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Sustainable development of water resources in a semiarid country such as Namibia

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Abstract In an arid to semiarid country, such as Namibia, water may be the single most important limiting resource in sustainable development. The planning and operation of surface water supply must therefore take into account the natural variability and unpredictability of the rainfall and river flow. Environmental water requirements of unique wetlands at the mouths or deltas of internationally shared rivers have to be duly considered should any form of development be undertaken. Historically the westward flowing rivers were opportunistically utilized by nomadic people and their cattle. An increase in population has resulted in increased pressure on the limited available resources. In the event of construction of dams on the ephemeral rivers, careful consideration has to be given to the possible effects on the downstream sites in these linear oases. All of the above factors point to the need for improved hydrological monitoring and modelling in arid zones with inherently uncertain hydrological regimes.

AVAILABLE WATER RESOURCES

Namibia is the driest country in sub-Saharan Africa. Rainfall is low, varying from 600 mm year^{-1} in the northwest to less than 50 mm year^{-1} at the coast, and its occurrence, which is limited to convective showers during the rainy season from October to April, is extremely variable both in space and time. This is coupled with high evaporation rates, resulting in a deficit in surface water resources over most of the country. River flow occurs only as a result of direct surface runoff during and after rainfall events, and all streams in the interior are ephemeral, showing no flow at all during the drier years. The rivers flowing through the Namib Desert in the west of the country reach the Atlantic Ocean only in some years and most other river systems in the interior are endoreic.

The only perennial rivers are those on the northern and southern borders of the country, which are fed from drainage basins with more favourable rainfall and runoff characteristics in Namibia's neighbouring countries. Some comparative statistics given in Table 1 illustrate the very low and unreliable features of the interior rivers as well as the apparent lower regime during the past 15 years, as described also by Van Langenhove *et al.* (1996).

Groundwater forms a substantial part of the water resources in Namibia, with a large artesian aquifer in the southeast, alluvial sand beds in many ephemeral rivers, karstified groundwater systems in the north and relatively small fractured aquifers throughout the country.

Table 1 Flow characteristics of Namibian rivers.

River/site	Mean annual runoff (Mm^3 $year^{-1}$)	Median annual runoff (Mm^3 $year^{-1}$)	Ratio median/ mean	Coefficient of variation	Mean over last 15 years (Mm^3 $year^{-1}$)	Ratio: mean 15 years/long term mean
Kunene at Ruacana	5 053	4 448	0.88	0.469	4 618	0.91
Okavango at Mukwe	9 753	9 440	0.97	0.231	8 452	0.87
Kwando at Kongola	1 052	795	0.76	0.640	-	-
Zambezi at Katima Mulilo	36 744	33 193	0.90	0.401	26 850	0.73
Ugab at Sebraskop	19	9	0.49	1.432	19	1.00
Swakop at Okahandja	16	9	0.57	1.409	11	0.65
Fish at Hardap	164	80	0.49	1.582	76	0.46
Total for ephemeral rivers	< 1000	-	-	-	-	-

CURRENT AND FUTURE WATER DEMANDS

Namibia has a population of about 1.4 million people, and a growth rate of 3% per year. The average population density of only 1.6 persons km^{-2} is low compared to the African average of 18 persons. The distribution of the population, from du Toit *et al.* (1994) is shown in Fig. 1. More than half of the population is concentrated in the north, along the perennial rivers on the border and in the ephemeral Cuvelai Delta, where most people are engaged in forms of subsistence agriculture, mainly dry-land crop cultivation and stock farming. The remainder of the country is sparsely populated and suitable for extensive stock farming. Irrigation based agriculture is at present limited to a few selected sites, mainly along the border rivers. Commercial economic activities are centred around mining and fishing industries, which primarily take place around the capital Windhoek in the central area of Namibia and along the central west coast, where the Walvis Bay harbour, the Swakopmund and Henties Bay holiday resorts and the Rössing uranium mine are situated.

Increasing pressure on the limited water resources results from the high population growth rate, of 3%, as well as the uneven spatial distribution of the population relative to the available resources.

WATER SUPPLY POLICY

The objective of the Namibian Department of Water Affairs is the supply of water in sufficient quantities and of acceptable quality from the available resources, on a

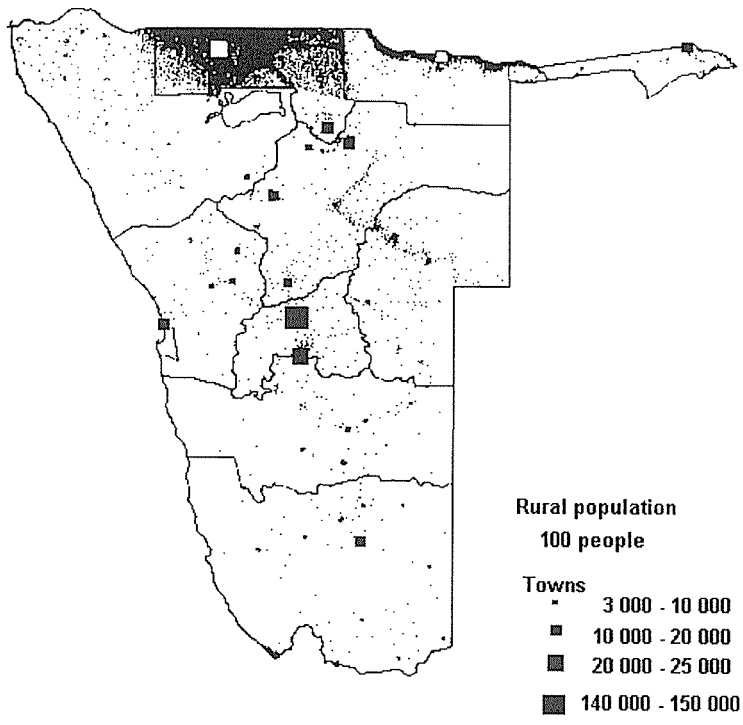

Fig. 1 Distribution of population in Namibia.

sustainable and environmentally sound basis, by utilizing affordable means, to meet the reasonable demands of the consumers.

PRESENT AND FUTURE WATER DEMAND AND SUPPLY

Table 2 shows the volumes of bulk water supplied by the Department of Water Affairs to the various groups of users during the period 1989-1994. This excludes water used by farmers from their own boreholes, wells, small dams and access to perennial rivers. Groundwater sources meet approximately 57% of the water demand, with the remaining 43% being supplied from surface water resources: 20% from surface water storage schemes in ephemeral rivers and 23% directly from flow in the perennial rivers.

Expectations for a rise in living standards, coupled with large scale migration to urban centres, are likely to increase domestic water supply challenges in the future. As an example, the projected water demand for Windhoek is expected to double in the next 20 years, and the future need for improved capacities of existing water supply sources and for the development of new sources is evident.

Because most potential water sources in the interior of the country are already fully utilized, the importation of water from the country's border rivers and the introduction of alternative sources are being considered. For a combination of reasons, such as longer

Table 2 Bulk supply of water by the Department of Water Affairs.

User group	Supply in million cubic metres					
	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995
Human consumption	41.31	42.35	46.12	44.37	48.70	56.81
Stock drinking	5.99	5.43	6.88	6.39	5.76	6.03
Irrigation	32.51	30.60	29.07	22.26	30.37	32.66
Mines	7.79	7.47	6.10	5.41	5.07	5.00
Total	87.60	85.85	88.17	78.43	89.90	100.50

distances, availability of water and other uses, for instance for hydropower, it is not considered to be feasible to use water from the Kunene, Kwando, Zambezi and Orange Rivers. Importation from the Okavango River to the central area, and desalination of sea water at the coast and brackish water in the northern areas are the most likely new sources that will be introduced in future.

SUSTAINABLE UTILIZATION OF WATER RESOURCES

Sustainable water supply development implies the use of water in such a manner that no adverse effects are induced for people or ecosystems that have been dependent on the availability of natural water resources, and in a way that sufficient quantities of acceptable quality will be available to future generations. As ever increasing agricultural and domestic demands are placed on the resources, the basic water related requirements of the environment should be given attention. This is in particular the case for some ephemeral rivers and the few wetlands in Namibia.

The westward flowing ephemeral rivers have formed linear oases supporting unique flora and fauna in the arid Namib Desert. Traditionally these river courses were used opportunistically by nomadic pastoralists. Increase in population density has limited the movement of such people and their livestock during times of drought, placing pressure on the environment. It is therefore important that the present degree of utilization is not further increased.

Wetlands are a rare ecosystem type in Namibia, making up only an apparently insignificant percentage of the landscape. Most of these wetlands are ephemeral and are of a fragile nature, requiring special management. They are, however, important both in socio-economic and environmental respects and the increasing population and associated demand for water is placing them under threat. The preservation of their biodiversity and assurance of minimum water requirements for life support is essential.

The apparent change in hydrological regime, resulting in a decreasing trend for river flows, as illustrated in Table 1, is an important factor to consider for the development of the water sources affecting these sensitive ecosystems. Continued hydrological monitoring is therefore of the utmost importance.

AFFORDABLE MEANS FOR INCREASED SUPPLY

The map in Fig. 2 shows the most likely sources of water for different regions in Namibia. The policy followed in water supply development is that local resources are tapped first. Once these are being fully utilized regional resources are considered and finally national ones.

Technological improvements often make it possible to utilize a particular source more efficiently. An example was the construction in Windhoek in 1969 of a recycling plant which enabled the use of purified sewage water to drinking standards for domestic use. The viability and affordability of other alternative sources are being investigated such as desalination of sea water and saline groundwater as well as small-scale fog harvesting.

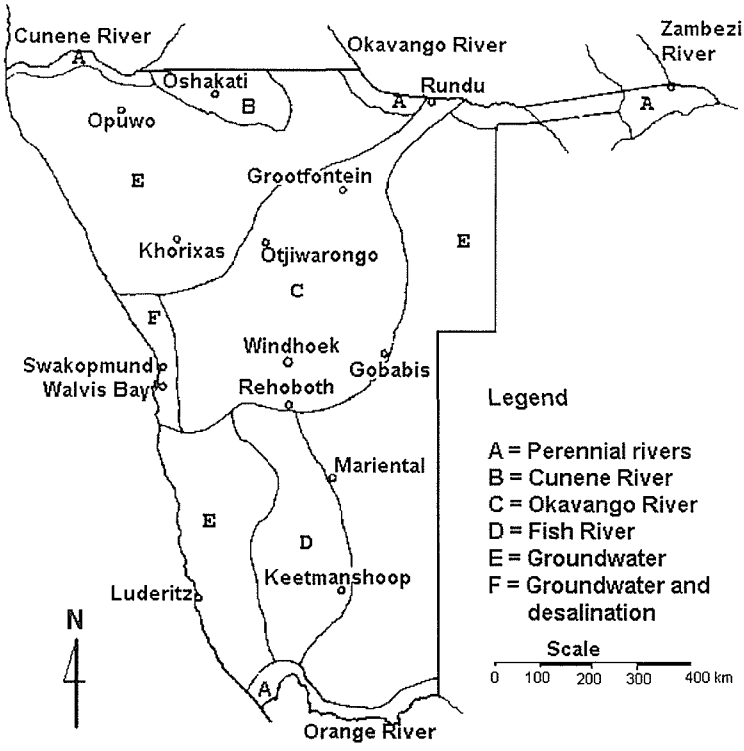

Fig. 2 Water resources strategy in Namibia.

DEMAND MANAGEMENT

There is a limit to the optimization that can be achieved by technological advances. In the past water saving measures and restrictions were introduced only at times of drought because of water supply problems. There is, however, an increasing awareness that this approach should be phased out and that sound long term water supply management

should include sensitization of all end users to the scarcity of this commodity. Especially in the capital Windhoek, strict water utilization measures, for instance for the watering of gardens, and differential water tariffs have become a permanent feature.

CONCLUSIONS

Recent changes have been detected during the last 15 years in flow regimes in both ephemeral and perennial rivers. Changes in the rate of replenishment of renewable resources need to be accurately recorded and this points to a need for improved hydrological monitoring. The increasing need for a holistic approach to basin management points also to a need for improved tools for modelling and system analysis.

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