BRITISH GEOLOGICAL SURVEY
Natural Environment Research Council

TECHNICAL REPORT IR/01/27
Hydrogeology Series

Technical Report IR/01/27

Groundwater Research Priorities for the SADC Region: Report of a Workshop at the IAH 30th Congress, Cape Town, November 2000

P J Chilton

This report was prepared for
the Department for International Development

Bibliographic Reference

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Groundwater Research Priorities for the SADC Region, Report of a Workshop at the IAH 30th Congress, Cape Town, November 2000
British Geological Survey Report IR/01.27

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CLIENT		
Department for International Development	CLIENT REPORT #	
	BGS REPORT#	IR/01/27
	CLIENT CONTRACT REF	CNTR O1730
	BGS PROJECT CODE	ERE39900122
	CLASSIFICATION	Open

	SIGNATURE	DATE		SIGNATURE	DATE
PREPARED BY (Lead Author)		12.02.2001	CO-AUTHOR		
			CO-AUTHOR		
PEER REVIEWED BY			CO-AUTHOR		
			CO-AUTHOR		
CHECKED BY (Project Manager or deputy)		01.03.2001	CO-AUTHOR		
			CO-AUTHOR		
APPROVED BY (Project Director or senior staff)			CO-AUTHOR		
			CO-AUTHOR		
APPROVED BY (Programme Manager)			OS Copyright acknowledged		
Layout checked by	C. Sharratt	2/3/01	Noted by QA Officer		

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Contents

1. INTRODUCTION

The initial idea for a workshop on groundwater priority issues for the SADC region came from discussions between the Congress organising committee and BGS in September 1999. One experience from BGS involvement in the organisation of the 1997 Nottingham IAH Congress was that it remains extremely difficult for African groundwater specialists to attend international meetings, increasing their already acute sense of professional isolation. The intention of the organising committee was that, by associating workshops such as this one with the Congress, and taking account of probable lower travel costs within Africa, this would be a rare opportunity to gather southern Africa practitioners together. It might encourage employers and other agencies to support attendance, as the Congress will not be in Africa again for many years to come.

Once the concept had been established, support for BGS involvement (PJC) was requested from DFID and agreed under the Infrastructure and Urban Development Department (IUDD) Resource Centres scheme. The agreed Terms of Reference for this support were:

- To prepare, co-chair, facilitate and report on a workshop to review gaps in knowledge concerning the development, management and protection of groundwater resources in the SADC region.
- To stimulate participation of, and to the extent possible assist in obtaining funding for groundwater specialists from within the region.
- To encourage participation of other groundwater specialists with relevant experience in the region.
- To disseminate the outcome of the workshop, and stimulate where possible the take up of recommendations or proposals coming from the workshop.

Both BGS workshop facilitators also gave keynote presentations at the Congress which drew partially on DFID-funded work.

2. SCOPE AND APPROACH

The workshop, which was one of five, was scheduled for a two-hour slot within the Congress programme at a time when parallel technical sessions would be underway. In view of the limited time, it was decided that the main focus would be on the key water-supply development issues of the very extensive areas of Africa underlain by less productive aquifers, such as the weathered crystalline basement and other hard-rock aquifers, together with thin superficial unconsolidated aquifers. One of the other Congress workshops would be dealing at the broader scale with larger aquifers and trans-boundary groundwater resource management issues within the SADC region.

Further, in view of the very large and growing rural populations living in such terrains in the SADC region and still without access to secure and safe water sources, and taking account of the increasing incidence of extended droughts in the region, this had to be a high-priority topic. It was also considered appropriate by the workshop and congress organisers to extend the geographical scope of the workshop to the larger sub-Saharan region. In these areas, the main concerns are often:

- improving the success rate for siting and constructing water sources which can provide a supply of adequate volume and quality for installation of a hand-pump, and
- examining the prospects of larger supplies for small town water-supply and/or small-scale

irrigated agriculture, and the security of such supplies during extended drought.

Thus, in establishing a framework for the workshop, an attempt was made by the BGS facilitators to differentiate between hydrogeological understanding, tools and research needs related to:

- the **planning phase** (feasibility study and investment appraisal)

from those related to

- the **implementation phase** (well construction and source operation)

and to take an investment-oriented view of this difference. In essence, the question was posed as to which shortcomings in knowledge most prejudice investment (in either phase) in groundwater supplies, and where would research effort be most effective in improving and protecting such investment.

Some 40 participants attended the workshop, 70% from Africa with 10 African nations represented. They were drawn 50% from government or quasi-government water-sector organisations, 22% from universities, 18% from European technical assistance organisations and 8% from the private sector. In spite of considerable efforts before the Congress, a number of key countries in the region were completely absent (Nigeria, Kenya, Mozambique) or inadequately represented (Zimbabwe). A full list of participants is included as Annex 1.

The opening presentation highlighted the distribution of four main geological subdivisions (and hence aquifer types) in sub-Saharan Africa, and the large populations living on each of them (Figure 1). Under the first sub-heading above, it then highlighted the main hydrogeological features and constraints of each of these subdivisions, as they affect project and programme planning for varying levels of water demand and uses. Under the second sub-heading, the characteristics of the weathered basement aquifer were briefly described, and the way in which these affect choices of water point type (wells or boreholes) and methods of exploration were referred to. Given that the total cost of wells or boreholes has components of exploration, construction, pumping and protection and maintenance, and that these will vary in proportion according to the hydrogeological environment, the question was posed as to where, i.e. which component, investment would be most effectively made to obtain maximum improvement in productivity and sustainability of groundwater supplies. The overheads used are included here in Annex 2, drawing heavily on the recent World Bank Policy Paper on rural water supplies (Foster *et al*, 2000).

Following short presentations by the BGS facilitators, a brief presentation was made by Hans Beekman on an IGBP (International Geopsphere-Biosphere Programme) initiative on "Recharge and sustainable use of groundwater in arid and semi-arid Africa". This comes under the Biospheric Aspects of the Hydrological Cycle (BAHC) programme element, managed from the project office in Potsdam, Germany. The purpose of the initiative is to implement successful strategies for the integrated and sustainable exploitation, management and protection of land and groundwater resources in the region. Within this initiative, it is proposed to have a network of contributing projects which respond to a set of identified user requirements and research gaps. Further details are given in the copies of the overheads included her in Annex 2. Discussion was then opened to the floor. An attempt has been made to group and discuss the points raised according to whether they are primarily related to planning or implementation but, given the limited time available, this intended framework did not prove very helpful in practice.

3. GROUNDWATER ISSUES ARISING

3.1 Regional Communication

It was clear from the early remarks of a number of the participants that, in spite of various regional initiatives, there was poor communication with and dissemination to practitioners and professionals. SADC and its hydrogeological sub-committee, the Southern Africa Water Partnership, the IGBP project, the UNESCO IHP, all need to improve their dissemination approaches within the region. Many participants were more or less unaware of some or all of these initiatives.

3.2 Hydrogeological Maps

There was a measure of agreement that hydrogeological maps of appropriate scale and format were a valuable tool for the planning phase, including the selection and costing of geophysical and geological well-siting techniques in difficult terrains, the probable type and cost of well installations and the probability of success. Conventional hydrogeological maps with a common legend would be particularly useful in the transboundary situation. There were, however, concerns that the capabilities of conventional maps, and their limitations were not well understood.

At the planning level, it was considered worthwhile pursuing interpreted or derivative maps (or translations) from the standard map, including well yield prospects/predictability, probable well construction costs, likelihood of natural groundwater quality problems, aquifer pollution vulnerability, groundwater supply drought security, longer-term abstraction sustainability, etc. However, there was concern that heavily interpreted or simplified maps, especially if targeted at non-specialists, could be misused and provide erroneous results. In particular, it was felt by some that map producers sometimes attempted to depict hydrogeological characteristics which were better left as point data. It was also felt that such interpreted maps often did not (and indeed could not) depict uncertainty, whereas professionals working in the region are continually confronted by uncertainty due to the complexity of the hydrogeology and a lack of data.

In parallel, it was considered highly desirable to produce or acquire maps summarising existing/projected water demand (at the simplest level population density distribution could serve as a surrogate), existing water-supply installations and areas of ecosystem dependence on groundwater.

Many advantages were identified for incorporating all of this information on an appropriate (and flexible) GIS platform, which would allow rapid comparisons/correlations and regular up-date.

3.3 Mapping and Data Management for Implementation

There were more doubts expressed about the value of such data compilations at more detailed scale for the implementation phase, and some thought it more useful simply to facilitate access to the records of all previous boreholes in the general vicinity. One approach would be the use of GIS/databases which would allow data windows to be opened on a map, giving details of the exact data at any point, its method and date of collection, and its reliability.

The greatest and almost universal concern about data was that it was not adequately collected or archived. Many, many large rural water supply projects or whole programmes had been undertaken, in which hundreds or thousands of boreholes had been drilled. However the extra incremental effort at the time to record and archive vital hydrogeological data – depths, water strikes, yields, drawdowns, lithology, water quality etc had not been put in and/or such data as had been collected had been lost. To be cost-effective, hydrogeological data acquisition, archiving and interpretation for research purposes has to be built into the implementation of groundwater supply projects and the operational monitoring of their performance.

A critical point which emerged from the workshop was that financial provision was frequently not made for such basic R & D in either construction or operation and that there was little scope for 'incremental learning' as a result. This was seen as a failing by both donors and implementing agencies. As a result, there was no subsequent benefit to future investments from access to the improved hydrogeological knowledge which could have been obtained. Further, there was inadequate data to allow feedback loops between drilling results (including details of failed boreholes) and siting methods, from which the latter could be properly evaluated. It was agreed that donors, NGOs and local implementing agencies should be urged to plan and budget for such data to be collected and archived, and this recommendation was built into the Cape Town Statement at the end of the congress. Thus it is strongly recommended that:

(1) **a 10-15% budget provision should be built in to projects or programmes to allow for hydrogeological data collation and critical appraisal of the experience gained in rural water-supply development projects and its feedback to national databases and**

(2) **small investments in post-case evaluation and documentation of the performance of existing systems, including hydrogeological aspects, would reap many long-term benefits.**

3.4 Groundwater Exploration

Many of the workshop participants were heavily involved in groundwater exploration in difficult terrains, and therefore considered themselves to be very much at the "sharp end" of operational hydrogeology. Their needs were often not recognised by the research community, and there was a need for greater dialogue between practising field hydrogeologists and the researchers of both developed and developing country institutions.

There was a sense that satellite imagery was still under utilised and that geomorphological techniques (such as digital terrain modelling from aerial photos) had not been fully exploited – this was a possible research area for SADC to pursue at regional or sub-regional level.

Although geophysical methods are extensively and routinely used in groundwater exploration, there was (perhaps surprisingly) little comment on geophysics, with the exception that aeromagnetic surveying was a cost-effective approach which could be more widely used.

3.5 Groundwater Quality Problems

Natural groundwater quality problems (notably elevated concentrations of fluoride, iron, magnesium sulphate, sodium chloride and nitrate) are being encountered on quite a widespread scale, although there was uncertainty about the most profitable lines of research to predict their distribution. Improved conceptual geological and hydrogeological models would appear to be the best route to pursue, and geomorphological terrain analysis and bedrock geochemical databases could provide useful inputs. Better geological indicators of the potential for natural water quality would be a great help.

In relation to the pollution risk to rural water-supply wells from human and livestock excreta (especially pathogens and nutrients), guidelines based on recent research are soon to appear, produced by BGS with DFID funding. These guidelines would need to be systematically applied with better microbiological monitoring and improved protection of the wellhead area in many instances; continued R & D is also needed in this area to refine the general guidelines according to local hydrogeological conditions.

Inadequate laboratory and field analytical capability and poor QA/QC procedures continued to be of concern in some countries. It was suggested that the mining industry could provide support and

collaboration to improve the situation in the region. SADC could also be approached to facilitate inter-laboratory comparisons for improved QA/QC, provided laboratories were willing to participate.

4. SUGGESTED RESEARCH PRIORITIES

Participants from the main countries in the region were asked to provide a few summary issues which they would consider to be research needs, and these are summarised below. In fact, many of these are more a matter of dissemination and/or adaptation of current best practices rather than a need for truly new research initiatives, again reflecting the degree of technical isolation in which many of the participants work. It had been intended to produce a summary table, but in the event the suggestions are simply listed here.

4.1 Zambia

Lack of investment in water resources research and development was said to have exposed the resource to neglect and it was vulnerable to quantity depletion and quality degradation. To halt and reverse this trend, investigations are required in the following areas:

- determination of levels magnitude and sources of groundwater contamination
- groundwater resources estimation
- levels and quantities of groundwater abstraction
- awareness raising and education campaign programmes to promote sustainable aquifer utilisation
- a regulatory framework promoting aquifer protection in terms of both quality and quantity, with regard to patterns of peri-urban settlements, location of disposal sites including cemeteries and types of sanitation practices
- establishment of early warning (quality and quantity) monitoring systems
- assessment of surface and groundwater quantity and quality.

4.2 Tanzania

Research priorities:

- determination of loading rates to aquifers from different pollution sources
- developing vulnerability maps and guidelines

4.3 Namibia

- Research needs:
- re-assess current and proposed new national monitoring system
- assess potential of artificial recharge within various parts of the country and specifically with a view to supplying the central areas
- review the water potential of the carbonate aquifers and the Kalahari multi-layered aquifers in the extreme northern part of the country where half of the population is located

- quantifying leakage from existing boreholes within the south east Kalahari (Stampriet) artesian basin with to develop ways of dealing with the problem

- assessing the problems of water quality within various aquifers, specifically understanding the occurrence and origin of high nitrate and how to control it.

4.4 South Africa

In South Africa, a co-ordinating committee on geohydrological research (CCGR) has recently drafted a strategic plan for groundwater research for 2000-2005. Against an overall background of alleviating poverty in the country, the need for research to be a) relevant to solving specific development problems, b) targeted at supporting policy-making and c) empowering people and communities is stressed. The drivers for groundwater research are summarised in the strategy, particularly the social and economic costs and health impacts of lack of adequate, clean and safe water supplies. The link between research and the new water legislation is also emphasised, especially the integration of groundwater fully in the hydrological cycle and management on a catchment scale.

Thus (and greatly summarising the strategic plan), the principle research needs are expressed in the following terms:

- identification and characterisation of South Africa's aquifers in terms of their occurrence, quality and development potential.

- determination of the occurrence, degree and potential for groundwater contamination

- optimisation of groundwater utilisation for all communities through an integrated management approach

- investigation of groundwater – environmental interactions

- development and implementation of suitable tools and techniques that would aid in achieving the objectives set out above.

4.5 Uganda

A contribution from Uganda on research priorities for sub-Saharan Africa:

- hydrogeological mapping to produce maps for planning and management of groundwater resources at country and lower levels. Some of the maps to be produced include feasible water supply options, yield distribution, water quality distribution, lithology, aquifer thickness etc

- correlation of geophysical survey results with lithology and well yields in different parts of the country

- groundwater recharge assessment in various parts of the country

- determination of the contribution of groundwater to surface water bodies – Lake Victoria, River Nile etc

- determination of wellhead protection areas.

4.6 Malawi

- water quality: routine water quality monitoring is often not undertaken after groundwater

development, for various reasons. But some areas have known quality problems such as fluoride and other ions. The existence, evolution and removal methods appropriate in various settings such as rural handpump supplies, semi-urban piped supplies and urban supplies need to be explored

- conjunctive use: some urban areas and some district centres experience supply shortages. The general practice has been to concentrate on one source (surface or ground) largely depending on which source was first developed, not necessarily because it was the most feasible

- recharge and drought: groundwater development is almost entirely for handpump supplies. The abstraction rate being small, the assumption has tended to be that recharge from annual rainfall is adequate. In the last ten years, the country experienced some drought spells which posed challenges to this broad assumption. Recharge studies in various settings would provide more insights

- drilling methods and depths: there has been a growing bias towards machine-based drilling methods. The large unserved population would need thousands of water points to be developed within the next decade. Low cost solutions such as hand-drilling still have a major role to play. Some often argue that shallow drilled tube wells (20 m) are not sustainable, yet hand drilled (augured) tube wells can be developed to the same standard as the machine drilled (rotary/percussion) wells. Research into sustainable drilling depths in various settings would produce more informed technology choice

4.7 Zimbabwe

- capacity building of groundwater professionals – most hydrogeologists in the country lack adequate skills to carry out aquifer investigations i.e. they have education at B Sc. geology level

- groundwater data from about 35,000 boreholes has been captured and imported into Groundwater for Windows at a district level. Quality control of the data is currently being carried out, and there is a need to change to a more open (intermediate) database structure (such as Access) to better communicate with technical software

- groundwater resource assessments of three major sedimentary aquifer systems have started since 1998 as part of a capacity building programme for hydrogeologists in the Groundwater Branch. Although some progress was made, a lot of work still has to be done, particularly with regard to the quantification and modelling of aquifers both from a groundwater flow and solute transport point of view. Much more work is of course needed in crystalline basement aquifers to ensure adequate water supplies to rural communities

- groundwater resource planning and management require groundwater allocation, and implementation of groundwater regulations (drafted in 1999) is becoming a major topic within the framework of integrated water resource management

- transboundary aquifers could be studied at a later stage – e.g. the Karoo aquifers in Matabeleland North bordering Botswana.

5. SUMMARY

The main emerging issues can be summarised as follows, using the overall subdivision into planning and implementation.

5.1 Emerging Issues - Planning

- There was general agreement that hydrogeological maps could be a useful planning tool
- There was some good experience with derivative and interpretative maps, especially in South Africa, but concern about the dangers of over-simplification for use by non-specialists
- It was desirable to produce innovative maps to depict features such as water development potential and drought susceptibility, using GIS approaches
- Natural groundwater quality problems are widely experienced – and there was uncertainty about how to predict them

5.2 Emerging Issues - Implementation

- There were doubts about the value of maps and accessible point data with indications of reliability were widely preferred
- Satellite imagery and geomorphology are under-utilised in site selection
- Suitable and useable guidance on pollution risk is required
- There is scope for improved regional laboratory collaboration for improved QA/QC and there was a suggestion that SADC could help in this
- There was almost universal lost opportunity for incremental learning. Water supply projects should be obliged to collect, collate and accessibly archive data, and donors and implanting agencies should be obliged to budget for this.
- There was a lack of feedback and discussion between implementers and researchers, both North-South and within developing countries.

It was agreed that the two hours of the workshop had been far too short a time to explore these issues in anything like the depth they deserve. Given the continuing programmes of rural water supply provision in the region, many of the issues highlighted in the discussions imply significant loss of investment in water sources which have insufficient yield or poor quality water and/or are not sustainable in drought conditions. It is proposed, therefore, that a mechanism be found to organise a 2-3 day meeting for hydrogeological practitioners and researchers from the region at which these issues could be debated at greater length in a structured forum.

6. REFERENCES

Foster S S D, Chilton P J, Moench M, Cardy F and Schiffer M. 2000. Groundwater in Rural development: facing the challenges of supply and resource sustainability. World Bank Technical Paper No 463, Washington DC, USA, 98 pp.

Annex 1

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Annex 2

Overheads used in Workshop Presentations

GROUNDWATER RESEARCH PRIORITIES FOR THE SADC REGION

Workshop W4
IAH Capetown Congress
Wednesday 29 November

SUGGESTED WORKSHOP FRAMEWORK

Take an investment-oriented viewpoint:

- At the planning level
- At the operational level

and consider key hydrogeological issues at these two stages: - noting the importance of scale

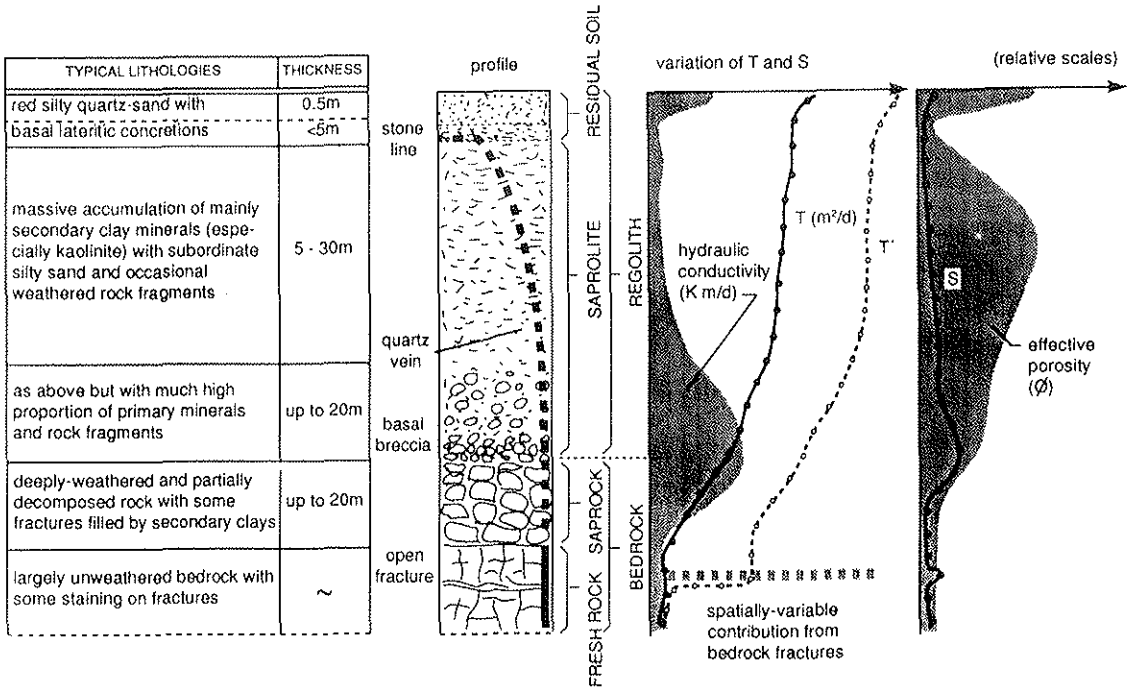


Table 4: Suitability of geophysical methods in different hydrogeological environments

Hydrogeological environment	*Electrical resistivity*		*Seismic refraction*	*Electro-magnetics*
	Sounding	*Profiling*		
Major Alluvial Formations	++	+	+	o
Consolidated Sedimentary Aquifers	+	+	+	o
Volcanic Formations	+	+	o	+
Weathered Crystalline Basement (regolith)	++	+	++	+
Weathered Crystalline Basement (fractured bedrock)	+	++	++	++
Fresh/Salt Water Interfaces	++	+	o	+

++ very suitable
+ suitable
o not suitable
Note: This gives a general overview of the more commonly used techniques.
Source: Van Dongen and Woodhouse, 1994.

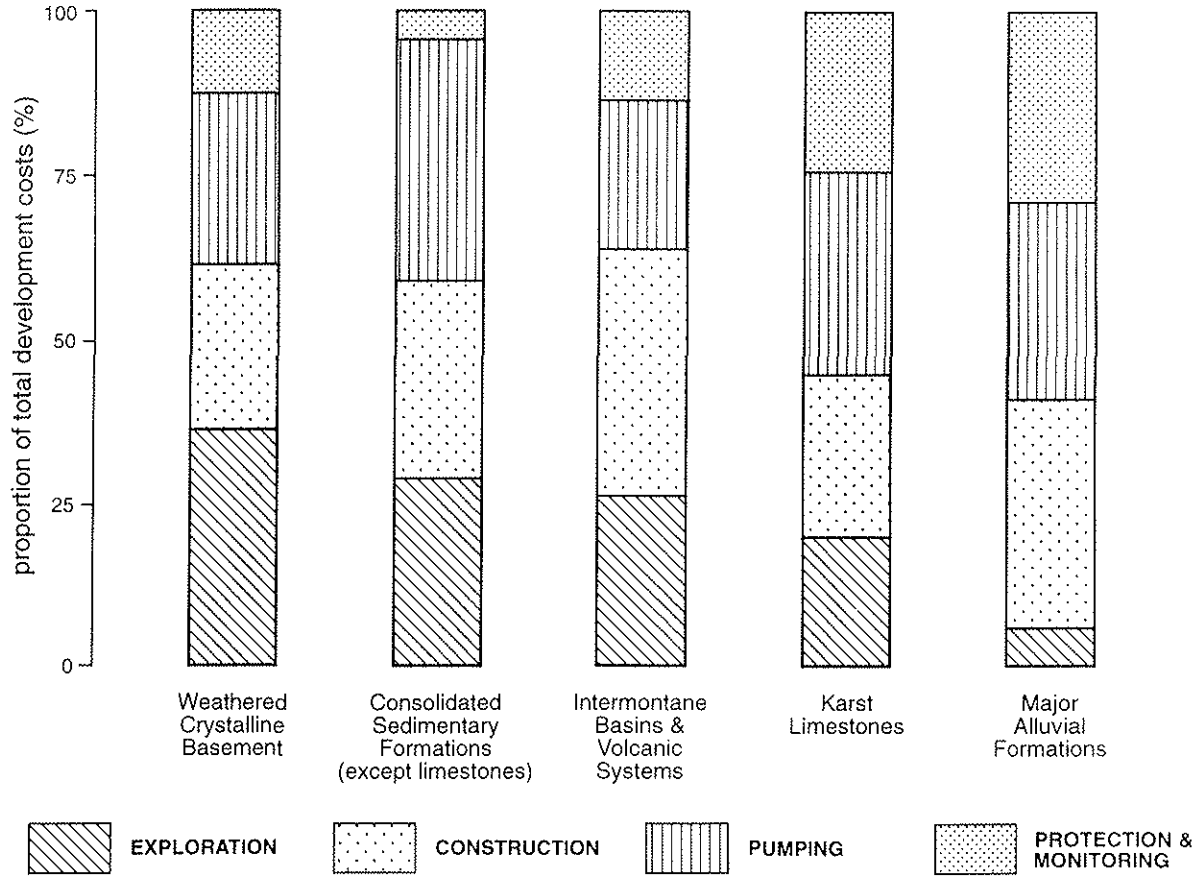
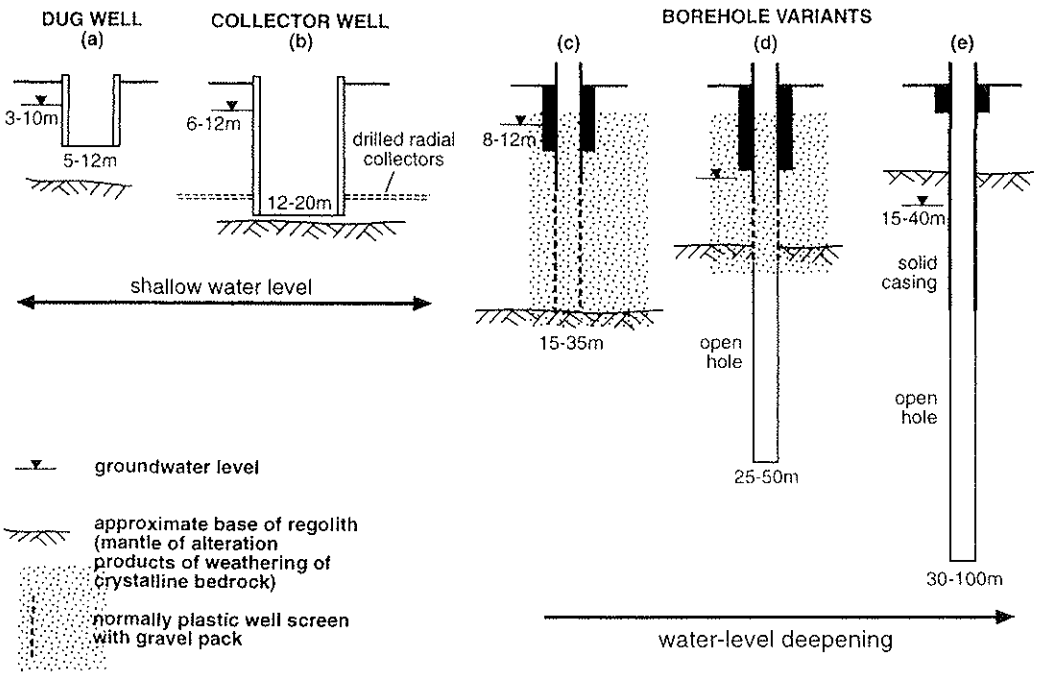


Figure L: Variation of types of groundwater resource development cost with hydrogeological environment

Figure 7: Harmonizing design of rural water supply wells with hydrogeological conditions in weathered basement aquifers



Note: Shallow groundwater and thick regolith (c)(d) permit simple approaches to both design and siting, but a deeper water table with thin saturated regolith (e) requires complex and costly siting of boreholes aimed at locating bedrock fractures and thin saturated regolith (a)(b) requires careful siting and increased well diameter

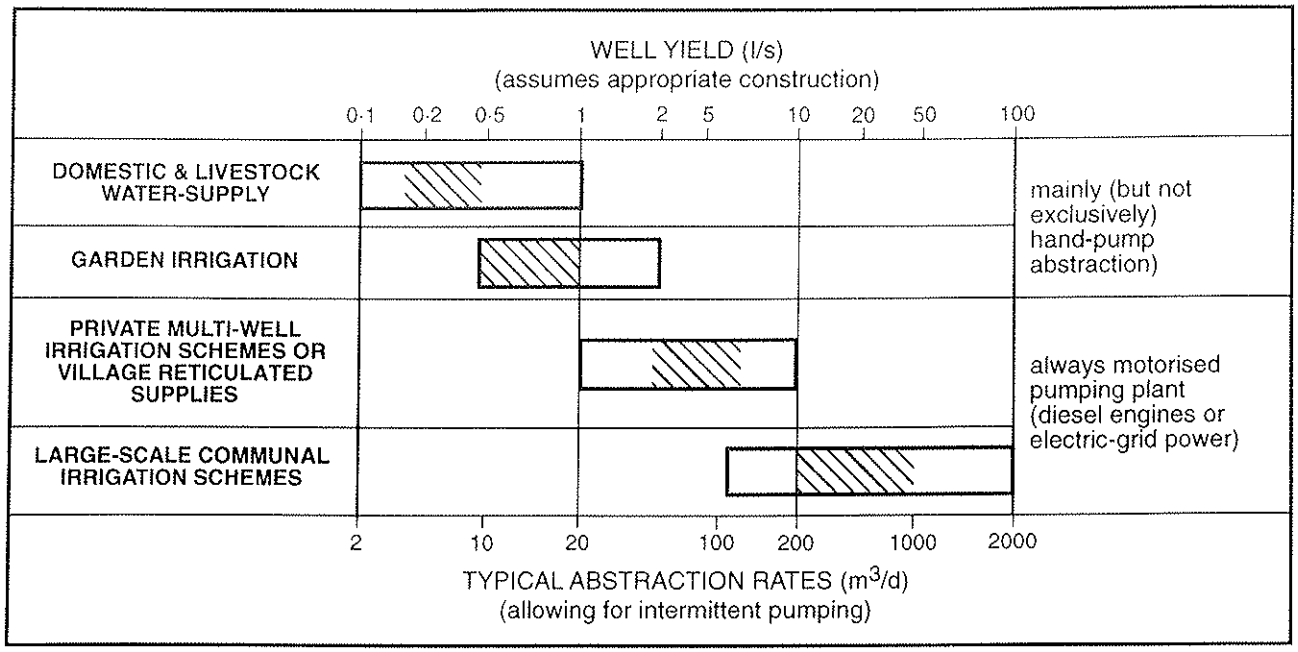
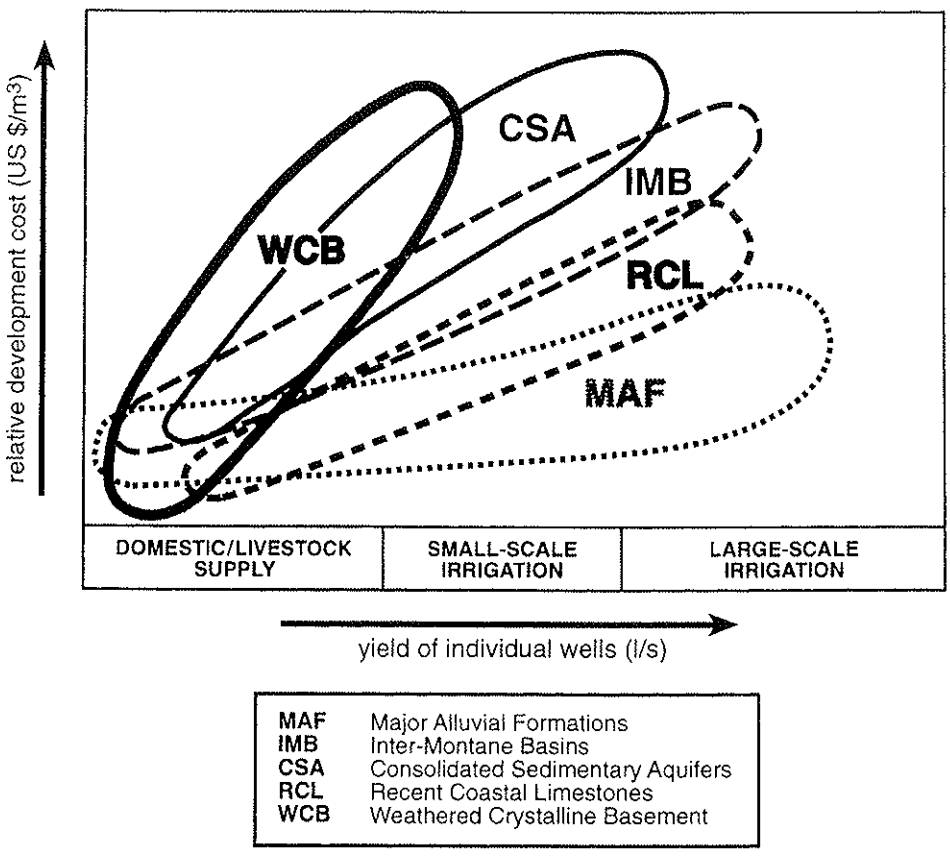


Figure E: Variation of well yield requirement and abstraction rates for rural groundwater utilisation

Figure 5: Variation of groundwater supply development options/costs with aquifer type



Note: This much generalized figure indicates both the overall yield limitations for rural development of some aquifer types and the general way that costs escalate if exploration for larger supplies is embarked upon

"Groundwater research priorities for the SADC region"

IAH 30th Congress – Cape Town, 29 November 2000

Groundwater in Africa increasingly being exploited to meet water and food requirements amidst threats posed by global change

⇩

Over-exploitation and degradation of quality

⇩

Initiative: IGBP- BAHC and its partners

⇩

Develop and foster co-operative research, development and use of technical applications, through an integrated natural and social science approach, on

"Recharge and sustainable use of groundwater in arid and semi-arid Africa"

Background initiative

- Nairobi - Oct. '99: Workshop "Sustainability of freshwater resources in Africa" (scientists, policy makers, representatives funding agencies)

  Objective: to develop issue driven research, development and application program through integrated natural and social science approach to the sustainability of fresh-water resources (..what contribution IGBP can make..)

  Outcome: Constraints identified in the way water is managed and used
  - •Information and understanding
  - •Institutions
  - •Human capacity
  - •Integrated Land and Water Management (ILWM)
  - •Stakeholder involvement

  Within ILWM: research might be effective in area of groundwater exploitation
  Priority research topic: understanding groundwater recharge but integrated approach required to fill gaps in underpinning physical and social knowledge

- Pietermaritzburg – May '00: follow-up meeting Nairobi workshop
  - Brainstorming and drafting initiative on recharge and sustainable use of groundwater in arid and semi-arid Africa

- Jun. – Nov. '00: approaching potential partners

"Recharge and sustainable use of groundwater in arid and semi-arid Africa

IGBP- BAHC: to co-ordinate network of contributing projects from Africa and other parts of the world

Goal:
"Groundwater resources in arid and semi-arid Africa should be exploited in an optimal and sustainable manner and protected against pollution as well as being allocated on a socially equitable basis"

Purpose:
"Implementation of successful strategies for integrated and sustainable exploitation, management and protection of land and groundwater resources"

"Recharge and sustainable use of groundwater in arid and semi-arid Africa

Outputs:

1. Generally applicable cost-effective methods and methodologies for assessment of groundwater recharge and sustainable groundwater yield
2. Regional meta-database on land and (ground)water resources management (type, location and availability of natural and social sciences data)
3. Active stakeholder participation in the development and testing of strategies and guidelines for integrated sustainable land, surface water and groundwater resources management
4. Institutional networks, improving communication, technology and data transfer between researchers, water management professionals and end-users on national and regional levels
5. Increased capacity in water resources research and operations with regard to sustainable abstraction, resource protection, monitoring and operational use of information
6. Raised awareness among decision-makers, land and water resources planners and end-users with regard to the sustainable use and protection of land and groundwater resources
7. Documentation of above mentioned outputs as well as dissemination of materials to operational users, policy makers, researchers and students

"Recharge and sustainable use of groundwater in arid and semi-arid Africa

Research gaps

1. Cost-effective methods and methodologies: Cross calibration and evaluation of existing methods; monitoring networks for chloride deposition and groundwater level fluctuations
2. Regional meta-database: Availability and compatibility of data
3. Active stakeholder participation: Methods for improving water use efficiency

User demands

1. Cost-effective methods and methodologies: Inventory of existing methods
2. Regional meta-database: Data on precipitation, climate, groundwater recharge, levels, quality, sustainable yields, land use, water use, etc.
3. Active stakeholder participation: Water pricing

⇨ Currently building network of research and operational institutes to become partners in the initiative

⇨ Intend to co-ordinate initiative closely with the new UNESCO/WMO International Groundwater Resources Assessment Centre