Science, Water and Sanitation:

Supporting Equitable and Sustainable Development in southern Africa

Applying scientific thinking in the service of society

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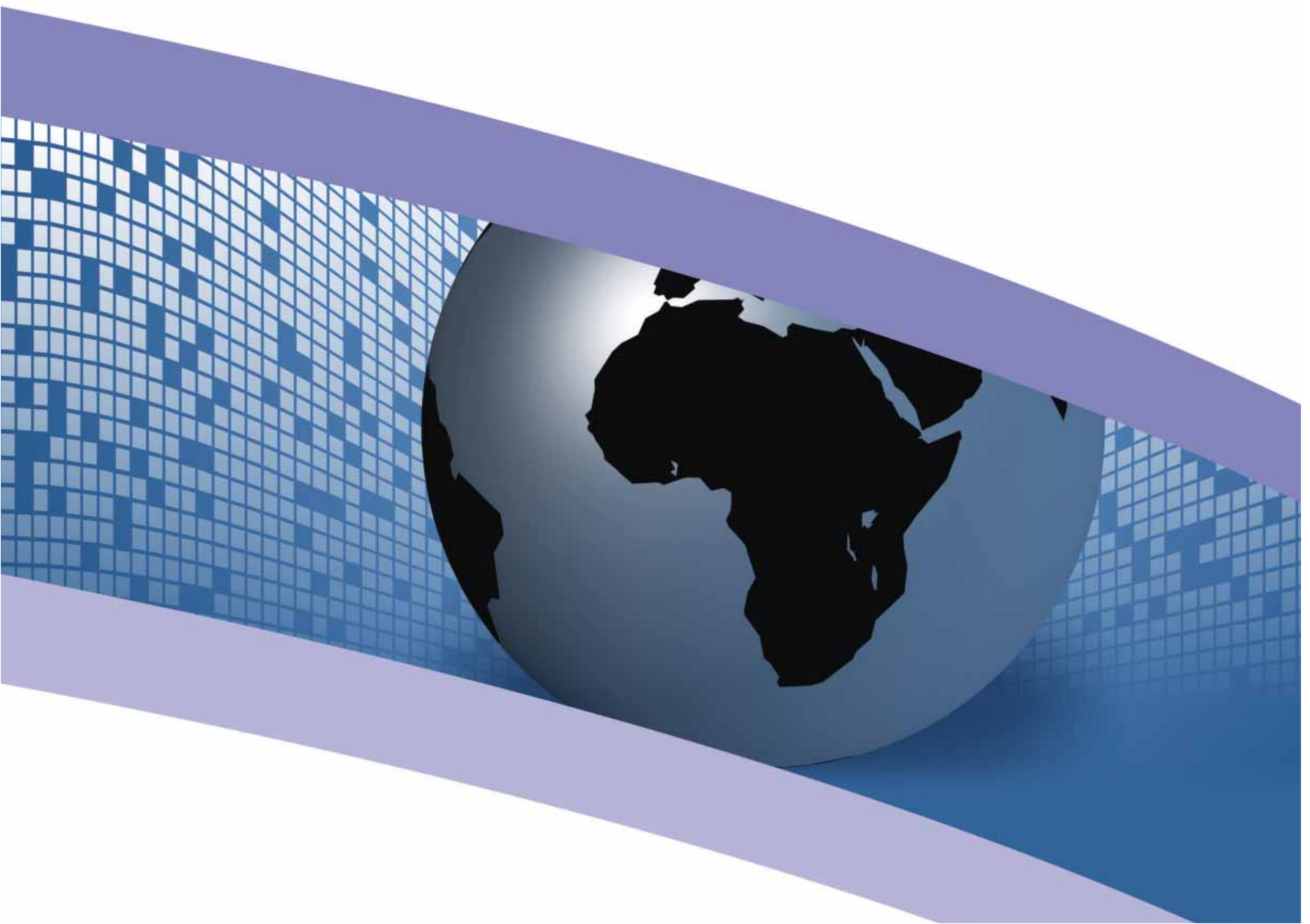
The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996 in the presence of then President Nelson Mandela, the Patron of the launch of the Academy. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science for the benefit of society, with a mandate encompassing all fields of scientific enquiry in a seamless way, and including in its ranks the full diversity of South Africa's distinguished scientists.

The Parliament of South Africa passed the Academy of Science of South Africa Act *(Act 67 of 2001)* which came into operation on 15 May 2002. This has made ASSAf the official Academy of Science of South Africa, recognised by government and representing South Africa in the international community of science academies.



Statements from Academy Presidents

Water is life, and its availability is a global concern as a result of unsustainable lifestyle patterns that we have encouraged over the years. In the face of increasing scarcity due to climate change and global warming, our first step is to use available and new technologies to harvest, store and thriftily use water, along with recycling of used water. For this, we have to start with education at all levels to alert our people.

Professor Soodursun Jugessur
President, Mauritius Academy of Science and Technology

Mozambique´s water resources are characterised by high spatial and temporal variability, influenced by the climate of the region. The country is faced with challenges of inadequate infrastructure capacity for water management, compounded by issues of low human capital to lead the transformation of the water sector to meet the global objective of improved access to water and sanitation, and water for economic development. The Academy of Science of Mozambique is committed to fostering science to inform water sector development. In this context, human capital and decision-making based on sound knowledge are fundamental to national development and regional integration in the context of water resource development and management.

Professor Orlando Quilambo
President, Academy of Science of Mozambique

Improving our understanding of the state of water in southern Africa is pivotal for future planning to ensure that the region has a long-term, sustainable supply of clean water. Access to water and sanitation remains a challenge in southern Africa and it is important for policy-makers across the region to work together to ensure that water planning is beneficial to all people and countries. It is also important for researchers and academics to work closely with one another to ensure that new policies take into account the latest research and technologies. In addition, it is important to make provision for skilled human resources required to manage waters resources. By highlighting the key issues and opportunities in various aspects of the water sector, we hope that this booklet will act as a guide and baseline for policy-makers and researchers.

Professor Robin Crewe
President, Academy of Science of South Africa

This report on water in southern Africa could not have come at a better time. The onset of climate change adds to the need to review the effectiveness of current water policies. The region is now witnessing frequent droughts, while at the same time experiencing floods within the same localities. The proportion of people with no access to clean water and sanitation in the region is unacceptable. There is a need to invest in primary, secondary and tertiary water treatment levels to increase access to clean water and sanitation for all. In addition, the region has to invest in technologies to conserve and recycle water. There is an urgent need to have policies that rationalise the use of water.

Dr Mwananyanda Mbikusita Lewanika
President, Zambia Academy of Sciences

Most parts of southern Africa, including Zimbabwe, lie within a semi-arid zone characterised by high seasonal, inter-annual, and multidecadal variability of available water resources. The same region is experiencing a rapid growth in water demand due to population growth, improvement of lifestyles, high urbanisation rates, and expansion of agricultural and industrial activities to meet the needs of the growing population. Climate change will affect both the availability and demand for water. Sustainable water resources management in southern Africa requires improvement in the understanding of the nature and causes of the variability of water resources at various temporal and spatial scales, and how to achieve an appropriate balance between the demand for water including environmental water requirements and available water resources. An integrated approach to water resources management has been widely accepted as being most appropriate in southern Africa. There is however a need to improve knowledge about operationalising this concept in the various socioeconomic, cultural and political settings in southern Africa.

Prof Chris Mutambirwa
President, Zimbabwe Academy of Sciences

The aim of this policy-makers' booklet is to outline the role that science academies can play in assisting policy-makers and managers to address some of the key water challenges in the southern African region. This is part of a process of building a strong partnership between the science community and government actors. It is intended to be useful to policy-makers in the water sector, and to policy-makers in those sectors that are major water users, such as the agricultural, industrial and mining sectors, as well as those with a mandate to protect the natural environment and whose policies and decisions impact directly or indirectly on water quantity, quality and accessibility.

The booklet is focused on six countries, namely Zimbabwe, Zambia, Mauritius, Mozambique, South Africa and Namibia, each of which has an established science academy, or one that is in the process of being established. However, the messages in this booklet are relevant to the broader southern African region as a whole.

This booklet should resonate with policy-makers in the southern Africa region, and together with other similar studies from East, West and North Africa, present an overview of water issues in the continent. The main aim will be to inform the African Ministers' Committee on Water (AMCOW) and other political and technical leadership in the continent.

Main Acronyms

AMCOW	African Ministers' Committee on Water
ASSAf	Academy of Science of South Africa
IPCC	Intergovernmental Panel on Climate Change
NASAC	Network of African Science Academies
SADC	Southern African Development Community
MFEZ	Multi-Facility Economic Zone
WRC	Water Research Commission

1. Introduction

Science-based policy formulation

Access to sufficient water of an appropriate quality is necessary for life, for economic growth and for social development. It underpins the well-being and prosperity of any country and any community. The challenges that lie ahead for water resource professionals, in agriculture and other disciplines, are substantial. We must continue to gain insight into how water is captured, allocated, and used in a variety of settings, while advancing our knowledge of the science and policy aspects of water resource management.[1,2] In southern Africa, there are a number of challenges in this regard, ranging from the provision, operation and maintenance of effective water services (water supply and sanitation systems) to ensuring sufficient water for economic activities in the face of frequent droughts that affect the region.

Policy-makers and managers, whether they are in the water sector, or in other closely related sectors, such as the agricultural, mining and industrial sectors, are frequently required to make decisions that impact on water. These policy- and decision-makers may be operating at the local, national, regional, or even continental scale. It is critical that their decisions are supported by the best scientific knowledge available at the time.

During the past 30 years, physical and social scientists have learned a great deal about water's role in agricultural production functions and industrial processes.[2-4] The growing scientific community in southern Africa is well placed to undertake rigorous scientific research to generate knowledge in support of evidence-based policy-making. Science plays a critical role in informing and supporting management and policy decisions in the water sector. In both regards, scientific information must be communicated to water policy-makers and managers in an accessible manner that assists them to make informed decisions.

Given this outlook, it is essential that agricultural scientists, natural resource specialists, water and sanitation engineers, and other scholars continue pressing forward to enhance the productive potential of agriculture and appropriate water and sanitation in both developed and developing countries.[5,6]

The science academies and development

There are several models for national science academies, ranging from a purely honorific function (i.e. to honour top scholars), to those that have both an honorific and a science advisory role, to those that include under the academy umbrella a range of research institutes engaged in primary research. Most academies are adopting the 'working academy model', which combines the honorific and policy advisory functions.

Science academies are independent bodies, comprising an assembly of top scholars from many disciplines who are well networked both nationally and internationally, and have shown interest in and capacity for promoting the development of a prosperous and fully enabled society. Membership of an academy is by election only, and it is both an honour and an obligation to work individually and collectively (as the academy) to ensure that decision-making requiring scholarly scrutiny and analysis is based on the best and most integrated understandings and insights available to the country.

The academies thus aim to mobilise the best intellect, expertise and experience to investigate and provide evidence-based solutions to national problems from within or outside their membership.

The academies can be regarded as the 'brains trust' of a nation, but are vastly under-utilised, particularly in Africa. They are apolitical, trustworthy and not motivated by profit, and able to foster innovation. Multi-disciplinary in nature, they feature scientifically rigorous analyses of evidence and the consensus of diverse experts, and thus they form a credible 'second opinion' in the face of politically charged issues.

Science academies can play a critical role in translating scientific knowledge into a language accessible to policy-makers and managers and in engaging with multi-stakeholder platforms to forge and maintain policy-science dialogues. They can promote networks of scientists that can address critical and emerging issues around water development and management, and work across borders to drive collaborative research.

Academies have a vital role in supporting policy-makers and managers in managing water in an era of increasing uncertainty. Academies have a role to play at national as well as at regional levels. Addressing water issues, the members of an academy represent distinguished scientists in the country who can be mobilised to provide independent scientific advice to policy-makers and water managers.

2. Water for equitable and sustainable development

Introduction

The Southern African Development Community (SADC) region faces a number of challenges in ensuring water for equitable and sustainable development. In most of these countries water resources infrastructure is underdeveloped, and significant climate variability means economic sustainability and development is hostage to rainfall.

Most of the river basins in southern Africa are transboundary in nature so that the issue of joint management of these basins is of high importance.

In terms of water supply and sanitation in the SADC region, 37% of the population relies on formal or improved groundwater supplies and 23% on reticulated supplies from surface water sources, while 40% depend on unimproved sources from either ground or surface water.[7]

Access to safe, sufficient and affordable water in rural Africa will not increase unless financing strategies are developed which ensure the sustainability of existing water services.[8] Water is a critical input to sustainable growth and development, be it at the local, national or international level. In addition to its role as a critical input in crop production, water is required for many activities at the household level.[9,10] All countries need to ensure sufficient water of appropriate quality and quantity to support their planned economic growth paths. This requires effective water resources management and adequate water supply and sanitation services.

Moreover, innovative strategies are also needed to ensure that the rural poor are adequately served.[8] In developing countries, many smallholder households have inadequate access to high-quality water for crop production, drinking, cooking, and bathing.[11]

In the context of southern Africa, there are a number of water-related challenges that, if not addressed effectively, could impact significantly on sustainable economic development and human well-being and prosperity. Some of the key challenges are highlighted below.

Water availability

Rainfall varies significantly across southern Africa, as depicted in Figure 1. Rainfall varies in time, intensity and spatial distribution across the region. Namibia is the driest of the six countries, in terms of mean annual rainfall, with large portions of South Africa also being extremely dry. Mauritius, Mozambique, Zambia and Zimbabwe all receive higher average annual rainfall than South Africa and Namibia. Interestingly, because of its greater population density, South Africa, which receives a higher average annual rainfall than Namibia, has a lower *per capita* water availability.

The region is vulnerable to irregular inter-annual rainfall variation, with frequent periods of prolonged drought, particularly in the south-west, while the northern and eastern areas are vulnerable to floods, sometimes with devastating impacts. In addition to this, many areas in the region experience high temperatures and evaporation rates.

Drought and floods cause 80% of the loss of life and 70% of the economic losses related to natural hazards in sub-Saharan Africa[12], with famine being the most severe consequence of drought. Managing floods and droughts is therefore a critical part of ensuring sustainable socio-economic development.

The level of water storage of a country is critical to ensure sufficient water during drought periods, while well-developed flood and disaster management plans are also important.

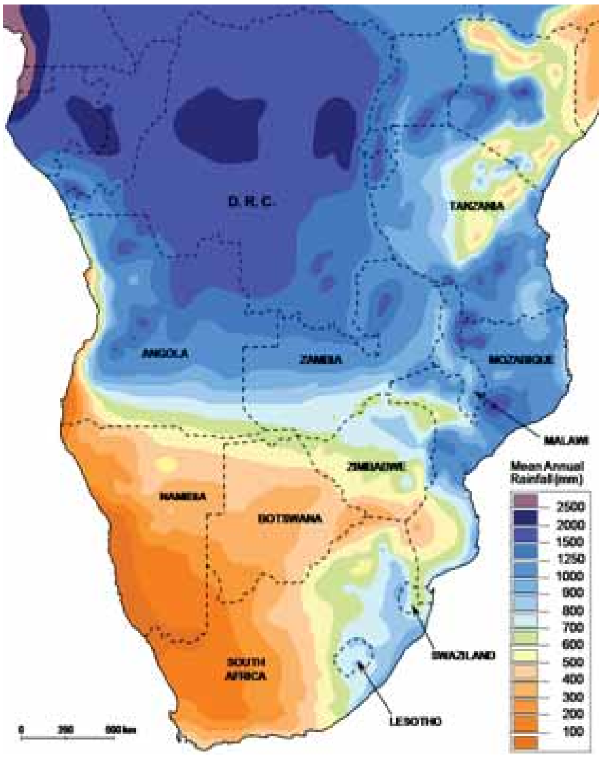


Figure 1: Average rainfall across the SADC region *(Source: Ashton, pers. comm., 2011)*

Infrastructure and agricultural use

Large and small water storage infrastructure in the region is poorly developed. Figure 2 shows the distribution of dams in the SADC region, with the concentration of dams being in South Africa and Zimbabwe. In Zimbabwe, many of the dams are relatively small, and the country is still vulnerable to periods of low rainfall and droughts. In most of the region, rainfall is limited to a few months of the year, increasing the need for effective storage to ensure water availability during the dry months. Sufficient storage is also critically needed to enable these countries to survive lengthy drought periods.

The lack of storage infrastructure has major negative social and economic impacts, particularly in a drought-prone region where insufficient water is stored to see countries through multi-year droughts. Water storage is essential for providing adequate water supply to a variety of economic activities and land uses. It should allow for the supply of drinking water, appropriate functioning of sanitation services, mining and industrial activity, as well as commercial and subsistence agriculture. Many of the region's irrigated areas face the challenge of aging infrastructure and a limited revenue base from which to fund maintenance and repairs. The drive towards full cost recovery for storage and delivery services arising from emerging water reform policies means that both water suppliers and irrigators need to consider a strategic evaluation of infrastructure and the cost of renewal.[13]

Investments that maintain water infrastructure include improvements in dams, canals, pipelines, aqueducts, pumping plants, drainage and flow-regulating structures.[14] These investments are generally for the purpose of improving the quantity, quality, timing, or reliability of water itself at the place where the farmer needs it. In much the same way as a lower cost of maintaining infrastructure improves farm income, greater amounts of water saved from that investment that is made available for irrigation use on the farm have a similar economic effect. However, water lost to poor infrastructure maintenance at one point in a river basin can result in greater water supplies at another point or another time period in the same basin.[14] Small infrastructure, such as rain-water harvesting, is an important element of water and food security at the local level.[15]

Since hydropower is an important (if underdeveloped)[3] source of energy in the SADC region, the management of water resources and water storage is critical in ensuring a sustainable energy supply throughout the year. Managers of reservoir/dam projects that store and channel water for irrigation and generate power are faced with a decision on how to allocate the joint costs common to both activities. These costs are allocated between irrigators and power consumers, including costs of construction and maintenance of the dam and reservoir.[13]

Groundwater is also important, particularly for providing drinking water sources to rural communities, stock watering, and the domestic needs of small towns.[7] However, there is insufficient awareness of and ability to implement effective management of groundwater in the region, despite the fact that groundwater is the source of water for more than 70% of the population.[7] Further research into groundwater potential and sustainable abstraction is needed.

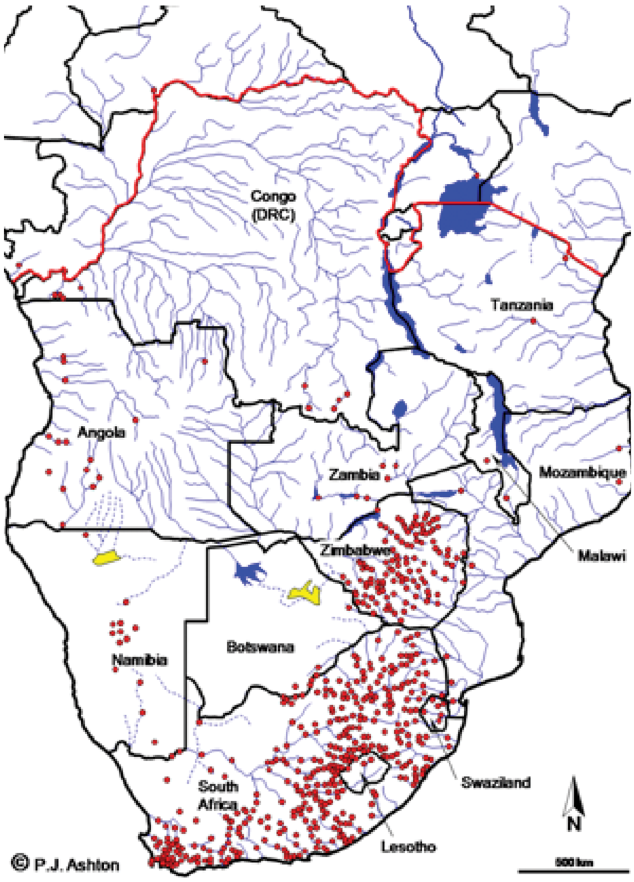


Figure 2: Distribution of large dams in SADC *(Source: Ashton and Turton, 2009)*[16]

Box 1: Water Augmentation to the Central Areas of Namibia through Managed Aquifer Recharge

Namibia is the most arid country in sub-Saharan Africa and is largely dependent on groundwater. Perennial rivers are only found on the northern and southern borders of the country, but they are a considerable distance from the major demand centres such as the capital city, Windhoek.

The main source of water supply to the larger urban centres in central Namibia is from dams on ephemeral rivers. Inflow into these dams is irregular and unreliable, and evaporation rates in Namibia's arid climate are high. The assured safe yield of these dams is consequently low. Increasing water demand in these areas will result, in the near future, in existing water resources not being able the meet the expected demand in a sustainable way.

The best option for alternative water supply augmentation to the central region was found to be the creation of a water bank through managed aquifer recharge of the Windhoek Fractured Rock Aquifer, in combination with deep boreholes. This managed aquifer recharge option involves taking water from the 3-dam system when there is surplus water available, purifying it and injecting it into the Windhoek Aquifer via the boreholes. This will reduce evaporation losses at the dams. In years when surface sources are insufficient, the stored underground water can be abstracted. The managed aquifer recharge project needs to be fast-tracked as water shortages and non-availability in times of drought will have a devastating effect on the economy. Windhoek contributes approximately 50% of the manufactured goods in the country (excluding fish processing on shore), and the closure of industry due to non-availability of water would result in a loss estimated at N$ 5.04 billion per year.

Water quality

The degradation of water resources is a common concern across the region. The challenges include loss of aquatic habitats, alien plant invasions in rivers and dams, and deteriorating water quality arising from industrial, agricultural and domestic pollution. Soil erosion from poor land-use practices results in increased sedimentation in dams and rivers, while increased nitrates and phosphates from agriculture are causing eutrophication in many areas. Mining is also a significant cause of pollution in some areas. Wetlands play an important role in water quality by filtering out nutrients, pollutants and sediment.[16] However, wetlands in many parts of the region have been drained for agriculture or infrastructure development, or have been affected by reduced river flows, over-harvesting of reeds and other materials, and choking by invasive species. Combining technologies is of particular relevance when considering water quality. There is a link between quality and quantity of water and there may be a perceived trade-off between supplying water of high quality and increased quantities of water for productive purposes that do not necessarily have to be treated or disinfected.[16] There are different (combinations of) technology options for dealing with the potential trade-off between increasing water quantity and quality. In this case, not only costs, but user priorities, should be considered.

Groundwater is widely used for domestic water supply across the region, and increasing pollution of groundwater is a particular challenge as domestic water supplies from groundwater are seldom treated before use. The challenge is exacerbated by the difficulties in rehabilitating groundwater sources once they have become polluted.

Box 2: Use of Isotope Techniques in Sustainable Development and Management of Groundwater Resources in Zambia

The intention of this project was to contribute to the development of a sustainable groundwater management system through identifying all potential sources of pollution, determining the extent of pollution and identifying the main groundwater recharge zones. This information would be used in the development of guidelines for the protection of groundwater resources from pollution.

Isotopic results showed that the recharge area for Lusaka's groundwater was a Lusaka South Local Forest Area where the government intended to put up a Multi-Facility Economic Zone (MFEZ). From the Lusaka South Forest Area the groundwater flows north-west into the city. The borehole microbiological results indicated that almost all the unplanned settlements in Lusaka were contributing to faecal contamination to Lusaka's groundwater through pit latrines.

The results of the study contributed to making provisions for regulating groundwater in the newly enacted Water Resources Management Authority Act of 2011.

Ecosystem protection

Most of the countries in the region have committed themselves to environmentally sustainable water resources management, and the protection of aquatic ecosystems as a crucial element of integrated water resources management. The translation of this commitment into practice has proven difficult.

Aquatic ecosystems offer a range of goods, services and attributes in the form of fish, reeds, water for productive or spiritual purposes, or water purification services, that generate value and contribute to human welfare. The deterioration of aquatic ecosystems thus has direct and long-term consequences from an economic, social and ecological point of view as the natural capital is consumed at a faster rate than it can regenerate and the goods and services that should be provided diminish.[17]

Climate change

Climate change will add to the water challenges in southern Africa. Figures 3 and 4 below show the projected temperature variations and the projected changes in rainfall as determined by the Intergovernmental Panel on Climate Change (IPCC).[18]

In summary, Figure 3 indicates a broad trend of decreased precipitation across the region, particularly during the winter months, while Figure 4 indicates a significant rise in temperature across the region. The changes in rainfall vary when observed at a finer scale. Changing precipitation and temperature conditions will alter the distribution and availability of freshwater resources. Temperature increases (Figure 4) combined with decreases in precipitation (Figure 3) are likely to affect the scope of water control options available and the costs of these different options.[19] It should be noted that while most of the climate change models agree on the likelihood of increasing temperatures across the region, there is little agreement on whether climate change will increase or decrease rainfall in a number of areas, with different models showing very different trends.[20] Nonetheless, there is a strong likelihood that droughts and floods will escalate in intensity, with droughts posing a particular challenge to the region. Increased temperature will result in increased crop stress and crop water needs, with potential impacts on food security.[20]

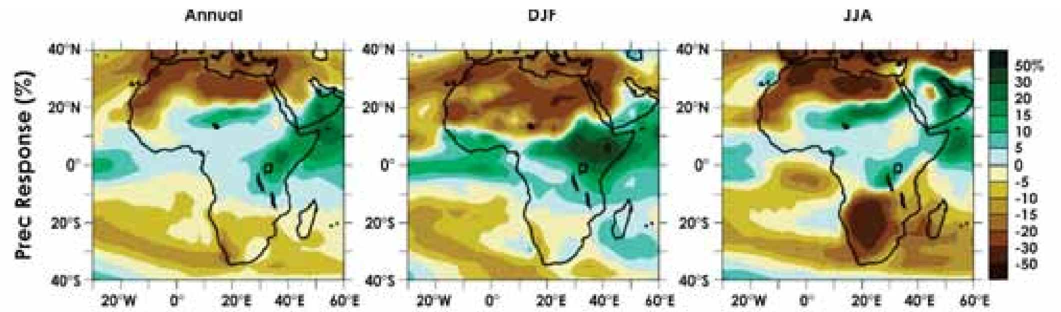


Figure 3: Projected rainfall variance in Africa (until 2099) as a result of climate change
(Source: Christensen et al., 2007)[18]

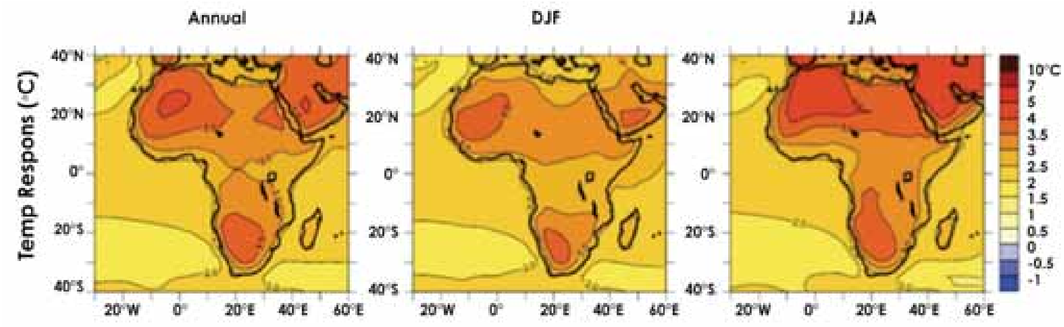


Figure 4: Projected temperature variance in Africa (until 2099) as a result of climate change
(Source: Christensen et al., 2007)[18]

Improved water resources and water services management are a critical part of any strategy for adaptation to the impacts of climate change. Improved transboundary water resources management will also be needed to deal with the fact that climate change will impact on the amount, quality and timing of water flowing across country borders.[21]

3. Water supply and sanitation provision

Introduction

The provision of safe drinking water and adequate sanitation facilities is critical to improving the health and well-being of a population, as well as to supporting economic development. The World Health Organisation (WHO) estimates the return on a US$1 investment in improved water supply in developing countries as being between US$5 to US$28.[22]

Provision of water supply and sanitation

Provision of water supply and sanitation across the region varies greatly, with Mauritius having the highest levels of service provision based on studies undertaken in 2008 (Figures 5 and 6). Mozambique and Zambia are the worst off of the six identified countries in terms of the provision of water supply and sanitation. The provision of adequate sanitation lags well behind the provision of water supply, with rural sanitation being particularly poorly addressed (Figure 6).

The majority of poor rural communities are dependent on groundwater for domestic water supply. However, only a few of the SADC countries are monitoring groundwater use effectively and managing it sustainably. Contamination of groundwater is exposing millions of people living in rural areas to water-borne diseases.[22]

Figures 5 and 6 below highlight the percentage of population with access to improved water sources and sanitation in urban and rural areas. While the data provide us with a basic measure of progress, or lack of progress, regarding the provision of water and sanitation coverage and the region's strive towards achieving the Millennium Development Goals set for 2015, there is a further need for more conclusive and detailed data as a basis for decision-making.

The issue of operation and maintenance is critical in the provision of ongoing and effective services. Poor operation and maintenance have, in many cases, contributed to increasing levels of water wastage through leakages, with increasing demands being imposed on limited water resources and water treatment works as a result.

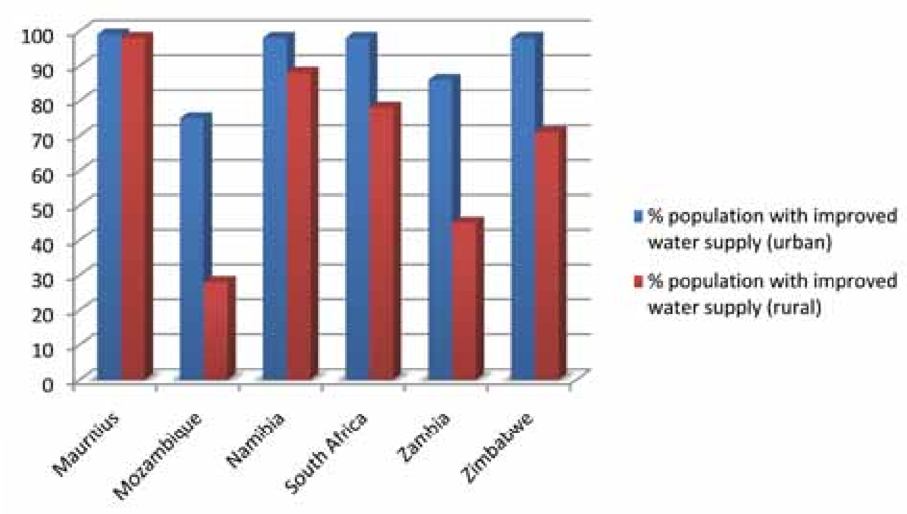


Figure 5: Percentage of population with access to improved water sources; urban and rural in 2008
(Source: www.wssinfo.org)

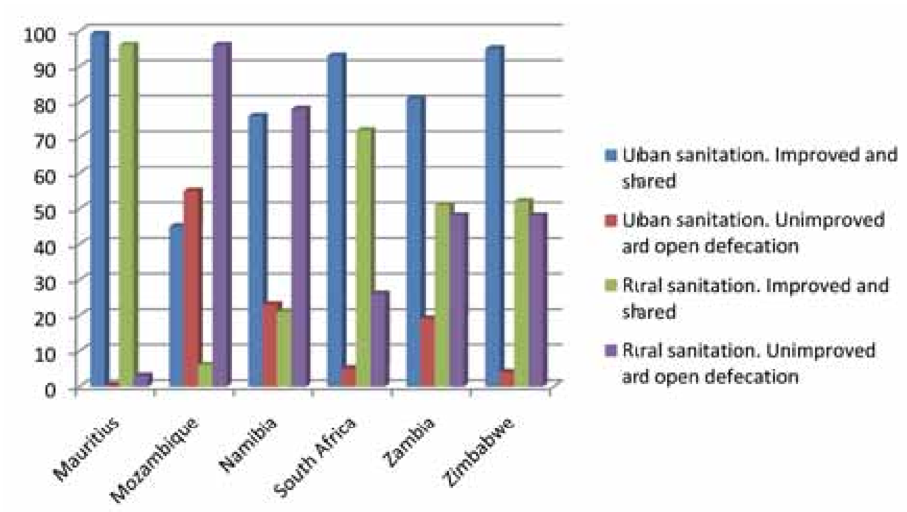


Figure 6: Percentage of population with access to sanitation services by four categories in 2008
(Source: www.wssinfo.org)

Box 3: New Goreangab Water Reclamation Plant

Windhoek, the capital of Namibia, lies in the central highlands of a country classified as the most arid in sub-Saharan Africa. Perennial rivers lie 750 km either to the north or south. Continuous growth since early 1900 put natural water resources, underground as well as surface water under stress. Direct drinking water reclamation from the Goreangab Reclamation Plant, has been a reality since 1968. Potable reclamation is a fixed part of the water supply and waste water has become an indispensible resource for the survival and continued growth of the city.

Reclamation is based on the multi-barrier principle to ensure consistent high-quality potable water. The scheme has operated reliably and has saved Windhoek numerous times from severe water restrictions. In this way, potable reclamation has contributed to a stable economy despite severe droughts and water shortages.

4. Key Messages

The key messages are derived from a consultative processes with experts and literature review as highlighted in earlier sections of this booklet.

Ensure access to reliable data

Perhaps one of the greatest challenges facing the water sector in the six countries is access to reliable data, in both the water resources and water services sectors. These challenges include poor monitoring and physical and chemical analyses infrastructure and inadequate information systems for water resources, unreliable data on water use and water loss in municipalities and by different sectors, and inadequate data on access to water and sanitation.

National governments have a critical role to play in providing the necessary infrastructure and systems for the collection of reliable data. The science community, on the other hand, has an important role to play in identifying data needs, providing a scientific basis for setting data-quality standards, and developing innovative technology for monitoring and analysing various aspects of water.

Equally important, however, is the role of both government and the science community in ensuring that data and information are widely and easily accessible to all, including to the research community.

Develop human and institutional capacity

Limited human resource capacity in both the technical and managerial fields is a key weakness in the ability to deliver sustainable water services and to manage water resources effectively in all of the countries. The building of appropriate capacity includes:

Building human resource capacity in the management and technical fields

Increasing research and knowledge generation and facilitating communication across the science/management divide.

Making sure that the related institutional arrangements are relevant and adequate and can be realised with available human capacity and other resources. To this end, the critical role of local and traditional structures should be recognised, and where necessary emphasised.

Ensuring good governance of water sector institutions

Both the state and the universities have a major role to play in building human and institutional capacity in the water sector, ensuring appropriate education, training and exchange and in building, in particular, centres of research excellence in the water sector. One recommendation is to establish a national structure that will lead and coordinate research on water in each country or in the region. The Water Research Commission (WRC) of South Africa is an example of such a structure.

The Water Research Commission of South Africa

The WRC is a statutory body which was established by an Act of Parliament, the Water Research Act of 1971 (*Act 34 of 1971*). Recognising that water would be one of the limiting factors in South Africa's economic development in the 21st century, it was deemed necessary to generate new knowledge and to promote the country's water research purposefully. Thus the WRC was established to:

- promote co-ordination, co-operation and communication in the area of water research and development;
- establish water research needs and priorities;
- stimulate and fund water research according to priority;
- promote effective transfer of information and technology;
- enhance knowledge and capacity-building within the water sector.

The WRC is funded through a unique model – the government imposes a small levy on permissible water use per each hectare of land and from a metered water supply for purposes other than irrigation of land. This levy is ring-fenced for water research purposes and forms the WRC budget. The levy is revised as necessary. As of August 2010, R4.16 was levied in respect of each hectare of land permitted under the control of an irrigation board or water management institution, and 4.05 cents per m^3 in respect of metered water supplied from government works for purposes other than the irrigation of land. The WRC funds about 300 research projects annually and since most of these are multi-year projects, they allow for the support of postgraduate studies (about 500 students per annum).

Improve infrastructure provision and maintenance

Apart from South Africa, there is limited water resources storage infrastructure in the region, making countries vulnerable to droughts and to the impacts of climate change. Further, water resources and water services infrastructure, including large dams, irrigation canals, pumps, water and waste water treatments works, and reticulation systems are often poorly maintained, resulting in safety issues and water wastage.

In four of the countries, there are still large numbers of people with inadequate access to water and sanitation infrastructure and related services. High levels of illegal connections result in water theft, reduced revenue and high rates of water loss.

There is thus an urgent need for the development, operation and maintenance of appropriate infrastructure, according to clear standards. Equally, however, there is an ongoing need for technological innovation in the sector to improve water delivery and management, to reduce costs, and to ensure that systems are appropriate to the African context. The science community has an important role to play in this regard.

Address investment and financing

Inadequate financial resources, in relation to capital for service-provision infrastructure development and expansion, are cited as challenges in most of the countries, and for operation and maintenance in all of the countries. Poor revenue collection for water services remains a major challenge that impacts on the ability to deliver sustainable services. This links to a weak understanding of actual costs of service delivery, insufficient investment in maintenance, and a reluctance in government to increase water tariffs.

The nature of the water sector means that the state, at various levels, has a critical role to play in financing water projects and in ensuring the effective financing of operation and maintenance of infrastructure over time. Innovative approaches to financing should include the use of private sector financing in appropriate contexts.

Adapt and mitigate implications of climate change

Considerable further work is required to understand fully the implications of climate change and appropriate mitigation and adaptation response. This is particularly true at the catchment level. This requires further research and investment, including improved flood management, extended hydrological gauging networks, improved hydrological modelling, improved groundwater modelling, improved data processing, appropriate drought management, enhanced disaster/risk management and improved communication and transfer of information.

In addition, it is important for government to mainstream climate change considerations into all water-related decisions, whether water resources or water services, to ensure appropriate responses to impending future changes.

Manage water quality

There are two critical aspects to managing water quality that need to be addressed – protecting the water quality in surface and groundwater resources, and ensuring safe drinking water quality. The former links to issues of pollution control and treatment, including pollution from domestic, agricultural, industrial and mining waste. The latter requires effective treatment of water to potable standards, in urban and rural areas.

In managing water quality, it is important to recognise that prevention is better than cure, that there are always upstream and downstream linkages, and that the cumulative impacts of small polluters may be severe. The management of diffuse pollution is a particular problem that the scientific community should assist the state to manage.

Address sanitation challenges

Sanitation delivery has lagged behind the delivery of water services in the region. There are a number of challenges around ensuring appropriate sanitation, including issues of sustainable, waterless or low water-use sanitation that are appropriate to the local context.

A further challenge that should be addressed in the region is how to manage productive and safe wastewater, excreta and faecal sludge for nutrient re-use in agriculture and aquaculture, and how this can improve food production and enhance resilience to climate change. This includes understanding not only the science, but investigating suitable business models, and addressing the social aspects as well.

5. Conclusion

The combination of science, engineering, management and people presents the best option for achieving sustainable water management, particularly in the face of climate change. The scientific understanding of water, in all of its challenging complexity, will remain essential in these efforts.

In meeting the current and future challenges, science and technology must respond to the needs of the people in the basins. Public officials and natural resource managers should increase their use of recommendations arising from scientific investigation, and provide support and use of new and appropriate technologies. The role of science should be emphasised in water management. A strong partnership between the science community, the decision-makers, water managers, and the people living in the basins, provides a remarkable opportunity to ensure sustainable and appropriate water resources and water services management in the region.

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