Protocol for the Assessment of the Status of Sustainable Utilization and Management of Groundwater Resources with Special Reference to Southern Africa

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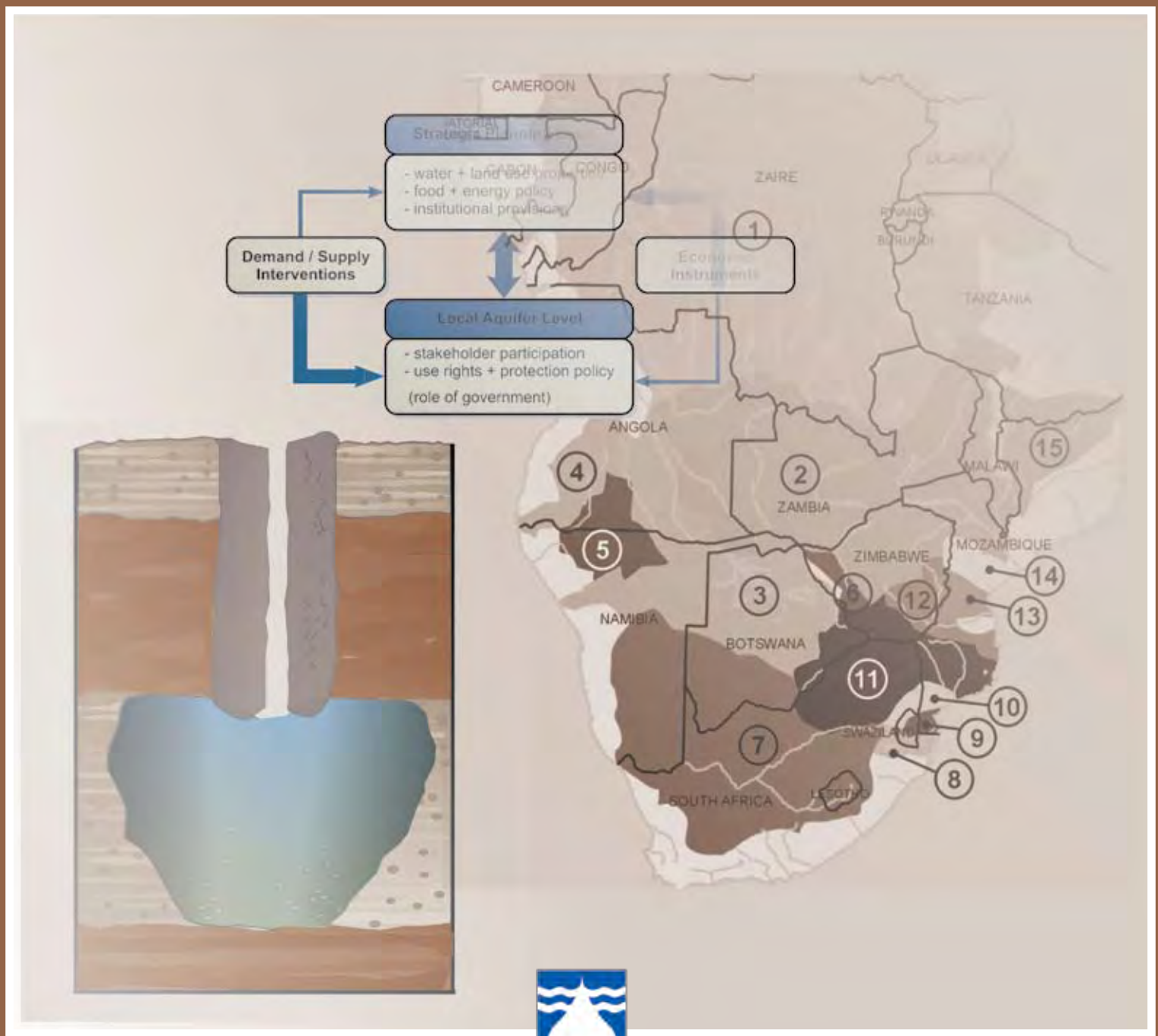

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Water Research Commission

Protocol for the Assessment of the Status of Sustainable Utilization and Management of Groundwater Resources with Special Reference to Southern Africa

by

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1. EXECUTIVE SUMMARY

Southern African members of the Technical Advisory Committee (TAC) of AMCOW (African Ministers' Council on Water) have requested an assessment of the status of groundwater resources management in Southern Africa. The purpose of the assessment will be to position the region for a possible piloting of the recent resolutions of AMCOW regarding groundwater resources management in Africa. The Water Research Commission undertook to fund the development of a methodology for this purpose and the testing of the protocol with readily available information for the region. As a follow up, the GTZ of Germany had indicated funding support for a strengthening of the assessment, in particular through a multi-stakeholder workshop in the region.

The approach adopted was to assess the groundwater resources management status in SADC based on available groundwater documents and scientific literature from the area and weigh it up against some form of generally accepted 'best practice', summarized from the international groundwater management literature, to obtain a measure of management status. The key premise for the assessment methodology is that groundwater resources management must take place within an IWRM framework. To achieve this, the IWRM Toolbox developed by the Global Water Partnership was used as scope and content for the assessment under the main headings of 'Enabling Environment', Institutional Development' and 'Management Measures'. A management performance rating of 'good', 'limited' or 'below expectation' was assigned to different elements within this framework, by comparison with the benchmark provided in the best practice analysis.

The assessment took the socio-economic development situation and the status of water resources management in SADC into account to ensure that different aspects of groundwater management were relevant in the area. Context for the assessment for southern Africa was provided by an introductory overview of major groundwater issues and problems in Africa.

The overarching goal of SADC is 'Regional Integration and Poverty Eradication'. Cooperation in various sectors was initiated by way of protocols to the SADC Treaty. Protocols are instruments in international law. In the case of water, there is the SADC Protocol on Shared Watercourses, which entered into force in 1998 and was revised in 2003. The Protocol fully caters for groundwater. At a planning level, work on a regional strategy for the newly formed water sector was initiated in 1996 and its first 5-year programme became the RSAP-IWRM (1999-2004). One of the components of the integrated action plan is a Groundwater Programme. A comprehensive Regional Water Policy and Regional Water Strategy have been developed since then. An important vehicle for implementing this policy is the existence of well-functioning river basin organizations (RBOs), mandated by the Protocol and operating under sound legislation and systems for planning and stakeholder involvement and embracing IWRM principles.

Integrated or comprehensive approaches are internationally accepted as a basic principle for effective water management throughout the world. They are more readily understood, particularly in the case of groundwater, in terms of managing elements of the hydrological cycle, both quantity and quality, for example surface water and groundwater, waste water and groundwater in urban situations, and groundwater as part of land management and integrated catchment management. Managing groundwater within an IWRM framework will focus the attention on the equally important socio-economic and institutional aspects of water.

Some of the particular challenges to groundwater resources management relate to its resources management. The overriding criteria of equity, environmental sustainability and economic efficiency in water use best express the comprehensive IWRM approach, common pool

nature and its widespread distribution and generally dispersed abstraction points. Because the links between users and the resource are often not apparent, and because many of the benefits associated with groundwater are public goods (such as environmental maintenance, health and poverty alleviation), the overall economic value of groundwater goes largely unrecognized. For this reason, it is critical that the approach to groundwater resource management should be one of 'top-down facilitation of local actions'. This matches IWRM thinking, with one of its key tenets being that traditional top-down approaches to management have to be supplemented by, and indeed partly replaced by, bottom-up strategies to ensure that the water sector is demand-driven and can deliver welfare gains to the whole range of end users. For bottom-up strategies to be effective new institutions are likely to be needed.

Groundwater, despite the hard rock and generally low yield nature of aquifer systems in most parts, has a major development role to play in Southern Africa, particularly in rural development and the servicing of urban fringes. Its potential role, conjunctively with surface water, particularly in drought risk management, has not yet been systematically addressed.

SADC is well placed to address groundwater resources utilization more strategically through the IWRM institutions and processes that are already in place. The groundwater resources management shortcomings that have been identified lie largely at national level. Here you still find a general bias towards surface water resources, except in countries with a strong dependence on groundwater. This is reflected in poor attention to groundwater planning at all levels, in particular macro-planning. It is also obvious in the relatively low priority accorded groundwater in funding commitments, in particular for vital but completely inadequate groundwater monitoring, exploration and data gathering. Of considerable concern is the wide-spread lack of capacity of institutions tasked with the management of groundwater resources, in national as well as new, decentralized institutions, in particular river basin organizations. Evaluated against international 'best practice', the status of water resources management in SADC was assessed as 'below expectation', using the above-mentioned classification. There appears to be awareness at decision-making level about the importance of groundwater, but this is not yet adequately reflected in national policies and practices.

The international experience is that turning around this type of situation will require strategic action across sector and international boundaries. A number of recommendations are made, based on the study and in line with the AMCOW resolutions, which could precipitate such strategic action in the region. They address a strategic groundwater management framework and action plan at regional level and groundwater management plans at national and river basin organization level. There are also some specific recommendations on how to attract financial resources and ongoing attention for such an initiative.

These recommendations should be confirmed and expanded on at a SADC multi-stakeholder workshop and should be seen as an expansion of the SADC Groundwater Management Programme.

It is felt that the South African capacity for IWRM and, in particular for groundwater resources management, can make a much greater contribution than at present to developments in southern Africa and that the Water Research Commission should strategically position itself for such a role.

2. BACKGROUND AND OBJECTIVES OF STUDY

The study has resulted from a request by members of the AMCOW Technical Advisory Committee (TAC) from Southern Africa as follow-on to decisions regarding groundwater resources management taken by AMCOW in Brazzaville in May 2007 and recommendations coming from the AMCOW Conference on River and Lake Basin Management in Kampala in October 2006.

"The 6th Session of AMCOW decides to request TAC to:

- *Promote the institutionalisation of groundwater management by river basin organisations to ensure regional ownership of the initiative;*
- *Create synergy with the RWSSI to ensure groundwater's inclusion in resource assessment and the sustainable management of groundwater resources;*
- *Become the custodian through whom the strategic initiative can be fast-tracked and a continent-wide impact can be ensured; and*
- *Consider endorsing and supporting the efforts to secure core financial support from the African Water Facility that could be leveraged to raise additional resources from development cooperation partners, such as the European Union. "*

The background to this has been a long-standing concern of African stakeholders about the strategic importance of groundwater on the one hand and its unsustainable utilization throughout Africa, on the other. This was documented through a UNESCO/UNEP - led study in eleven African countries on the vulnerability of groundwater resources. Stakeholders discussing these findings at a concluding workshop in Cape Town in November 2005 decided to draft a 'Message to Decision-makers' at the highest international and regional level. This message was taken to the World Water Forum in Mexico in April 2006 with support from the African Development Bank and finally to AMCOW in Kampala. A strategic, continental-wide approach to remedy the situation was strongly supported, in the expectation that it could ultimately lead to "An Africa where groundwater resources are valued and utilized sustainably by empowered stakeholders."

To take these decisions forward in a systematic and ongoing manner, AMCOW has further decided to establish an Africa Groundwater Commission. In recognition of the key strategy of 'partnerships' coming out of the WSSD Plan of Implementation, this initiative should be seen as a major opportunity for North-South and South-South cooperation as well as between international agencies in the water and related fields (AMCOW, 2007). The door has already been opened for cooperation of this nature in the georesources field through AEGOS, the ACP-EU Georesources Observation System Initiative, and in 2006 the supporting Maputo Declaration on the Development of Georesources in Africa.

In support of this important development, Southern Africa members of AMCOW-TAC decided to trigger and move forward the initiative in SADC and commissioned this scoping study of groundwater resources management in SADC. Their main consideration was the significant progress that had already been achieved in SADC in the joint management of shared water resources and the platform this could provide for piloting the Africa Groundwater Initiative in SADC.

The basis for cooperation among member states in SADC was established in 1992 with the signing of the SADC Treaty. Cooperation in various sectors was initiated by way of protocols. In the case of water, there is the SADC Protocol on Shared Watercourses, which first entered into force in 1998 and was revised in 2003. The Protocol fully caters for groundwater and defines a 'watercourse' as a system of surface and ground

waters (SADC, 2003). This high level agreement in international law has been translated into action through the Regional Strategic Action Plan for Integrated Water Resources Management (Phase II) and a Groundwater Programme as one the components of the integrated action plan (SADC, 2005a). The Groundwater Programme has recently received a considerable boost through the launch of a GEF-funded 'SADC Groundwater and Drought Management Project' (GEF, 2007).

The overall goal of this scoping study is to create momentum towards a systematic, sub-region-wide, and ultimately region-wide, programme and approach for building the capacity required to ensure that groundwater resources are utilized and managed sustainably in the SADC sub-region.

The specific objectives of the study are to:

- assess the state of sustainable utilization and management of groundwater resources in the sub-region;
- develop a plan of action that will lead towards a broad-based, multi-sectoral initiative aimed at building the sub-region capacity for sustainable, integrated management of groundwater resources, which can also serve as prototype for the wider region.

All the above activities will be undertaken within the regional development, water and groundwater management frameworks, programmes and ongoing activities already existing in SADC to avoid duplication and be able to build on the significant advances already made.

The study is conducted in two phases, i.e.:

- ***Phase I*** (with funding from the Water Research Commission of South Africa);
  Development of a protocol for assessing groundwater resources management status and testing of the protocol with a broad-brush assessment of the status in the southern Africa sub-region.

The findings of Phase I are presented in this report.

- ***Phase II*** (with funding from GTZ of the Federal Republic of Germany)
  - Planning of a SADC groundwater-related, multi-stakeholder workshop, together with the AMCOW-TAC and the SADC Water Division with the above-mentioned protocol and findings as basis;
  - Execution of the multi-stakeholder workshop (40 people over 2 days), facilitated to address the study objectives;
  - Preparation of final report with workshop findings and recommendations.

3. METHODOLOGY FOR THE PHASE I STUDY

For the success of the overall study and its acceptance within SADC and wider it is important that the assessment of groundwater resources management status is objective and reflects the situation on the ground as best as possible, within the limits of the information that could be gathered in the desk study plus workshop approach.

The approach adopted was to assess the groundwater resources management status in SADC based on available groundwater documents and scientific literature from the area and weigh it up against some form of generally accepted 'best practice' to obtain a measure of management status. The key premise for the assessment methodology is that groundwater resources management must take place within an IWRM framework and to achieve this, the IWRM toolbox was used as scope and content for the assessment under the main headings of 'Enabling Environment', Institutional Development' and 'Management Measures'

In Chapter 4 a general case is made for groundwater resources management to take place within an IWRM framework and a summary of international 'best practice' based on available literature is provided.

Chapter 5 follows with a southern Africa context, illustrated by the Southern African Development Community's regional development as well as water resources management objectives and institutions.

Chapter 6 provides the groundwater resources situation in the SADC region and a description of its Groundwater Resources Management Programme.

Chapter 7 starts with a general view of major groundwater issues and problems in Africa as context to the analysis of the groundwater resources management status in southern Africa, using the IWRM framework and the best practice measures developed in Chapter 4.

Conclusions regarding the suitability of the methodology are made in Chapter 8 together with recommendations to verify appropriately the desktop findings on groundwater resources management status in southern Africa. Recommendations are also made for an appropriate expansion of the SADC Groundwater Management Programme for consideration at a SADC multi-stakeholder workshop, in response to the groundwater resources management status assessment and .the AMCOW groundwater resolutions of May 2007.

4. GROUNDWATER AS PART OF IWRM

4.1 Purpose

In this chapter a general case is made for groundwater resources management to take place within an IWRM framework and a summary of international 'best practice' based on available literature is provided.

4.2 Groundwater and IWRM

The concern and challenge that was posed by Agenda 21 for fresh water resources, and which introduced IWRM thinking world-wide, clearly also holds for groundwater:

> *"Scarcity and misuse of fresh water pose a threat to development and protection of the environment. Human health and welfare, food security, industrial development, and ecosystems on which they depend are all at risk unless water and land are managed more effectively than they have been in the past."* (UN, 1992)

The challenges of sustainable development led to increasing 'integration' requirements, which are well captured in the definition from the Global Water Partnership:

> *"IWRM is a process which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems"*

This includes more coordinated development and management of a number of areas, which could all be seen from a groundwater perspective:

- the natural and human resource system interaction;
- freshwater and coastal zone management;
- land and water management;
- surface and groundwater management;
- quantity and quality in water resources management;
- upstream and downstream water-related interests;
- mainstreaming of water resources in socio-economic activities;
- cross-sectoral integration in national policy development;
- macro-economic effects of water development (Global Water Partnership, 2000).

Groundwater is often a cornerstone in the foundation of many economic and environmental systems. However, even in the contemporary accounts of 'integrated' water management, the unique nature of the groundwater system that underpins the whole resource base, is rarely discussed and addressed. Some of the particular challenges to groundwater resources management relate to its common pool nature and its widespread distribution and generally dispersed abstraction points. Because the links between users and the resource are often not apparent, and because many of the benefits associated with groundwater are public goods (such as environmental maintenance, health and poverty alleviation), the overall economic value of groundwater goes unrecognized.

4.3 Groundwater uses and impacts

Some of the key groundwater uses and impacts of its development are briefly touched on below as basis for the discussion on more integrated management of the resource.

While agriculture is generally the highest volume user, its most widespread role is that of reliable source of supply for potable water. The agricultural role is particularly important in drier regions because of its buffering capacity during droughts. In parts of South Asia as well as in much of Africa, groundwater irrigation offers a big opportunity for enhancing the livelihoods of the poor. In the former, the population density and concentrated rural poverty are high; but the untapped resource is large too. In many parts of Africa, the resource is modest and largely undeveloped; but the population density is low, too. In both these regions, the central challenge is to put the pump into the hands of the poor (FAO, 2003). Because of the importance of this use and many remaining challenges in this regard, some further background is provided in Appendix H.

Equally important to its role as a critical source of water supply for agriculture and municipal uses, groundwater plays a more subtle role related to poverty alleviation, health and social vulnerability. Access to groundwater is perhaps the most critical factor enabling many rural populations to maintain sustainable livelihoods. Assured water supplies greatly reduce the risks poor farmers face when investing in such agricultural inputs as seed and fertilizer and lead to a more viable farming practice. Similarly, a secure and safe water supply in close proximity to the point of use has major health benefits. Overall, by enabling individuals to accumulate reserves, access to groundwater enables rural populations to reduce their vulnerability, not just to drought, but also to the full range of economic and social hazards that generate much rural poverty (Burke and Moench, 2000).

As a result of their unique storage and recharge characteristics, groundwater systems have major advantages, when used complimentary to surface water systems. Various forms of conjunctive use of the two systems, from daily peak demand management to inter-annual drought management, can achieve considerable gains in beneficial use of the combined resource, in water security and in distribution system outlay (Braune and Dziembowski, 1997; Braune, 2000b).

Finally, groundwater plays a crucial role in the environment and water-related ecosystems. It is the primary source of base flow in streams and rivers and is a major water source for most surface vegetation and wetlands (Colvin *et al.*, 2007).

Like most other renewable natural resources, groundwater has come under increasing human development pressures during the last century. Because of its unique role in the landscape and its largely unseen nature, groundwater and the aquifers that host it are particularly vulnerable to these impacts. Lack of understanding of groundwater in a hydrological systems context has maintained traditional perceptions of groundwater access and use that are intensely ‘private’, irrespective of its legal status. Its large-scale exploitation, in particular for irrigation, is really a phenomenon of the late 20th century and is related to advances in pumping and drilling technology rather than a development based on broad national needs. Such increasing groundwater usage has had unexpected consequences in many parts of the world, inducing widespread drawdown externalities, including the depletion of all-important shallow aquifers. This is even the case for apparently low-intensity use of shallow groundwater in rural communities, and in many semi-arid zones of the world, the locally exploitable groundwater resource is often depleted or drained by the end of the dry season (FAO, 2003).

Besides the serious socio-economic consequences of the loss of a live-giving resource, particularly for vulnerable rural communities, there are clear signs of irreversible impacts on the environment through this drying up of whole landscapes, e.g. destruction of wetland and terrestrial ecosystems as well as migration of poor quality water. Furthermore, the disposal of human waste is increasingly affecting the utility of groundwater resources. Groundwater is particularly vulnerable to this kind of over-use, because the impacts can stay hidden for many years and by the time they are discovered they are very difficult and costly to remediate. Again, the problem has only become acute with heavy use as in the case of industrialization, modern agriculture and dense settlements (Xu and Usher, 2006).

4.4 Approaches to groundwater resources management

Integrated or comprehensive approaches are internationally accepted as a basic principle for effective water management throughout the world. They are more readily understood in terms of managing elements of the hydrological cycle, both quantity and quality, for example surface water and groundwater, waste water and groundwater in urban situations, and groundwater as part of land management and integrated catchment management. While development of integrated approaches to the physical system is an important first step, it is equally important to recognize and integrate socio-economic and other factors that directly and indirectly affect surface water and groundwater conditions (see above the suggested areas for integration). In pursuing IWRM comprehensively, there is a need to recognize some overriding criteria that take account of social, economic and natural conditions (Global Water Partnership, 2000):

- ***Economic efficiency in water use:*** Because of the increasing scarcity of water and financial resources, the finite and vulnerable nature of water as a resource, and the increasing demands upon it, water must be used with maximum possible efficiency;
- ***Equity:*** The basic right for *all* people to have access to water of adequate quantity and quality for the sustenance of human wellbeing must be universally recognized;
- ***Environmental and ecological sustainability:*** The present use of the resource should be managed in a way that does not undermine the life-support system thereby compromising use by future generations of the same resource.

Three major gaps in groundwater management have emerged, each with significant implications for sustainable development (FAO, 2003):

- The inability to cope with the acceleration of degradation of groundwater systems by over-abstraction, and effective resource depletion through quality changes (pollution, salinity).
- In general, a lack of professional and public awareness about the sustainable use of groundwater resources. In particular, a lack of coherent planning frameworks to guide all scales of groundwater development and the consequent lack of appropriate policy responses and institutional development to prevent and attenuate degradation to groundwater systems.
- The failure to resolve competition for groundwater and aquifer services between sectoral uses and environmental externalities.

According to the FAO review, two broad types of management approaches for groundwater emerge: (i) 'thin and wide'; and (ii) 'thick and deep' (FAO, 2003). 'Thin and wide' approaches may encompass blunt tools such as power pricing, subsidies for efficient technologies, economic policies that discourage water intensive crops, etc. They can be applied over whole countries or regions. 'Thick and deep' approaches deal with specific aquifers based on command and control management whereby aquifer management targets are set and enforced through a resource regulator.

Against the 'soft' institutional strategies, it is possible to define sets of technical options that relate directly to groundwater. Although these options may present expanded opportunities to manage groundwater, they would have to be applied strategically in circumstances that are amenable (where uptake of technical strategies will succeed). Such technical options include:

- conjunctive management (conjunctive use and aquifer storage and recovery);
- conservation enhancement and protection;
- water harvesting and supply enhancement;
- irrigation efficiency improvement and demand management.

Technical regulation, economic incentives and participatory management approaches may offer the means to address groundwater management in an IWRM framework in the common interest. However, the character of initiatives will be determined necessarily by the local realities of the groundwater occurrences and the associated groundwater economy.

The largely technocratic, vertically integrated basin management models built around surface water schemes and the sets of incentives to surface water managers and users differ markedly from the management 'models' and incentives associated with the more imprecise character of aquifer systems and groundwater use. In addition, while the 'client base' for a basin manager would typically consist of a set number of well-identified user groups (irrigation schemes, water user associations, municipalities, etc.), the manager of an aquifer system may in practice have to engage with millions (in Asia) of individual users. Dealing with such diversity involves a different order of adaptability and flexibility than that normally associated with surface water or river basin management, which often still has an ‘engineering hydrology’ focus and has remained largely centralized and technocratic (FAO, 2003).

Foster (2006) has summarized the groundwater management challenge well by describing it as a widely distributed resource affected by plethora of local users and polluters. But the behaviour of these users and polluters is also greatly influenced by national policy decisions affecting land and water use. He thus sees the approach to resource governance and information provision to be functioning at both the micro and macro level and calls the desired approach a ‘top-down facilitation of local actions’.

The design of a suite of institutional and technical strategies and their implementation at the scale required to make an impact (to conserve or reallocate groundwater resources) is unlikely to be achieved in the short term and periods of decades are now seen as reasonable. According to the FAO review, standard management approaches depend heavily on the presence of basic data and on institutional capacities for regulation, scientific research, etc, that are absent in many countries. Because such capacities and data often require decades to develop, alternative approaches are essential in order to address the types of problems now emerging in many regions. Furthermore, this research suggests that strategies that build off existing trends within society or help populations to adapt may be as effective as strategies that attempt to manage the groundwater resource base directly. Further research to clarify existing coping mechanisms and to identify or test the viability of adaptive strategies could represent a major starting point for an initiative to 'rethink groundwater'. The development of criteria suggesting where traditional forms of groundwater management may or may not be possible is also a key area for work. This could be of critical importance to governments and other actors seeking to identify locations where different approaches are likely to prove viable (FAO, 2003).

Guidance relating to all these groundwater management issues can be found within an appropriate IWRM framework., for example the one by the Global Water Partnership, broadly focusing on the enabling environment, institutional development and management instruments (Global Water Partnership, 2000).

Under all circumstances a proper enabling environment is essential to both ensure the rights and assets of all stakeholders (individuals as well as public and private sector organizations and companies), and also to protect public assets such as intrinsic environmental values. The enabling environment is basically national, provincial or local policies and the legislation that constitutes the "rules of the game" and enable all stakeholders to play their respective roles in the development and management of water resources; and the for a and mechanisms, including information and capacity building, created to establish these "rules of the game" and to facilitate and exercise stakeholder participation (Global Water Partnership, 2000).

While the type of institutional development depends on stage of development, financial and human resources and can not be covered in a blueprint, nevertheless institutional development is critical to the formulation and implementation of IWRM policies and programmes. Key issues are clarity on the roles and responsibilities of different institutions and the creation of effective co-ordination mechanisms between different agencies. Importantly for groundwater, a key tenet of IWRM is that traditional top-down approaches to management have to be supplemented by, and indeed partly replaced by, bottom-up strategies to ensure that the water sector is demand-driven and can deliver welfare gains to the whole range of end users. For bottom-up strategies to be effective new institutions are likely to be needed. In many situations it will be essential to create community based organizations, which can actively participate in the development and management of water supply systems (Global Water Partnership, 2000).

As indicated above, a wide range of management instruments have been developed for groundwater throughout the world. The art of IWRM is about knowing the available elements of the "tool box" and selecting, adjusting and applying the mix of tools appropriate to the given circumstances, including agreed policies, available resources, environmental impacts and the social and economic consequences (Global Water Partnership, 2000).

4.5 International cooperation for sustainable groundwater utilization

Given the expected slow pace of change in groundwater resource management, there is a general feeling among concerned groundwater professionals and stakeholders that this will only receive the necessary attention and ongoing development momentum if countries join forces regionally and globally. However, "*international law has so far only rarely taken account of groundwater. While surface water treaties abound, groundwater is either nominally included in the scope of these instruments, mainly if it is "related" to surface waters, or it is not mentioned at all"* (Burchi and Mechlem, 2005). To be able to have a regional and even global impact, future groundwater transboundary initiatives will have to go well beyond issues of hydraulic connections, to common socio-economic issues and implications relating to groundwater, bringing an IWRM approach also to international groundwater resources.

Developments towards international cooperation for a more sustainable groundwater resources utilization and management can be found on both a global and regional front. The World Bank has, for example, requested the International Association of Hydrogeologists (IAH) to prepare a proposal for a framework for groundwater resource governance, with appropriate regional variants and options, whose application would facilitate local actions in sustainable groundwater use, management and protection (IAH, 2006). In Africa, AMCOW, the African Ministers' Council on Water, has already taken the further practical step to establish an Africa Commission for Groundwater to allow AMCOW to become custodian for a strategic, continent-wide groundwater action (Tekateka, 2007).

On the global scientific front, the UNESCO-IHP ISARM initiative (Internationally Shared Aquifer Resources Management) (www.isarm.net) and the establishment of IGRAC, the International Groundwater Resources Assessment Centre in Utrecht, The Netherlands, are important steps in this direction. In Africa, a strategic

initiative is AEGOS, the Africa Caribbean Pacific (ACP)-European Georesources Observation System for Africa, which could potentially bring together 22 partners and 16 associate partners towards a regional groundwater cooperation objective (AEGOS, 2006).

4.6 A strategic framework for groundwater resources management within IWRM

While it is crucial to encourage whatever management actions are currently feasible, the long-term process of developing flexible, integrated management systems should not be delayed. A strategic framework is seen as an essential precursor and progressive instrument for effective groundwater management (Burke and Moench, 2000). In it, the intended relationships between diverse sets of interventions or management approaches and the management goals are specified. It should also specify the relationship between the diverse set of interventions, discussed above – how together they are to form an approach to management that is internally consistent. A descriptive model change process for groundwater management is illustrated in Figure 1 (Burke and Moench, 2000). In practice, this should result in a groundwater management plan that will identify actions necessary to contribute to an effective water resources management framework of policies, legislation, financing structures, capable institutions with clearly defined roles, stakeholder participation and a set of management instruments (Global Water Partnership, 2002). In terms of the crucial need for integration across the resource dimension, this should normally be part of the IWRM plans, which have become standard practice.

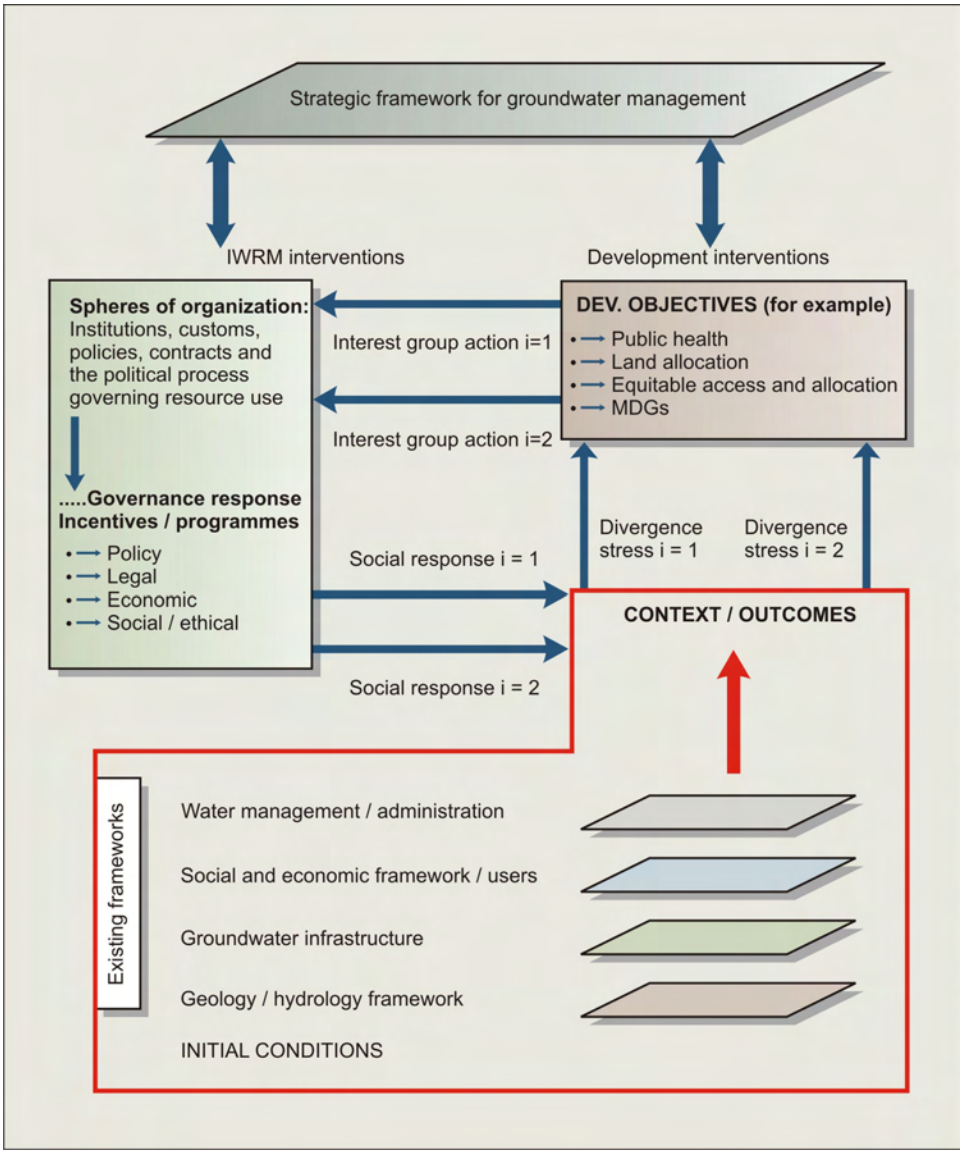

Figure 1: Descriptive model change process in groundwater management

(Burke and Moench , 2000)

To bring out the importance of local level management for groundwater as well as the need for its facilitation, the governance diagram of Foster (2006) is also included here as Figure 2.

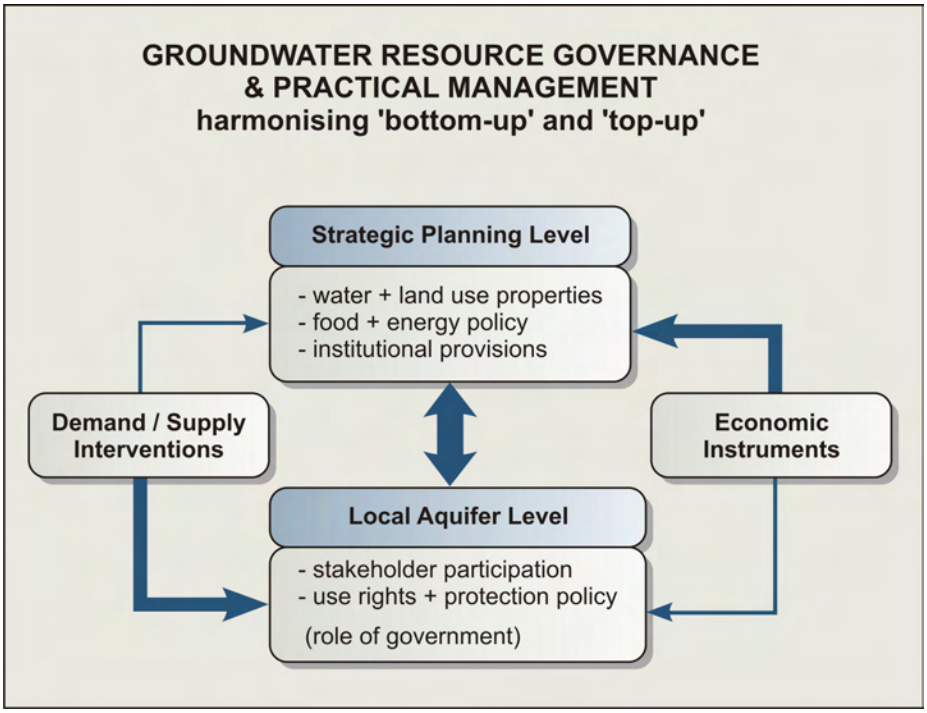

Figure 2: Groundwater resource governance (Foster, 2006)

Currently, there are only a limited number of agreed indicators of what constitutes good groundwater management. What has been published addresses mainly resource quantity and quality, resource use and resource vulnerability (Vrba and Lipponen, 2007). Other, more readily available indicators of good management could be expressions of the available information on groundwater, e.g. how current records are, how regularly published and how well expressed in predictive models. However, with the increasing devolution of water resources management to lower levels, in particular river basin organizations, clear guidance will also become increasingly important for the full spectrum of management actions.

A compendium of 'best practice' direction is probably the closest we will come to indicators of good management, given the complex management environment touched on above. An example of such an approach has been an evaluation of IWRM performance in SADC countries (Hollingworth and Chiramba, 2005). A very good summary of the scope and practice of groundwater management can be found in The World Bank Briefing Note Series on Groundwater Management (World Bank, 2002).

4.7 Groundwater 'best practice in an IWRM framework

To allow for a systematic evaluation of the status of groundwater resources management in SADC, the content of the IWRM Toolbox developed by the Global Water Partnership (Global Water Partnership, 2002) was chosen as a framework. It was populated with expressions from the international groundwater management literature as 'groundwater best practice' for specific parts of the IWRM framework that were subdivided broadly into 'Enabling Environment', 'Institutional Development' and 'Management Instruments'. This is shown in Table 1 below.

Table 1. Best Practice for Groundwater Resource Management in an IWRM Framework

A. Enabling Environment

A1. POLICIES

- The social, economic and environmental values of groundwater are often unrecognized and undervalued (Burke and Moench, 2000);
- Groundwater is a highly important source of domestic water supply and a key resource for poverty alleviation and the economic development of rural areas (Burke and Moench, 2000; Foster, 2006);
- The importance of the whole water cycle should be seen and the link existing between ground and surface water for their use and management (Kouvelis, 2005);
- The maintenance of the ecological integrity of most wetlands, especially those located in arid and semi-arid ones, is closely linked to the supply of groundwater and should be considered in groundwater management (Kouvelis, 2005);
- All water, wherever it occurs in the water cycle, is a resource common to all, the use of which shall be subject to national control. All water shall have a consistent status in law, irrespective of where it occurs. (National Water Act, 1998 of South Africa);
- The location of the water resource in relation to land shall not in itself confer preferential rights to usage. The riparian principle shall not apply (National Water Act, 1998 of South Africa);
- Governments should formulate and adopt a long-term policy to protect groundwater by preventing pollution and overuse. This policy should be comprehensive and implemented at all appropriate levels. It should be consistent with other water management policies and be duly taken into account in other sectoral policies (ECE, 1989);
- States shall take all appropriate steps to acquire the information necessary to manage groundwater and aquifers efficiently and effectively (ILA, 2004);
- Inherent limitations in the nature of scientific information in conjunction with the widely occurring dynamic process of social and institutional change, make adaptive responses to water problems and policy approaches increasingly important (FAO, 2003);
- Meeting of basic human needs of water users in terms of a safe water supply and sanitation as well as an adequate supply for sustainable food security is at this stage the highest priority in Africa (Organization of African Unity *et al.*, 2000).
- Common policy and implementation is required here, because domestic water supply and water for food security is usually dealt with by different Ministries;
- States shall use there best efforts to manage surface waters, groundwater, and other pertinent waters in a unified and comprehensive way (ILA, 2004);
- States shall use their best efforts to integrate appropriately the management of waters with the management of other resources (ILA, 2004);
- To achieve a more sector cross-cutting view of groundwater, there should be regular consideration of groundwater constraints and needs in economic and land-use policy dialogues (Foster, 2006);
- Effective approaches to groundwater management will require multi-pronged mechanisms with a delicate balance between individual, community and government roles and educational, economic, legal and regulatory mechanisms, in most cases requiring a long-term process to develop (Burke and Moench, 2000);

- Overall, there is a need to reconcile in groundwater resources management 'top down' (strategic planning level) and 'bottom up' (local) institutional level(Foster, 2006).

A2. LEGISLATIVE FRAMEWORK

- A solid legal / institutional framework needs to be established that creates equity and clarity for all stakeholders involved (Garduno, 2003);
- Legal provisions specific to the peculiarities of groundwater management should be formulated and promulgated.
- Legislation should contain provision for its effective implementation, including the mandate, competence and power of the relevant authorities in accordance with uniform principles (ECE, 1989);
- Ownership of groundwater should be clearly defined in water legislation. Groundwater should be declared in the public domain or authority should be vested in government to restrict, in the public interest, the rights accruing from its private ownership. New legislation should strive towards changing ownership rights to use rights subject to a government-controlled, permit system (ECE, 1989).

A3. FINANCING AND INCENTIVE STRUCTURES

- Securing sustainable financing from national and international sources, not only for tackling urgent water needs and for water resources management, but also for information generation and management is essential.
- Groundwater, because of its concealed nature, its vulnerability and slow response to impacts and its past neglect, needs systematic attention to resource monitoring (Organization of African Unity *et al.*, 2000; Braune, 2000b; Tuinhof, 2003).
- Major investment in groundwater during drought emergencies is often wasted because it takes place unplanned and very poorly recorded and therefore falling into disuse. (Calow *et al.*, 1997); What is required is an ongoing, planned and systematic expansion of groundwater infrastructure to be prepared for the drought events that groundwater can naturally buffer. this type of approach has been followed by the City of Windhoek for many years (Murray and Tredoux, 2002);
- Groundwater, because of its ubiquitous and localized nature, can only be developed optimally through a lot of private initiative. This requires completely new approaches to financing, i.e. micro-financing, practiced basin-, country- and even region-wide, as born out by the experience in India (Puri, 2007).

B. Institutional Development

B1. CREATING AN ORGANISATIONAL FRAMEWORK

- In general, developing and implementing institutional reform and capacity-building, in particular at local level, is essential, as well as mainstreaming management at the lowest appropriate level and creating institutional arrangements for full stakeholder participation (Organization of African Unity *et al.*, 2000);
- Water authorities or coordinating bodies should have the competence to integrate all aspects of water management and should be rendered competent to arbitrate among various competing demands, and diverging interests regarding groundwater abstraction and use, both in the short-term and in the long-term. The authority or body should collaborate with other authorities, competent for public health, land-use planning, soils management, waste management etc. (ECE, 1989);
- The complexities of integrated management approaches are very demanding on institutions charged with making groundwater management effective. They require strong and stable institutional arrangements, need to be knowledge driven and be capable of building widespread community support for courses of action across sectors and administrative jurisdictions (Burke and Moench, 2000);
- It is necessary to empower water users and stakeholder organizations in order to help ensure equitable access, joint decision-making and self-management or shared management, wherever possible (Garduno *et al.*, 2003);
- Water user associations and other appropriate forums should be utilized to strengthen the user advocacy role and achieve new partnerships and a joint management of the common resource (Braune and Karar, 2003; (Garduno *et al.*, 2003);
- More investment and commitment should be provided to groundwater resource institutions at appropriate
- (generally local) level (Foster, 2006).

B2. BUILDING INSTITUTIONAL CAPACITY

- Personnel is required which is capable of developing a broad interdisciplinary understanding of water management issues (Burke and Moench, 2000);
- Broadening the skills base of those involved in groundwater resource management and governance is necessary to achieve a much more multi-disciplinary approach (Mukherji and Shah, 2005);
- In most developing countries, intensive groundwater development only started in the last few decades. Most government organizations concerned with groundwater were formed primarily to provide technical support services (exploration and drilling) to support development. They often still lack the experience and the capacity to manage the resource base. (Burke and Moench, 2000);
- In cases where regulatory approaches are still failing, a capacity is required in government for outreach and education (Burke and Moench, 2000);

C. Management Instruments

C1. WATER RESOURCES ASSESSMENT

- Data and predictive analyses of hydrogeological system behaviour play essential social and technical roles in planning and management processes and need to be designed with that focus. Understanding the physical complexity of groundwater resources is fundamental to developing management approaches(Burke and Moench, 2000);
- Long-term collection of targeted high-quality information (basic data and research) is essential on groundwater systems and their dependent communities. Hydrogeological information on its own is of relatively little use for management purposes (Burke and Moench, 2000; FAO, 2003);
- The continued support for basic data collection and groundwater evaluation is justified on both scientific and social process grounds(FAO, 2003);
- Establishing a sustainable system for data collection, management and dissemination, including standardization and harmonization of data, is also seen as essential in Africa (Organization of Africa Unity *et al.*, 2000);
- More effort should go into field monitoring and proper dissemination of groundwater resource and quality status information (Foster, 2006);
- It will be essential to establish drought monitoring systems which extend beyond rainfall, surface water and food security indicators to groundwater and groundwater supply status, including the appropriate prediction of future hydrogeological conditions (Farr *et al.*, 2005).
- International cooperation should put emphasis on groundwater data collection, standardization and exchange as well as the establishment of joint inventories (ECE, 1989).

C2. PLANS FOR IWRM

- Special attention should be accorded to the application of planning tools and forecasting methods when managing groundwater and protecting aquifers against pollution and over-use. Programmes for continuous assessment of both quantity and quality of groundwater should be implemented, particularly for those aquifers vulnerable to or threatened by pollution and over-use (ECE, 1989);
-
- More effective planning and cost-effective implementation approaches are required for the establishment of hundreds of small localized schemes from groundwater and other low cost appropriate technologies for community supplies (Braune, 2000a);
- There is a need for affordable, small-scale and indigenous solutions which have some chance of self-replication without outside interference (UNCCD, 1996).
- Attention is needed to government planning and information provision focused on water services providers (Foster, 2006);
- Planning should help integrating water and sanitation investments with primary health care strategies as well as waste disposal and storm water drainage (Braune, 2000a);
- States, in accordance with the precautionary approach, shall take early action and develop long-term plans to ensure the sustainable use of groundwater and of the aquifers in which the groundwater is contained (ILA, 2004);
- Drought management plans should be drawn up for transboundary groundwater in which, inter alia, conservation measures to be observed by all water users are spelled out (Hayton and Utton, 1989);
- In Africa, planning should help direct and coordinate groundwater development for meeting of basic human needs, for food production and for socio-economic development (Organization of African Unity *et al.*, 2000).

C3. EFFICIENCY IN WATER USE

- National mechanisms for the management of water resources should apply the best measures to improve the existing systems and the best available techniques for planning and design of conservation and distribution systems in the most efficient way and should equally attend to proper maintenance, control at the regional, national and farm level and operation of delivery systems to increase efficiency (United Nations, 1977).

C4. SOCIAL CHANGE INSTRUMENTS

- Education and information should promote greater awareness of the inherent groundwater problems at all levels, contributing to efficient implementation of the measures taken (ECE, 1989);
- A high degree of social consensus regarding problems and potential solutions will often be required to make policy instruments politically possible. Information and education of the general public and of policy makers should be used for this purpose (Burke and Moench, 2000);
- Broad-based participation of stakeholders in the case of groundwater resources management is essential, because abstraction is geographically dispersed and generally under the effective control of numerous well (borehole) owners (Burke and Moench, 2000);
- Women should be involved in decision-making and the implementation of groundwater supply schemes and food security development programmes to harness their unique role in the rural society (Organization of African Unity *et al.*, 2000; Hay *et al.*, 2005).

C5. CONFLICT RESOLUTION

- Data for the understanding and quantification of aquifer systems provide the foundation for social agreements and can serve as a key tool of conflict resolution (FAO, 2003).

C6. REGULATORY INSTRUMENTS

- The flexibility offered by the South African National Water Act, 1998 in terms of water use allocation, in particular the ability to provide general authorizations for areas or types or levels of use which do not yet present a significant impact, can prevent an unnecessary load on the regulator (DWAF, 1998) ;
- However it requires an intelligent application, jointly with hydrogeologists, and good monitoring of the situation (Parsons, 2006);
- Increasing attention is needed to groundwater resource protection (Foster, 2000);
- Permits issued to regulate the discharge, disposal and possibly the storage of waste should specifically take into account the vulnerability of the aquifer concerned and the provisions necessary for its protection. These should apply above all to waste water treatment plants and hazardous as well as domestic waste disposal sites (ECE, 1989);
- Drilling and sinking of wells and boreholes should as a rule be carried out by qualified and properly skilled personnel and with appropriate equipment (ECE, 1989).

C7. ECONOMIC INSTRUMENTS

- Economic measures such as fees and waste disposal charges should be applied in coordination and have sufficient impact to constitute an effective incentive to use groundwater rationally or be a disincentive to use groundwater rationally (ECE, 1989);
- Application of the "polluter pays" principle, where appropriate, to all kinds of sources, including on-site and off-site sanitation (United Nations, 1992).

C8. INFORMATION EXCHANGE

- Groundwater data access is probably the single most important factor determining the ability of social auditors (e.g. NGOs and other civil society actors) to press governments and society as a whole to address emerging problems and their social or environmental impacts. Dissemination of national groundwater data to a variety of stakeholders is therefore of strategic importance (FAO, 2003);
- Governments and communities in many parts of the world are trying different approaches to groundwater monitoring, analysis and management. Harvesting and disseminating the lessons from these initiatives could serve as a catalyst for the development of approaches that are effective even in the most difficult locations (FAO, 2003).
- Groundwater monitoring should represent an integral part of the resource management process, in which decision-makers should be provided regularly with interpreted management-relevant information and programmes are evaluated regularly to ensure that they continue to meet this objective (Tuinhof *et al.*, 2002; UN-ECA Taskforce on Groundwater Monitoring & Assessment, 2000).

5. THE SADC CONTEXT

5.1 Purpose

This chapter provides information on the socio-economic situation and the regional development objectives as well as water resources management objectives and institutions within SADC as context for the analysis of appropriate groundwater resources management in the region.

5.2 Socio-economic situation

The socio-economic conditions characterizing the SADC sub-region, include rapid population growth, high rates of urbanization, high HIV/AIDS and malaria prevalence, high poverty and income inequality levels, and high incidence of food insecurity. These socio-economic drivers have placed increasing demand for water resulting in increased stress on the limited water resources, and exacerbated competition and conflict between and among sectoral users (Economic Commission for Africa, 2006). This growing demand on the resource has to be balanced with the challenge to maintain land and aquatic ecosystems on which the resource sustainability depends.

As background to the groundwater situation assessment, only two socio-economic indicators are shown here, namely demographic trends (Table 2) and Gross Domestic Product (Table 3).

The sub-region has one of the fastest growing populations in the world, with growth rates between 1.6 and 3.1% per annum, while the urban population is growing at a rate of 6.5% per annum (Economic Commission for Africa, 2006). The greatest urban growth is expected to be in small urban centres (< 0.5 million) where people are dependent on agriculture and agriculturally related industries. Rapid urbanization leads to considerable problems – squatter settlements, unsanitary conditions, inadequate water services and urban waste.

About 60 percent of the population in Southern Africa still live in rural areas. The major factors that have fuelled rural-urban migration include recent wars and conflicts as well as economic factors, landlessness and the effects of drought (Economic Commission for Africa, 2006).

Table 2: Demographic trends in Southern African Countries (UNDP, 2005)

	Total population (millions)			Annual population growth rate (%)		Urban population (% of total)			Population under age 15 (% of total)		Population ages 65 and above (% of total)	
Country	1975	2003	2015	1975-2003	2003-2015	1975	2003	2015	2003	2015	2003	2015
Angola	6.8	15	20.9	2.8	2.8	17.4	35.7	44.9	46.7	45.5	2	2.4
Botswana	0.9	1.8	1.7	2.5	-0.4	12.8	51.6	57.5	38.2	34.7	2.6	4.8
DR Congo	23.9	54.2	78	2.9	3	29.5	31.8	39.7	47.1	48	2.2	2.6
Lesotho	1.1	1.8	1.7	1.6	-0.3	10.8	18	21	39.3	36.6	4.2	5.8
Malawi	5.2	12.3	16	3.1	2.2	7.7	16.3	22.2	47.1	44.9	2.4	32
Mauritius	0.9	1.2	1.3	1.1	0.8	43.4	43.3	47.3	25.1	21.3	5.4	8.3
Mozambique	10.6	19.1	23.5	2.1	1.8	8.7	35.6	48.5	44.1	41.6	2.7	3.6
South Africa	25.9	46.9	47.9	2.1	0.2	48	56.9	62.7	32.9	30.2	3.2	6.1
Swaziland	0.5	1	1	2.4	-0.3	14	23.6	27	42.1	37.2	2.7	4.6
Zambia	5.2	11.3	13.8	2.8	1.7	34.8	359	40.8	46.1	43.7	2.4	3.2
Zimbabwe	6.2	12.9	13.8	2.6	0.6	19.6	35	41.4	41	36.6	2.9	4.1
Average/ Total	**87.2**	**177.5**	**219.6**	**2.4**	**1.1**	**22.4**	**34.9**	**41.2**	**40.9**	**38.2**	**3**	**4**

Table 3: Economic and Demographic indicators for Southern Africa (Energy Information Administration, 2005)

Country	Gross Domestic Product (GDP) 2004 (Billion US $	Real GDP growth estimate (%)	Per capita GDP, 2004 (US$)	% Share of sub regional GDP
Angola	20	12.2	1.381	6.7
Botswana	9	5.4	4.852	3
DR Congo	6	5.7	110	2
Lesotho	1.5	4.4	682	0.5
Malawi	2.8	3.6	248	0.9
Mauritius	6.3	4.1	5.174	2.1
Mozambique	6	7.3	305	2
South Africa	213.1	3.7	4.562	71.9
Swaziland	2	2.1	1.772	0.7
Zambia	5	4.6	489	1.7
Zimbabwe	3.9	-4.3	296	1.3
Average/Total	**296.4**	**4**	**1.985**	**100**

SADC is made up of fourteen Member States at different stages of development, but predominantly underdeveloped. Poverty is widespread in the sub-region, with an estimated 70% of the population living below the international poverty line of US$2 a day, and 40% living in extreme poverty (less than US$1 a day) (Economic Commission for Africa, 2006).

In spite of the economic imbalances amongst its Member States and the relatively small size of the market (only comparable to Belgium or Norway), in the African context SADC's aggregate GDP of USD 226.1 billion

is more than double that of ECOWAS, and equivalent to more than half the aggregate GDP of Sub Saharan Africa (SSA). It also has the highest GNP per capita in the whole of SSA.

Food and nutrition security remain one of the most fundamental challenges for human welfare and for economic growth, with 34% of the population of the sub-region being undernourished (Economic Commission for Africa, 2006).

The socio-economic picture of the sub-region is strongly overshadowed by the prevalence of the HIV/AIDS epidemic. By 2003, 10 million people had already lost their lives to HIV/AIDS and the prevalence among the ages 15-49 ranges between 20 and 40% in some of the countries. Malaria is also putting a heavy burden on the socio-economic development of the sub-region (Economic Commission for Africa, 2006).

5.3 Focus on the poverty situation

The overarching goal of SADC is 'Regional Integration and Poverty Eradication'. The discussion below serves to see possible linkages of this goal with water resources and their appropriate management.

The poverty situation in the region is largely reflected in the low levels of income and high levels of human deprivation. The greatest deprivation is mainly in the area of low access to safe drinking water and child malnutrition. Almost half of Member States' indicators on these two components of human poverty are below the regional average. In terms of access to safe water, the most affected countries are Angola, Mozambique, Lesotho, Malawi, Zambia and Swaziland. With regard to child malnutrition, nearly all the afore-mentioned countries (except for Lesotho and Swaziland), including Tanzania and Namibia have more than 26 percent of under-five children affected by malnutrition.

The problem of poverty is reflected in poor access to water. Malnutrition is aggravated by the regular droughts, often manifested in a food crisis. Currently about 14 million people are threatened with starvation in the region.

Poverty in the SADC region is particularly acute among vulnerable groups such as households headed by the elderly and children that are now on the increase due to the impact of the HIV/AIDS pandemic. Low and unsustainable rates of economic growth in the wake of higher rates of population growth result in low incomes. Often, the poor lack adequate capital assets – physical, financial, human, natural and social. Among other things, lack of adequate physical and financial capital may be caused by unwillingness or inability to postpone consumption and lack of access to financial markets. Lack of adequate human capital can be the result of absence of educational facilities, high opportunity cost of being in school, high cost of education and training or limited appreciation of the value of education. Lack of adequate natural capital may be the consequence of environmental degradation, unequal distribution of land or pressure on the land caused by growth of population or marriage systems that lead to settlement in areas that are already overpopulated. And lack of adequate social capital may be the result of absence of relatives, neighbours, friends or other people with whom the poor can interact.

Apart from lack of adequate capital assets, the rates of return on the physical, human and social capital of the poor are generally low due to low physical productivity and low prices for their goods and services, which are the by-products of:

- Inefficient use and management of scarce capital assets as defined above;
- Unequal economic power between the rich and the poor within their countries and between their countries and rich states, both of which work to the disadvantage of the poor who have little control over the determination of the prices of their goods and services;

- Limited economic opportunities characterised by small domestic markets for goods and services and lack of avenues for productive paid-and self-employment; and
- Soil erosion and degradation, water pollution and scarcity, and depletion of forests and other natural resources caused by inappropriate agricultural practices, urban development and growth of population.

Low physical productivity is also the result of the use of unimproved technology the reasons for which include:

- Lack of interest by governments in promoting appropriate indigenous technology;
- Lack of access to modern technology due to high cost and restrictions on the use of patented technology; and
- Inability to make effective use of modern technology because of lack of knowledge and due to illiteracy. (SADC, 2003)

From the discussion above it is clear that there are many and diverse factors affecting poverty in the region, of which water and its appropriate management is just one, albeit an important one. An integrated development approach is thus critical and this is what the Regional Indicative Strategic Development Plan tries to achieve in SADC. In recognition of the magnitude of the poverty problem, the ultimate objective of the plan, designed to provide strategic direction to SADC programmes, projects and activities, is to deepen the integration agenda of SADC with a view to accelerating poverty eradication and the attainment of other economic and non-economic development objectives (SADC, 2003).

5.4 IWRM as part of regional development in SADC policy development

The SADC sub-region has made excellent progress in establishing cooperation amongst member states in Integrated Water Resources Management and Development. Most of the river basins in the sub-region are shared between two or more countries (Appendix A). The basis for cooperation among member states was established in 1992 with the signing of the SADC Treaty. In 2003, the SADC States agreed to the Regional Indicative Strategic Development Plan – RISDP (SADC, 2003) as central policy instrument to achieve strategic direction on how to achieve the long-term goals of the SADC Treaty in an integrated way.

Cooperation in various sectors was initiated by way of a protocol. These protocols to the SADC Treaty are instruments in international law. In the case of water, there is the SADC Protocol on Shared Watercourses, which entered into force in 1998 and was revised in 2003. The Protocol fully caters for groundwater and sees a 'water course' as a system of surface and ground waters. (SADC, 2003). At a planning level, work on a regional strategy for the newly formed water sector was initiated in 1996 and its first 5-year programme became the RSAP-IWRM (1999-2005). One the components of the integrated action plan is a Groundwater Programme (SADC, 2005a).

Water-related developments at the international level that had a significant influence on the SADC water agenda include the IWRM paradigm coming from the Second-, Third- and Fourth World Water Forums held in 2000, 2003 and 2006 respectively and the adoption of the MDGs in 2000 by world leaders. Targets such as reducing poverty, halving the number of people without access to the basic services of water supply and sanitation and ensuring environmental sustainability in all developmental activities, highlighted the contribution water can make to human development. The World Summit on Sustainable Development (WSSD) set targets to help countries accelerate the provision of water to people, including the development of IWRM and efficiency plans by 2005. Significant also was the 2004 African Union (AU) Summit, which instructed the Ministers of Agriculture and Water to take measures necessary to achieve food security by enhancing agricultural output through utilising available water resources.

A conceptual framework for the sub-regional water policy is shown in Figure 3.

It reflects the key water related objectives of industrial development, food security, access to water and sanitation, water for peace, energy security, safety from disasters and sustainable development as part of SADC regional integration and poverty eradication.

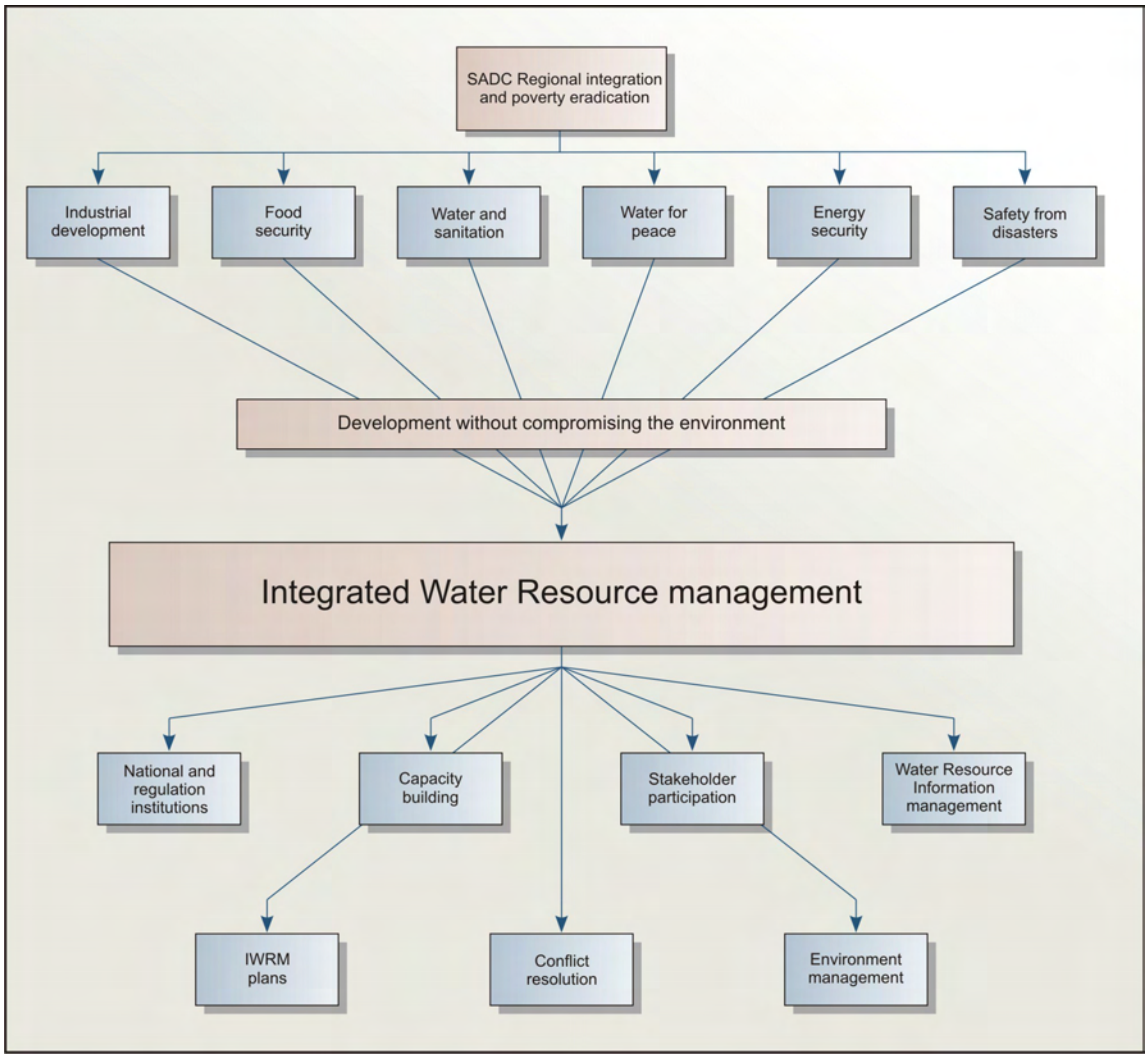

Figure 3: Conceptual framework for the sub-regional water policy (SADC, 2005a)

Within this framework, integrated water resources management is the fundamental approach that has been adopted by the SADC water sector, From the Regional Strategic Action Plan I (RSAP I) – the SADC Water Division developed the Regional Water Policy, which provides context and intent for water resources management at a SADC regional level. The Regional Water Strategy has also been developed through intensive regional stakeholder consultations. The main policy areas are (SADC, 2006):

- **Regional Cooperation in Water Resources Management:** Including policy provisions on water for regional integration and socio-economic development, cooperation in water resources management of shared watercourses, inter-sectoral and international cooperation, and the harmonization of national policies and legislation.
- **Water for Development and Poverty Reduction:** containing policy provisions on water for basic human needs and for industrial requirements, water for food and energy security.
- **Water for Environmental Sustainability:** containing policy provisions on water and the environment, water quality management and control of alien invasive species in watercourses.
- **Security from Water-related Disasters**: including policy provisions covering people's protection from water-related disasters, disaster prediction, as well as management and mitigation.
- **Water Resources Information and Management:** covering data and information acquisition and management, as well as information sharing.
- **Water Resources Development and Management**: including policy provisions on a river basin approach, integrated planning of shared of shared watercourses, dams and dam management, water conservation and water demand management, and alternative sources of water.
- **Regional Water Resources Institutional Framework**: including policy provisions covering institutional arrangements at regional and national levels and for shared watercourse institutions.
- **Stakeholder Participation and Capacity Building**: including provisions focusing on participation and awareness creation, capacity building and training, gender mainstreaming and research technology development and transfer.
- **Financing Integrated Water Resources Development in the Region**: The relationships between the Regional Water Strategy, the Policy and the Protocol, and other sub-regional and national policy and strategy processes are highlighted in Figure 4.

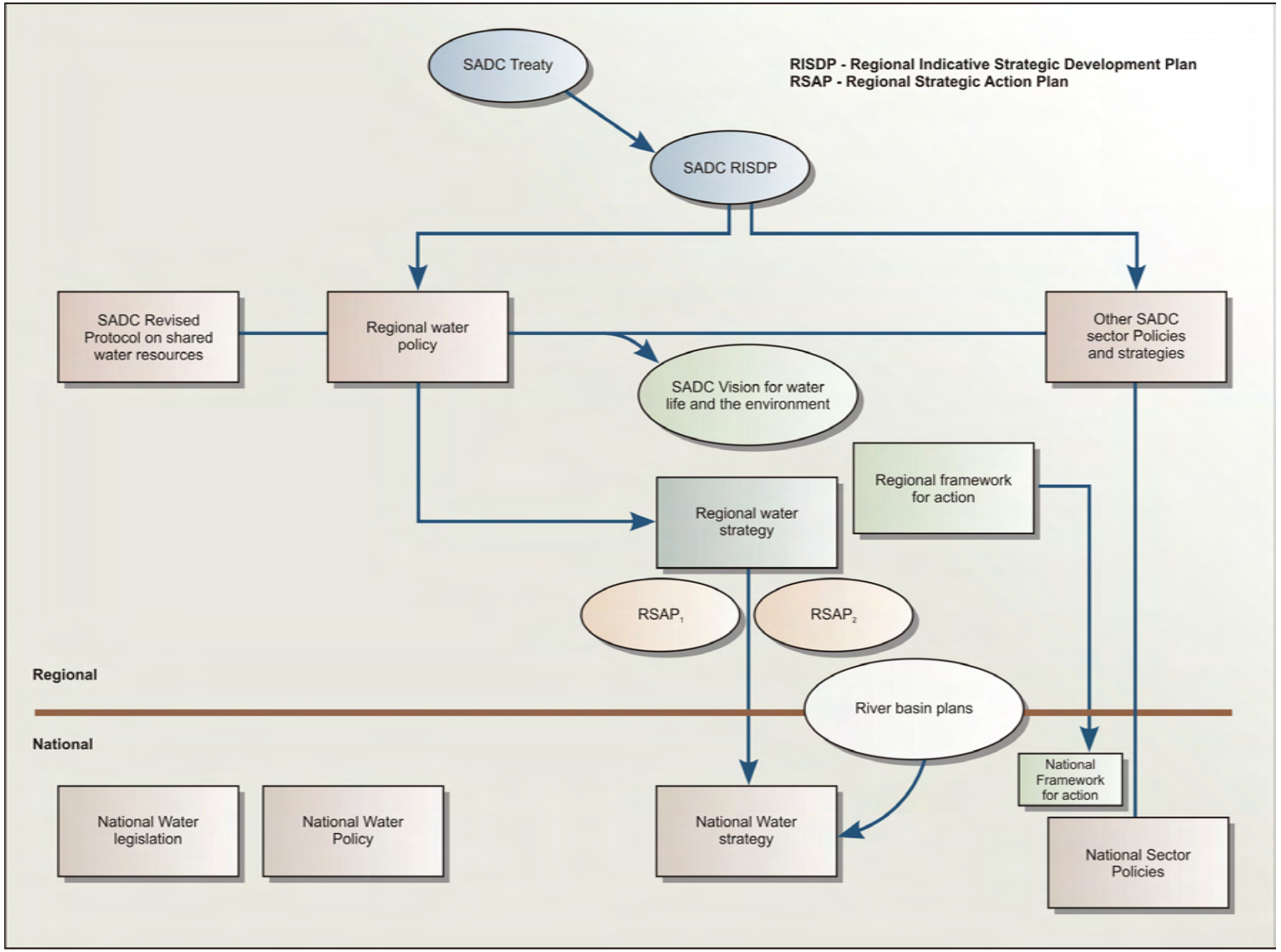

Figure 4: The relationship between the regional Water Strategy (RWS),the Regional Water Policy (RWP), the Protocol and other sub-regional and national policy and strategy processes (SADC, 2005a)

An important vehicle for implementing this policy is the existence of well-functioning river basin organizations (RBOs) operating under sound legislation and systems for planning and stakeholder involvement and embracing IWRM principles. It is important to note that RBOs are mandated by the Protocol. In order for the Regional Water Policy to be implemented at national level, member states would need to harmonise their policies with those of the regional policy (SADC, 2003).

It is also fundamentally important that there should be closer coordination of the Regional Water Policy with other sectoral policies in SADC, especially the major water use sectors, including agriculture, energy and environment. Inter-sectoral coordination at SADC level would be an important building block for integrated water resources development that is the basis for sustainable development (SADC, 2003).

5.5 Roll-out of water policy and strategy in SADC

The Regional Strategic Action Plan is the main vehicle for rolling out water policy and strategy in SADC. Its first 5-year planning period (1999-2004) was recently reviewed (Hollingworth and Chiramba, 2005). A total of US$ 60 million was mobilized for 31 projects of a wide-ranging nature. Implementation has made significant progress in relation to the creation of an enabling environment in such areas as Regional Water Policy, adoption of the Revised Protocol on Shared Watercourses, guidelines for harmonisation of the legal and regulatory frameworks, roll out of the SADC HYCOS Programme, establishment of training and capacity in IWRM, as well as facilitating the setting up of transboundary river basin organizations (RBOs) e.g. ZAMCOM, LIMCOM and ORASECOM (Hollingworth and Chiramba 2005).

A new medium term plan of the RSAP-IWRM has been developed for the period 2005-2010(SADC, 2005a). The new vision of the RSAP should take cognisance of the fact that the RSAP is fundamentally a SADC Water Programme and is therefore a catalyst to promote regional integration, socio-economic development and poverty alleviation through the application of IWRM. The mission should define the main focal areas through which the vision will be achieved. The importance of a conducive or enabling environment should be highlighted to ensure that gains made in creating an enabling environment are not lost or taken for granted. In this regard consolidating the Protocol on Shared Water Courses is important as well as building upon the progress made in its implementation.

The **VISION** of the RSAP is to be an

> Effective and dependable framework contributing to poverty eradication, regional integration and socio-economic development in a sustainable manner

The **MISSION** of the RSAP is to

> Provide a sustainable enabling environment, leadership and coordination in water resources strategic planning, use and infrastructure development through application of integrated water resources management at member state, regional, river basin and community level

Projects have been aggregated into four strategic areas, namely:

(i) Regional Water Resource Development Planning with focus on developing planning mechanisms for the distribution of water within and across catchment boundaries covering the entire region. Emphasis is to be on international river basins and the necessary mechanisms needed to assess quantity, quality and demand issues, including those of the natural environment.

(ii) Infrastructure Development Support with focus on support mechanisms for the development of strategic and integrated infrastructure in order to achieve regional integration and development, socio-economic development and poverty alleviation with particular emphasis on energy generation, agriculture, food security, and water and sanitation.

(iii) Water Governance focused on ensuring the necessary level of participation needed to legitimise the co-operative management of shared transboundary water resources, along with appropriate norms, rules and procedures.

(iv) Capacity Building focused on building and strengthening human and institutional capacity for sustainable management of water resources at basin, national and regional level.
Because of their potential relevance for groundwater resources management, specific targets listed in the RSIDP are included in this report for easy reference in Appendix I.

6. GROUNDWATER RESOURCES IN SADC

6.1 Purpose

This chapter provides the groundwater resources situation in the SADC region in terms of the hydrogeological setting, the resource use and its assessment together with a description of its Groundwater Resources Management Programme.

6.2 Hydrogeological Setting

Groundwater occurrence in southern Africa is characterised by the large variety of geological structures (shown as Hydrogeological Provinces in Appendix B) and the climatic differences that condition the regional hydrogeological settings. According to a report (BGR *et al*., 2007), approximately 60 to 65% of the region is covered by crystalline rocks with aquifer systems developed in the weathered regolith and in the fractured bedrock. These crystalline rocks areas are the proto-cratons (e.g. Zimbabwe, Kaap-Vaal, Kalahari and East African cratons) that coalesced to form the African plate. Metamorphic and mobile belt rocks occur in the zones between these proto-cratons. The aquifers developed in these areas are unconfined, locally developed and not spatially extensive. In general, only modest groundwater supplies can be abstracted sustainably from these aquifers and large-scale groundwater well field developments are not feasible.

Major groundwater basins cover 25 to 30 percent of the area. They are spatially extensive and exhibit primary porosity and permeability. These basins include the Permian-Triassic Karoo sedimentary basins that cover large areas in South Africa, Botswana, Zimbabwe, Zambia, Namibia and Angola. The Karoo basins developed as a response to extensional tectonic forces that lead to the break-up of Gondwanaland. A number of fault bounded graben and half-graben basins developed throughout the southern part of the continent, and were filled with varying thicknesses of sediments. Sedimentation took place in pulses, resulting in a series of generally fining up terrestrial sequences, capped by a thick aeolian sandstone unit indicating an arid climate, brought about by the movement of the continent to a climatically arid latitude. In addition to the Karoo basins, there is a very large Tertiary sedimentary basin in the DR Congo and western Angola. This basin has hardly been exploited at all since it lies in a humid zone. Along the coastal areas, especially Mozambique and Tanzania, extensive Cainozoic coastal plain deposits constitute an exploitable aquifer resource. Similar deposits occur to a lesser extent along the west coast of the region. The Kalahari basin is a vast area of unconsolidated aeolian sand, tertiary to recent in age that potentially forms a huge primary aquifer resource. However, saline groundwater in the Kalahari has been reported from the more arid areas in Botswana and Namibia, where this unit occurs extensively.

About 10% of the area is covered by areas designated as “complex hydrogeological structures”. Many of these are folded and faulted meta-sedimentary sequences, such as the Table Mountain group in South Africa, the Transvaal group metasediments and the Ventersdorp Lavas in South Africa and Botswana, and the Umkondo sediments in Zimbabwe. These complex systems tend to have reduced primary porosity due to fabric changes as result of metamorphism and cementation, but may exhibit secondary porosity from fracturing and bedding planes to considerable depths.

Because of semi-arid and arid conditions, groundwater storages are recharged for the most part by heavy rain that infiltrates through the soil into the underlying layers. Occasionally the groundwater storages are augmented by the streams and rivers that lose water to the underground strata. As a consequence of the climate, the arid and semi-arid countries, especially southern Angola, Namibia, Botswana and western South Africa, and western Zimbabwe, have lower recharge rates as showed in Fig 5, and hence tend to place a

higher value on their water resources than the humid countries. In these areas, groundwater recharge may be limited and probably largely localized to line and point sources such are streambeds and dam basins respectively. Surface water resources are largely ephemeral, and most perennial rivers in these areas receive their recharge from humid areas. As a result, the groundwater resource has assumed great importance as the principal source of fresh water.

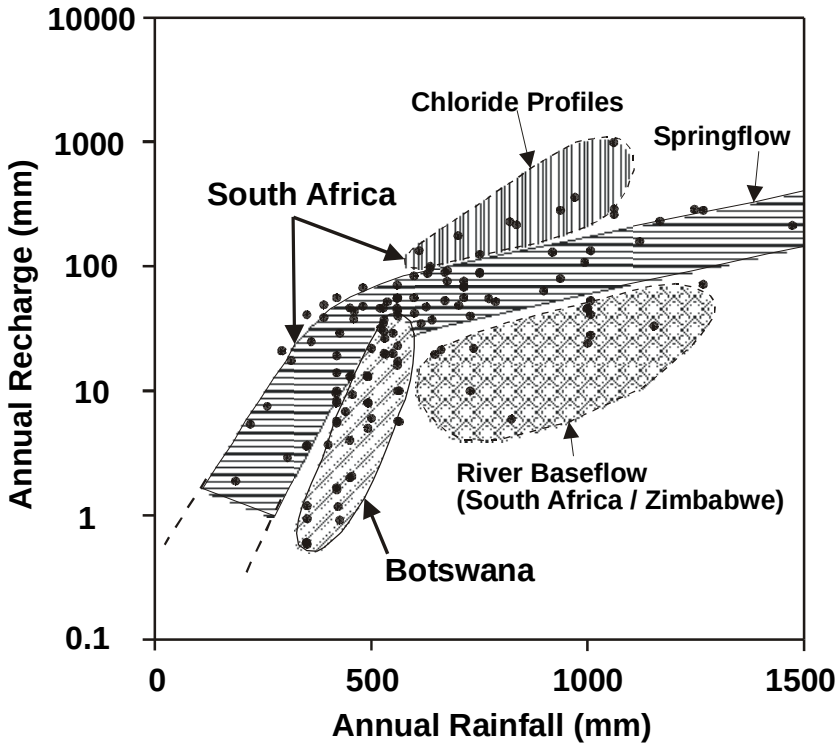

Figure 5: Comparison of results of recharge studies in southern Africa (Beekman and Xu, 2003)

The eastern and northern part of the SADC region may be characterized as humid tropical and humid equatorial climates. These countries are northern Angola, DRC, Tanzania, Mozambique, Malawi, Zambia, eastern Zimbabwe, eastern South Africa, Lesotho and Swaziland. In addition, the islands of Mauritius and Madagascar are also humid climates. These areas generally have more abundant water resources with perennial surface water. The groundwater resource, while potentially more abundant than in the arid countries, receives less attention and is generally not as carefully monitored and managed. This overall situation is illustrated in Appendix C: Hydrogeological Resources of Southern Africa.

6.3 Resource use

The status of the groundwater sector within the individual countries relates primarily to the role it plays in water supply and the complexity of its occurrence. In countries with a strong dependence on groundwater, such as Botswana, Namibia and Mauritius, the level of development in the sector is quite high. The recurring droughts in the Region have also reinforced the potential value of groundwater as a reliable source often less

affected by dry periods than surface water systems resources. The discussion below on groundwater utilization in SADC is largely based on SADC, WSCU (2001).

Groundwater is the largest water supply source for the domestic water supplies in the Region, while it also plays a significant role in stock watering and other uses (see Table 4 below). Its contribution to total utilisation in the Region is estimated at 11.6% by volume, while in domestic supplies it contributes approximately 20% by volume (Molapo *et al*., 2000).

Table 4: Groundwater Dependency Summary

Member State	Rural	Urban	Agriculture	Industry	Overall dependency
Angola	**	**	**	*	**
Botswana	***	**	***	***	***
D R Congo	*	*	*	*	*
Lesotho	**	**	*	*	*
Malawi	***	*	**	*	**
Mauritius	**	**	**	**	**
Mozambique	**	**	*	*	**
Namibia	***	***	***	***	***
Seychelles	**	**	*	*	*
South Africa	***	**	**	**	**
Swaziland	***	*	**	*	**
Tanzania	***	**	**	*	**
Zambia	**	**	*	**	**
Zimbabwe	***	**	***	**	***

Scale *** major, ** moderate, * minor *Adjusted from WCS & BGS (2003)*

Groundwater contribution is very critical to majority of the rural community and small towns. For rural, peri-urban and scattered settlements in stand-alone communities, commonly groundwater is the most economically viable drinking water source. The remoteness of the rural population and the rugged topography also influences the degree of groundwater development. In areas where rural infrastructure is minimal, rural communities often rely only on informal, traditionally developed (i.e. hand dug wells, springs, sand river abstraction) groundwater sources. It should be noted that there is still a backlog of between 30 and 50 per cent in terms of access to improved water sources in several countries of the region, the largest portion of unserved being in the rural areas. Groundwater resources should thus be seen as strategic in SADC (Molapo and Puyoo, 2002 and Appendix F).

Groundwater's changing role can best be illustrated with the example of South Africa (Braune and Mutheiwana, 2007). Until the new National Water Act of 1998, groundwater was defined in law as "private water" and was seen of local importance only. The predominately hard rock systems, of which basement aquifers make up a major part, only contributed about 12% to total bulk water supply. With the democratization of the country in 1994 there was a strong policy shift towards providing basic services, including water and sanitation services, to the whole population as soon as possible. The indication at that time was that 15 million people or about 40% of the population did not have the most basic water supply. By 2006 the backlog has been reduced to 4 million and groundwater has played a major role in this regard. Already the rural domestic use from groundwater in South Africa has increased from 120 million cubic meters in 1986 to 310 million m^3 per annum in 2000. Overall, groundwater supplies more than 60% of the country's

population with water and going up to 90% in some provinces. This is in line with international trends, where groundwater's worldwide role is a reliable source of drinking water. Its special characteristics also make it ideally suited for various forms of conjunctive use, together with other water resources, thus achieving a more optimal utilization of the total resource.

A similar picture of groundwater's growing importance is emerging from other countries in southern Africa with a high proportion of basement aquifers. In Zimbabwe 70% of the rural population relies on groundwater (Sunguro *et al*., 2000) and in Swaziland this figure is as high as 90% (Integrated Regional Information Networks, 2002). Overall, it is estimated that 75% of the African population is using groundwater as its main source of drinking water (ECA *et al*., 2000).

It is estimated that 37% of the total population of the SADC Region is supplied with drinking water from groundwater sources, as compared to 23% that is supplied with surface water. The remaining 40% of the population remains unserved (Molapo *et al*., 2000 and Appendix E). A summary of groundwater usage in the SADC Member States is presented in Table 5. Greater detail is available in Appendix G.

Table 5: Groundwater Usage in SADC Member States

Country	Part of Groundwater in total Water Supply (%) (1)	Part of Groundwater in Domestic Water Supply (%) (2)	Other Main Users (3)
Angola	1	22	
Botswana	64	41	Agricultural (Stock-water); some small-scale irrigation
DRC	-	25*	
Lesotho	41	58	
Malawi	3	29	
Mauritius	21	50	Irrigation, Industrial
Mozambique	6	34	
Namibia	50	37	
Seychelles	2	-	
South Africa	16.5	35**	Agricultural (Stock-water) 60 to 70%
Swaziland	2	70	
Tanzania	4	25	Small scale irrigation
Zambia	9	40	Irrigation
Zimbabwe	10	10	Livestock, local irrigation

from: SADC- WSCU (2003)

1. Groundwater contribution by volume in total water sector including all uses
2. Groundwater contribution by volume in domestic/potable water supply
3. Other sectors outside domestic water supply that are the main user of groundwater
** Only for urban water supply*
*** Based on population served*

Although the importance of groundwater as a viable and economically feasible source is now widely recognised in the Region, its importance for bigger settlements and larger scale water supply is often underplayed. It is estimated that 36% of the urban population in the SADC Region relies on groundwater (Molapo *et al.,* 2000). There are numerous examples in the Region where groundwater significantly contributes to supply to bigger settlements. In Mauritius, groundwater contributes almost half of the water supply to urban centres. In South Africa, about 20% of water supply to Pretoria comes from groundwater and approximately 100 other smaller towns depend on groundwater. In Tanzania in such towns as Singida, Mtwara, Lindi and Dodoma, groundwater accounts for approximately 70 to 80% of the supply and Dar-es-Salaam now depends significantly on groundwater supplies. In Zambia, groundwater contributes 50% of the water supply to Lusaka.

Groundwater is also a major source for small-scale irrigation and livestock farming in many of the SADC Member States. Groundwater for these purposes is largely developed at private level and, as such, reliable statistics are not available. It is estimated that groundwater now accounts for about 14% of the total irrigated area in Namibia, 18% in South Africa, and as much as 56% in Botswana (FAO AQUASTAT database). Small-scale irrigation using groundwater is set to increase in the near future (WCS & BGS, 2003). This statement must be read together with the FAO prognosis that groundwater irrigation offers a big opportunity for enhancing the livelihoods of the poor in much of Africa. The central challenge, according to the FAO is to put the pump into the hands of the poor (FAO, 2003b). To this, one can add the challenge of achieving cost-effective , wide-spread development of localized hard rock aquifers, which would only be possible through massive private initiative coupled with government planning, financial and logistic support.

Apart from agriculture, groundwater is also an important input into small-scale production activities, such as brick making and brewing that often contributes significantly to local employment and income generation (WCS & BGS, 2003).

Drought is endemic in the SADC region and presents a major challenge to the achievement of sustainable development. Events like the 1991/92 drought had a region-wide impact, causing substantial socio-economic hardships, decline in public health on a large scale, land degradation and bio-diversity loss. Presently, about one third of the people in the region live in drought prone areas. In the driest parts of the region, groundwater is the primary source of drinking water for human and livestock and groundwater has a predominant role to play in drought management issues. A meteorological drought usually precedes the surface water and then a groundwater drought. These extreme events are impacted by global climate changes, and their frequency and intensity are expected to increase in the future. However, policy responses to drought have, in the past, been based on short-term crisis reactions, which have generally proved to be inefficient or ineffective. Thus, groundwater has not yet been able to play its strategic role in this regard (Wellfield Consulting Services and British Geological Survey, 2003).

The above indicates a changing role for groundwater in the SADC region, at this stage most obvious for community water supply in rural areas. This must be seen together with the large backlogs in basic water services, averaging 40% for the region, of with about 80% are in rural areas. Groundwater will be able to address these needs and will even be able to go further in meeting basic livelihoods. Local ground water supplies, including the widely occurring crystalline basement rock systems, are adequate for community gardens, for stock watering and other local productive needs like brick-making. In this way, groundwater holds a vital key to community development and thus to poverty alleviation. The challenge lies not so much in stretching local groundwater resources, but in integrated local development efforts.

6.4 Resource Assessment

South Africa, Botswana, Namibia and Mauritius appear to have well developed and well managed groundwater databases. Zimbabwe and Lesotho also have electronic databases, but these appear to be less well developed. Tanzania, Mozambique, Malawi and DRC appear to have only rudimentary groundwater information systems, and do not possess any electronic format database. Only Lesotho reports that they have external support for their database system. The national groundwater databases are usually stored and maintained by the relevant department in a government ministry. Zimbabwe has now established a quasi-statal entity, ZINWA (Zimbabwe Water Authority), which manages the groundwater sector and the database. Most countries indicate that some level of support for their database management would be valuable.

Data is normally available only at a central level, but there may be certain procedures to be completed before data is made available. In South Africa, data is available readily to all areas, and it is not necessary to travel to the database host to obtain data.

With regards to the nature of the data available in the database, South Africa, Botswana, Namibia and Mauritius appear to have the most comprehensive data, with large scale (1:250,000 and 1:100,000) hydrogeological maps, water level and water chemistry data, and scientific studies on the major aquifer resources. Groundwater recharge rates are only well known in South Africa, Botswana and Mauritius. Second ranked countries with intermediate level systems would include Zimbabwe and Lesotho, while Tanzania, Malawi and DRC have only rudimentary groundwater data systems. Other data such as climatic and river flow data are generally available in all countries. All countries report that groundwater abstraction is generally not known, and typically, for private boreholes only the borehole user(s) know how much water is being pumped.

6.5 The Groundwater Management Programme for the SADC Region

The Water Sector has developed a 'Groundwater Management Programme for the SADC Region'. The Programme is part of the Regional Strategic Action Plan for Integrated Water Resources Development and Management in the SADC Region, undertaken with the support of many cooperating partners. The Programme, far from being a substitute to the responsibilities of individual member States, is rather, a support and incentive mechanism to increase the efficiency of national programmes with due consideration of transboundary issues. The Programme includes 10 projects listed in order of priority (Box 1).

Box 1/…

Box 1: Tools for shared management of shared aquifers and aquifers contributing to shared river basins

Plans to develop exchange of information and consultation regarding Shared Aquifers in SADC are still in their infancy. The Groundwater Management Programme for the SADC Region creates an enabling environment for joint management by putting in place a framework and specific tools, which are a prerequisite for the management of Shared Aquifers, in particular:

- *A good knowledge base: Understanding of aquifer characteristics, geometry, limits, amount and location of recharge, direction of groundwater flow, vulnerability, prediction on impact of abstraction*

    1) Capacity Building within the Context of Regional Groundwater Management Programme.
    2) Develop Minimum Common Standards for Groundwater Development in the SADC Region.
    3) Development of a Regional Groundwater Information System.
    4) Establishment of a Regional Groundwater Monitoring Network.
    5) Compilation of a regional Hydrogeological Map and Atlas for the SADC Region.
    6) Establish a Regional Groundwater Research Institute/Commission.
    7) Construct a Website on Internet and publish quarterly News letters.
    8) Regional Groundwater Resource Assessment of Karoo Aquifers.
    9) Regional Groundwater Resource Assessment of Precambrian Basement Aquifers.
    10) Groundwater Resource Assessment of Limpopo/Save Basin.,
- *A network of institutions, which create interaction between local, national, regional, global levels: Examples are the Sub- Committees at the SADC regional level and river basin organisations, which can address issues of transboundary nature and could be adapted to large shared aquifers, some of them extending across River basins,*
- *A network of experts from countries involved, as custodians of the technical knowledge,*
- *A network of decision makers and NGOs, facilitating or developing dissemination of information, awareness building, public participation in water management issues,*
- *Tools such as Harmonised Procedures, Code of good practice, Regional Hydrogeological map, models, etc.*
- *Training and capacity building to develop national groundwater management structures, including community participation.*

The main objectives of the programme are to:

- Promote the sustainable development of groundwater resources at regional scale, in terms of research, assessment, exploitation and protection,
- Develop a regional framework for technical support to national groundwater assessment and management programmes (including capacity building, institutional and legal framework, policies, socio-economics and financing),
- Groundwater resources adequately taken into consideration in the regional integrated water resources development and management approach, with a particular emphasis on major transboundary aquifers and on the role of groundwater in drought management issues.

It is important to note groundwater issues should also be addressed by other thematic projects, which are not resource specific, such as the development of river basin organisations, capacity building or human resources development in the realm of IWRM.

The SADC Sub-Committee for Hydrogeology, so far has established a full situation analysis in the 14 SADC Countries regarding groundwater management setting and standards and procedures for Groundwater Development, and prepared a 'Regional Code of Good Practice for Groundwater Development'. This code of good practice initiates harmonisation and improvement of practices, serves as guideline and is on the SADC Agenda for implementation, through the SADC project on Standardisation (SADCSTAN).

An important recent development is the SADC Drought and Groundwater Management Programme, approved for funding by the Global Environmental Facility (GEF) in 2005. (SADC WSCU, 2000; World Bank, 2005). Its objective is the development of a SADC regional strategic approach to support and enhance the capacity of its member States in the definition of drought management policies, specifically in relation to the role, availability (magnitude and recharge) and supply potential of groundwater resources.

It represents an important part of the roll-out of the SADC Groundwater Management Programme and is operating on two levels, namely,

Regional level:

- Identify transboundary impacts of groundwater development in select basins.
- Identify priority groundwater drought prone areas and provide regional management tools (such as groundwater drought vulnerability maps, monitoring networks and a groundwater information system to support the mapping tool).
- Develop groundwater management tools to be applied through the SADC institutional network. and

River Basin level:
The role of groundwater management in pro-active drought mitigation will be demonstrated in the semi-arid Limpopo river basin taking, into account applicability and replicability for the region as a whole. The outputs will consist of:

- infrastructure interventions;
- institution and social interventions;
- formation of groundwater user groups; and
- heightened awareness of the need to manage groundwater, groundwater drought and dependent ecosystems on a long-term basis.

Specific project components are:

1. Testing of practical community level groundwater drought management strategies at a pilot level;
2. Research into groundwater-dependent ecosystems, their occurrence, vulnerability, value and protection;
3. MSc research grants to promote and advance groundwater knowledge;
4. The development of groundwater drought management tools and guidelines; and
5. The establishment of a regional Groundwater Management Institute of Southern Africa.

6.6 Observations on groundwater management capacity

First hand insight into the groundwater management capacity was gained through the attendance in November 2007 of a project steering committee for the recently initiated, GEF-funded, Groundwater and Drought Management Project. The observations are captured in Appendix K under the headings of 'Importance of groundwater', 'Capacity to manage groundwater resources', 'Monitoring of groundwater resources' and 'Education and training of groundwater practitioners'. These indicate that generally capacity for groundwater resources management is still very low and most countries have a need for education and training in hydrogeology, which can not be addressed within the country.

7. ANALYSIS OF THE GROUNDWATER RESOURCES MANAGEMENT SITUATION IN SADC

7.1 Purpose

This chapter describes the analysis of the groundwater resources management status in southern Africa based on the methodology outlined in chapter 3 and the IWRM framework developed in chapter 4. As context and focus for the analysis, a general view of major groundwater issues and problems in Africa is provided as introduction.

7.2 Major groundwater-related issues and problems on the African continent

Attention to the groundwater issues and problems shown below is seen as essential in moving towards a more sustainable utilization and management of groundwater on the African continent. Groundwater resources account for about 15% of Africa's renewable water resources. It's most important role is for community water supply, with an estimated 75% of the African population using groundwater as its main source of drinking water (ECA *et al.*, 2000). At this stage 300 million people in sub-Saharan Africa still have no access to safe water supplies – approximately 80% of these live in rural areas. The health and socio-economic implications of the above situation are enormous. This makes groundwater a potentially highly strategic resource in Africa.

Key issues relating to its sustainable utilization include:

- The general lack at all levels of appropriately valuing groundwater, a natural resource that is life-giving, and by its nature at the doorstep of every community and could therefore make a major contribution to the achievement the Millennium Development Goals, Africa's Water Vision, and the SADC IWRM Vision and Mission.
- The lack of appropriate approaches for the planning, financing, developing and sustainably utilizing a resource that can normally only be exploited in the form of many, widely distributed, relatively small, individual sources, given Africa's largely hard-rock aquifer environment.
- The wide-spread degradation of groundwater and the resulting diminishing resource base, mainly because of pollution of underlying groundwater in both urban and rural areas, but also over-abstraction, particularly in higher-yielding aquifer systems. There are also strong indications of severe land degradation (soil and vegetation) in areas of poorly managed stock watering from groundwater.
- The well-known human challenges of equity, justice, power and governance. These are at the heart of the debate on any finite natural resource and particularly pressing for groundwater because of its unseen and poorly understood nature. The challenge is a major one in Africa, because of the much greater lack of information and knowledge about the resource and a general lack of appropriate governance structures to help achieve objectives of equity and sustainability.
- The transboundary nature of aquifer systems and the environmental and societal systems that depend on them. It can be foreseen that growing water scarcity will bring increasing water resources as well as related land resources degradation and the accompanying human conflicts, increasingly across international boundaries. Again, these problems are exacerbated through the unseen and poorly understood nature of groundwater.

- The lack of data, information and knowledge about groundwater and its functioning as a critical hydrological and environmental system component and the serious lack of institutional capacity in this regard. This problem is an underlying cause to most of the other groundwater issues mentioned above.

These key issues and problems particularly prevalent in Africa, but also elsewhere in the world, are discussed in slightly more detail below.

Lack of appropriate valuing of groundwater

The management of groundwater has to date failed to feature prominently in the national and regional water agendas in Africa, except for countries that are virtually dependent on underground water resources. The continued use of a 'private water' legal classification for groundwater is just one of the expressions of its lack of recognition.

At the heart of moving forward with a more sustainable utilization lies the need for a much clearer understanding and articulation of groundwater's role and contribution to national and regional development objectives, in particular:

- community water supply;
- public health;
- rural development;
- small farmer development;
- urban development;
- mining development;
- functioning of vital ecosystems.

Deeper understanding of these roles and relationships is bound to establish that groundwater has a major, still largely locked up, role to play in the fulfilment of the Africa Water Vision of:
"An Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation and the environment."

Lack of appropriate regional development approaches / instruments

No appropriate planning approaches

Large surface storages are often inappropriate for a wide spread of the resulting benefits – and still the alternative solutions called for have not yet addressed groundwater in a systematic way. Planning processes and accompanying study and exploration investment, addressing groundwater systematically through all phases of planning, are not in place.

No appropriate financing approaches

There are obvious hurdles to be overcome in financing many small groundwater schemes with limited accountability and initial cost recovery, compared to large schemes where national governments are ultimately accountable. However, solutions are being explored all over the world and in related sectors, which need to be evaluated and pilot-tested in Africa.

No appropriate sustainable resource development approaches

South Africa's very successful approach of BOTT (Build, Operate, Train, Transfer), for example, utilized to achieve the rapid reduction in the large, country-wide water services backlogs, was not designed to cater for the special needs of water supply from local groundwater sources. The challenge lies in the internationally accepted principle that local and vulnerable groundwater resources need a much more participative approach to development, operation and protection than was possible in this, largely, top-down programme designed to achieve rapid results.

Lost opportunities as a result of such shortcomings not only relate to conjunctive use of surface and groundwater resources, but also for mainstreaming of drought risk management and for development planning, both requiring integrated land and water management approaches. The above present a particular challenge to AMCOW policy direction referred to in chapter 2 regarding the institutionalization of groundwater management by river basin organizations.

Widespread degradation of groundwater resources

In contrast to the potentially strategic role for groundwater outlined above, it has remained a poorly understood and managed resource. This has become a clear threat to sustainable water service delivery and meeting the Millennium Development Goals on water. Poor understanding and mismanagement is the norm rather than the exception. Examples of vital water supply sources and even whole aquifers being abandoned due to pollution are cited and polluted water served to communities through piped water supply systems leading to typhoid outbreaks and national repercussion (Xu and Usher, 2006). Because of its unique role in the landscape and its largely unseen nature, groundwater and the aquifers that host it are particularly vulnerable to these impacts. In addition, impacts can stay hidden for many years and by the time, they are discovered they are very difficult and costly to remediate.

This situation was brought to the international attention by a major UNEP/DEWA and UNESCO/IHP project undertaken in 11 African cities (Abidjan (Côte d'Ivoire), Dakar (Senegal), Ouagadougou (Burkina Faso), Bamako Mali), Cotonou (Benin), Keta (Ghana), Mombasa (Kenya), Addis Ababa (Ethiopia), and Lusaka (Zambia). The overall conclusion from all countries was that pollution of the vital underlying groundwater sources has reached critical levels.

The human issues relating to the sustainable utilization of the common property resource

The 'common property resource' issues of economic efficiency, equity, safeguarding of basic needs and of avoiding harm to others are all particularly important for groundwater, because its essential role in meeting a most basic human need and because of its hidden and little understood nature.
The key instruments of local control and popular participation as well as orderly conflict resolution and an enabling environment are challenging to implement and need, first of all, political will.

The issues relating to the transboundary nature of aquifer systems

The different categories of transboundary issues emerging for large regional ecosystems (UNDP, 1999) are all relevant for groundwater and aquifer systems, i.e.:

- Regional/national issues with transboundary causes/sources;
- Transboundary issues with national causes/sources;
- National issues that are common to at least two or more countries and that require a common strategy and collective action to address;

- Issues that have transboundary implications, e.g. free basic water or drilling subsidies.

A particular issue is that the general lack of understanding about groundwater system functioning could introduce transboundary issues where they may not exist in reality.

The lack of information and information management relating groundwater resources management.

Key issues here are:

- No systematic data base and resource assessment;
- Ad hoc groundwater exploration;
- Inadequate investment in groundwater information;
- Inadequate planning resulting in a lack of drive for improved information.
- Lack of capacity of the groundwater science sector to influence national/regional decision-making.

While poor and deteriorating hydrological networks and institutions were already seen as a major concern by AMCOW at its Pan-African Conference in 2003, it should be recognized that groundwater information services are the least established and in many African countries virtually non-existent.

7.3 Analysis of groundwater resources management status in SADC

In the analysis, summarized in Table 6 below, each element of the IWRM toolbox was assessed, using available documentation and scientific literature on groundwater from the sub-region, and evaluated against the best practice benchmarks established in chapter 4. A management performance rating of 'good', 'limited' or 'below expectation' was assigned to different elements within this framework, by comparison with the norm provided in the best practice analysis. The intention is to refine the analysis in a representative workshop.

Table 6: Assessment of Groundwater Resources Management Status in SADC

GROUNDWATER RESOURCE MANAGEMENT EVALUATION FRAMEWORK	**PERFOR-MANCE (*G, L or B**)**
Performance: ***G: Good*** ***L: Limited*** ***B: Below expectations***	
A. Enabling Environment	
A1. POLICIES In place are the *SADC Protocol on Shared Watercourses* as well as the *Regional Strategic Action Plan for Integrated Water Resources Development and Management* (RSAP) and a Groundwater Management Programme for the SADC Region in support of its implementation. The attitude towards groundwater as a resource is often not positive among many decision-makers and even technical cadres (WCS and BGS, 2003). This results in neglecting the potential use of groundwater as a valuable alternative to surface water and also the protection of existing groundwater sources Molapo and Puyoo, 2002). Within SADC, the Water Resources Technical Committee (WRTC), the Sectoral Committee of Senior Officials and the Sectoral Committee of Ministers of Water, have acknowledged that more attention should be given to groundwater development and protection. While the Protocol explicitly refers to groundwater, its overwhelming emphasis is on surface water resources (WCS and BGS, 2003). The groundwater resource management links to other groundwater-dependent sectors like agriculture, health and environment, are not well established in policy or in practice. The choice of the water supply system is still biased towards surface water, irrespective of the characteristics of a given area and nature of groundwater occurrence.	**B**
A2. LEGISLATIVE FRAMEWORK All Member States possess some form of water law - many of these statutes make no specific reference to groundwater. Groundwater within a water law is most comprehensive in Botswana, with different regulations relating to different uses and different situations. In terms of the law, it appears that in all countries, groundwater rights are vested in the state and there is no private ownership of groundwater (BGR *et al.*, 2007). Most countries require users to obtain permits for groundwater abstraction, but these procedures are generally not strongly enforced (BGR *et al.*, 2007). Policy, legislation and regulations pertaining to the management of groundwater resources is extremely old in many States, scattered through various legislative articles, out of line with national/international environmental views, and is sometimes almost non-existent (WCS and BGS, 2003).	**L**
A3. FINANCING AND INCENTIVE STRUCTURES The status and level of funding to groundwater development depends on the perceived	**B**

importance of groundwater at the national level. The dependence of the majority of the SADC Member States on external funding sources has an important bearing on groundwater development in these Member States, particularly with respect to the establishment of a stable local development capacity (SADC-WSCU, 2001a). There is a Programme on Implementation of Water Supply and Sanitation in SADC (SADC, 2005) with significant funding and opportunity for groundwater infrastructure development. However, there is no special strategy to link this to improved groundwater resources management. In Member States with strong dependence on groundwater, the funding commitments are often high and groundwater development is a priority. On the other hand, where surface water sources are in abundance, groundwater development is generally accorded a low priority that is reflected in funding commitments, in particular for vital groundwater monitoring, exploration and data gathering (WCS and BGS, 2003).	
B. Institutional Development	
B1. CREATING AN ORGANISATIONAL FRAMEWORK Groundwater management in the region is the responsibility of a variety of different ministries: Water, Minerals, Natural Resources and Irrigation are cited as parent ministries. Division of functions between national water authorities and catchment management authorities is not always clear-cut. River Basin Organizations have not yet taken groundwater adequately on board. No coordination with respect to groundwater development and use exists between different users of the same resource (WCS and BGs, 2003). Little progress has, been made with the implementation of groundwater user associations. Decentralisation is now a common feature of the SADC Region, with the transfer of implementation of water supplies to provincial and local governments and authorities. Communities themselves are becoming a more and more significant component of informal institutional arrangements. Awareness of their potential role in implementing effective groundwater development and management is growing throughout the Region (SADC-WSCU, 2001a). During drought emergencies, many countries still rely heavily on external assistance channelled through government or intermediary agencies and non-government organisations (NGOs). Despite the broad success of relief efforts in averting famine, many weaknesses in drought preparedness and emergency response were exposed, particularly in relation to rural water supply (WCS & BGS, 2003). While groundwater's role in rural water supply, in particular during droughts, is growing, this is offset by ineffective maintenance, making a large proportion of water points inoperative even during normal (non-drought periods) WCS and BGS, 2003).	**B**
B2. BUILDING INSTITUTIONAL CAPACITY Shortage of indigenous groundwater personnel at all levels is apparent in many Member States. (WCS and BGS, 2003). While there are a number education and training institutions in the groundwater field in SADC (see Appendix J), overseas institutions are often still preferred, because of technical assistance support.	**B**

There is a lack of coordination amongst the various agencies involved in groundwater development activities. Maintenance of groundwater infrastructure is not effective in most countries within SADC. This means that many boreholes are not functioning at all, at any time. A "Development of a Code of Good Practice for Groundwater Development in the SADC Region" (SADC-WSCU, 2001b) has been developed. However, systematic implementation is still lacking. In the past, the science of hydrogeology was still being developed and hydrogeological input did not always benefit community development as much as it benefited the science (BGR *et al.*, 2007). The key concerns for most organisations involved in groundwater development are resource sustainability, information gaps, provision and maintenance of water supplies, water quality, finance, lack of a qualified work force. In terms of capacity, two key factors stand out: human resources development at all levels and an improved knowledge and understanding of the groundwater resource (BGR *et al.*, 2007).	
C. Management Instruments	
C1. WATER RESOURCES ASSESSMENT SADC has a Regional Groundwater Management Programme, overseen by a Sub-committee on Hydrogeology (SADC-WSCU website). However, the planned regional monitoring and mapping activities have not yet materialized. Lack of coordination has been identified as the major cause of poor data collection and management in most member states. Information that is vital for developing groundwater resources is not readily accessible. Adequate hydrogeological monitoring in the SADC region is a critical deficiency (WCS & BGS, 2003) Groundwater abstraction information is generally not known (BGR *et al.*, 2007). There are huge variations in practices, methods, procedures and techniques that are employed for borehole siting in the SADC Member States. The lack of reliable and timely information on the status of rural water supplies, fundamental to any form of groundwater drought planning and mitigation. has been a serious constraint on sector planning and management (WCS & BGS, 2003). However, some countries have started to invest community water supply funds for the systematic collection of data for all water supply schemes (GRIP project). Inadequate professional supervision of groundwater development activities is often pointed out as the single most common reason resulting in sub-standard borehole construction, poor quality data collection and inappropriate yield recommendations. The most arid countries like Botswana, South Africa, and Namibia have devoted understandably the most attention to groundwater resources exploration, assessment, development and monitoring. Manual data collection and sampling in countries having limited financial resources with large	**B**

land areas and poor road networks are expensive. Donor (and country) funded groundwater projects are usually of short duration, with little if any hydrogeological monitoring input in their design. A major cause of poor monitoring or poorly defined monitoring programmes is the lack of an identified person or group that are specifically responsible for national monitoring. The understanding of data quality and consistency is rarely recognised and quality assurance protocols for monitoring data are not implemented in any of the SADC member states.	
C2. PLANS FOR IWRM There are still big differences among the countries in terms of implementing IWRM. A lack of macro planning for groundwater prevails, as most of the programmes are undertaken on an ad-hoc or crisis response basis. This is one of the most problematic areas in relation to groundwater development. (SADC-WSCU, 2001a).	**B**
C3. EFFICIENCY IN WATER USE Demand management for groundwater is not effectively in place in almost all the countries. Initiatives towards water conservation, in particular rainwater harvesting and artificial recharge of groundwater, are taking off in a number of SADC countries. Namibia indicates that it has advanced demand management practices with discharge monitoring and fees charged for water used (BGR *et al.*, 2007).	**L**
C4. SOCIAL CHANGE INSTRUMENTS Awareness raising about groundwater is not yet undertaken systematically, despite the vulnerable nature of the resource and widespread ignorance about it. There is record of very good ad hoc awareness raising initiatives. In several cases, Ministers of Water Affairs have become champions of groundwater.	**L**
C5. CONFLICT RESOLUTION There are a number of transboundary aquifer systems in the SADC region (see Appendix D), covering long distances of international boundaries, because of their widespread occurrence. This brings a significant danger of conflict over groundwater resources, because of the unseen nature of groundwater and the general lack of understanding about its functioning. The SADC Protocol on Shared Watercourses opens the door to more detailed measures of conflict resolution.	**L**
C6. REGULATORY INSTRUMENTS Groundwater pollution must be seen as one of the main threats to the achievement of sustainable water resources management and meeting the Millennium Development Goals in many African countries (Xu and Usher, 2006). All countries indicate that there is legislation in place to prevent pollution but they all also indicate that there is insufficient capacity to monitor groundwater problems and to enforce the legislation. Not enough information could be gleaned from the published material on groundwater regulations that are in place.	**L**
C7. ECONOMIC INSTRUMENTS Not enough information could be gleaned from the published material on groundwater	**L**

regulations that are in place. In Namibia and Botswana, towns and commercial users pay for groundwater. In Zimbabwe, commercial users pay for groundwater. In Mauritius, private boreholes pay for water abstracted. The other countries indicate that users do not pay for groundwater (BGR *et al.*, 2007).	
C8. INFORMATION EXCHANGE In Namibia and Botswana, towns and commercial users pay for groundwater. In Zimbabwe, commercial users pay for groundwater. In Mauritius, private boreholes pay for water abstracted. The other countries indicate that users do not pay for groundwater (BGR *et al.*, 2007). Serious deficiencies exist in reporting of groundwater development activities. The reports, by and large, lack the analytical aspects and only provide 'data' that is not interpreted or analysed and thereby converted into 'knowledge'. A SADC groundwater website with a quarterly newsletter, as foreseen in the Groundwater Management Programme, has not yet materialized.	**B**

While the above analysis was only performed on readily available published material from the region and without individual country information, some general conclusions on the status of groundwater resources management in SADC can be drawn.

- The natural water inputs in the form of rainfall are relatively low and very irregular, showing both seasonal and high inter-year variability. Access to reliable and safe water supplies is one of the highest regional development issues, particularly for the high percentage of poor living in largely unserved rural and also peri-urban areas;
- SADC has made excellent progress to address groundwater in its comprehensive regional water resources policies and strategies and in initiating implementation through its Groundwater Management Programme. In this respect SADC is leading the other Regional Economic Communities.
- When it comes to implementation in individual countries, the performance in groundwater resources management must still be generally rated as "below expectation", compared to relevant international best practice. This is the case across the full spectrum of IWRM framework used in the analysis.
- A few countries have legislation specifically focussing on groundwater, while others have modern integrated legislation. However, several countries have outdated legislation and, while harmonization across the region is on the SADC agenda, this has not yet been implemented for groundwater-related legislation.
- Despite the inability of bulk water supply solutions to address most of the widespread and diffuse water demand required to meet the remaining water services backlogs, there is still a general bias towards surface water resources in the region. Groundwater management links to groundwater-dependent sectors like agriculture, health and environment, are not well established in policy or in practice.
- Investment in groundwater, relative to its potential to address national objectives, is limited and this is still offset by pollution and ineffective maintenance, making a large proportion of water points inoperative.
- The relatively low priority accorded groundwater is reflected in funding commitments, in particular for vital but completely inadequate groundwater monitoring, exploration and data gathering;
- Major changes in institutional development for water services delivery and IWRM are taking place in SADC, but groundwater's unique role has not been adequately reflected in this new development, for example in river basin organizations and water user associations;

- While decentralization is becoming a common feature in SADC, institutions have not yet been properly capacitated in terms of their new groundwater responsibility;
- Lack of adequate monitoring and assessment of groundwater resources is resulting in poor attention to groundwater planning at all levels This is particularly serious for drought risk management in which groundwater resources should play a critical role.
- A lack of macro planning for groundwater prevails, as most of the programmes are undertaken on an ad-hoc or crisis response basis. This is one of the most problematic areas in relation to groundwater development.
- The dependence of the majority of the SADC Member States on external funding sources has an important bearing on groundwater development in these Member States, particularly with respect to the establishment of a stable local development capacity. Donor (and country) funded groundwater projects are usually of short duration, with little if any hydrogeological monitoring input in their design.

The typical groundwater challenges of Africa are all present in the SADC sub-region, Based on worldwide experience, this situation will not change significantly, unless there is a strategic, multi-sector intervention across the full spectrum of groundwater management issues touched on in the analysis.

To confirm and provide more weight to these conclusions, a SADC groundwater stakeholder workshop in cooperation with the SADC Water Division is already in an advanced state of planning.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

Like in the rest of the continent, poverty is the dominant development issue in the SADC region, and water and its proper management will have to play a major role in its mitigation. Drought is endemic in this region and risk management requires wide-spread balancing storage for both basic domestic water services as well as for productive uses, in particular small-scale agriculture. This will be completely infeasible, both technically and financially, from surface water resources alone. Groundwater, given its unique characteristics of a protected underground storage and distribution system, can fulfil such a role in Southern Africa, despite the hard rock and generally low yield nature of aquifer systems in most parts here.

This development role for groundwater in Africa and Southern Africa is still poorly understood, resulting in underutilization and poor management of the important resource. The international experience is that turning around this situation will require strategic action across sector and international boundaries. The African Ministers' Council on Water (AMCOW) would like to launch such an action for groundwater in Africa, following its resolutions in Brazzaville in May 2007.

A forerunner to such a strategic action would have to be a trustworthy and widely accepted assessment of the status of utilization and management of groundwater resources in the area of focus. The purpose of this study has been to develop a methodology by which such an assessment can be undertaken and to test the methodology in the SADC region, where excellent progress has been made in integrating groundwater into regional water resources policies and strategies.

The key principle of the methodology is that groundwater resources management should not take place in isolation from the rest of the hydrological cycle and from the country/region development environment, but within an established IWRM framework, which provides for integration across different water resource components and economic sectors. This has been achieved by using the IWRM toolbox, put together by the Global Water Partnership, as framework. In this way the full spectrum of management, in particular the enabling environment, institutional development and various management instruments are addressed. Measurement of the level of management is achieved by expressing performance in different categories. The non-offensive, but never-the-less descriptive, categories of 'good', 'limited' and 'below expectations' were chosen. As a benchmark against which a particular level of groundwater management can be measured, a summary of international 'best practice' was compiled and used in the assessment for each element of the IWRM toolbox. Socio-economic development and water resources information for the SADC region are provided as context to ensure that the different aspects of groundwater management in the IWRM toolbox are relevant in the region.

The methodology developed in this study was used in an assessment of the status of groundwater utilization and management in SADC.

Despite being only a desk study, it is believed that the methodology and the findings of this assessment will find general acceptance and lead to critical decision-making because of the systematic nature of the assessment and because of the complimentary nature of the different elements of 'best practice' and how they were experienced in this region.

The study confirmed that SADC has made excellent progress to address groundwater in its comprehensive regional water resources policies and strategies. Groundwater is explicitly referred to in the SADC Protocol on

Shared Watercourses. It is also featuring in the SADC Regional Strategic Action Plan for Integrated Water Resource Management and the Regional Water Policy and it has its own Groundwater Management Programme for the roll-out of this plan. In this respect SADC is leading the other Regional Economic Communities.

When it comes to implementation in individual countries, the performance in groundwater resources management in SADC must still be generally rated as "below expectation", compared to relevant international best practice. This is the case across the full spectrum of IWRM, framework used in the analysis. It can also be expected that individual countries would continue to struggle with the traditional bottlenecks to sustainable groundwater utilization if there is no radical change in approach.

The importance of groundwater in this region, the cooperative regional IWRM structures and institutions that already exist and the understanding there is already for groundwater at the highest decision-making levels, offers a major opportunity to initiate a systematic, region-wide, and ultimately continent-wide, programme and approach, as foreseen by AMCOW, for building the capacity required to ensure that groundwater resources are utilized and managed sustainably in the SADC region.

As a result of this study, the senior author was invited on 27/28 November 2007 to a meeting of the SADC Water Division, which serves as steering committee for SADC Groundwater Management Programme. Enough interest in the work was created to result in the establishment of a task team to plan a SADC multi-stakeholder workshop regarding groundwater resources management, in which this study would be tabled. To improve its credibility within in SADC, the study would be peer-reviewed before the time.

8.2 Recommendations

SADC region

1. *Strategic groundwater resource management programme in SADC*

   SADC should respond to the groundwater resources management challenges in its region by means of a strategic, region-wide programme and approach for building the capacity required to ensure that groundwater resources are utilized and managed sustainably. Such a programme should be acting simultaneously at region, country, river basin and local level. It should be fully integrated into existing water resources policies, strategies and action plans and should be developed as an expansion of the SADC Groundwater Management Programme, Such a systematic study would have benefits for the continent as a whole and could serve as a pilot for AMOW's Africa groundwater initiative.

2. *Stronger groundwater focus in existing IWRM-related frameworks in SADC*

   The existing IWRM-related frameworks in SADC based on, in particular, the RISDP and the RSAP-IWRM, and conceptual diagrams of relationships, e.g. figures 3 and 4 in chapter 4, need to be reviewed to make more systematic provision for groundwater. Such a revised framework should bring out the intended relationship between groundwater interventions or management approaches and regional development and IWRM goals. It would also help to pull various interventions together towards a management approach that is internally consistent. It would make the "who, why, how and when" of groundwater a lot clearer. Once such a framework is accepted, it can be put into practice as an instrument of social and institutional change (e.g. policy, legal, economic and technical reform).

3. *Comprehensive scientific and technical assessment and plan for groundwater resources in SADC*

   To be able to move forward with a fresh vision for groundwater in the region, will require full integration of groundwater into the well-established regional development and water resources management instruments, in particular the RISDP, RSAP, RWP and RWS. These must in turn be based on an agreed understanding of the key groundwater issues and problems of the region and their major root causes and impacts. To the best of the authors' knowledge, such a comprehensive analysis does not yet exist for groundwater in SADC.

   The present desk study only allows for very general recommendations. A comprehensive plan, as recommended, would provide the basis for linked regional and national multi-sector actions and a set of targeted and costed activities that, once implemented, will together contribute to solve the major groundwater-related problems of the region. The plan could form the basis for technical assistance, partnership initiatives and capacity building. It should be a once-off exercise to bring groundwater focus in the region to the same level as for surface water and should then be incorporated into the regional water resources policy, strategy and action plans.

   Such a comprehensive plan will have to be developed out of a scientific and technical assessment, through which the groundwater-related issues and problems of the region are identified and quantified, their causes analyzed and their impacts, both environmental and economic, assessed. The analysis should involve an identification of causes and impacts at national, regional, and global levels and the socio-economic, political and institutional context within which they occur. The identification of the causes would specify sources, locations, and sectors and allows identification of potential preventive and remedial actions. It is suggested to consider the development of such an assessment and plan as an extension to the existing, GEF-funded SADC Drought and Groundwater Management Programme Framework and Plan (1. and 2.) are strongly linked. Development of the plan would need considerable groundwork down to country level to achieve the desired region and country buy-in and action response.

4. *Country groundwater resources management plans*

   Each country already has the target to develop IWRM plans by 2005. Each country should incorporate specific groundwater aspects into their overall IWRM plan. The plan should also address any specific issues and needs of groundwater in a river basin context as relevant for that country (to empower RBOs with respect to groundwater issues and give effect to the resolution in this regard by AMCOW).To achieve a comprehensive approach in all Member States, SADC should develop a prototype for such a country groundwater resources management plan.

5. *Strategy for groundwater resources management as part of the Rural Water Supply and Sanitation Initiative (RWSSI)*

   To give effect to the AMCOW resolution in this regard, countries should develop a strategy to ensure that groundwater resources management will benefit from the major investment in the RWSSI and thus significantly contribute to the sustainability of the investment. It is proposed that SADC should develop the prototype for such a strategy.

6. *River Basin groundwater action plan*

   To give effect to the AMCOW resolution, all RBOs should establish groundwater technical committees. The first task of Groundwater Technical Committees would be to develop a groundwater action plan for their basin. The country plans (3.) can provide direction.

7. *Commissioning of key thematic reports*

   These should preferably flow out of the Groundwater Strategic Action Plan. Topics that would need early attention are:
   "Critical assessment of the role and benefits of groundwater resources in Southern Africa."
   "Feasibility of widespread use of groundwater for small-scale farming and alleviation of poverty in Southern Africa."

8. *Momentum with SADC Groundwater Centre of Excellence*

   Such a centre, linking and growing existing groundwater management capacity in SADC, will be essential to create the necessary continuity with a SADC-wide rollout of a strategic groundwater resources management programme. Development of such a centre (Groundwater Management Institute for Southern Africa) is already foreseen under the SADC Groundwater and Drought Management Project.

9. *Implementation of SADC Groundwater Management Website*

   This should be a key part of the 'knowledge management system' planned as part of the Groundwater Management Institute for Southern Africa.

South African participation

10. *In general, it is felt that the South African capacity for IWRM and, in particular, groundwater resources management, to which the Water Research Commission has greatly contributed, can make a much greater contribution than at present to developments in this regard in Southern Africa. In terms of its present mandate, the WRC would only be able to focus on generally applicable methodology and assessments like this SADC scoping study. The challenge will be to position itself strategically in various regional water-related initiatives and interventions to ensure that this type of contribution can have the desired maximum regional impact and appreciation. This is already been done in other fields, in particular surface water assessment and environmental governance.*

11. *The WRC could consider applying the methodology in an assessment of groundwater resources management in South Africa as a contribution to the evaluations that are presently conducted regarding the progress with the implementation of the National Water Act, 1998*

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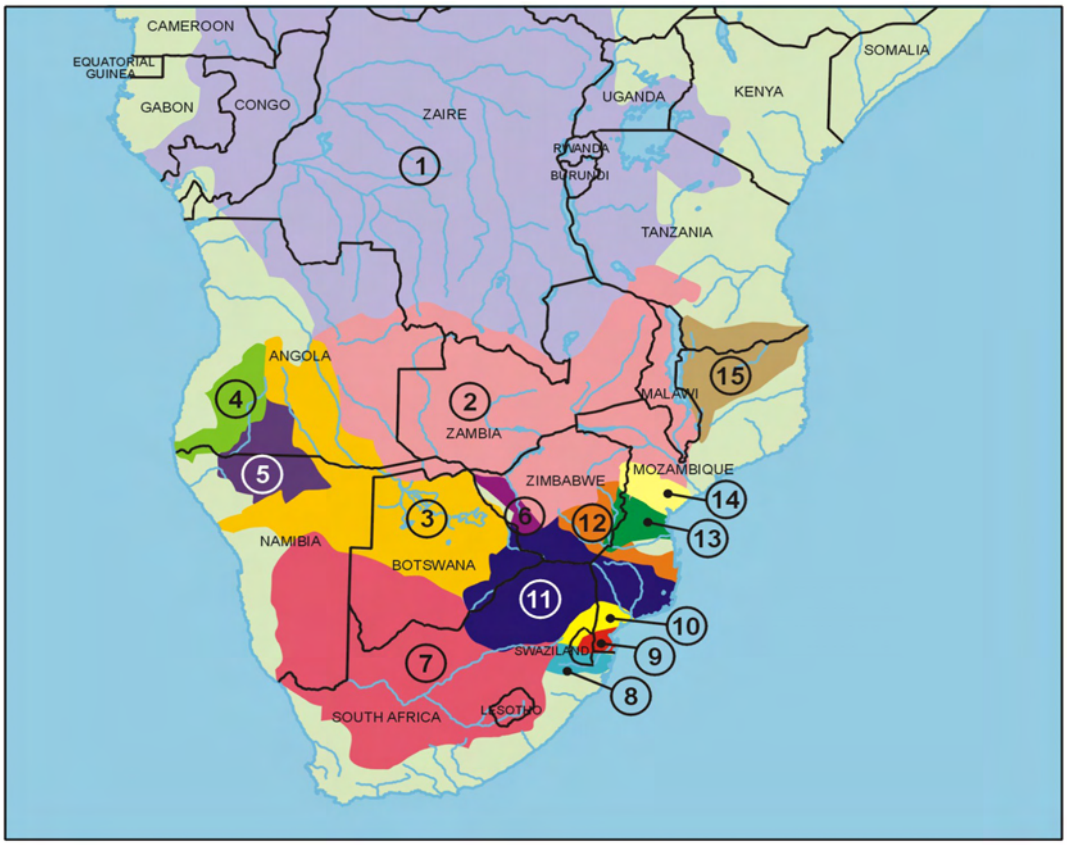
Appendix A: Shared water courses in SADC

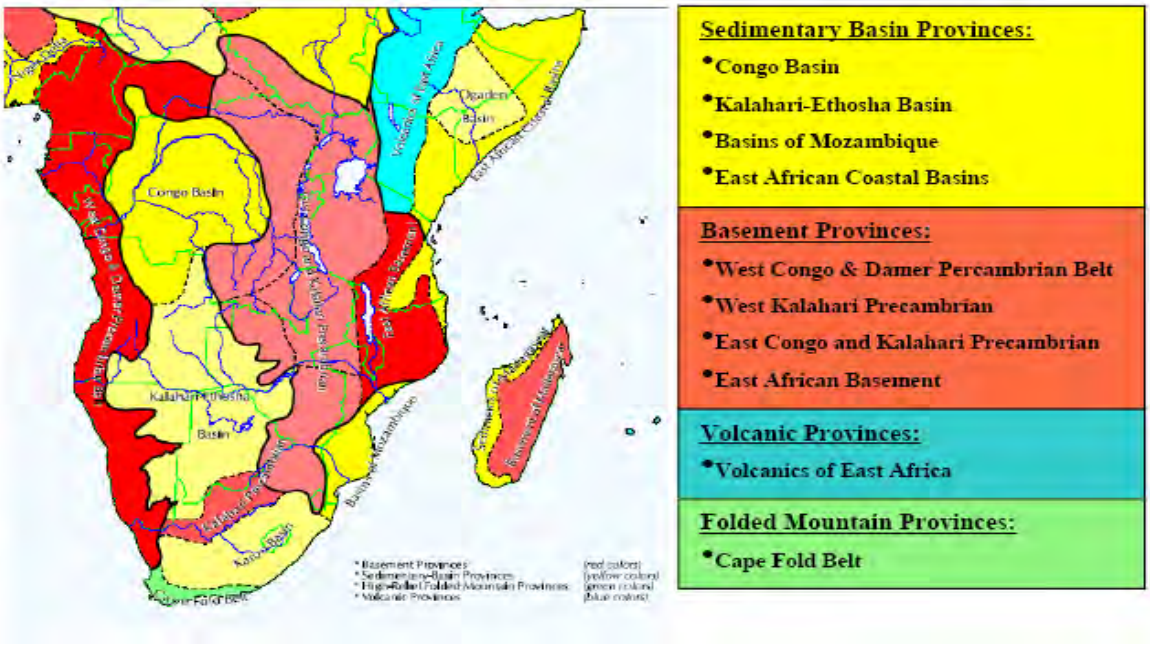


KEY:	
1 – Congo Basin	2 - Zambezi Basin (including Lake Kariba, Cahora Bassa Dam)
3 – Okovango Basin	4 – Cunene Basin
5 – Cuveli Basin	6 – Nata Basin
7 - Orange-Senqu Basin	8 – Maputo-Usutu-Pongola Basin
9 – Umbeluzi Basin	10 – Incomati Basin
11 – Limpopo Basin	12 – Save/Sabi Basin
13 – Buzi Basin	14 – Pungwe Basin
15 – Ruvuma Basin	

River Basin	Basin Area (Km^2)	River Length (Km)	Mean Annual runoff (Mm^3/a) at River Mouth	Numberof States	Basin States
Buzi	31 000	250	2 500	2	Zimbabwe, Mozambique
Cunene	106 500	1 050	5 500	2	Angola, Namibia
Cuvelai	100 000	430	Ephemeral	2	Angola, Namibia
Incomati	50 000	480	3 500	3	South Africa, Swaziland, Mozambique
Limpopo	415 000	1 750	5 500	4	Botswana, South Africa, Zimbabwe, Mozambique
Maputo	32 000	380	2 500	3	South Africa, Swaziland, Mozambique
Nile	2 800 000	6 700	86 000	10	Tanzania, Burundi, Rwanda, Kenya, Uganda, Democratic Republic of Congo, Eritrea, Ethiopia, Sudan, Egypt
Okavango	570 000	1 100	11 000	4	Angola, Namibia, Zimbabwe, Botswana
Orange	850 000	2 300	11 500	4	Lesotho, South Africa, Botswana, Namibia
Pungue	32 500	300	3 000	2	Zimbabwe, Mozambique
Ruvuma	155 500	800	15 000	3	Tanzania, Malawi, Mozambique
Save	92 500	740	7 000	2	Zimbabwe, Mozambique
Umbeluzi	5 500	200	600	2	Swaziland, Mozambique
Congo	3 800 000	4 700	1 260 000	9	Burundi, Rwanda, Central African Republic, Tanzania, Cameroon, Congo, Democratic Republic of Congo, Zambia, Angola
Zambezi	1 400 000	2 650	94 000	8	Angola, Namibia, Botswana, Zimbabwe, Zambia, Malawi, Tanzania, Mozambique

Source: Adapted from Pallet, J. (Ed.), Sharing Water in Southern Africa (1997) in SADC (2005)

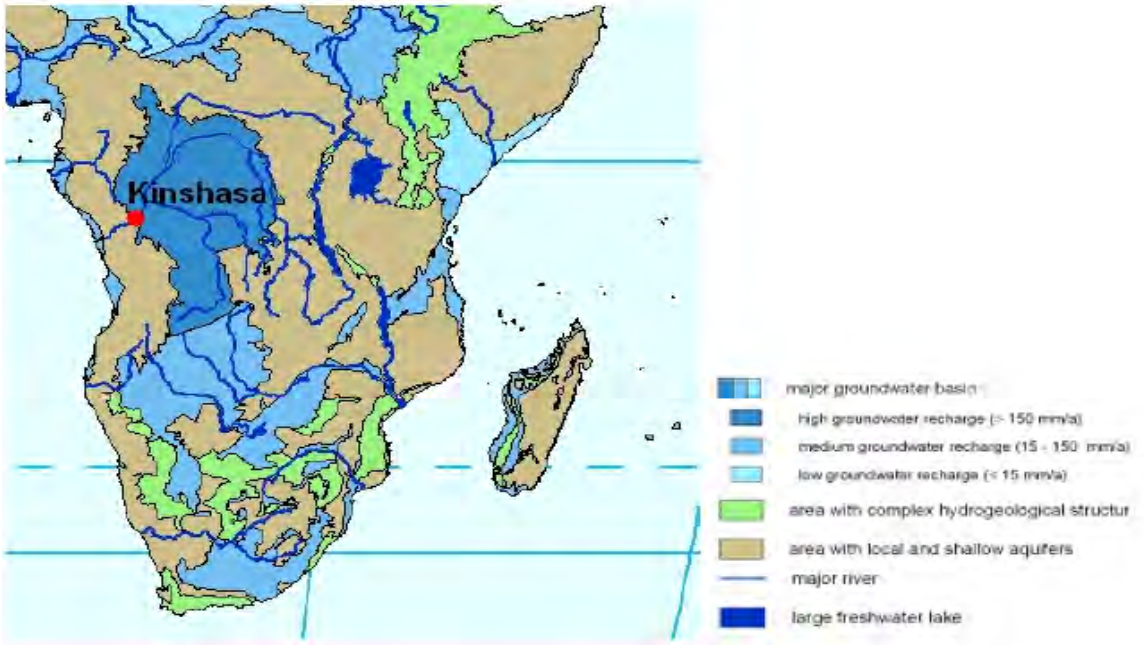
Appendix B: Groundwater provinces in Southern Africa



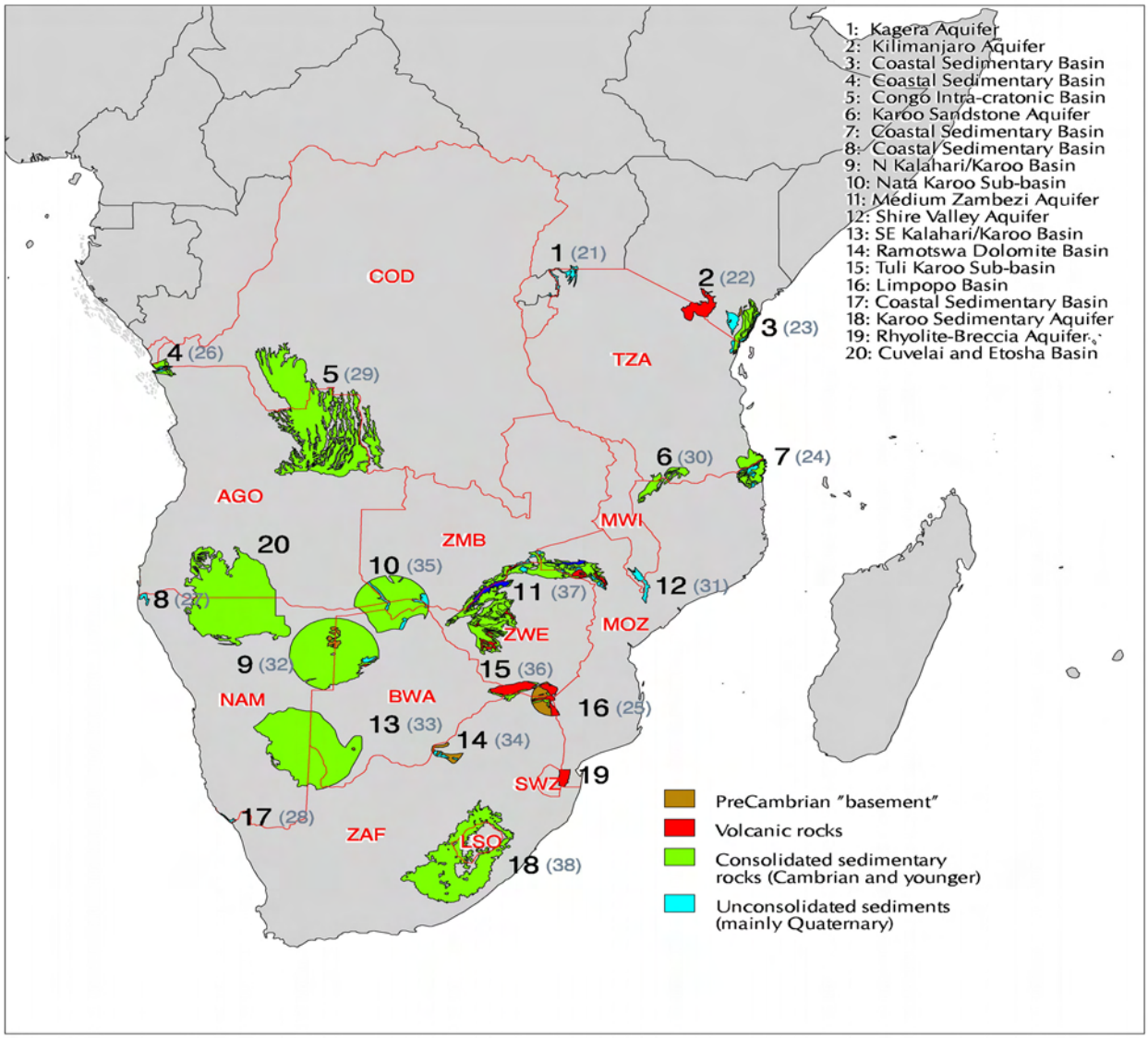
from: IGRAC (2005)

Appendix C: Hydrogeological resources of Southern Africa

from: Groundwater Resources Map of the World (BGR / UNESCO, 2004)



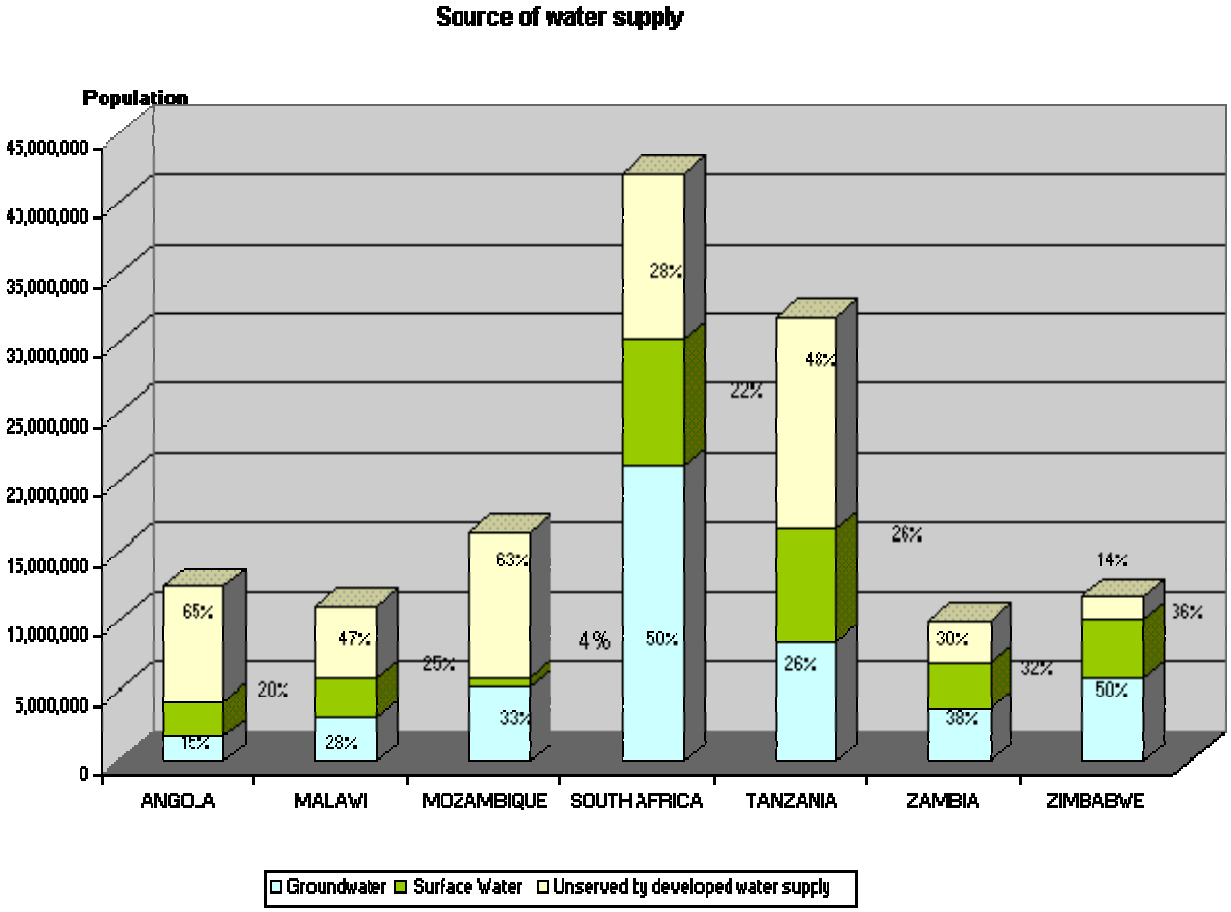
Appendix D: Transboundary aquifers in Southern Africa



from: ISARM (2004)

Appendix E: Sources of water supply in SADC

(Information up to 1999: SADC, 1999



Appendix F: Access to developed water supply within the SADC region

(Information up to 1999: SADC, 1999)

SADC Member	Area	Total Population	Population density	GDP per cap	Population Ration		Part of the population served by developed water supply			Urban population served by developed GW supply	Rural population served by GW supply	Total population served by GW supply
					Urban	Rural	Urban	Rural	Total			
	(sq km)	Inhabitants	inh/km2		%	%	%	%	%	% urban pop	% rural pop	% total pop
Angola	1 247 000	12 600 000	10,1	396	37	63	60	20	35	9	18	15
Botswana	582 000	1 600 000	2,7	2 953	43	57	98	50	71	66	50	57
DRC	2 435 409	49 000 000	20,1	38	20	80						
Lesotho	30 355	2 100 000	69,2	485	27	73	65	56	58	14	56	45
Malawi	118 484	11 200 000	94,5	206	13	87	82	49	53	25	29	28
Mauritaus	1 968	1 150 000	584,3	3 785	50	50	98	98	98	46	46	46
Mozambique	799 380	16 500 000	20,6	90	15	85	34	37	37	7	37	33
Namibia	824 268	1 620 000	2,0	1 966	32	68	99	62	74	27	43	38
Seychelles	455	76 000	167,0	6 781								
South Africa	1 221 090	42 300 000	34,6	2 985	59	41	80	60	72	56	41	50
Swaziland	17 364	970 000	55,9	1 148	25	75	80	45	54	4	40	31
Tanzania	945 000	32 000 000	33,9	215	22	78	68	48	52	20	29	26
Zambia	752 614	10 100 000	13,4	345	43	57	85	58	70	20	52	38
Zimbabwe	390 757	11 910 000	30,5	645	31	69	98	80	86	1	72	50
SADC					32	68	77	50	60	35	38	37

Appendix G: Distribution of water uses within the SADC region

(Information up to 1999: SADC, 1999)

SADC Member	Distribution of total water use					Distribution of groundwater use						
	Domestic /municipal	Mining/energy industry	Livestock/ aquaculture	Irrigation, forestry and wildlife	Total	Domestic / municipal	Mining/energy industry	Livestock/ aquaculture	Irrigation, forestry and wildlife	Total groundwater	Part of groundwater in total water use	Part of groundwater in domestic water supply
	10^6 m^3/year					10^6 m^3/year					%	%
Angola	130		44	2 300	2.474	28		7		35	1	22
Botswana	36.6	22.5	35.3	24.9	119	15	15	28	18	76	64	41
DRC												
Lesotho	19	4	11.5	3	37	11		2	2	15	41	58
Malawi	120	32		1 009	1 161	35				35	3	29
Mauritaus	170			450	620	80	5		16	101	16	47
Mozambique	107	14		509	630	36				36	6	34
Namibia	144	29.2		105	278	53	10	77		140	50	37
Seychelles		1 581										
South Africa	2 128	12.6		15 256	18 965	319	237		2 288	2 844	15	15
Swaziland	24.2		12.9	1 666	1 716	8				40	2	33
Tanzania	263	170	60	2 100	2 423	66	13		42	108	4	25
Zambia	271	20	90	1 690	2 221	75		42	59	189	9	28
Zimbabwe	410	1 885.30		3 500	3 930	40			350	390	10	10
SADC	3 823		253.7	28 612.40	34 574	766				4 009	11.6	20

Appendix H: Groundwater and Rural Poverty

David Seckler, Director General of the International Water Management Institute, has suggested that few irrigation technologies have had as wide-ranging and profound an impact on the lives of the people as the small mechanical pump; and this becomes evident in the Ganga basin and in sub-Saharan Africa where poor households could transform their farming and their livelihoods if only they could lay their hands on a pump. Indeed, much recent evidence links the agricultural dynamism in parts of Bangladesh, West Bengal and Eastern India to the growing offtake of pumps and tube wells by private farmers (see, for example, Rogaly, Harris-White, and Bose, 1999). But the poorest in these regions are often too poor to save enough to buy a pump; further, often, their holdings are too small to make a mechanical pump a viable investment.

In South Asia, rapid groundwater development has supported a booming pump industry which, in India, has grown at a compound rate of 20 percent since 1982; this growth is characterized by both economies of scale and intense competition. As a result, South Asia's rural poor have benefited from low costs of pumps and borings. In the Sahel, in contrast, pump irrigation development is so slow and limited that costs of pumps and washbores are high and quite beyond the reach of smallholders. Researchers from UK's Cranfield university found that "In Africa the cost of a borehole drilled by a truck-mounted rig can be extremely high in absolute terms (f3,000-6,000) as well as in relative terms (10–20 times the cost of the pump and many times the cost of well drilling in Asia). High unit costs mean that too few wells are drilled and communities and farmers remain dependent on international aid programs for this form of infrastructure development" (Carter, 1999). In Nigeria, for example, the groundwater irrigation potential is estimated at 870,000 for washbores and tube wells; but the actual numbers in use at the turn of the 1990s were a few thousand. In West Africa as a whole, thus, "The [groundwater] potential remains almost untapped; only 0.2 percent of recoverable safe yield and 0.02 percent of the groundwater held in reserve is presently used. Main reasons that militate against groundwater exploitation for agricultural production are the [high] cost of drilling wells and lifting water onto the land." (Sonou, 1994, 73).

There is therefore enormous room for institutional and technological innovations that can put groundwater irrigation at the service of the poor. In South Asia, emergence and spread of water markets have helped improve poor people's access to groundwater. Tube wells owned and operated by groups of poor farmers also offer possibilities. Micro-diesel pumps made in China have become extremely popular with smallholders in Bangladesh because they cost less to buy as well as to run compared to 5-hp diesel pumps that have become industry-standard in India. Among the most exciting are innovations in manual irrigation technologies; the treadle pump—selling as *Krishak Bandhu* (Farmer's Friend) in South Asia and "Money Maker" in Africa—costs US$12–25 a piece and can be operated by anyone including children. This has become hugely popular in Bangladesh where there already are over a million sold; it is spreading to Eastern India and Nepal terai where water tables are in the range of 2–5 m.

(FAO, 2003)

Appendix I: Nine RSAP targets listed in the RISDP

1. Long term regional water policy and strategy developed and approved by March 2004
2. Increased awareness, broad participation and gender mainstreamed in water resources development and management by 2005
3. Centres of excellence for water research and technology development are identified, strengthened by 2005
4. Water sector policies and legislation harmonised by 2006
5. Establish and strengthen at least eight River Basin Organisations by 2006
6. Water data banks and planning networks are established and fully operational by 2007
7. Training and institutional capacity strengthening programmes developed and implemented by 2008
8. Halve by 2015 the proportion of people without access to safe drinking water and sanitation services
9. Develop by 2015 water resources infrastructure needed to double land under irrigation.

SADC (2005a)

Appendix J: Groundwater Academic and Training Institutes

WCS and BGS (2003)

Member State	University	Course Level	Training Institute	Course Level	Comments
Angola	Geology Department University Agostinho Neto	BSc Geology – no hydrogeology			
Botswana	Geology Department University of Botswana	BSc Geology, MSc Hydrogeology			
DR Congo	Department of Geology, University of Lubumbashi		REGIDESO has training centres in Kinshasa and Lubumbashi.	Modules for groundwater development methods	
Lesotho	University of Lesotho	General BSc			Training through workshops and seminars
Malawi	Chancellor College, University of Malawi	BSc Geology, MSc Environmental Science – some groundwater	University of Malawi, Blantyre	Groundwater technicians short course	World Bank funded course with BGS
Mauritius	Department of Physics, University of Mauritius	Engineering Geology with some hydrogeology			
Mozambique	Geology Department, University Eduardo Mondlane, Maputo	Geology and some environmental science taught	No government technical training		Hydro-geologists trained abroad
Namibia	Department of Geology, University of Namibia. Desert Research Institute	Module in basic hydrogeology	Technicians trained in South Africa		Hydro-geologists trained abroad
Seychelles					No training facilities
South Africa	University of Fort Hare University of Pretoria University of the Free State University of the Western Cape University of the Witwatersrand University of Venda University of Zululand	Part of BSc Geology Part of BSc Geology BSc and MSc in Geohydrology BSc and MSc in Hydrogeology Part of MSc in Environmental Science Part of BSc and MSc in Hydrology Part of various BSc Hydrology courses	College of Advance Technical Education Pretoria Technicon	Diploma course for geological technicians Diploma course in Geotechnology includes hydrogeology	Research in aspects of hydrogeology funded by the Water Research Commission
Swaziland	University of Swaziland	No geology - General BSc			
	Geology Department University of Dar es Salaam	BSc Geology with some hydrogeology Water Resources Engineering MSc	Rwegarulila Water Resources Institute (RWRI)	Water supply engineering, hydrology, hydrogeology	

				and water quality.	
Zambia	School of Mines, Geology Department, University of Zambia	BSc Geology – some hydrogeological research			
Zimbabwe	Geology Department University of Zimbabwe, Harare	BSc in Geology, MSc Exploration Geology – no hydrogeology			

Appendix K: Observations on Groundwater Management Capacity from a GDMP Project Steering Committee

The attendance by the senior author on 27/28 November 2007 of a project steering committee for the recently initiated, GEF-funded, Groundwater and Drought Management Project proved extremely valuable for the scoping study, because 11 of the 14 member states had sent groundwater representatives to the meeting. All reported briefly on the state of groundwater management in their country and key challenges in this regard. A regional picture emerged which is summarized here under a few relevant headings.

Importance of groundwater

Groundwater is strategically important in all member states and not only in the drier parts of the region. Examples are Zimbabwe and Swaziland, where 90% of water supply in rural areas is coming from groundwater. The situation in Angola may describe what is happening in many of the wetter parts of the region. Intensive groundwater development through the systematic drilling of boreholes is only happening in the 25% of the country where there is not enough surface water. However, the largely informal mode of water supply in the wetter areas is actually from shallow groundwater by way of depressions in the ground, shallow dug wells, handpumps etc. To change these into secure supplies would mean attention to appropriate technologies that can extend the resource over drought periods and protect it, in particular through proper sanitation. Given the high backlogs in the meeting of basic needs, in particular in rural areas, groundwater indeed has a strategic role to fulfil.

Zambia and Mauritius quoted the importance of groundwater also for urban water supply. This may be strategic too, given the trend of rapid urbanization in the region.

Capacity to manage groundwater resources

Many member states have not yet made the institutional changes to provide for groundwater resources management. The groundwater specialists in government are still focusing on water service delivery (borehole siting and drilling support, e.g. they are called super drillers in Malawi). Where there is recent legislation to control groundwater use, there is no capacity to undertake this function. A concern is a recent proliferation in private drilling companies and no capacity to control their activities. The institutional development in Zimbabwe reflects this widespread situation in the region – no hydrogeologist in the Ministry of Water, none in the Catchment Councils established since 1998, and two in the National Water Authority.

Based on the brief reports, only Botswana has a strong contingent of well-educated hydrogeologists that undertake systematic resource assessment and well field monitoring. A number of countries have only one or two Hydrogeologists and even here, the training emphasis has been on exploration, rather than on resource management. As put well by Malawi, staff are not trained to a level that can make an impact. Put in another way, Lesotho indicated it was presently not able to quantify its groundwater resources.

Even Botswana expressed concern that it had no staff with a groundwater modelling capacity, essential for the management of the groundwater mining presently taking place. In more established situations like Zambia, Botswana and South Africa, retention of trained staff is becoming a problem, particularly because their skills are very marketable in the mining sector.

Monitoring of groundwater resources

Only Botswana and South Africa reported on systematic groundwater resources monitoring taking place. South Africa qualified their information, saying for monitoring to impact resource management, it needed to be real-time, which was not yet the case in South Africa. All other countries reported that monitoring was still its infancy or non-existent and a number of countries reported that there were no functioning groundwater databases. This is a clear indication that groundwater resources management is not yet taking place in most of the region.

Education and training of groundwater practitioners

Only South Africa and Botswana reported universities providing education and training in Hydrogeology. A number of countries specifically requested SADC to help in this regard, as they did not have appropriate institutions for this purpose.

Most countries reported using medium-level technicians, some up to Diploma level, but there were no indications where such training is obtained. The regional short courses for hydrological technicians that were ongoing under SARCCUS, are not taking place anymore. Even South Africa, which was well supplied with Diploma Technicians from Technical College, reported that new technicians were now unavailable.

A new challenge, not yet addressed, was reported as a concern by South Africa. A lot of devolution of groundwater functions was taking place, for example to local government, but there was yet no attention to the transfer of groundwater knowledge essential to fulfil these functions.