage of technical staff. Many rural water-supply schemes are also too complex to allow for greater community involvement. Moreover, as water minders are unpaid and usually untrained, very few settlements have a permanent water minder.

The Urban Water Services Corporation

The Urban Water Services Corporation (WSC) is understaffed and depends on expatriate technical advisors. Recent internal restructuring has distracted WSC from the need to make urgent decisions about infrastructure upgrading and expansion. At current levels of consumption and urban growth, Mbabane will start running out of water in 1998. WSC has not decided yet been how to address this problem.

Current urban-development strategies stress full cost recovery but do not achieve this, as tariffs only cover O&M costs and do not provide for expansion and development. Formal settlement areas, on the other hand, have individual, metered connections, and revenue collection is well administered. These high-level, metered reticulation networks in formal settlements coexist uneasily with a dearth of infrastructure in the informal settlements. An estimated 140 000 people in urban and peri-urban informal settlements are without running water, and settlements in the greater Manzini area are growing at a rate of 5% per year. Urban community structures, however, are not involved in water management.

A few public standpipes were installed by WSC in informal settlements in the 1980s, after a cholera outbreak, but no attempt was made at cost recovery. Several pilot projects are now under way to get standpipe users to pay for water, despite the lack of precedent for this in Swaziland. One expedient is lockable standpipes, with keys for those who pay a flat rate. However, there are problems with vandalism by those locked out. Water kiosks seem to be more successful.

The NGO sector

Coordination between the government and some elements of the NGO sector is poor, leading to inefficiencies and duplication. RWSB is highly critical of some

NGOs, which, it argues, often install inadequate water schemes fitted with nonstandard equipment that RWSB is then obliged to maintain.

International institutions

As a result of the construction of the Driekoppies Dam, an international water-management institution has been established through an agreement between Swaziland and South Africa. The Komati Basin Water Authority will have the task of monitoring land use and runoff within the Komati catchment, which includes parts of Swaziland.

Major constraints and recommended research

Drought relief

PROBLEM — As Swaziland has only one major storage dam, Mnjeli, used mainly for irrigation, and has inadequate water-supply coverage in rural areas, the country is extremely vulnerable to drought. An elaborate scheme to erect water tanks in stressed areas and have them filled by government tankers failed conspicuously when it was realized that no funds had been voted for the O&M of the tankers. Moreover, the logistics of supply in the rural areas proved prohibitive. Local residents expressed their frustration in some areas by vandalizing the empty tanks.

RESPONSE — A borehole-drilling program provided by RWSB on behalf of the Disaster Relief Task Force is under way to improve rural water supply, particularly in vulnerable areas.

Natural-resource management

PROBLEM — Poor resource management in communal lands, controlled by the chiefs on behalf of the King, is compounding erosion and aggravating the sedimentation of rivers and reservoirs in the southwest. The main water-supply catchment for the greater Manzini area (the industrial hub of the country, with rapidly growing informal settlements) lies in badly degraded communal lands. The combination of steep slopes, erodible granitic soils, overgrazing, and high-intensity rainfall has led to major sedimentation. The silting of dams and reservoirs is, therefore, a serious problem, particularly in the Matsapha–Manzini area.

RESPONSE — Major dredging operations have been necessary for the past year to improve the storage capacity of the Matsapha Dam, but the soil-conservation measures of the Department of Agriculture have proven ineffectual.

RESEARCH — Community-based socioeconomic-incentive systems that encourage the matching of livestock levels to the carrying capacity of the land need to be developed.

Institutional coordination

PROBLEM — There is little overall coordination among agencies implementing water and sanitation programs. Communication between the various agencies happens largely at a personal level, rather than an institutional level. There is no monitoring system at the national level.

RESPONSE — There has been no apparent action.

International water sharing

PROBLEM — South Africa abstracts heavily from two of the three main rivers entering Swaziland, with six dams on these rivers. Swaziland wants this water for irrigation, but government officials maintain that flows through Swaziland are declining because of South Africa's dams. Bilateral negotiating mechanisms were introduced in 1979, after five of the South African dams were completed.

RESPONSE — Because of Swaziland's size and location, government officials in Swaziland feel relatively impotent in asserting the nation's right to a more equitable share of river flows. Response has been correspondingly limited.

Water conservation measures

PROBLEM — In urban areas, the estimated volume of water lost between the water supplied and water billed is 60%.

RESPONSE — Private consultants were commissioned to investigate loss-reduction schemes, such as replacing valves, upgrading shutoff devices, and redesigning mains. However, government is stalling on the implementation of the recommendations, and there is no evidence of water-conservation measures being applied in the other user sectors.

Conclusions

This regional overview highlights the different ways water is supplied and managed in southern Africa, but it is not an evaluation of those water-management systems currently in place. The focus is on water stress and how governments, institutions, and local communities perceive such stress and respond to it. However, as water stress is often the product of institutional or management

failure, this report tends to overlook the successes and achievements of the countries reviewed. Such achievements have been considerable, and the necessary planning to meet future needs is often well developed. Unfortunately, the resources (skills and finance) to sustain these successes and implement new schemes seldom exist. In the highly stressed areas, this has led to water management based on survivalism, sometimes at the expense of the environment and economic development. Thus, there is a need for a dualistic approach to water supply in the region: (1) to consolidate existing systems and ensure their effectiveness and sustainability; and (2) to meet future demands for both domestic use and economic development.

Despite shared characteristics and somewhat similar geography, each country reviewed has a distinctive approach to policy and has specific strengths and deficiencies. A number of problems concerning water supply are common to all four countries:

- a looming water shortage;
- little popular awareness that regional water resources are finite, coupled with a widespread perception that government has the ability to provide abundant water;
- inappropriate tariff structures, poor cost recovery, and problems in getting users to pay for the water supplied;
- an emphasis on installation of water-supply systems, rather than on their maintenance;
- inadequate water-management education, training, and support for rural users;
- serious environmental-degradation problems, particularly relating to rural land management;
- poor coordination among water-management agencies; and
- inadequate attention to sanitation.

More positively, there is a wealth of water-management experience in the subregion. Now that South Africa has moved beyond apartheid, targeted regional-cooperation initiatives may become possible, with benefits to the subcontinent as a whole. Lesotho, for example, has many years of experience in developing low-cost, low-technology, community-driven rural water schemes. Swaziland has experience in using Afridev pumps, which many regard as the most accessible and manageable borehole technology for rural women. South Africa has excellent technical expertise and an impressive record in the development of bulk water-

supply infrastructure, and the model Namibia has recently developed for managing rural water supply has widespread application. However, there are some problems in the area of water management:

- lack of demand-management strategies;
- absence of any sustainable grazing-management systems in key water-supply catchments;
- poor record of skills and technology transfer, especially at local levels; and
- lack of government realization, policies, or actions regarding the need for water-supply education and training focused on rural women, even though women's community ties are strongest and their benefits from improved water-supply schemes would be the most significant.

Despite critical water shortages, either current ones or those expected in the not too distant future, policymakers pay little attention to curbing the demand for water or creating incentives for water conservation. The people of southern Africa believe that their respective governments can supply unlimited quantities of water indefinitely, and the governments themselves seem to be labouring under the same misconception. The attention being given to new and elaborate water-supply engineering projects by recently democratically elected governments suggests a fixation with supply-based solutions. Whether this is the preference of the politicians or of the engineers advising them is not clear. However, there does seem to be a reluctance of governments to control consumption or practices that threaten the sustainability of water supplies. Indeed, it has been suggested that some water-supply agencies are unsupportive of non-drought-related water-conservation initiatives because of the prospect of reduced revenue. Increased international encouragement for governments to consider and adopt one of the many types of demand-management strategies may well be justified. The development and tailoring of such strategies to the individual countries and situations could be a primary area of research.

Southern Africa is reasonably well off in terms of water-supply skills. However, these continue to be vested in a centralized minority, many of whom are expatriate. Apart from the recent training efforts of Namibia, which have still to bear fruit, there are few, if any, programs to transfer water-supply and management skills to individual rural communities. Furthermore, there is no evidence of governments' acknowledging the indigenous skills that have historically enabled rural communities to secure reliable water supplies before reductions in river flows resulting from upstream development and population increase. The belief that rural communities are simply incapable of looking after their own water-supply systems

still prevails in many government departments, although it is seldom openly admitted. One result of this is that no attempt is made to educate communities about the reality of the water situation in the region and thereby provide a foundation for future water conservation.

Finally, broad consensus can be found in the development agencies of all four nations that there is considerable merit in focusing water-supply education and training on rural women. Their community ties are strongest, and they benefit most from improved water-supply schemes. However, this realization is not, as yet, reflected in either the policies or the actions of governments.