

Groundwater Capacity Building Initiative Africa



Capacity Building for Groundwater Management in West and Southern Africa

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List of Acronyms

2IE	L'Institut International d'Ingénierie de l'Eau et de l'Environnement
AMCOW	African Ministers' Council on Water
BGR	Federal Institute for Geosciences and Natural Resources (Germany)
BGS	British Geological Survey
BMZ	Federal Ministry for Economic Cooperation and Development (Germany)
BSc	Bachelor of Science
CWP	Country Water Partnership
DWAF	Department for Water Affairs
DRC	Democratic Republic of Congo
ECOWAS	Economic Community of West African States
GIS	Geographical Information System
GWCB Africa	Groundwater Capacity Building Initiative Africa
GWP	Global Water Partnership
IWRM	Integrated Water Resources Management
MDG	Millenium Development Goals
MSc	Master of Science
NGO	Non-Governmental Organisation
PhD	Philosophiae Doctor
R/LBO	River/Lake Basin Organisation
SADC	Southern African Development Community
UN	United Nations
UNEP	United Nations Environment Program
UWC	University of Western Cape (South Africa)
VLOM	Village Level Operation and Maintenance
WA-Net	West Africa Capacity Building Network
WaterNet	Southern Africa Network for Capacity Building in IWRM
WRCU	(ECOWAS) Water Resources Coordination Unit

Tables

Table 1: Key Recommendations for the Improvement of Groundwater Management in Africa

Table 2: Respondants to the questionnaire

Table 3: Area of each aquifer type as a proportion of total land area

Executive Summary

This section presents the main outcomes of regional studies carried out in West Africa and Southern Africa to examine capacity needs for improved groundwater management (chapters three and four). A number of core challenges and recommend specific activities to address the most urgent and/or most important capacity needs in groundwater management have been identified. The recommendations are summarised in table 1 and outlined in the two **Proposals for Action Plans** (p. 6-11). The action plans are based on the results of regional workshops in West and Southern Africa which were held in Ouagadougou (February 15-16, 2007) and Johannesburg (February 19.-20, 2007). There the outcomes of the surveys and the recommendations were discussed. A broad range of regional experts (e.g. ECOWAS-WRCU, GWP West Africa, 2IE, SADC, MAWRD Namibia, DWAF South Africa) participated in these discussions and identified three target groups for each recommendation:

- the political level / decision makers
- the scientific / technical level / groundwater specialists
- the user level / general public

It is crucial to address all these target groups to succeed in improving groundwater management and for enhancing its inclusion into broader integrated water resources management approaches. Of course not all of the problems described in the report can be finally solved through capacity building alone. The weaknesses of groundwater management in Africa are often embedded in structural governance problems and thus require reforms that go beyond the reach of capacity building approaches. However capacity building measures might be able to catalyse processes which can lead to the necessary changes in the water sector.

For the implementation phase of the recommendations, the regional capacity building networks and organisations such as the regional economic commissions (RECs) are key players. It has to be discussed further how the proposed activities can become part of their working plans. International donors are encouraged to contact WA-Net or WaterNet for collaboration on the implementation of one or several fields of activities.

Table 1: Key Recommendations for the Improvement of Groundwater Management in Africa

West Africa	Southern Africa
Groundwater assessment and development	
<ul style="list-style-type: none"> ➤ Establishing effective groundwater monitoring and database systems ➤ Developing groundwater mapping programmes on national and transboundary level. ➤ Providing training for specialists in form of short courses on different subjects <ul style="list-style-type: none"> ➤ Developing a standard drilling form 	
Maintenance	
<ul style="list-style-type: none"> ➤ Promoting best practices on maintenance 	
Institutional and Legal arrangement	
<ul style="list-style-type: none"> ➤ Establishing a regional exchange platform for discussing best practices of institutional arrangements 	<ul style="list-style-type: none"> ➤ Initiating the collection of groundwater legislation from different countries into one accessible archive ➤ Ensuring institutional arrangements for better integrating groundwater in IWRM ➤ Strengthening enforcement of water legislation
Groundwater protection	
<ul style="list-style-type: none"> ➤ Assessing hazard areas and key environmental threats to groundwater and building an accessible register of threats 	
Groundwater Education and Training	
<ul style="list-style-type: none"> ➤ Sharing information on educational systems 	<ul style="list-style-type: none"> ➤ Reviewing undergraduate course modules in hydrogeology and available technician training courses

Proposal for Action Plan for West Africa

Groundwater Assessment & Development

- Establishing **effective groundwater monitoring and database systems** in the West African countries.

For this purpose it is indispensable to **address the political level to raise awareness** among decision makers for the necessity of groundwater monitoring. Their support is essential for a sustainable financing of monitoring networks and a viable institutional basis. Decision makers should be addressed on national level as well as on a regional level. Appropriate implementing organisations for activities in this regard might be the Country Water Partnerships (CWP, national level) or WA-Net and ECOWAS-WRCU (regional level).

But also the technical level requires attention when dealing with monitoring systems. An important field of action for capacity builders is the implementation / rehabilitation of piezometric networks and the implementation / improvement of database systems through supporting groundwater specialists in the national water ministries. This can be achieved through regional trainings in direct cooperation with the national institutions as well as on regional level through WA-Net and ECOWAS-WRCU.

- Developing **groundwater mapping programmes** on national and transboundary level.

Maps are an essential tool for better knowing and describing the resources base. This field of action refers to the political as well as to the technical level. Appropriately adapted maps can be used to raise awareness among decision makers about the character of water resources and e.g. about their possible transboundary nature. Thus politicians should be addressed through R/LBOs on a sub-regional level and through ECOWAS-WRCU on regional level for an improved joint management of transboundary aquifers in West Africa. On national level particularly groundwater specialist could benefit from capacity building in groundwater mapping programmes through the actual outcome of such programmes (i.e. maps and information systems that facilitate their work) and through trainings that should be part of the process. These specialists should be addressed through R/LBOs and ECOWAS-WRCU for transboundary issues and through the national water ministries for national or sub-national groundwater maps.

- Providing **training for specialists in form of short courses** on different subjects.

Improving the human capacity of national groundwater management institutions was identified as key for improved groundwater management. Thus short courses on geophysics, hydrogeology, modelling as well as pump technology were discussed as being very valuable. Also the “training of trainers” approach was identified as promising especially for dissemination of knowledge on pressing hydrogeological issues. These courses can be advertised and implemented on a national level through CWP, universities and research institutions.

Institutional Arrangement

- Establishing a **regional exchange platform for discussing best practices** of institutional arrangements.

Such regional exchange mechanism for learning from the experience of other countries in the region was identified as a way for improving the often fragmented and inadequately structured institutional arrangement in the different countries. It was suggested to be established under the auspices of ECOWAS-WRCU and should clearly target decision makers.

Groundwater Protection

- **Assessing hazard areas** for identifying threats to groundwater.

This field of action aims similarly at groundwater specialists and at the general public. Identifying groundwater hazard areas could help specialists to better protect the resources. At the same time protecting natural resources requires a certain understanding of pollution risks and how to prevent these on the side of the general public. Capacity building and awareness raising on a national level could be implemented by local governments and local sanitation officers (if existent).

- Implementing specific **groundwater quality monitoring** networks.

Groundwater monitoring should deal with quantity and quality issues at the same time. This was identified as a major task for capacity building especially due to the low level of existent groundwater quality monitoring in West Africa. It seems necessary to address at the same time the political level as well as groundwater

experts in the national ministries and administrations. It is important to focus not only on water ministries and institutions but also on other (e.g. health) ministries that have an interest in protecting the groundwater resources to prevent the spread of water borne diseases.

Education and Training

➤ **Sharing information** on educational systems.

The different educational programmes in the groundwater sector in the West African countries are currently not well linked. Thus a regional exchange on these programmes through the ECOWAS-WRCU might not only improve groundwater management in the region but also enhance regional cooperation.

Proposal for Action Plan for Southern Africa

Groundwater Assessment & Development

- Designing of statistically representative **groundwater monitoring systems** / Developing and maintaining **groundwater databases** / Developing a **groundwater mapping programme**

These three recommendations were seen as closely linked to each other, requiring a range of similar capacity building activities. All of them certainly need to address all three target groups. At the political level awareness raising for financing and the provision of an adequate institutional arrangement is needed. Furthermore, lobbying activities for facilitating the access to all kinds of groundwater data for all stakeholders should be enhanced.

At specialists' level training courses for on-the-ground implementation are required; including issues such as database management, GIS, etc. For the general public it is important to raise awareness for the relevance of groundwater data and the resulting necessity of data provision to the water resources managing institutions. These activities should be implemented on a regional basis with a focus on sharing best practices among different countries.

- Developing / adapting a **course on water drilling issues**.

This recommendation targets directly the technical level of specialists for borehole drilling and well design, in the public sector as well as in private companies. Capacity building in this regard should not only include classical aspects like logging of boreholes, but should also provide a deeper understanding of basic aquifer characteristics to drillers. Hydrogeologists could also take part in such a course to strengthen the link and exchange between the scientists and the drillers.

- Developing a **standard drilling form**.

One of the major challenges for informed decision making in groundwater management constitutes the loss of valuable groundwater information due to poor data collection and transfer mechanisms. Standardised drilling forms together with a certification of drillers could ensure that all data gathered during the various private drillings is provided to national groundwater databases.

Maintenance

➤ **Advertising best practices** on maintenance.

This field of activity is directed towards both, the political level as well as the general public. Institutional set-up for maintenance of groundwater facilities (boreholes and pumps), especially at local level is often not adequate. The fact that there is a large difference between the countries in the region is reflected by the recommendation to exchange best practices among the countries. Decision makers should become aware of how it can work better and especially of the costs and benefits of continuous maintenance compared to new installations. Also the general public (the water users) need to be sensitised for the benefits that they would receive from state-of-the-art maintenance of existing facilities.

Institutional & Legal arrangement

➤ Initiating the **collection of groundwater legislation** from different countries into one accessible archive.

The process of improving the integration of groundwater into the general water legislation could be facilitated by providing all relevant legislative texts from the region at one accessible place, e.g. SADC Water Division, allowing also for a comparative and critical review.

➤ Ensuring institutional arrangements for **better integrating groundwater in IWRM**.

Although this is the actual aim of all capacity building activities discussed in this initiative, it was highlighted as a special field of activity. The workshop participants recommended creating an exchange platform for discussing best practices for institutional arrangements. At a political level, this platform could be attached to SADC. But also on national level, the discussion on how to develop the institutional arrangement should be enhanced e.g. by the establishment of a working group of experts as an advisory body to national decision makers.

➤ **Strengthening enforcement** of water legislation.

A crucial point for the implementation of all well-intended legislation is the enforcement. Awareness raising for the general public should display the benefits for the water users that derive from accepted, enforced and applied rules.

Groundwater Protection

- **Identifying key environmental threats** to groundwater and building an accessible register of threats.

This field of activity is meant to target the political level as well as groundwater specialists. Decision makers should know which point pollution sites are critical and which consequences would arise from groundwater pollution. For specialists, training is necessary to be able to cope with specific pollution problems and to better protect the resources from accidental spills.

Education and Training

- **Reviewing undergraduate course modules** in hydrogeology and existing technician training courses

This recommendation reflects the lack of exchange on existing training and education programmes. Thus it is highly recommended to review existing programmes of WaterNet members and others to see where the development of new modules or training elements is needed.

The same should be pursued for technician training courses (e.g. pumping tests, groundwater monitoring) throughout the region. Promoting best practices in other countries of the region and facilitating the access of professionals or students (fellowships) to these programmes could develop capacity in countries where groundwater education is not adequate at the moment.

Introduction

The Groundwater Capacity Building Initiative Africa has started as a joint initiative by the Federal Institute for Geosciences and Natural Resources (**BGR**), Germany, **Cap-Net**, a UNDP programme for capacity building in water and two of Cap-Net's regional networks: **WA-Net**, the West Africa Capacity Building Network, and **WaterNet**, the Southern Africa Network for Capacity Building in IWRM.

Both regional networks are composed of a large number of tertiary institutions from most countries of the respective regions. WaterNet has got 49 member organisations from 14 countries, mainly university departments as well as research and training institutes specialised in water¹. WA-Net is comprised of 81 individual members and member organisations from 16 countries². Both networks are dedicated to strengthen human and institutional capacity for IWRM through education, training, research as well as outreach by harnessing the complementary strengths of their members.

BGR (Federal Institute for Geosciences and Natural Resources), as the German Geological Survey, has a long standing experience in groundwater management projects in Africa on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ). Its fields of experience include -among others- groundwater resources assessment and protection. Since the 1960s, BGR is also involved in geological mapping and database management³.

For this initiative, BGR, Cap-Net, WA-Net and WaterNet joined to combine their specific knowledge for addressing capacity constraints in the field of groundwater management in Sub Saharan Africa, especially in West and Southern Africa. In spite of considerable efforts undertaken in capacity building⁴ for groundwater management during the last decades, human as well as institutional capacity is still lacking. Interestingly, for many experts it was difficult to be more specific on what kind of capacity building would be needed in the respective countries. This was the main

¹ <http://www.waternet.ihe.nl/>

² <http://www.cap-net.org/ShowNetworkDetail.php?NetworkID=29>

³ <http://www.bgr.bund.de/EN/Themen/Wasser>

⁴ Capacity Building is used in this report synonymically to capacity development according to the definition of UNDP: “**Capacity** is the ability of individuals, institutions and societies to perform functions, solve problems, and set and achieve objectives in a sustainable manner. **Capacity Development** (CD) is thereby the process through which the abilities to do so are obtained, strengthened, adapted and maintained over time”.

http://www.capacity.undp.org/index.cfm?module=ActiveWeb&page=WebPage&s=capacity_development

reason why the partners decided to begin the initiative with a survey on capacity needs. Two regional consultants⁵ in strong cooperation with the regional networks WA-Net and WaterNet conducted a qualitative survey among groundwater professionals and academics in the networks' member countries. The outcome is resumed in this report which will build the basis for the second phase of the initiative, the implementation of capacity building activities at regional/national level. Furthermore, the report should serve as input into the international discussion on how to improve water management in Africa. It should clarify for development agencies and national ministries and institutions in the African countries why groundwater management is so crucial for achieving the Millennium Development Goals (MDGs) and thus which trigger points have to be addressed with capacity building.

The survey was conducted as a qualitative research based on a questionnaire sent to groundwater professionals in national ministries and water resources departments as well as to groundwater academics in the countries of West and Southern Africa. In accordance to the concept of Integrated Water Resources Management (IWRM), the questionnaire addressed groundwater management in a broad sense including economic, ecologic and social aspects. Thus the survey was asking for capacity needs not only in the 'classical' aspects of groundwater development or borehole siting, but also in the wider sense of groundwater management being part of an integrated environment and resources management. In addition, it was intended to focus not only on human capacity, but also on the institutional and systemic weaknesses of the management system. This was done by elaborating a comprehensive questionnaire and gathering information on different aspects from institutional setup to gender inclusion.

It is important to note that this methodology did not allow for conducting a representative study of the status quo in each country. Rather the survey tried to capture a snapshot of the situation by gathering and interpreting opinions from a range of experts as broad as possible. Thus there is certainly room for discussion on the results and the recommendations and discussion is what we want to boost with this report.

⁵ Dr. Moustapha Diene (Senegal) for West Africa and Dr. Richard Owen (Zimbabwe) for Southern Africa.

The report consists of four main parts. The first part outlines the relevance of groundwater management for human development in Sub Saharan Africa. In addition, it gives a brief overview on how groundwater management was evolving in the past in African countries and what kinds of problems are encountered by today's water managers. The second part introduces the survey by providing information on the scope and the methodology. The third and fourth part summarise the survey results for the two regions. The consultants have analysed the results and worked out several main recommendations to show a way for BGR and Cap-Net as well as for other international development agencies how to get involved in capacity building for groundwater management.

1. Groundwater Management and Sustainable Development

Water is one of the most fundamental elements of life and indispensable for human development. The 2006 Human Development Report states: “People need clean water and sanitation to sustain their health and maintain their dignity. But beyond the household water also sustains ecological systems and provides an input into the production systems that maintain livelihoods” (UNDP 2006, 2).

The international development scene has realised this relation at least since the beginning of the 1990th. Since this time a new paradigm of water management has evolved by bringing together the social, economic and ecologic aspects of water and focussing on water management as a social interaction. This overcame the engineering approach to water that was dominating the earlier decades. Today’s major challenge is the on-the-ground implementation of this integrated approach to water resources management (IWRM).

One of IWRM’s premises is that all water resources have to be taken into consideration according to their relevance and their natural characteristics. Groundwater resources are usually still managed separately from surface water resources. The following sections will highlight the relevance of groundwater for sustainable human development and thus explaining why the integration of groundwater management into broader water management approaches is a major task for improving water management for the future.

1.1 Water and the MDGs

The international community has acknowledged the relevance of water by including it explicitly and implicitly at various positions in the system of Millennium Development Goals (MDGs), the basis of current development efforts (see Annex 1). Under the MDG 7 (Ensure Environmental Sustainability), there is one target that addresses directly the global situation of water supply and sanitation: The international community should halve the number of people without access to improved water supply and improved sanitation by 2015 (Target 10). But there are several other MDGs that depend implicitly on water. The following outline shows clearly that improved water supply and sanitation is maybe the element of human development that creates the most cross linkages and positive side effects for other MDGs.

MDG 1: Eradicate extreme poverty and hunger

Water is an essential factor for production in Africa as agriculture is the most important economic sector all over the continent. Improved water management will enable farmers to use scarce resources more productively and thus to raise their income. For instance, until now only a small portion of Africa's arable land is under irrigation mainly due to inaccessibility of water for small scale farmers. Sustainable water management is supposed to provide poor people with improved access to means of productivity with taking into account ecological requirements.

Furthermore, extremely poor people suffer much more often from illness due to bad diet and bad water and sanitation conditions than wealthy people. There is a clear linkage between improved water supply and sanitation and improved health status. Better water supply and sanitation constitutes an important factor for improving productivity by rising nutrient absorption and by reducing expenditure on health care. Improved water supply can also reduce the time people have to spend for fetching water thus saving time for more productive and beneficial activities.

MDG 2: Achieve universal primary education

The above mentioned improved health status will improve the possibilities for children to attend school, especially when they benefit additionally from a reduced burden of carrying water every day. Furthermore, improved sanitation in school buildings plays an important role for increasing girls' attendance to school.

MDG 3: Promote gender equality and empower women

Improved water supply gives women more time for other activities like work or education. In addition, it reduces their daily work load and improves personal security when water supply is near to or in the house.

MDG 4: Reduced child mortality

Diarrhoea is the major child illness with millions of children suffering from it worldwide. A large portion of the children under five years who die every year are weakened by diarrhoea and thus more susceptible for other diseases. Therefore clean drinking water and hygienic sanitation are crucial for reducing child mortality rates.

MDG 5: Improve maternal health

Maternal health depends in two ways on water. Firstly, accessible water sources leading to reduced labour burdens of women and thus to reduced health problems

from carrying water, diminish the risk of maternal mortality considerable as women are in better physical conditions. Secondly, for giving birth to children clean water is an essential element of the process as unhygienic conditions raise the risks for the mother considerably.

MDG 6: Combat HIV/AIDS, malaria and other diseases

Water related diseases are a major threat to the health of many people worldwide. Diarrhoea as the most common water related disease is on the top of a number of horrible illnesses that relate directly to the lack of clean and sufficient drinking water as well as hygienic sanitation (e.g. Guinea worm, helminths). Also people infected with HIV/AIDS are strongly affected by bad water and sanitation conditions.

In addition, the management of water in and around settlements is an important factor for the transmission of water borne diseases like Malaria and Dengue Fever.

This above standing makes clear that water is crucial for achieving the MDGs. But unfortunately Sub Saharan Africa is the region worldwide that is most 'out of track' in most of the indicators. Regarding the directly water related MDG 7, there are a considerable number of African countries that perform poorly: Sierra Leone, Guinea, Guinea-Bissau, Togo, Benin, Nigeria, Burkina Faso, Niger, Chad, Angola, Mozambique, Malawi and Madagascar. Some of these countries are war-torn, but by far not all of them.

All together, Sub Saharan African countries increased the access to improved drinking water supply for their people only from 49% to 56%⁶. In urban areas the number is even decreasing (from 82 to 80%). For improved access to sanitation the situation is equal. From 1990 to 2004 the figure was rising from 32% to 37% with minimal augmentation in urban areas (from 52 to 53%). These slight improvements are by far not enough to reach the MDG 7 until 2015. Additionally it should be taken into consideration that these quantitative figures do not give insights on the quality of service provision, e.g. the service time of water supply or the water quality. For other MDGs the picture is more or less similar. Sub Saharan Africa as a whole is lacking behind other regions in terms of MDG achievement. This is even more frustrating when regarding the low starting level of Africa in 1990. The fundamental aspects of human development that are reflected in the MDGs are still a major challenge for Sub Sahara Africa and it should by now be very clear to the international community

⁶ All figures in this section taken from: UN Statistics Division (2006)

that the MDGs will not be reached without major additional efforts in and for Africa. As shown above, water will be a key aspect in this struggle.

1.2 The Relevance of Groundwater for Africa

When reflecting about this African water challenge, groundwater comes automatically in mind. In many parts of Sub Saharan Africa groundwater is the major water source. Especially in semi-arid and arid countries a majority of people serves itself from groundwater, e.g. in Mauritania 80% of the population. But also in more humid countries groundwater plays an important role for water supply. In Nigeria 70% of the rural/small town population relies on groundwater. These two figures are just to show a situation that is to be found anywhere in Sub Sahara Africa: the more arid and the more rural a region is, the more people depend on groundwater for their water supply (drinking water and irrigation for subsistence farming).

For handling the above outlined challenge, groundwater is the resource that has to become more in the focus of water managers and development specialists. It provides a number of key advantages compared to surface water:

In many areas which are characterised by an absence of surface water, groundwater is nevertheless accessible. In addition, it is not only accessible during rainy season but mostly all year round.

Groundwater is relatively easy to develop. Often even hand dug wells are sufficient to access a convenient water source. Thus investment in infrastructure is limited which makes groundwater the most appropriate water source for poor people.

Furthermore it is possible to develop groundwater on an individual basis which provides advantages in terms of participatory management. Users do not need to depend on the provision of a central institution but are able to decide by themselves on their water allocation.

Last but not least groundwater mostly provides better quality water than surface water due to the natural protection of the resource by its soil cover. The soil cover allows only a slow and gradual pollution of aquifers. But once the quality of the groundwater has deteriorated, recovery is difficult and may only take place over very long periods of time.

This last advantage, the protection by local soil cover, already indicates that these aspects can not be generalised. Groundwater as a natural resource is strongly

influenced by human activities. Thus human development does not only depend on the resource base but also on the future availability of the resource that in turn depends on a certain level of sustainable management.

Achieving the MDGs and paving the way for sustainable development depend on successfully facing the water challenge in Africa. Achieving this success depends on managing groundwater resources sustainably and making groundwater work for human development.

1.3 Groundwater Management in Africa

Sustainable groundwater management includes a broad range of activities. It does not only mean to develop / make groundwater use technically possible but also to protect the resource base and to secure that people can benefit from it in the long term. Thus managing groundwater means: regulating the interaction between human life and the resource base. Even if groundwater is generally better protected against pollution than surface water there are today severe quality problems in Africa especially around large urban areas. Pollutants that infiltrate groundwater due to lacking or leaking sanitation facilities lead to a massive deterioration of the resources on which people depend for their drinking water supply. Pollution of groundwater may also occur on a large scale in the surrounding of industrial and mining complexes.

Additionally, human activities influence the available quantity of water. Even if many African countries possess large underdeveloped resources, there are decreasing groundwater tables due to overexploitation in densely populated areas. This leads to a drying up of wells or a need for stronger pumps with rising energy costs. In many places the consequence is saline intrusion as an irreversible form of aquifer deterioration; either in the form of seawater intrusion or saltwater from larger depths.

Regulating these interactions is therefore crucial if groundwater should contribute to human development in Africa. However groundwater is a very complex natural resource. Its character, e.g. its vulnerability against infiltration of pollutants, depends strongly on the surrounding geological structures. Recognising these characteristics requires a certain scientific knowledge and developing the resource for human use should be based on this knowledge. But management in the broader sense brings up the need for building political decisions on scientific and technical know-how including social and economic considerations. A very diverse set of knowledge is thus required to manage groundwater in an integrated way, from the identification of

aquifer characteristics over the technical aspects to the regulation of human activities influencing the aquifer. The mere existence of these different types of capacity, however, does not lead automatically to sustainable groundwater management. Bringing them together in an adequate institutional context and making their results work for political decisions is also a critical factor for success.

Therefore, capacity building has always to look on the institutional environment in which human capacity is working and should identify ways to influence both sides.

1.4 Capacity for Groundwater Management

Groundwater management has quite a long history in Africa at least in terms of scientific research and large-scale development. In the Anglophone countries hydrogeological and geophysical investigations were undertaken for a long time and formed a considerable knowledge base on the groundwater resources especially in Eastern and Southern Africa. At the same time the use of groundwater for public water supply as well as for irrigation and industrial purposes increased dramatically in the years following independence of the majority of African countries. In the 1970s large investments in motorised well fields for supplying irrigation schemes and new mining activities with water took place often with support of international donors. Time has proven that many of these investments did not consider sufficiently the hydrogeological conditions and therefore did not provide the benefits that were expected. But at the same time, scientific know-how was not yet applicable for water management. As Robins et al. stated: "The science of hydrogeology was still being developed and hydrogeological input did not always benefit the African people as much as it benefited the science" (Robins et al. 2006, 1486). Thus capacity in groundwater management aspects was accumulated in parallel structures. Mining industry and specialised consulting firms became important holders of knowledge on groundwater development and drilling technology and public geological surveys gathered hydrogeological data often supported by international donors, e.g. the BGS (British Geological Survey) in Botswana or the BGR in Namibia and Djibouti. But in the public institutions the focus was clearly left on data storage not on use. Also the data cycle remained usually incomplete as private groundwater development activities were not supposed to deliver any form of data to public management organisations. Nevertheless, capacity building started to prove successful in terms of human capacity. An increasing number of trained indigenous hydrogeologists

became available throughout Africa. However, this growing human capacity did not lead to an institutional strengthening of the national groundwater management organisations as high staff turnover rates from the public to the private sector became the persistent problem that it is still today.

With the UN World Water Decade in the 1980s, the focus in groundwater management shifted from the investigation of the resource base further to service delivery. The development of the resources increased with the aim to provide reliable and safe water supply for rural communities. Non-governmental organisations (NGOs) appeared on the scene and community management of boreholes was encouraged by donors and national governments. This engagement of new stakeholders together with general decentralisation and rationalisation tendencies in the public sector led to institutional fragmentation of groundwater management in many African countries. This brought up a collapse of national data base systems, e.g. in Zimbabwe 1984, as well as problems in the division of labour between the various organisation engaged in groundwater management.

This fragmentation led to an increase of uninformed drilling programmes what still constitutes a considerable annoyance to groundwater management in many countries. The integration of technical knowledge, hydrogeological data and user participation is lacking in most groundwater development projects. National groundwater management organisations have not yet recovered from the draw back of water management organisations in the 1980s and 1990s.

Even if large differences are to be found between different African states, from a general perspective Africa's groundwater management faces some similar problems. And additional challenges arise like the HIV/AIDS pandemic that further threatens the institutional memory of groundwater management organisations. Thus capacity building that targets both levels of capacity, the human as well as the institutional, remains an urgent need for Sub Saharan groundwater management.

2. Scope and Methodology of the Survey

2.1 Groundwater Management as part of IWRM

The aim of the Groundwater Capacity Building Initiative Africa is to strengthen groundwater management as part of Integrated Water Resources Management. For the survey it is thus indispensable to analyse groundwater management in the broad sense including its social, economic and environmental implications. After describing briefly the current situation in terms of hydrogeology and resource use, the analysis is splitted into eight parts trying to cover the field of groundwater management comprehensively⁷. These eight parts are as follows:

1. Resource assessment

In this part the survey asked for the existence of data bases and how they are used. It is unarguable that sound groundwater management is not possible without comprehensive data on the resource base. Informed decisions for instance on water allocation depend on knowing how much water is available at each time of the year. Water quality, flow direction, recharge rates and extend of the aquifer are just a few other parameters that are necessary for indeed managing groundwater and not just exploiting it. Respondents were asked which type of data is gathered in the respective country and how it is stored in the data base. Especially for countries where groundwater is a critical resource, it is important that data is not only available from singular points but that there is countrywide information available.

For making available the information stored in national data bases it is crucial that institutions tasked with management functions have easy access to the data they need. Thus accessibility was also in the focus of the survey.

2. Groundwater development

Making groundwater work for human development clearly depends on how to give people access to the resource. Finding adequate locations for boreholes and drilling them professionally is thus imperative. Defining borehole sites depends mainly on hydrogeological and geophysical knowhow and thus on human capacity. The pure

⁷ See questionnaire in Annex 1. For Francophone countries a french translation was used.

fact of the existence of major un- or underdeveloped aquifers give an insight on how strong the capacity is in the respective country.

But important for groundwater development is also the drilling sector. Thus the survey asked if there is a viable drilling sector in terms of technical and human capacity.

3. Maintenance

The drilling of boreholes even at adequate positions does not benefit anybody if the well is not properly maintained. Especially in rural areas where groundwater is used for drinking water supply maintenance is usually a task for the user community. Thus respondents were asked what the main capacity constraints in the 'village level operation and maintenance' (VLOM) policy in the respective country is. In addition, it was intended to get information on the number of boreholes out of function what is usually a very reliable indicator on the quality of maintenance.

4. Institutional arrangement

The performance of the above outlined functions of groundwater management depends largely on how tasks are distributed among different organisations. A clear separation of responsibilities is necessary to enable them to perform their duties. Several aspects of groundwater management, like running a groundwater database, should be setup at the national level. Others, like borehole maintenance work better when organised at a lower level. The IWRM policy of management organisations was also requested in this part. Water management should not be organised according to political but according to natural boundaries and thus operate on catchment level.

An additional aspect which is important for the effectiveness of water management organisations is the inclusion of women. Especially at local level it is very important that women play a role in water management and thus respondents were asked about.

5. Legal arrangement

Sound groundwater management should be based on clear rules that are effectively enforced. To some extent, the existence and implementation of 'rules of the game' are a prerogative for sustainable resources management. Therefore questions on existence, type and enforcement of regulations figured part in the questionnaire.

6. Economic aspects

Economic sustainability is a must for each investment. As boreholes and pumps constitute more or less large investments for small communities, cost recovery should be tried to achieve in every groundwater development project. In reality, this turns difficult because of social reasons. But subsidies always imply the danger of drying up with changing political conditions leading often to halt service delivery. Thus the survey analysed if economic sustainability plays a role in groundwater management in the focus countries.

In addition, it was looked on demand management aspects. In many African countries groundwater is physically scarce and should thus used as effective and efficient as possible. Water pricing according to the scarcity of the resources is therefore a crucial instrument.

7. Groundwater protection and environment

The benefits people can draw from water supply or irrigated fields do not only depend on available quantities of water. Sufficient quality is also crucial for most kinds of water uses. The protection of groundwater resources and the groundwater dependent ecosystems is thus an integral part of IWRM and was questioned in the survey. The existence and enforcement of environmental laws and regulations were especially in the focus.

8. Education and training

Last but not least it should be taken into consideration that groundwater management as a social process depends on the interaction of individuals. The possibilities of these individuals to improve their know-how have been analysed in this part. The existence of training institutions at technical, university and on-job level are very important for the improvement of groundwater management.

2.2 Methodology of data gathering

The survey was planned as a desk study. A questionnaire was designed composing the eight parts of groundwater management outlined above. For each aspect between four and ten questions were posed. This resulted in a very comprehensive assessment giving respondents the chance to express their opinion on groundwater

management in their country. It was a qualitative survey, asking for individuals' opinion with keeping in mind that everybody has its personal and institutional interests as well as his or her view on a limited piece of reality only.

The questionnaire was sent to government representatives in the focus countries, to academics and to resource persons in the region. All together, over 300 individuals were targeted resulting in a return of 40 filled questionnaires (15%). This was actually less than expected. Likely reasons for this weak return rate might include that filling such a comprehensive questionnaire is a very time consuming undertaking and a lack of exchange between the consultants and respondents to get to the same understanding of each question, and for the latter to get a feedback of how their responses are used for.

It should be taken into account, however, that each single respondent was chosen at senior level from an important management institution in his or her country and thus provided markedly expert knowledge to this report.

Table 2: Respondents of the questionnaire		
West Africa		
Country	Respondents from Government Agencies	Respondents from Academic / Research Institutions
NIGERIA	1	1
COTE D'IVOIRE	1	1
MALI	1	1
SIERRA LEONE	1	
CAPE VERDE	1	
LIBERIA	1	
BENIN	1	
SENEGAL	2	
GAMBIA	1	
TOGO	1	
MAURITANIA		1
GHANA	1	
GUINEA	1	
BURKINA FASO	1	
GUINEA BISSAU	1	
NIGER	1	
Southern Africa		
Botswana	1	2
Democratic Republic of Congo (DRC)		1
Lesotho	1	
Malawi		1
Mauritius	1	1
Mozambique		2
Namibia	1	1
South Africa		3

Tanzania		2
Zimbabwe	1	2
Total:	21	19

The survey was completed by two research travels in each region undertaken by the authors of the regional chapters. In each region a dry and a more humid country were visited to get more in-depth information and to discuss the preliminary results with groundwater professionals (West Africa: Guinea-Bissau and Niger; Southern Africa: Tanzania and Botswana).

On the basis of this information together with their long standing experience in groundwater management in Southern respectively Western Africa, the two authors melted out a number of recommendations for capacity building. The whole process was accompanied by active discussions within the working group especially with the regional networks WaterNet and WA-Net.

3. Groundwater Management in West Africa

3.1 Hydrogeologic setting

Large parts of the West African region are characterised by Precambrian basement comprising mainly magmatic and metamorphic rocks. Sediment deposits, aging from Primary to Quaternary overlie them. Groundwater that is suitable for drinking water purposes is stored within pore spaces and fractures in rocks. Its availability depends primarily on the geology. Great sedimentary basins dominate in West African geologic features, storing important groundwater resources. Among these, lullemeden, Taoudeni, Chad, the Senegalo-Mauritanian and the coastal basin of Guinean gulf contain thick sediments extending from Quaternary to Cambrian.

The relevance of groundwater stored in aquifers depends thus on the geological nature of its layers. Aquifer layers can be continuous, discontinuous or mixed. Continuous aquifer layers (unconsolidated formations) are the most important in many respects: potential, extension, renewal, and discharge rate. Geological formations that present such characteristics are sand, clayey sand, sandy-clayey clay. The discontinuous aquifer layers are localised and linked to fracture systems in both arid and semi-arid zones as well as in humid tropical zones. These aquifer layers are found in crystalline and crystallophyllian formations.

In West Africa, over 60% of all aquifer layers are discontinuous, on an average less than 30% are constituted of continuous formations (Diagana 1994). Table 2 shows that groundwater stored in fractured rocks is the prevailing hydrogeologic setting in most of the countries. This situation highlights the difficulties encountered for mobilising groundwater resources.

State	Land area (km ²)	Continuous		Mixed		Discontinuous	
		(km ²)	(%)	(km ²)	(%)	(km ²)	(%)
Benin	112 622	11 262	10	13 515	12	87 845	78
Burkina Faso	274 200	10968	4	32 904	12	230 328	84
Cape Verde	4 033	-	-	-	-	4 033	100
Côte d'Ivoire	322 463	12 899	4	-	-	309 564	96

Gambia	11 295	9 375	83	1 920	17	-	-
Ghana	238 537	14 312	6	95 415	40	128 810	54
Guinea	245 857	2 459	1	66 381	27	177017	72
Guinea-Bissau	36 125	14 450	40	21 675	60	-	-
Liberia	111 500	2 230	2	-	-	109 270	98
Mali	1240710	645 169	52	459 063	37	136 478	11
Mauritania	1030700	515 350	50	237 061	23	278 289	27
Niger	1267000	836 220	66	329 420	26	101 360	8
Nigeria	923 768	230 942	25	138 565	15	554 261	60
Senegal	201400	128 896	64	56 392	28	16 112	8
Sierra Leone	71 740	8 609	12	7 174	10	55 957	78
Togo	56 000	4 480	8	8 960	16	42 560	76
Average		163174,7	28,5	112957,3	24,8	159420,3	60,7
Source: adapted from Diagana 1994							

3.2 Resource use

In West Africa, the **main use of Groundwater is for drinking water supply**, both in rural and urban areas. This is particularly important in semi-arid countries located in Sahelian zone, where surface waters are not perennial. Due to the geographical location of major West African countries entirely or partly in the Sahel, groundwater is very relevant for the daily life of inhabitants. Aquifers states as the principal sources of water resources in West Africa, as in 8 countries⁸ groundwater represents more than 80% of total water use. Major towns located near coast line (Abidjan, Dakar, Lomé, etc.) are supplies from aquifers.

Groundwater use for irrigation, however, is insignificant excepted for Cape Verde, in several cases the development of groundwater use to sustain agriculture is expected in short or middle term. In many countries, it is planned to develop irrigation in the upcoming years that will rely inevitably on aquifers. Even nowadays small scale irrigation uses shallow aquifers, which may dry up with the decrease of precipitation related to climate variability.

The **main user group in all countries is rural population**, which is usually provided with water by various means (unfitted hand-dug wells, hand pump; motorized pump; network supply etc). Groundwater use in rural areas is widespread, mainly because it is the only available resource and accessible with relatively rudimentary and cheap means.

⁸ Cote d'Ivoire, The Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal, and Togo

Apart from six countries (Sierra Leone, Cape Verde, Ghana, Guinea, Burkina Faso and merely South Nigeria) there is **large-scale use of groundwater in urban areas** in West Africa. The main constraints that restrict urban use are:

- Difficulties to mobilize resources due to hydrogeologic settings (crystalline basement rock prevails);
- Abundance of surface water (all are humid countries), excepted for Cape Verde, which use desalinated seawater for urban use.

Burkina Faso is using surface water as principal resources and groundwater as complementary resources.

3.3 Resource assessment

The state of groundwater knowledge as expressed by the respondents is in general low to average, mainly in areas with fractured rocks that constitute about 60 % of total aquifers layers in the region (see table 2). Aquifers are not well known in their extension, as surveys usually do not encompass all exploited resources. Information about groundwater is not really captured by the large public. It is provided through main documents detained by official institutions what limits accessibility since it is only available on request.

Many of West African countries have long **standing experience with national databases**, usually in an MS-Access format. Where Different formats are in use they were generally considered as not adequate with ambitions to replace them. Six countries have no national Data Base at all⁹ or have only fragmented groundwater data¹⁰ that reside in various organisations implied in Water resources management. Except for countries that suffer from civil war aftermath, all others have piezometric network, parameters such as static water level, EC and pH used to be monitored.

Despite of the existence of data bases, **resources are not continuously monitored**. Data gathering is done usually over shorts periods coinciding most of the time with support projects which allow for monitoring. Groundwater chemistry data

⁹ Benin, Guinea, Liberia and Sierra Leone

¹⁰ Ghana and Nigeria

are usually punctual, meaning that most of them are obtained just after water point implementation. From the survey it results that only six countries declare monitoring effectiveness: Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Senegal and Niger.

It is obvious that knowledge about groundwater resources is lacking mainly in fractured rock settings. It is essential to assess hydrogeologic settings of major aquifers, i.e. extend, nature of layers, available resources, recharge rate, etc. The mapping of major aquifers is not completed or is out-of-date, what hinders sound management. The lack of skills and insufficient qualified personnel (hydrogeologists, geophysicists, modelling specialists, etc.) is part of the problem as well as financial constraints.

The **monitoring system needs to be revised** since it is not effective. Usually groundwater monitoring networks exist, but field measurements are not frequent. It is essential to define for each aquifer system a minimum observation network, define a minimum of parameters to be monitored, and find out a mechanism for financing monitoring operations beyond short-term projects. In many cases piezometric levels, EC and pH are measured but abstraction as a key observation parameter has to be added.

Major constraints thus include thorough or/and continuous monitoring on resources availability and the monitoring of GW chemistry due to deficits in human and financial resources. It is important to raise data monitoring as a priority since it is indispensable for sustainable water supply. Additionally, awareness should be raised on the relevance of groundwater monitoring among political authorities and users. In order to ensure sustainability of monitoring systems, it is essential to identify ways to **mobilise internal resources** (financial and human) to sustain groundwater monitoring and to update databases.

Recommendations for Capacity Building:

- Organise seminar/workshop, on **how to set up an effective groundwater monitoring** system:
 - at national and sub-regional level for all departments involved in the water sector (water resources, agriculture, environment, tourism, etc),

finance departments, research and education institutions and other stakeholders (especially civil society and water users). Resource-persons specialised on financial engineering and monitoring networks might be provided by WA-Net on request. The event should focus on:

- how to mobilise internal resources apart from those provided by short-term projects
 - developing communication strategies to raise awareness of political authorities and the public on the relevance of groundwater monitoring
- at regional level for public institutions involved in water resources management. WA-Net in synergy with WRCU¹¹ (that is setting up a regional water resources observatory) can initiate this process with the support of German Cooperation, The event should deal with:
- sharing best practices among West African countries and gaining experience from other developing countries that already have addressed this issue, for instance in the SADC region;
 - defining main groundwater quantity and quality indicators to store in database and defining a framework to facilitate data exchange maybe with WRCU as a focal point for centralising data;
- Set up a project of **trans-boundary aquifers investigation and mapping** to assess common resources as well as to develop a model for better planning and exploring experiences from trans-boundary surface water basins. This initiative should come from riparian countries (public water agencies) and WA-Net may provided specialists on request. The German cooperation can give support herein.
- Support requesting countries to **implement / improve database system** that aims to strengthen monitoring by assessing databases and providing equipment. Short-term technical visits of database specialists are needed to give **training to water agency employees in GIS and database**

¹¹ Water Resource Coordination Unit of ECOWAS (Economic Community of West African States) which promotes IWRM practices in West Africa. All its 16 members belong to WaA-Net as well. WRCU, as an organ in charge of follow-up and supervision of ECOWAS activities in the domain of water management, is an appropriated framework for regional co-operation on Integrated Water Resources Management, harmonisation of policies and legislation on water issues and exchange of experience.

management. For countries which do not have a database a project should be initiated to build up a national database system.

- Support agencies in charge of groundwater resources in the countries, according to expressed needs in **implementing/restoring/improving piezometric networks**. The aim should be to help countries to define and/or build a minimal monitoring network that ensures dynamic groundwater assessment and early warning mechanisms. Therefore monitoring network specialists are needed mainly for short-term missions.
- Improve groundwater knowledge of water sector employees (public and private water agencies, NGOs and education institutions) by initiating in-place **short-term training sessions (seminars, formal trainings) in geophysics, hydrogeology and modelling** as key tool for planning and decision-making.
- **Develop a groundwater mapping programme** in each country to assess major aquifers in collaboration of existing research and education institutions (national and international) and to develop local expertise. BGR can play a central role herein.

3.4 Groundwater development

It appears clearly that **capacity in borehole siting is insufficient**, mainly in areas of complex hydrogeologic environment like crystalline basements. In these areas the use of geophysical methods is appropriate to augment the drilling success (Macdonald et. al. 2005). Therefore, it is essential to strengthen capacity in this sector as nine West African countries over 60% of all aquifer layers are discontinuous and thus very complex.

Despite the importance of groundwater resources for the water supply in the region, **major aquifers** of great sedimentary basins **are underdeveloped** due to the depth of groundwater which increases drilling cost and low skills in resources assessment. The demand for additional resources in the outlook of irrigation development should be considered as some countries have initiated forward planning to augment their irrigated areas with the use of groundwater resources. Population growth and urbanisation are persistent trends in West Africa that will accelerate water demand. Considering a population growth rate in West Africa of about 3% per year as well as the growing needs related to higher life standards and the consequences of climate

change, **increasing stress on groundwater resources can be expected**. The demand is more accentuated in urban areas where the rate of population growth is higher. Taking into consideration that major urban areas are located at the coastline, the consequences resulting from high abstraction to face the demand are easy to imagine like for instance seawater intrusion.

The **borehole drilling sector as well as the pump sector are viable** but nevertheless both need capacity strengthening in well qualified operators (drillers, drilling supervisors, mechanics), in equipment replacement and in well developed spare parts network.

Recommendations for Capacity Building:

- Support **training in geophysics for hydrogeologists** in public and private companies to strengthen their capacity in borehole siting including support for purchasing geophysical equipments.
- Provide **training in modern drilling technology and pump electro-mechanics**, targeting young people (including women) in undergraduate schools to sustain the availability of professionals. Appropriate modules can be introduced in existing curricula and regional short trainings for trainers should be initiated for professionals in public, private and education sector.

3.5 Maintenance

In all countries of the region, the **same Ministry** that is in charge of **groundwater resources** holds the responsibility for **maintenance** of groundwater facilities. But the directorates managing the sector can be different, even though they belong to the same ministerial entity. In this case, it is necessary to well define the prerogatives of each directorate and to ensure a coordination of actions undertaken through their respective programmes.

Usually in **urban areas**, the responsibility for maintenance is assigned to **private or rarely semi-public water supply companies**, which take care of water system equipments encompassing abstraction facilities. In most cases the maintenance system is effective, even though some difficulties are encountered:

- meeting the demand with regard to population growth

- providing suburban areas with water
- replacing old equipment implemented during colonialism (boreholes, pipes)
- addressing pollution problems

It is especially the case in countries recovering from civil wars, e.g. in Guinea Bissau where the water supply network in the capital is characterised by old facilities and a lack of energy to supply production wells, conducting to a frequent disrupted service.

In **rural and semi-urban** areas, **user communities** are in charge of maintenance under the supervision of public institutions which keep the political responsibility. Apart from two countries¹², all others apply a VLOM policy by promoting so-called “**Water Point Committees**” in villages. These committees manage the borehole system and ensure its proper maintenance.

Unfortunately, VLOM policy is not effective in the region. The survey results reveal that the structural **maintenance system is not effective** in major cases (12 countries!), as **15 to 40 % of all boreholes are not functioning** at all at any time¹³. The best performance is recorded in Cape Verde, Gambia and Senegal (only less than 5% of boreholes on average encounter breakdown). Beside the age of infrastructure, (often 15 to 25 years without replacement or rehabilitation), the causes are various ranging from lack of technical know-how in maintenance and management to underdeveloped spare parts network. It is obvious that the institutional framework is not enough efficient to address these constraints. This question which institutional framework should be implemented to face maintenance issues, deserves an appropriated answer with regard to social and economic conditions in each country.

In any case, some “paths” should be prospected and strengthened (depending on each case), to ensure maintenance effectiveness in rural and semi-urban areas.

Recommendations for Capacity Building:

- **Promote small water supply networks** in semi-urban communities with a limited number of inhabitants (2500 – 5000) with strong implication of the

¹² Liberia and Sierra Leone, recovering from civil war

¹³ The worse situation is experienced by Cote d’Ivoire (due to unrest), Liberia (aftermath of civil war), Nigeria and Togo.

private sector in management (support the emergence of private operators services, develop tools for improved access to financing). Economic and legal specialists, as well as water resources specialists are needed to help decentralised water management bodies in strengthening capacity.

- In small communities (village level) **VLOM policy has to become more effective** through ensuring synergy between these three “chain links”:
 - representative water point committees (women and youth empowerment)
 - well trained area mechanics (frequent refresher training)
 - spare parts network easily accessible (private sector involvement, after sales services)
- **Support the harmonisation of actions of water sector stakeholders** (especially NGOs) to sustain and spread good experiences in maintenance issues. A framework of water sector NGOs should be created to enable information sharing. This can avoid duplication and overlapping activities. Involving the department in charge of water resources is necessary to provide data and technical advisory.

3.6 Institutional arrangement

Institutions that are tasked to manage water resources in general and groundwater resources in particular are at the same time users of these resources. In most cases, water resources are associated with agriculture, energy, mining, fisheries, etc. in the same Ministry. This situation implies a trend to **sectorial management** of the resources and does not foster a multidisciplinary and integrated approach. Indeed, each institution involved in water resources will act according to its sectorial needs and as the tasks devoted to each of them are not always well defined the consequences are duplication of efforts, waste of money and time, lack of information exchange, etc.

However, in almost all West African countries one can find **coordinating bodies** with such denomination like “National Water Resources Council, or Committee” that have been set up to coordinate the activities of water management institutions. Unfortunately, experience shows that these bodies do **not efficiently function**. It is interesting to notice that three West African countries, namely Cape Verde, Ghana,

and Mauritania seem to have trans-sectorial bodies as an institutional manager, according to official statements. An intense regional exchange of experiences is necessary to find out which institutional mechanisms perform best in the West African context.

The results of the survey show that there are still **big differences among the countries in terms of implementing IWRM**. Most countries have undertaken first steps of the IWRM process. In major cases they have already formulated IWRM policy, elaborated laws and regulation texts¹⁴.

However, the process of implementing IWRM depends on political commitment as well as socio-economic and natural context of each country. It has to be noticed that Gambia and Guinea Bissau, which use mainly groundwater to supply their population with drinking water, have not yet started this process. This situation highlights the need for awareness raising on IWRM, as well as the appropriation of IWRM to boost the process.

At regional level, important institutional components were set up for implementing an IWRM process such as:

- Development and adoption of the West Africa Regional Action Plan on IWRM;
- Effective establishment of the West African Partnership and Country Water Partnerships in 8 countries;
- Implementation of the Water Resources Coordination Unit within ECOWAS;
- Mobilisation of political authorities at high level.

The questionnaire results indicate also that groundwater authorities do not only operate on national level. In 9 participating countries national authorities managing the resources have decentralised bodies at local level. Generally, the adopted frame at lower level is structured accordingly to surface basins. It will be a future challenge to **adapt the existing bodies to hydrogeological basins** as groundwater is the main source of drinking water in most countries.

In all focus countries, **international partners, NGOs and public donor organisations are involved in the groundwater sector**. Their main concern

¹⁴ [http://www.wrcu.ecowas.int/en/pdf/prospectus_IWRM_in_West_Africa_and_____the_Target_2005_\(eng\).pdf](http://www.wrcu.ecowas.int/en/pdf/prospectus_IWRM_in_West_Africa_and_____the_Target_2005_(eng).pdf)

according to respondents is to provide the population with potable drinking water. Through their programmes, they finance borehole implementation and often assist beneficiary communities to deal with water point management. Beyond these activities confined in improving access to potable drinking water for population, it is imperative to **make their involvement in groundwater resources management more effective**. Moreover, it is necessary to ensure better coordination of all water sector interveners and to facilitate access to accurate and reliable groundwater resources information.

Gender issues are taken into account to some extent, as **women are key members of water management committees** in villages. Often they occupy sensitive positions like president, vice-president or treasurer. There is no specific regulation regarding gender issues in the groundwater sector but women are encouraged to participate in the process. They are not specifically involved in boreholes siting, however they are included in maintenance along with the management process for rural water supply. It is clear that the gender policy in many cases is just being developed, but it is interesting to notice that in water managing bodies at village scale, women involvement is relatively strong so that women often hold strategic position in the water management. But obviously large efforts have to be undertaken to reach equity in decision-making bodies. Public education and repeated awareness raising activities are key actions to give ownership of IWRM concepts to all stakeholders.

Recommendations for Capacity Building:

- Following the same scheme recommended in groundwater assessment chapter, a **platform of exchange should be set-up at national level** (workshop/seminar) including departments involved in the water sector, stakeholders and resource persons. This platform should work on:
 - the appropriate institutional framework for each case
 - the necessity to take into account hydrogeological basin scale in the division of labour attributed to water bodies
- Sub-regional workshops or seminars may be held on the subject to put a critical view on institutional framework and then to share experiences.
- Raise **awareness on IWRM** with a focus on groundwater aspects. Targeting women organisations and the youth via schools as well as decentralized

authorities to strengthen their capacity. It is necessary to **establish links with existing environmental education programmes.**

- **Foster coordination of NGOs and other donors activities** implied in groundwater issues, within the hydrogeological basin scale. Therefore water management bodies should initiate an **Action Plan for IWRM in hydrogeological basin scale** like such undertaken in national and regional levels.

3.7 Legal arrangement

There are **no specific groundwater laws.** Existing laws are related to water resources in general, without distinguishing much between surface and groundwater. Most of the West African countries (thirteen) already have formulated a comprehensive policy regarding water and even have elaborated the regulation texts. The rest¹⁵ has fragmented laws in each sector implied in water management (environment, mining, etc.).

In West Africa, **Water belongs to the public domain** and users are required to seek a permit for abstraction in all countries except Benin (where a law is process) and Sierra Leone where no licence at all is required. Interestingly, although it does not seem difficult to get such a permit and information about it is available, people do not adhere to the process. It is not clear if permits are accessible at appropriate level. In fact, **groundwater laws are usually not or only partly enforced.**

Private groundwater use is not very common apart from private companies that manage water supply in urban areas. Groundwater for drinking water supply usually is not covered by permits due to both socio-cultural factors (“water is a natural good”, why ask a permit to use it?) and unknown regulation. It is important to further decentralise permit authority to lowest possible level and popularise the regulation among domestic users as well as with the private sector to improve the control of private groundwater use.

Recommendations for Capacity Building:

¹⁵ Liberia, Sierra Leone and Togo

- **Popularise groundwater aspects** largely, the relevance of abstraction control and the laws related to groundwater through various media: poster in decentralised administrative authorities, communitarian radios in local languages or web sites to be implemented.
- **Support further decentralising of permit procedures** for water abstraction to local level for domestic water use and small irrigation use, but maintain the procedure at regional or national level for large scale uses (industry or agro-industry). This process requires that the **capacity of employees of regional management bodies is strengthened** in terms of skilled human resources to take control of all procedures.
- Assist groundwater resources institutions with enforcement by providing them with **water law specialists** in short term and by **giving training to local personnel in water law aspects** in long term. That may lead to better understanding of laws related to water sector.

3.8 Economic performance

In **urban areas** water supply is controlled by private companies, which have adopted **volumetric water pricing**, whereas in **rural zones** people usually pay only for **maintenance costs**. Nine countries do not apply volumetric water fees in rural area due to lack of awareness, acceptance, affordability and socially-sustainable systems to ensure costs coverage. Therefore, **cost coverage is not achieved** in none of the focused countries, except for Cape Verde.

However it is satisfactory to notice the **tendency to implement so-called water point committees** to manage abstraction wells. It can be a step forward in getting economic performance in rural and semi-urban areas, if the managerial constraints would be addressed by capacity building and private sector involvement. In addition, ineffective use of water is often related to technical problems encountered by water users in borehole management. **Water level and quality monitoring do not constitute a main concern for water point committees**. These findings highlight the fact that the priority for the population as well as for the authorities managing groundwater resources is to provide drinking water. There is a real need for groundwater sector stakeholders to enlarge basic knowledge about their principal drinking water source and to promote integrated concepts. Often communities still consider water as a natural and infinite gift. There is a huge need for the

management to capture the necessity to preserve the resource for future generations as a part of the management process.

Recommendations for Capacity Building:

- **Promote private sector involvement** in water sector in rural as well as in semi-urban areas through allowing and fostering small water supply networks where it is viable and entrust them to private organisations which have to implement water pricing on a socially and economically sustainable basis. Therefore it is necessary to:
 - Develop capacity of private operators
 - Facilitate their access to financial credit
 - Support the creation of water user associations
- **Strengthen water point committees'** capacity to deal with economically effective borehole management by ensuring appropriation of the new water policy. Information, education and communication (IEC) methods should be used to reach various social groups.
- Encourage financial viability of implemented boreholes by focusing on **economically and socially viable network extension**. This approach should stand as a guidance for projects related to the water sector. Therefore, a project to evaluate the current situation of water supply in rural and semi-urban areas should be implemented which aims at identifying the needs of water management communities in rural and semi-urban areas, to spread out good examples and propose a set of concrete actions to ensure economic viability of groundwater development.

3.9 Groundwater protection and environment

The main groundwater threats listed by respondents are:

- **lack of sanitation** or sewage network in urban areas what causes anthropogenic pollution of shallow aquifers
- **seawater intrusion** in coastal aquifers due to increasing water demands and abstractions for large towns
- **fertilizers & pesticides** where irrigated agriculture is practiced

- **waste from mining activities** in countries with gold, diamond or phosphates mines

With regard to urban growth, these threats like **poor sanitation** and **seawater intrusion** are very serious and are already listed as **severe** or become severe in the near future. The capacities to deal with pollution threats are insufficient and need to be strengthened. But surely the sector is aware of these problems: more than eight countries listed sanitation and seawater threats as severe. Legislation to protect groundwater against pollution and overexploitation exists in form of water codes or environment codes. However, in most cases the legislation is not enforced due to a lack of capacity (human and financial) to popularise existing laws and to sensitise the population about pollution threats.

Groundwater protection can be ensured through integrated monitoring systems which encompass physical as well as chemical parameters. It is necessary to **convince decision-makers about the relevance of groundwater monitoring and to set up a network system for continuous and frequent monitoring** of the state of groundwater. The survey shows again the relevance to couple water supply to suitable sanitation. The lack of sanitation is the main pollution factor threatening shallow aquifers in urban areas not fitted with sewage network as well as rural and semi-urban areas underlain by basement rocks with large fractures.

In West African region **seawater intrusion** to coastal aquifers has to be seen as a serious problem because not less than twelve of the focus countries are coastal states and one insular (Cape Verde) with the largest towns located at the coastline. The stress on groundwater resources is getting higher due to the trend of urbanisation. It is necessary to **assess the situation of water quality** in these areas and to **set up an adequate groundwater hazard management system** that aims to control and to warn at earlier stage.

The thread due to **high concentrations of fluoride** is not pressing although it is known that it occurs in some countries like Niger, Nigeria and Senegal. This pollution signifies a problem of public health in some areas where fluoride content is

excessively high and can lead to skeletal fluorosis. The appropriated filtration methods should be explored to address this issue of great concern.

Recommendations for Capacity Building:

- **Assess hazard areas and identify potential/existing groundwater threats** in each country.
- **Implement a specific monitoring network** with frequent measures as an early-warning mechanism ensuring that the data is integrated in a database. The data should be processed and disseminated (website, periodic issues) what may raise awareness on groundwater pollution. On request WA-Net can provide specialists and training, and the German cooperation could support the network implementation.

3.10 Education and training

Groundwater training is provided in various forms in the West African region:

- Universities provide geology courses at under-graduate level which does not lead to a specialization in groundwater matters. At tertiary level courses can lead to a doctorate (in French speaking countries) or a PhD (for English speaking countries) in hydrogeology.
- Schools of Engineers and Technical Institutes offer generally professional courses leading to an engineering degree or to a lower-level degree as technician. A specialisation in hydrogeology is often possible.
- Technical training in drilling or maintenance operations is provided through several technical schools.

The university courses in groundwater issues are usually more oriented to get fundamental background preparing attendees to receive a research degree. The universities in Burkina Faso, Cote d'Ivoire, Ghana, Nigeria and Senegal provide such education. The main technical schools in the region providing professional training in hydrogeology are:

- 2iE group (former EIER/ETSHER) a regional school based in Ouagadougou (Burkina Faso) shared by most French speaking countries. It provides mainly training in water engineering.

- The National Water Resources Institute of Kaduna (Nigeria) that provides short courses and professional on the job training (Induction courses, Drilling Technology, well siting techniques, alternative water resources).
- EMAIR (Air School of Mines) in Niger that offers mainly drilling and electro-mechanic training.
- INP (Polytechnic National Institute of Yamoussoukro, Cote d'Ivoire), ENI (National School of Engineers in Bamako, Mali), IST in Senegal (Earth Sciences Institute) can be listed as centres providing water-engineering courses.
- The Kwame Nkrumah University of Sciences and Technology (KNUST) and the Takwah School of Mines in Ghana provide BSc MSc and PhD training in hydrogeology

The education offer in the region shows a **deficit in subjects related to maintenance and development**. In fact, the training offer in drilling operations, pump maintenance, and borehole electronics seems to be very limited in the West African region. In the water sector there is a huge need for hydrogeologists in institutions involved in water resources management. Lack of qualified workers and skilled personnel is also a key constraint in groundwater development and maintenance. In public services, technical personnel that retires is often not replaced due to restricted budget.

Recommendations for Capacity Building:

- **Share information about educational offers** in the region and **strengthen regional cooperation in education** through exchange. Therefore WRCU may serve as focal point.
- **Support countries in improving existing curricula** and in augmenting/diversifying offer in drilling, pump maintenance, modelling and geophysics.
- **Promote short terms courses in acute hydrogeological subjects for professionals** in the groundwater sector (training the trainers programme).

4. Groundwater Management in Southern Africa

4.1 Hydrogeological Setting

Groundwater occurrence in the SADC-states¹⁶ differs largely due to the large variety of geological structures and the climatic differences that characterise the region. 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 (eg 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 are not very extensive. In general only modest groundwater supplies can be abstracted sustainably from these aquifers and large scale groundwater well field developments are not feasible.

25 to 30% is covered by major groundwater basins that are very 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.

¹⁶ SADC countries: Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

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.

In terms of climate and hence groundwater recharge, the south western part of the SADC region comprising western South Africa, Botswana, Namibia, southern Angola and western Zimbabwe may be characterized as semi-arid and arid terrain. As a consequence of the climate, these arid and semi-arid countries 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 as stream beds 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.

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.

4.2 Resource use

In the arid and semi-arid countries and areas, groundwater is often the only source of water and is used for all types of water use. For example, in Namibia groundwater is used for urban water supply (e.g. Windhoek, Swakopmund, Walvis Bay), irrigation (Stampreit aquifer, Grootfontein / Tsumeb aquifer), mining, and rural water supply. Botswana, also semi-arid, reports similar reliance on groundwater, while qualifying this by indicating that the irrigation sector is very small. In these countries, most

urban centres rely on groundwater supplies, except in the wetter parts of the country where surface water can be used.

In the humid countries, groundwater is mostly used for rural water supply and for mines in isolated areas. Irrigation demand for groundwater is expanding, although where surface water is abundant, this appears to be preferred. South Africa, Zimbabwe, Mauritius and Namibia indicate significant groundwater use for irrigation, while Tanzania, Kenya and Botswana indicate limited irrigation using groundwater. Urban water supplies (except for small villages) tend to be from surface water supplies, although many respondents indicate that groundwater is often used to supplement the surface water supplies. This supplemental use may be private, or in the case where a large aquifer exists (eg Karst aquifer near Tswane / Pretoria in South Africa) this may be exploited by the water supply authority for public use.

Water delivery of groundwater to rural communities is by motorized pumping with distribution networks in Botswana, Namibia and Mauritius. In the other countries, hand-pumps with single standpipes are typically used to supply the rural communities

4.3 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.

Recommendations for Capacity Building:

- **Best practices from the countries with well established databases** to be used in the development of databases in the other countries where data management and groundwater knowledge are less advanced. The groundwater database managers in the region should be involved in this exercise.
- Ideally there should be **harmonization of the software** systems used for the databases, or alternatively the data should be legible as text files.
- **Training by database specialists**, at a series of regional short courses. Individual country **short term technical visits** by such a specialist may also be motivated where a specific request is received.
- An **analysis of who uses the database** should be undertaken so that easier access can be promoted.
- **Capacity needs for the establishment of monitoring units** to monitor the use of groundwater should be identify, particularly in sensitive areas (e.g. saline intrusion and water shortage areas). The database should be linked to the development of a groundwater monitoring network.
- With regards to data collection, it is recommended that **standard borehole drilling forms** be developed and introduced to all drilling companies so that more data is recorded and submitted. This might require a change in law to include a clause requiring the submission of drilling returns.
- **Training of drilling crew in data recording** (public and private sector) can take place at a national level by local institutions, possibly with the support of a

roving technical specialist. A short “training the trainers” regional course may also be considered.

- A large scale **hydrogeological mapping exercise** should be started. The development of hydrogeological maps from databases could be stimulated by the mounting of a number of **regional short courses in GIS and map development** for database managers, academics and local professionals.
- An **electronic archive for groundwater reports, studies and theses may be developed**, either at national level or possibly at a regional level in the SADC Water Secretariat or other regional institution willing to host the database.

4.4 Groundwater Development

Most countries indicate that there is insufficient capacity in hydrogeology and in geophysics, and this hinders further groundwater development. Exceptions are South Africa, Botswana and Mauritius. All countries report that there is demand for more groundwater and that there are additional under-utilized aquifer resources. An exception is Mauritius, which indicates that saline intrusion is an issue and that there are no further large exploitable groundwater resources.

With regards to the water borehole drilling sector, most countries indicate that the drilling sector seems viable and adequate to meet demand. Most countries cite lack of professional standards in the drilling sector. The recording of drilling data appears to be done in a haphazard manner, and proper samples are not kept. Data is not forwarded to the relevant groundwater authorities and there are no standards with regards to the reporting formats.

The pumping sector is also regarded as viable in all countries except Mozambique and Malawi, which do not have pump manufacturers. Some respondents indicate that borehole test pumping is not carried out in a scientifically professional manner. Other respondents indicate that pump maintenance is a problem.

There seems to be a clear need for professional hydrogeologists and geophysicists in the region. It is recommended that there be a review training programs in the region and where indicated, support may be provided. There are three M.Sc. programs in hydrogeology (University of Western Cape, University of Free State, University of Botswana) and two M.Sc. programs in geophysics (Pretoria, University of Zimbabwe). However, it may also be appropriate to target undergraduate

programs in geology and physics with additional support for hydrogeology and geophysics respectively. The objective would be to produce more graduates with a strong foundation in hydrogeology and environmental geophysics.

Recommendations for Capacity Building:

- **Adapt existing undergraduate modules in hydrogeology / geophysics** for regional conditions, and then identify in country professionals who are prepared to teach these modules in the local universities.
- Regional **short refresher courses in hydrogeology and geophysics** for mid-career professionals may also be developed and delivered regularly.
- **Support groundwater mapping** in the various countries, focusing on major aquifer systems as a means of developing hydrogeological expertise as well as assessing the groundwater resources. This work could be integrated into a regional groundwater mapping exercise with specific quality standards set.
- Develop or adapt a regional module / course on **water drilling issues**, modern drilling technology, appropriate solutions for groundwater development (spring capture, shallow tube wells etc) and on the recording of drilling results.
- Develop / adapt some **standard water drilling report forms** and disseminate these throughout the region. Provide support for technical training to drilling companies.
- The project should **focus on pump repairs and maintenance issues**. Training courses, in cooperation with the pump manufacturer / supplier may be regularly mounted for pump maintenance authorities / units. Issues such as store-keeping and management of spare parts may also prove valuable. Technical training courses for pump technicians and for pumping tests could be considered.

4.5 Maintenance

In most countries it is the government departments and public institutions that are tasked with borehole maintenance. Lesotho, Mozambique, Tanzania and Zimbabwe report that there is some degree of community participation in the maintenance cycle. All parts of the maintenance supply chain are cited by most respondents as being under stress. Lack of trained personnel, lack of spare parts, vehicles, tools, finance

and leakages from the distribution network are all mentioned as problems. The identification and reporting of broken borehole pumps to the maintenance authorities is also seen as a point of delay leading to increased borehole down-time.

With regards to the effectiveness of the maintenance systems, it appears that there are large differences between the countries, even if the data on this issue is only a hint. Namibia and Mauritius report that almost all boreholes (90% for Namibia) are working. Zimbabwe reports that 30 to 50% of all public boreholes are not working at any time. The other countries do not supply any information on this, possibly because there is no knowledge on this issue. It is important to ascertain more widely and more accurately the percentage of public boreholes that are not working due to maintenance delivery or lack thereof. The comparative cost and benefit value of maintenance vs. new installations needs to be investigated to rationalize expenditures on groundwater supplies.

Recommendations for Capacity Building:

- Successes and failures of maintenance policies need to be highlighted and the **best practices** spread to all countries in the region.
- **Maintenance strategies and personnel training should be the focus of a regional workshop series** with maintenance institutions and donors working together.
- Enhance the **regional standardization of (hand) pumps** by undertaking a study on failures and key upgrades the India Mark IV and the MalDev¹⁷ may be well overdue by now. This might reduce the cost and accessibility of spare parts. Pump design may be supported with a view to improving the capacity for VL0M.

4.6 Institutional arrangement

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. Within these different ministries, there may be specific departments (e.g. Geological Survey) that are tasked to manage the national groundwater resource. In

¹⁷ In 1982, the World Bank tried as part of the world water decade to standardize hand pumps in Asia and Africa. The India Mark IV and the MalDev were selected by this time are now the most widely used pumps in Southern Africa.

addition to these government structures, there are regional (provincial) authorities, sectoral authorities (e.g. rural development departments), catchment management authorities, water boards, municipalities etc. Moreover, it is common for different ministries in the same country to both have management authority over groundwater (e.g. Irrigation division in an Agricultural ministry and the Water ministry).

In general the **sector does seem to have adopted IWRM principles**, although not all countries have specific IWRM policies. Most countries now have an IWRM policy or they are in the process of preparing such a policy. Although IWRM is understood and in many cases an IWRM policy is in place, some countries indicate that IWRM is not fully implemented at all levels. For example, women are generally reported as being under-represented in the groundwater sector. Zimbabwe has a gender policy that there must be at least 30% women in water structures. Other countries indicate women are involved in maintenance, but often excluded when it comes to site selection.

Integration between national water authorities and catchment management authorities is not always clear cut. In some cases, institutions act both at national and catchment level, while in other cases, the catchment authorities are more independent. Most countries indicate that groundwater development is carried out by many different entities, from NGO's to private individuals. However the resource management is usually only handled by the central / or catchment authorities.

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 qualified manpower. 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.

It is noted that with regards to institutional management, the **conditions for groundwater and for surface water are largely similar**. The issues of coordination between central authorities and catchment users are similar for groundwater and surface water, and it may be ineffective to focus on groundwater alone when addressing institutional issues. Clearly there may be specific groundwater departments that may benefit from capacity building, but such interventions are unlikely to have a major impact on sector wide co-ordination.

Many of the below given recommendations implicitly address issues of institutional management as they intend to improve the professional collaboration between national institutions and between different countries.

Since there are multiple water authorities, user boards etc. it is important to ensure that relevant data and information from these various sources is captured by the database managers and by the archives and that this data is readily accessible to all. This will require integration and coordination between water authorities and water sector professionals etc. and may require some capacity development input from the project.

Recommendations for Capacity Building:

- The program may have an excellent opportunity to **promote gender equity** in the water sector through granting women preferential access to the capacity building activities.
- There are a multiplicity of (ground)water authorities, and **better coordination may be required**. IWRM principles need to be promoted, and in particular the role of groundwater. The optimum use of resources and capacity needs to be achieved and duplication in different departments etc. needs to be minimized. This project can highlight these issues and help to identify solutions based on best practices in the various countries.
- The links between the central authorities and the periphery may be to some extent ineffective, or inefficient. Human resources development at both central and catchment level may help to overcome such problems, and can provide increased support for groundwater user communities.

4.7 Legal arrangement

All respondents indicate that those institutions which are empowered to manage the groundwater resource are the institutions that hold the legal responsibility for ensuring that the laws are adhered to.

It seems that in most of the countries (except Mozambique) there are specific laws that deal with groundwater. These groundwater laws are most comprehensive in Botswana, with different regulations relating to different uses and different situations. However, except for Mauritius, all respondents indicate that the laws are not effectively enforced.

With regards to use of groundwater, most countries require users to obtain permits from local authorities and catchment managers, but these procedures are not strongly enforced except in Mauritius and Namibia. Large scale groundwater abstraction does tend to be more closely monitored in all countries.

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. This effectively means that every user needs a permit to access and use groundwater.

In terms of capacity building, development of human resources and public awareness are seen as key requirements.

Recommendations for Capacity Building:

- **Investigate the capacity of the institutions** to apply the laws effectively.
- Collect copies of the legislation from different countries, archive them with the SADC water secretariat, and review them critically to **identify effective legislation.**
- **Improve public awareness** of the groundwater resource and the laws.

4.8 Economic Aspects

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.

With regards to measuring groundwater use: in Namibia, it is only measured in water shortage areas. In Zimbabwe, commercial use is estimated by electricity use and by irrigated area. In Botswana, urban networks that are supplied by groundwater and are monitored by water meters.

Every country indicates that groundwater development is not linked to economic sustainability issues. Mauritius and Botswana indicate that development is sustainable. In all other countries development is not sustainable in terms of costs.

All countries indicate that human resources capacity needs improving to ensure sustainability. Specific needs identified are: management, expert knowledge, capacity to develop local technologies.

With regards to demand management: Namibia indicates that it has advanced demand management practices with discharge monitoring and fees charged for

water used. Zimbabwe has laws, but lacks capacity to enforce these. Mauritius and Tanzania record some form of demand management, but no details are given. Large water supply schemes tend to pay for water, but private boreholes are usually free. Demand management for groundwater is not effectively in place in almost all the countries. However, care must be taken that the stringent requirements for demand management in arid countries does not hinder groundwater development in humid climates.

Recommendations for Capacity Building:

- With regard to economic sustainability, it is recommended that water ministries should be lobbied to **allocate higher budgets to the groundwater sector**.
- **National statutory groundwater organizations / boards should be formed** to discuss groundwater sector issues and to provide guidance for the sector. Such organizations could try to develop synergies between different countries and promote successful developments.
- **Identify demand management strategies for groundwater**. The examples from Botswana and Namibia should be studied and their strategies disseminated throughout the region.

4.9 Groundwater Protection and Environment

Responses are varied. All countries list many pollution problems ranging from saline intrusion, nitrate, industrial effluents, acid mine drainage, domestic sewage effluents, over pumping, natural geochemistry are all cited. Lesotho response indicates severe threats. Some indicate financial, management and technical constraints.

All countries (except DRC) 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. Implementation of the legislation is generally poor. No country indicates any focus on cleaning up existing problems.

Botswana indicates that groundwater is being mined, but other countries do not have data.

In the dry countries (Botswana / Namibia) groundwater is of great importance and the integrated management of water resources is more advanced. In the more humid countries, groundwater is seen as being important for rural and drinking water

supplies, and integration into the total water resources development is less. Only in Botswana is the aspect of surface water / groundwater interaction integrated into the actual monitoring activities.

Recommendations for Capacity Building:

- Build up a register of key threats and key constraints and provide support where most needed. Possibly **set up a small task team to identify key environmental threats to groundwater in the region** and build specific responses. This may be done the Groundwater Protection Initiative mainly driven by AMCOW, UNEP and the University of Western Cape. Synergies between different country needs may be identified and regional responses formulated.
- Identify means of **raising awareness among possible major polluters** and focus on getting support from mines / industry / city waste managers focussing on remediation as well as prevention. Key problem areas should be identified and monitoring / policing of these areas can be supported.
- In terms of groundwater / surface water interactions, case histories from Botswana / Namibia where the integration is advanced should be studied and then **disseminate the best practices to other countries**. Support studies / data that show this interaction. Support data collection and archiving of this type of information so that it is readily accessible regionally.

4.10 Education and Training

National universities are cited as the key training institutions in all cases. Most countries teach a section of hydrogeology within Geology undergraduate courses. South Africa has two hydrogeology M.Sc programs at the University of Western Cape and at the University of Free State. Botswana has an M.Sc program at the University of Botswana. These M.Sc programs are open to regional students.

Most countries record that technician training is adequate, and do not cite any specific capacity constraints except South Africa. Tanzania indicates that they have a technician training program.

Tanzania and Zimbabwe have regional courses for postgraduates (M.Sc.) in IWRM which include an optional module on groundwater. These IWRM programs receive sponsorship from WaterNet. There are no regional technician training programs.

Most countries indicate that there is no donor country that specifically supports groundwater training.

Recommendations for Capacity Building:

- **Specific hydrogeology course units, suited to the region, may be developed and included in undergraduate syllabuses.** Professional personnel / lecturers required to teach such courses may be found among the WaterNet partner institutions. Universities in the region may be approached to identify those interested in such an initiative. The existing M.Sc. programs in the region may be approached to participate in this groundwater capacity building exercise.
- **A detailed review of available technician training courses and needs is required.** Syllabus data for the various training programs should be compiled and reviewed. The need for a regional technical training program should be investigated. Those institutions that provide technician training should be approached to identify their capacity constraints.

Education could be a key area for the program to invest in by supporting existing training institutions that are already active in the groundwater sector. This will require a more detailed investigation of the conditions prevailing in this sector and the demand for additional education and training opportunities.

To achieve approved interventions, partner institutions in the region should be identified and programs developed in cooperation with these partners. All capacity building support should be within an IWRM framework.

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Annex 1: The Millennium Development Goals

MDG 1: Eradicate extreme poverty and hunger

Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day.

Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.

MDG 2: Achieve universal primary education

Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.

MDG 3: Promote gender equality and empower women

Target 4: Eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015.

MDG 4: Reduce child mortality

Target 5: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate.

MDG 5: Improve maternal health

Target 6: Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio.

MDG 6: Combat HIV/AIDS, malaria and other diseases

Target 7: Have halted by 2015 and begun to reverse the spread of HIV/AIDS.

Target 8: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases.

MDG 7: Ensure environmental sustainability

Target 9: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.

Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation.

Target 11: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers.

MDG 8: Develop a global partnership for development

Target 12: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system.

Includes a commitment to good governance, development, and poverty reduction – both nationally and internationally.

Target 13: Address the special needs of the least developed countries.

Includes: tariff and quota free access for least developed countries' exports; enhanced programme of debt relief for HIPC and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction.

Target 14: Address the special needs of landlocked countries and small island developing States (through programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the twenty-second special session of the General Assembly).

Target 15: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term.

Target 16: In co-operation with developing countries, develop and implement strategies for decent and productive work for youth.

Target 17: In co-operation with pharmaceutical companies, provide access to affordable, essential drugs in developing countries.

Target 18: In co-operation with the private sector, make available the benefits of new technologies, especially information and communications.

Annex 2: Questionnaire for Survey on Capacity Needs for Groundwater Management (English version)

QUESTIONNAIRE **COUNTRY:.....**

Respondents Details: Name:
Qualification:
Address:
Contact details: email:

Job Description:
Employer:
Telephone / Fax:

GW key components	Questions	Answers
1. Institutional Management	a- Which institutions / authorities are tasked by government with the management of groundwater?	
	b- Do these institutions have an IWRM policy?	
	c- Are these institutions only at National level or do they also operate effectively at catchment level?	
	d- Are there other organizations such as NGO's, donor organizations, etc. that are also involved in groundwater development in any way?	
	If yes please list	
	e- What are the key concerns of the organizations involved with groundwater?	
	f- What are the perceived capacity building requirements for these organizations?	
2. Legal Status	a- Which institutions are empowered by law to manage groundwater?	
	b- Is groundwater use and development covered by specific laws?	
	If yes, specify nature of laws	
	c- Are these laws effectively enforced?	
	d- At what level are users / developers required to seek permits from the relevant authorities? Are such procedures enforced? Are permits accessible and readily available?	
	f- What are the capacity building needs in terms of legal capacity?	

3. Resource Assessment	a - Groundwater database: Is there a groundwater database, and what is its format? Which organization hosts the database?	
	b- How accessible is this information at national and catchment level?	
	c- What are the capacity building requirements for these activities? Are there cooperation agreements with donor organizations targeted at groundwater database development?	
	d- Are the following data available?	
	Groundwater maps (piezometric, aquifer dimensions, well yield, water quality etc...)	
	Geological maps	
	Hydrogeological & Hydrological reports	
	Analysis of the major groundwater systems	
	Climatic data, rainfall and ET maps	
	Groundwater chemistry data	
	Groundwater recharge rates	
	Groundwater level vs time data	
	River runoff data.	
	g- Are there any other sources of groundwater data, not captured by the national database system?	
4. Resource use	a- Who are the principal users of groundwater?	
b- What are the main capacity constraints in providing groundwater for these groups?		
c- At what level is groundwater normally provided — hand pump; motorized pump; distribution network etc?		
d- Irrigation use- is there significant groundwater use for irrigation?		
e- Large scale urban use — is there large scale urban use of groundwater?		
f- How often do groundwater resources dry up? How do people deal with drying up of groundwater sources?		
g-.Does the use of groundwater vary significantly in different regions of your country?		
5. Maintenance	a- Institutional responsibilities. Who has institutional responsibility for maintenance of public groundwater installations?	

	b- Effectiveness of maintenance: what % of public boreholes are on average not working at any point in time?	
	c- What are the key problems and constraints associated with the maintenance of groundwater supplies?	
	d- VLOM — is there a village level operation and maintenance policy / practice?	
6. Integrated Water Resources Management	a- Surface water / groundwater interactions. To what extent does the national water policy take into account the interaction between surface and groundwater'?	
	b- In a national context, what is the comparative importance of groundwater vs surface water?	
	b- Gender issues — are women significantly involved in the selection of borehole sites in public water programs? Are women significantly empowered in the maintenance cycle for rural water supplies? Are there specific gender policies in place?	
	c- Demand management aspects- Is there any form of demand management on groundwater use?	
	d- Monitoring. What are the capacity constraints for groundwater monitoring?	
7. Groundwater development	a- Groundwater location — In terms of borehole siting and aquifer resource assessment, is there sufficient capacity in hydrogeology and geophysics?	
	b- Are there major under-developed or undeveloped groundwater resources?	
	c- Is there a viable drilling sector? What are the training needs for this sector?	
	d- Pumps and pump installation and maintenance Is there a viable borehole pump sector? What are the capacity building requirements for this sector?	
8. Groundwater protection and environment	a- Groundwater quality / threats. What are the main threats to groundwater quality? How severe is the potential threat?	
	b- Is the groundwater resource being over-exploited?	
	c- Is there sufficient capacity to identify / monitor such problems?	
	b- Groundwater protection — is there legislation to protect groundwater from pollution / overuse?	
9. Groundwater	a- Institutions providing such education — which national institutions provide any form of groundwater training?	

Education and Training	b- Level and nature of training available nationally. Identify the different type and levels of training courses available. Academic and technical. What are the capacity constraints?	
	c- Are there any regional training institutions in the country? Are there regional courses that are available in the country?	
10. Economic Aspects.	a- Do users pay for groundwater?	
	b- How is groundwater use measured?	
	c- Is there sufficient capacity to ensure that groundwater development is carried out in a cost effective sustainable manner?	
	d- Indicate the additional capacity needs in this sector.	

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