Ethiopia: Strategic Framework for Managed Groundwater Development (DRAFT)

Federal Democratic Republic of Ethiopia
Ministry of Water Resources

GW·MATE

Ethiopia: Strategic Framework for Managed Groundwater Development

Figures

Annexes

Abbreviations

AAU	Addis Ababa University
AAWSA	Addis Ababa Water Supply and Sewerage Authority
BCM^3	Billion Cubic Meters
ENGDA	Ethiopian National Groundwater Data Base
EGS	Ethiopia Geological Survey
GWMATE	Groundwater Management Team
MDG	Millennium Development Goal
MoWR	Ministry of Water Resources
NGIS	National Groundwater Information System
PASDEP	Plan of Action for Sustainable development to End Poverty
RBO	River Basin Organization
SNNPR	Southern Nations, Nationalities and People’s Region
WWDSE	Water Works Design and Supervision Enterprise

SUMMARY

'Water-centered development' is explicitly seen as the entry point for growth and improved livelihoods in Ethiopia. Increasingly water resource development is integrated with economic development and land use planning. Ethiopia has set ambitious goals for economic development – with a key role for agriculture-based industrialization – and for improving access to basic services. In domestic water supply the MDG goal for Ethiopia is to reach 70% of the populations by 2015.

In the last five years the large potential role and contribution of groundwater in water-centered development is recognized. Following a series of regional groundwater assessments the scope for sustainable groundwater use is larger than assumed previously and the knowledge is evolving. Groundwater so far is mainly utilized for drinking water supply, but schemes are afoot to develop groundwater based irrigation from shallow and deep aquifers. At the same time several areas with very shallow aquifers have recently developed for agriculture by farmers private initiative.

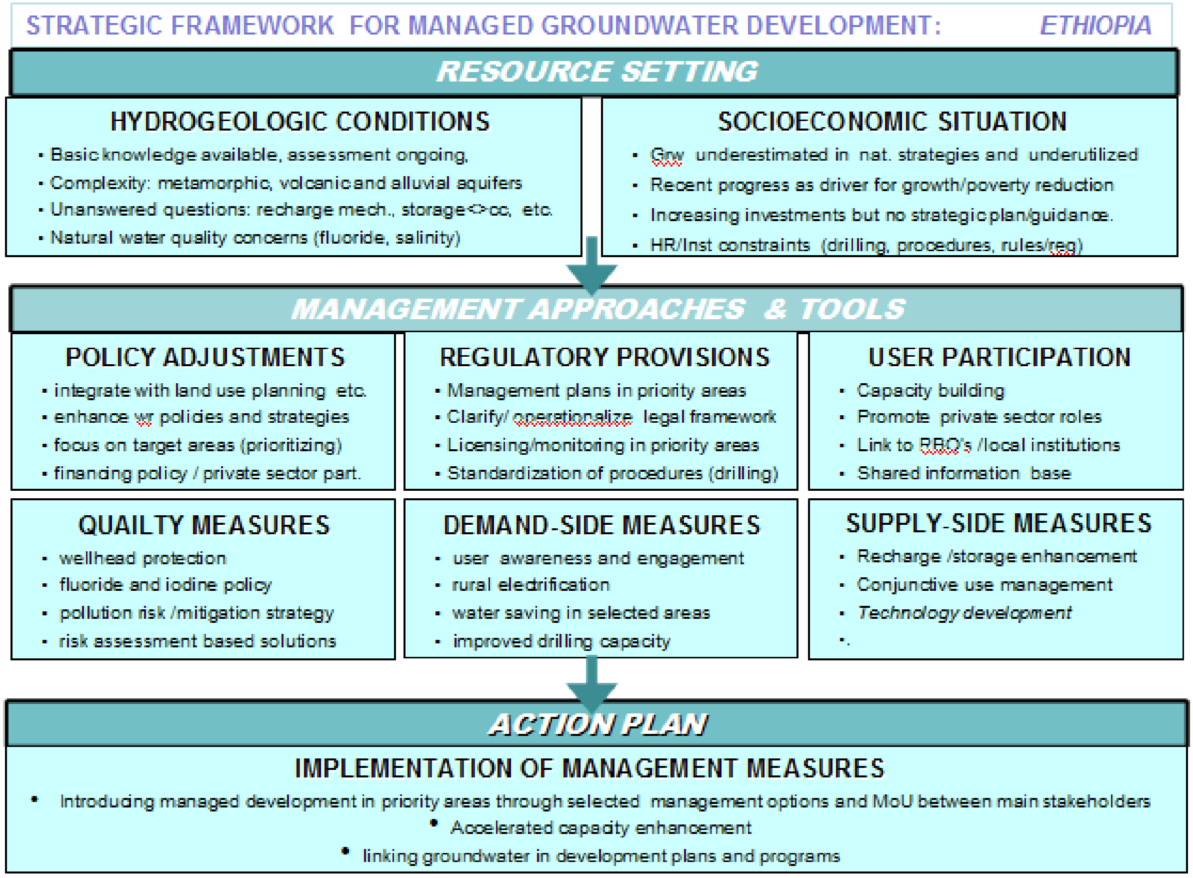
In the last three decades most water development globally has been from groundwater. In several countries the intense use of groundwater has turned the tide – economically and socially. At present an estimated 70% of the world's population depends for its basic domestic water services on groundwater. In 51% of countries groundwater withdrawal tops 100 m^3 per capita annually. Groundwater has been at the base accelerated agricultural production in rural economies in South Asia and North Africa and the Middle East - much of it driven by private initiative – in exploration, drilling and investment. Intensive groundwater development in Sub Saharan Africa still has to take off. In comparison Sub Saharan Africa does not have the large high yielding shallow aquifers that are found in Asia, but even where the groundwater potential exists it is not yet used intensively. The same is true for Ethiopia.

The current capacity to develop groundwater in Ethiopia goes hand in hand with the current very incipient level of groundwater use. Set against the ambitious plans there are major deficiencies in human resources and equipment. In the key water organizations – such Regional Water Resources Bureaus – there are 25-60% vacancies and particularly the need for drillers, hydrogeologists and water supply engineers is high. There is also a shortfall in the number of specialist drilling rigs and pumping equipments. At an entire different level the capacity skills at artisanal level to manually develop wells in area with very shallow aquifers is also insufficient still.

This report presents the Framework for Managed Groundwater Development for Ethiopia, prepared at the initiative of the Ministry of Water Resources by a core team assisted by the Groundwater Management Assistance Team (GWMATE) of the World Bank. The framework aims to balance the demand to make more use of Ethiopia's groundwater potential with the the need to start management and regulation of this valuable resource.

In the Framework for Managed Groundwater Development there are three building blocks – ***policy adjustments, regulatory provisions and user engagement*** that create the enabling environment for effective ***measures – in managing groundwater quality and in promoting demand-side management and supply-side management***, i.e. the subject of the other three building blocks. Within each of these six building blocks the most pressing actions for managed groundwater

management are identified. The figure below gives a bird's eye overview of the framework. On the basis of the Framework immediate priority actions are identified.



The most pressing policy adjustments are a stronger integration of groundwater development and land use planning, the selection of target areas for intense groundwater development and combining groundwater development – both recharge, retention and reuse - with other water resource programmes, such as the watershed programmes, drainage and flood plain development. The target areas should be areas with proven high reserves – often in the lowlands, high potential areas with very low aquifers and area where climate change creates the need for supplementary irrigation.

There is a need to scale up regulation of groundwater – by clarifying responsibilities of different organizations – at federal, regional and river basin level, and in the private and public sector and align all players for managed groundwater development. In areas of intense groundwater development groundwater management plans should be put in place and licensing should be put into effect – activating the legal provision that exists. In addition standard procedures for well drilling procedures should be developed.

In stakeholders participation capacity building and the promotion of private sector capacity are priorities. Private sector capacity can be nurtured through contract management, special investment programmes and education facilities. In capacity building the large need is for hydrogeologists and drilling masters, for artisanal well developers and for drilling equipment – in absolute number and in specifications. Work has started on a shared hydrogeological data base – which needs to be widely shared.

There are several measures to be taken with respect to groundwater quality, groundwater demand and supply.

In groundwater quality the main challenges are the natural problems and the contamination. A program of action needs to be developed to address the wide spread occurrence of fluorosis and the iodine deficiency. In high intensity areas pollution risk need to be reduced at all levels. Well head protection in both urban and rural environments figure importantly in this and should be integral part of well development designs.

At present groundwater use in agriculture is still modest. It should be stimulated by user awareness, increasing drilling capacity and strategically placed rural power extension. At the same water saving measures should be part and parcel of agricultural groundwater development – the promotion of efficient field irrigation, soil moisture conservation and better irrigation agronomy.

There is also scope for demand management measures. One is making groundwater recharge and storage a featured element in watershed programmes and planning the watershed activities in accordance to hydrogeological parameters. The other is to promote the conjunctive use of groundwater and surface water – for instance on the banks of Lake Tana.

From the Framework for Managed Groundwater Development a number of immediate actions follow:

- prepare and implement groundwater management plans for selected areas of high intensity use – linking to local land use plans and introducing monitoring and quality protection measures.
- integrate groundwater development in larger programmes – agricultural development, irrigation development, watershed protection or road planning – making sure to maximize the benefits of groundwater use within these programmes
- accelerate the development of capacity – human and material, public as well as private sector.

The strategic framework for the whole country should be used to define regional management frameworks for Regional States or for example for river basin or areas of intensive groundwater development. The national framework identifies the actions to be taken at national level – in terms of enabling frameworks and national policies as well as resolving the transboundary and interstate nature of groundwater management issues. The practical frameworks for regions on the other hand describe the issues to be attended to at the level of the regions or subbasins. As part of this report first and preliminary Frameworks were made for four Regional States (Amhara, Oromia, SNNPR and Tigray). For the Addis Ababa Region – consisting of the aquifer systems under Addis Ababa and the adjacent areas of Oromia a more detailed Regional Practical Framework was made – described in detail in this report.

Following the same set up for the Addis Ababa Region the following immediate priority actions were identified:

- Setting up an AMAR: a forum or body for groundwater management in the Addis Ababa and Oromia as a mechanism for coordination and stakeholder cooperation
- Strengthen and empower regulatory bodies in Addis Ababa and Oromia Region
- Enhance monitoring and information exchange for abstraction control , aquifer behavior and pollution prevention
- Reduce water losses/ unaccounted water and launch a water conservation campaign – as high losses sit uncomfortably with new resource development.
- Create awareness among major stakeholders and decision makers on the scope and importance of groundwater development and management.

1 INTRODUCTION

1.1 Background and introduction

'Water-centered development' is explicitly seen as the entry point for growth and improved livelihoods in Ethiopia. Increasingly water resource development is integrated with economic development and land use planning. Ethiopia has set ambitious goals for economic development – with a key role for agriculture-based industrialization – and for improving access to basic services. In domestic water supply the MDG goal for Ethiopia is to reach 70% of the populations by 2015. The ambitions in the PASDEP and Universal Access Plan on this indicator are even higher - improving coverage of safe drinking water systems to respectively 80% in 2010 and 98% in 2012. Most of this is planned to come from groundwater systems. The PASDEP is also banking on substantial increases in agricultural production. This is to increase with 129% over the five year period, almost all of it from productivity gains.

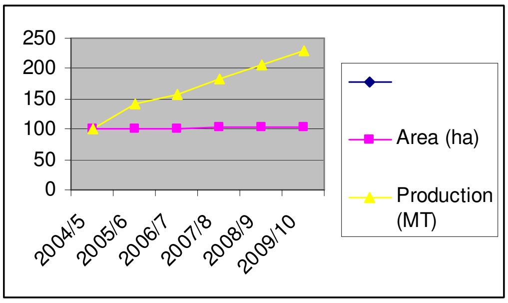


Figure 1 Agricultural Projections PASDEP

In the last five years the large potential role and contribution of groundwater in water-centered development is recognized. Following a series of regional groundwater assessments the scope for sustainable groundwater use is larger than assumed previously and the knowledge is evolving. Groundwater so far is mainly utilized for drinking water supply. It takes care at present of 70% of rural water supply and plays a major role in several of the largest cities (Addis Ababa, Dire Dawa, Mekelle, Harar) and a number of medium-sized towns. Groundwater use in irrigation is still extremely modest but several ambitious plans for groundwater based irrigation are on the table. In a number of areas with shallow groundwater farmer-driven groundwater development is taking off.

Along with the increasing groundwater development there is growing awareness that management is needed to ensure the sustainability of investments in groundwater development, to optimize the opportunities for groundwater recharge and reuse and to regulate the long term equitable use of the resource.

Coming up: groundwater irrigated farming near Lake Ziway

In this context the Ministry of Water Resources requested support of the World Bank /GWMATE in helping developing a strategic framework for managed groundwater development, with specialattention for areas of intensive groundwater development, in particular the Addis Ababa and surrounding area[1].

This document is the framework for managed groundwater development, prepared by a core team. It gives a brief overview of the current level of groundwater exploration and development in different part of the country and summarizes existing gaps in knowledge, capacity and management arrangements (section 1.2). It makes a comparison with international practice in groundwater development and management (section 2) and comes to a strategic management framework in section 3. This framework addresses the overall objectives to be set for groundwater and how to operate in the context of the uncertainties and the gaps in knowledge and management as well as the priority activities to be undertaken. Such management frameworks need to be worked out for several sub-areas in the country. In this report this is done for Addis Ababa and surrounding area (section 4).

The main text is supplemented by annexes providing more background on the status of groundwater development in the different regional states, the capacity needs and the expected impact of climate change as well as a number of tools to support the implementation of the strategic framework. The annexes also include proposed preliminary management frameworks for four regional states: Amhara, Oromia, SSNPR and Tigray.

1.2 Groundwater use and development: current situation

Table 1 is a birds eye view of the groundwater situation for the different regional states in Ethiopia: the expected potential and the current coverage. Groundwater is of paramount importance for Ethiopia to supplement the available surface water resources in providing drinking water to its population and for economic development (agriculture, livestock, industry, tourism) and in general to mitigate the effects of climate variability. It was acknowledged in World Bank Country Water Assistance Strategy[2] that the groundwater resources should be more fully explored. In the last five years groundwater assessment has accelerated and a number of ambitious projects for groundwater irrigation have been conceptualized.

Shallow well development on the increase

[1] The GWMATE team for this activity was Albert Tuinhof, Frank van Steenbergen and Melkamu Amare Guidance was given by Tesfaye Tadese (Head of the Groundwater Department – MoWR) and Ato Yitbarek Tesssema and Jagannathan (World Bank). The core team for the preparation of this framework consisted further of Dr Seifu Kebede, Ato Taye Alemehayu, Ato Solomon Waltenigus, Dr Feleke Zewge and Ato Zenaw Tessema.

[2] Ethiopia- Managing Water Resources to Maximize Sustainable Growth- The World Bank 2006

Table 1 Rural Water Supply: Performance and Plans

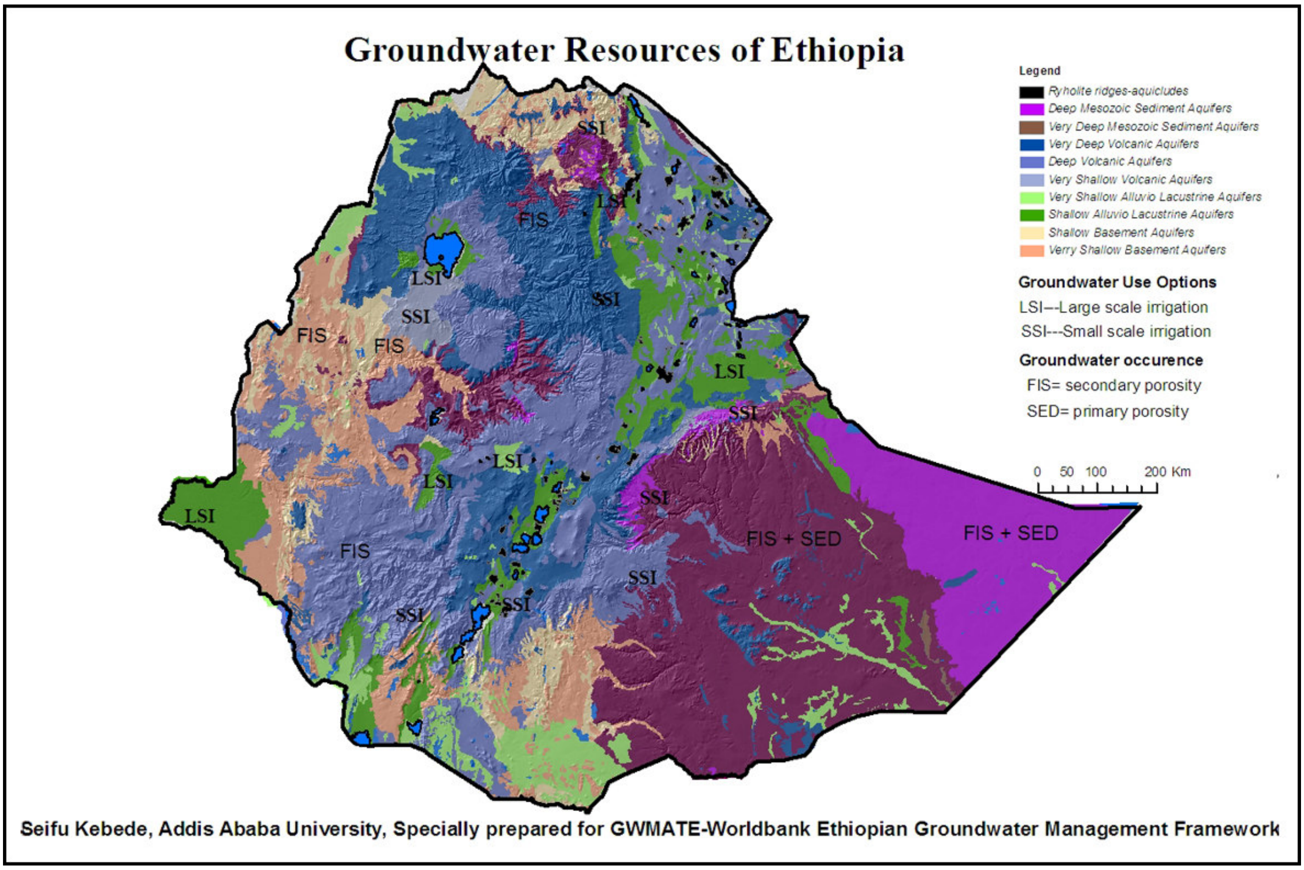
	Tigray	Gambela	Beni Shangul Gumuz	Dire Dawa	Hareri	Somali	Amhara	Afar	SNNPR	Oromiya	National
Rural population in 2008	3558526	238429	590068	112722	86208	3917203	15358567	1249006	13888229	24478295	**63546551**
Total population served	2056870	92942	261150	71725	35095	978750	8637456	682799	9012612	12589798	**34419197**
Coverage	58	39	44	64	41	25	56	55	65	51	**54**
Coverage planned 2012	109	94	89	97	83	61	118	92	100	95	**100**
No of water schemes planned 2009-2012	7928	610	1428	63	187	2141	37468	587	33955	26093	**110460**
Total cost per capita planned (in ETB)	466	446	192	516	636	493	109	101	198	174	**190**
Total cost per capita 2005-2008 (in ETB)	172	208	149	210	357	541	131	102	190	166	**181**
To be served from government budget (%)	68	7	19	86	0	70	27	69	59	58	**51**
To be served from donors budget (%)	8	77	27	14	100	8	35	8	38	22	**29**
To be served from NGO budget (%)	24	16	54	0	0	22	37	9	3	20	**20**

Source: Ministry of Water Resources

Ethiopia's hydrogeology is complex and at present only partly understood. Basement aquifers, volcanic aquifers and Mesozoic sediment aquifers predominate (see figure 2). These aquifers predominate as major lithology but are poor aquifers: rather alluvial and/or quaternary aquifers are more important. In the rift valley lacustrine aquifers are common too. The geology is often highly varied and due to tectonic movement areas with very shallow groundwater can be placed alongside rift areas with very deep groundwater. In several small river valleys small valley aquifers are in place with groundwater close to surface, often interacting with river flows.

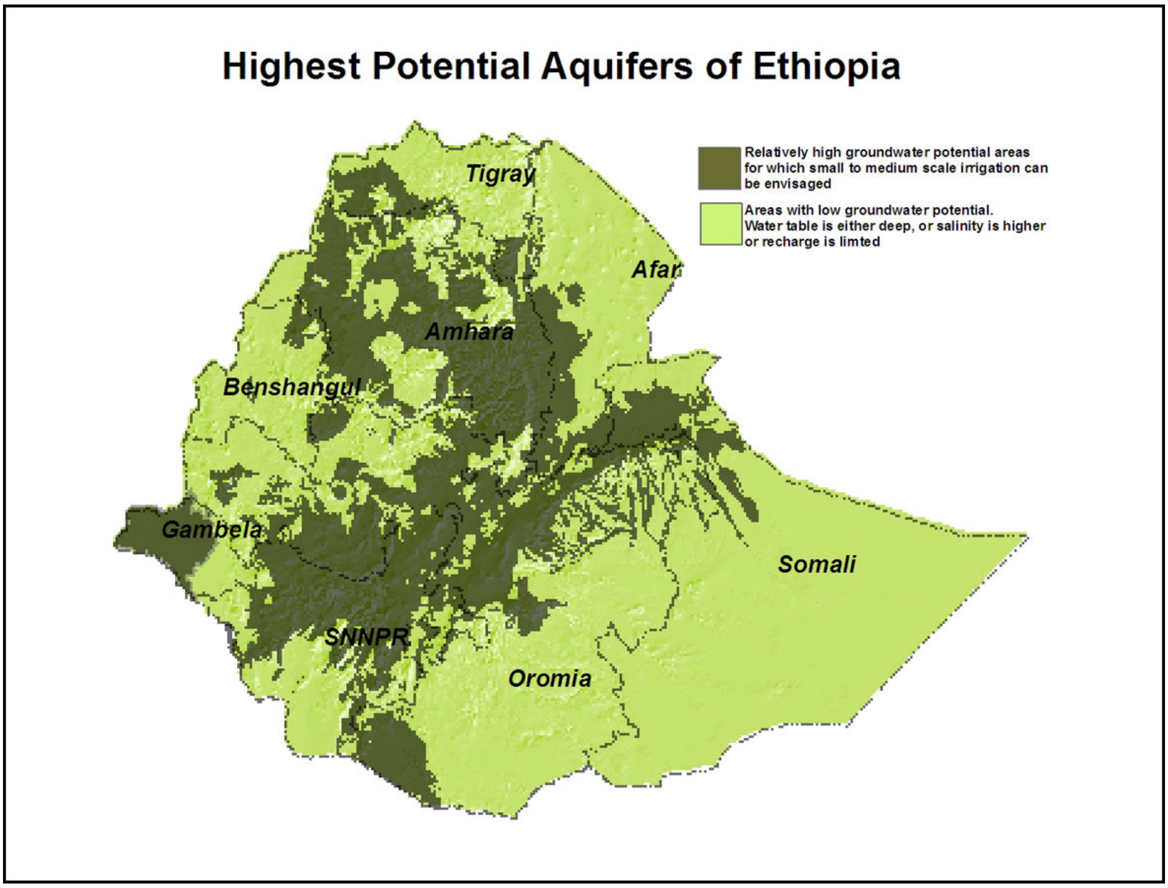
Metamorphic basement rock

Figure 2 Groundwater Resources of Ethiopia



Groundwater assessments are ongoing in several areas – see annex 1. Previously groundwater usage potential was estimated at 2.6 BCm^3 and this figure is still often quoted. Following the results of recently completed assessment for parts of the country, there is consensus that the 2.6 BCm^3 figure is an underestimate and that it needs to be considerably revised upwards[3]. Best guesses in this respect range between 12-30 BCm^3 or even more if all aquifers in the lowlands are assessed. Figure 3 makes an estimate on best available knowledge of the areas with potential for more intensive groundwater development. There are several large areas with potential for groundwater development in all regions – but especially in Amhara, Oromia, SNNPR and Gambela. In some areas such as Afar and South Omo the constraints to the potential are not so much groundwater availability but the salinity of groundwater.

Figure 3 Highest potential aquifers of Ethiopia



Source: Seifu Kebede (AAU)

There are at present still large gaps in knowledge, capacity and management systems in groundwater (see also annex 2). With respect to knowledge there are particularly large gaps in the understanding of very shallow aquifers (<30 meters) and in deep aquifers (which have only sporadically been explored). Also the knowledge on shallow aquifers is incomplete. Hydrogeological mapping has been done for part of the country but is now halted. A large number of project based assessment instead are instead going on. Very recently work has started on the National Groundwater Information System (NGIS) – replacing the earlier ENGDA system.

[3] See for instance the outcome of some local assessments. Preliminary analysis indicates that the yearly groundwater recharge of the Alaidege valley is about 112 MCM. The recent estimate for Kobo valley gives 1530 MCM of groundwater reserve available for sustainable abstraction.

Water quality mapping has not started yet. Monitoring of groundwater quality or groundwater levels is not done systematically – not even near vital assets such as the Akaki well field near Addis Ababa. There are different piecemeal efforts in groundwater monitoring but no central guidelines nor is the organizational responsibility for groundwater monitoring clear.

In capacity the shortages go hand in hand with the current very incipient level of groundwater use. Set against the highly ambitious plans there are major deficiencies in human resources and equipment. In the key water organizations – such Regional Water Resources Bureaus – there are 25-60% vacancies and particularly the need for drillers, hydrogeologists and water supply engineers is high (annex 3 is a detailed analysis). There are also bottlenecks in the educational system: there is for instance no current course offered for drilling masters – either from universities or from institutes such as the Ethiopia Water Technology Centre (EWTEC). Similarly the local knowledge on shallow well development is limited. Overall well failure is a major problem – it has been assessed by UNICEF to cause 30% of the non functionality in rural drinking water systems in the country, which in itself stands quite high – estimated at 38%.

There is also a large shortfall in the number of drilling rigs and pumping equipments. A conservative estimate – based on the demand for new drinking water systems – is that 200 more drilling rigs are required. There is a quality dimension to this too: there is no equipment available to develop shallow and deep wells in different hydrogeological conditions. At the other of the spectrum the capacity in manual drilling or digging of ultra shallow wells is very limited. All across the board the service sector in groundwater development has to develop still. This requires investment and stimulation measures – one important being in contract management and supervision, so that a conducive environment is created for high quality work.

In management some promising developments are taking place to link groundwater management into land use planning but more is possible – in the long term by forging stronger links with the river basin management and in the short term for instance by giving more attention to conjunctive management. Regulation of groundwater use is still largely absent. There is a standard procedure that licenses well development but in the regions it is largely unapplied. In groundwater quality protection the institutional basis is even weaker – even in fast growing cities that substantially depend on groundwater protection still has to take off.

Deep well drilling in Addis Ababa Region

At the same time there are many initiatives to accelerate the use of groundwater in irrigation and in drinking water. Annex 4 gives an overview of the groundwater situation in the different parts of the country – including the plans that are afoot in exploration and development. In some cases there are extremely high targets – that border on not being realistic given current constraints, but the point to make is that the current tendency is very upbeat – with the Government of Ethiopia dedicating considerable resources for assessments and the procurement of drilling rigs for instance. In groundwater based irrigation development in particular there are ambitious plans. The ongoing developments in Oromia, Raya (Tigray) and Kobo (Amhara) are seen as front runners, but large new groundwater irrigation development is also discussed in Somali Region and Afar, whereas supplementary (groundwater) irrigation is seen as a solution to address climate variabilities in the humid areas in the west of the country.

All this makes a framework for managed groundwater development opportune. In the next section a generalized framework is discussed based on international experience. Section 3 and 4 then discuss management groundwater development for the country and for Addis Ababa respectively.

2 MANAGED GROUNDWATER DEVELOPMENT GLOBALLY

In the last three decades most water development globally has been from groundwater. In several countries the intense use of groundwater has turned the tide – economically and socially. At present an estimated 70% of the world's population depends for its basic domestic water services on groundwater. In 51% of countries groundwater withdrawal tops 100 m^3 per capita annually. Groundwater has created the miracles of accelerated agricultural production in rural economies in India, South Asia, China, North Africa and the Middle East. Even in the extensive large surface irrigation systems in South Asia and North Africa 30-50% of the water at farm gate comes from groundwater, creating 'conjunctive realities'. Elsewhere the attractiveness of groundwater derives from its ubiquitous presence. Groundwater is available in many areas, even 'where there is no river'.

Much of the groundwater development globally is by private initiative – in exploration, drilling and investment. In particular in Asia in the 1980's groundwater was 'discovered' in agriculture: in South Asia more than 50% of the water 'at farm gate' is pumped up. In South Asia this has been supported by low diesel prices and expanding rural electricity. Groundwater is the resource that in several areas still provides the 'breathers', because in many areas all surface water is committed. Particularly if groundwater development is combined with increased recharge and retention of rain water, run-off and flood water there is still scope to expand the use of the resource. At the same time, there are several groundwater disasters – areas with lowered groundwater tables, unbalancing economic and ecological systems, and groundwater quality getting out of hand due to intrusion, up-coning or pollution.

Large-scale groundwater development in Sub Saharan Africa still has to take off. In comparison Sub Saharan Africa does not have the large high yielding shallow aquifers that are found in Asia, but even where the groundwater potential is high in Africa it is not yet used intensively. The same is true for Ethiopia. Traditionally throughout the Sub-Saharan Africa Region it was the accessibility of groundwater through dugwells, at springheads and in seepage areas that controlled the extent of human settlement beyond the major river valleys and riparian tracts. These sources were usually developed through community initiative. The introduction of deep drilling and pumping machinery from the 1970s enabled the area under groundwater exploitation and human settlement to be extended in response to increasing population. Today, over very large rural areas it is the presence of successful waterwells equipped with reliable pumps that allow the functioning of settlements, clinics, schools, markets and livestock posts in Africa – and failure to construct and/or sustain such waterwells directly impacts, in a number of ways, on the prospects for achievement of the UN-Millennium Development Goals (MDGs).

Reliable, comprehensive, statistics on groundwater use in Sub-Saharan Africa do not exist, but there is very high dependence for domestic water-supply, rural livelihoods and livestock rearing, and increasingly for urban water supply. Although the distribution of aquifers is now reasonably mapped over large areas, quantitative information on aquifer characteristics and recharge rates, groundwater flow regimes, abstraction rates and quality controls is uneven and generally incomplete. Regional estimates of potential groundwater resources based on analysis of climatic data alone are of little meaning. What is clear, however, is that Africa is subject to wide temporal and spatial rainfall variability, and this coupled with large areas of limited infiltration capacity tends to lead to relatively low and/or uncertain rates of groundwater replenishment.

The picture of Ethiopia conforms to this general picture for Sub Saharan Africa. Where the need in Asia and the Middle East is for regulation and management - including the use of very costly alternatives for fresh groundwater, such as treated waste water, desalinized sea water or treated brackish groundwater – underlining the very high value of groundwater, the need in most countries in Sub Saharan Africa[4] reflect a different stage of utilization and concerns the managed development of groundwater, consisting of:

- Developing the capacity to develop sustainable groundwater systems - including storage provisions to guarantee continuous supply of water
- Integrating groundwater management with broader area development framework
- In selected hotspot areas introduce regulation and pollution mitigation measures.

This document describes the framework for managed groundwater development in Ethiopia. The purpose of the framework is to guide the Government of Ethiopia and other stakeholders – including the Regional States - to define and integrate the management issues (figure 3), select management actions and develop an implementation plan (including the technical, institutional, legal/regulatory and capacity building issues) in order to ensure that:

- the investments in the groundwater assessment, development and recharge are sustainable
- the development of the resource serves the broader social, economic and environmental needs (both in the short term and in the long term).

The framework follows a similar format used in other countries and aims in a concise way to bring together the resource setting, the management approach and measures and the priority actions. The framework is developed from an IWRM approach, which implies that a number of generic elements are taken in account:

- consider the efficiency, equity and sustainability of existing groundwater and surface water use
- decide how to safeguard enforce the priority to basic drinking water supply
- balance increased resource demands with the needs to maintain environmental functions of groundwater
- consider cross-sectoral integration in policy development
- represent groundwater interests in land-use management and vice versa
- connect macroeconomic policies, broader socio-economic and environmental goals and the strategy for groundwater management and use
- give stakeholders a voice and a role. Special attention is needed to embed management in the river basin approach as the key planning unit for water resources management.

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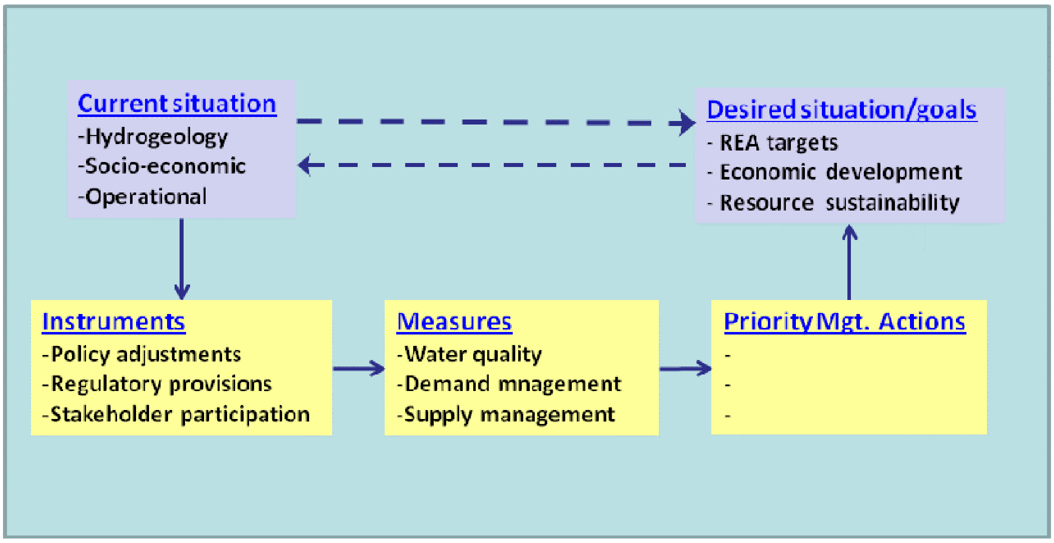
[4] A useful summary of the main issues regarding groundwater development and management is given in GWMATE Case Profile 15: 'Groundwater Development in Sub-Sharan Africa: a Strategic Overview of Key issues and Major Needs'

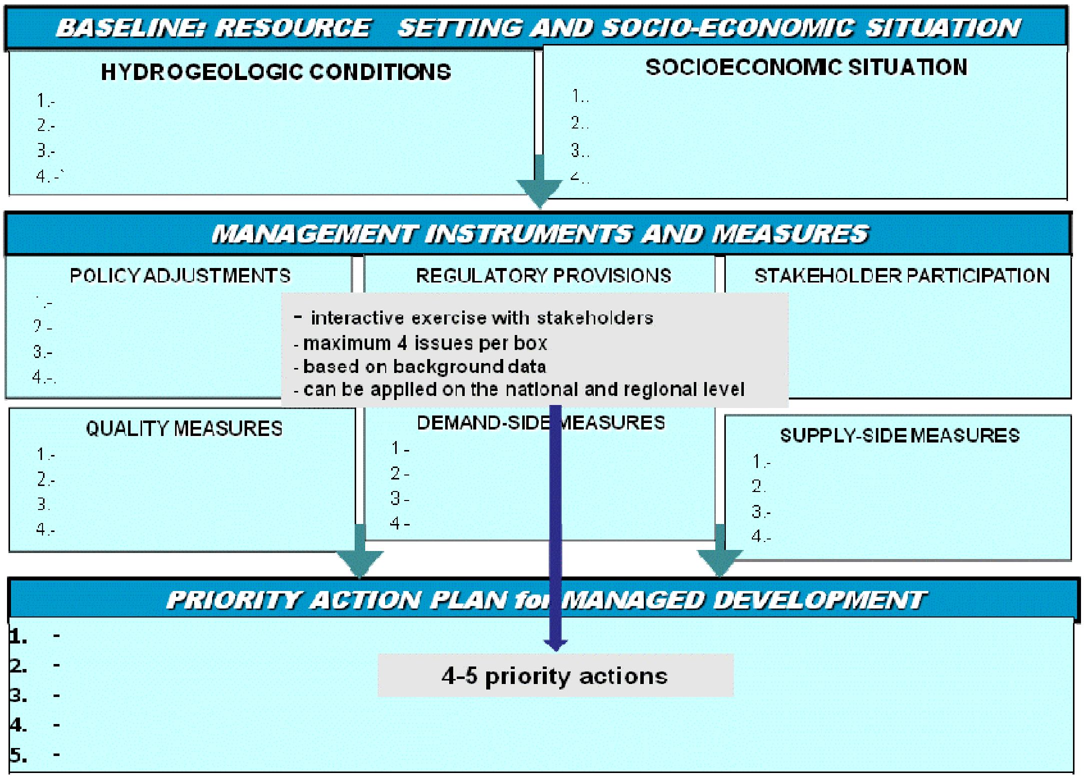
Within this context some of the key generic issues for successful groundwater management are the:

- use of sound scientific and technological principles
- recognition of specific hydrogeologic settings and stage of development of the groundwater – each requiring a different approach
- surface water – groundwater interaction and the options for its conjunctive use
- response to the impacts of changes in climate variability
- options and constraints of the legal and institutional framework
- prioritization of planned uses and functions: drinking, irrigated agriculture, industry, environment
- leadership by local government and maximum involvement of the users
- selection of economic feasible management options with attainable goals which are environmentally sustainable, social acceptable and institutionally implementable.

The framework provides a systematic template to address and debate issues in an interactive way. The main steps in the process are shown below.



These steps are summarized in the framework table, which is used in to organize interactive sessions with representatives of the different stakeholder groups. The aim is to agree on maximum 4 key issues in the different blocks and based on that conclude with 4-5 priority actions for management



In summary, the framework should allow for defining groundwater management plans which are practical by focusing on:

- a step by step approach
- start in priority areas where management of groundwater development has clear outputs
- focus on specific real issues and deal with them in a direct manner
- and identify initial targets to secure short term benefits (harvest the low hanging fruit).

3 STRATEGIC FRAMEWORK FOR MANAGED GROUNDWATER DEVELOPMENT IN ETHIOPIA

3.1 Applying the framework on the national level

This section describes the concise strategic general framework for managed groundwater development in Ethiopia. Figure 4 is an overview of the strategic framework.

The framework is set against the resource context in Ethiopia – i.e. its relatively complex hydrogeology, the ongoing accelerated assessment, yet also the remaining uncertainties and the concerns on natural groundwater quality – especially fluoride levels but also hardness, nitrate levels, salinity and iodine deficiency. The other part of the context concerns the socio-economic situation – the recent recognition of groundwater as a driver of growth and adaptation to climate variability. This 'rediscovery' follows a long period of groundwater being a largely unknown and underestimated factor as well as the absence of a strategic guidance. In addition there are broad capacity gaps – that are becoming all the more obvious with the accelerated development of groundwater resources in Ethiopia.

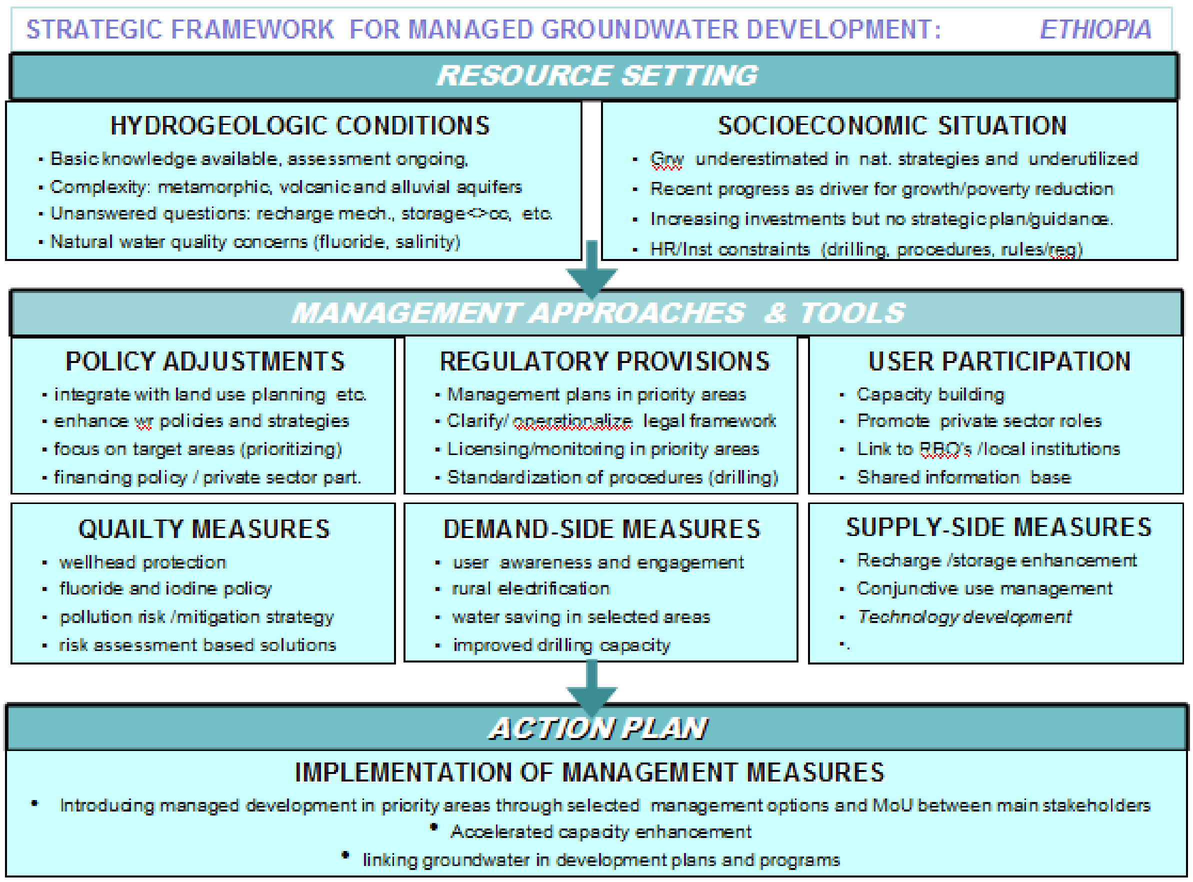


Figure 4 Strategic framework for management groundwater development in Ethiopia

3.2 Management approaches and tools

The resource situation and the socio-economic situation trigger a number of instruments and measures. The first three building blocks in the management approach – ***policy adjustments, regulatory provisions and user engagement*** – create the enabling environment for effective ***measures – in managing groundwater quality and in promoting demand-side management and supply-side management***, i.e. the subject of the last three building blocks. Within each of these six building blocks the most pressing actions (at a maximum of four[5]) for managed groundwater management in the country, as it currently stands, are identified:

Macro-policy adjustments

Groundwater is managed in a larger context of promoting economic growth and removing the vulnerability that comes with climate variation and hence alleviate poverty. This is the essence of the PASDEP (2006). It is also captured in the term 'water-centered' development of the recent Strategic Framework[6] (2009).

Both documents are ambitious and set the scene for managed groundwater development. PASDEP aims to increase agricultural value-added by 6.2% annually over the five year period 2005-2010. This is among others to be achieved by accelerated development of irrigation – the period carries a target of irrigation works to be completed for 430,061 hectares – a large part in surface irrigation but part in groundwater irrigation as well. The PASDEP also has ambitious targets on access to potable water. The people that live within 1.5 km of an improved drinking water systems is to go up from 44% to 80%. For the urban population the number of people within 0.5 km of an improved drinking water system was to increase from from 80.6% to 92.5% by the end of 2009/10. For rural water supply this translates into the planned development of 2135 deep wells, 14910 shallow wells and 77370 hand dugwells, and 13900 spring improvements. The targets in the Universal Access Plan that was issued subsequently puts the target for drinking water coverage even higher (section 1). Aiming at 98% drinking water coverage in 2012 it foresees the development of 2986 deep wells, 20817 shallow wells, 108308 hand dugwells and 14657 spring improvements between 2006 and 2012 – in addition to the rehabilitation of non-functional systems (table 2).

Substantial increase in drinking water coverage required

[5] Starting point was that a maximum of 4 issues per block are formulated in order to keep the framework concise and to ensure that the selection process keeps a focus on the priority issues.

[6] Government of Ethiopia, Strategic Framework For Countrywide Water Centered Development Program (2009) (internal document)

Table 2 Facilities required in period 2006-2012 to reach 98% access to drinking water

	Type of Water Scheme	Amhara	Ben Gumuz	Gamb	Harreri	Tigray	Oromia	South	Afar	Somali	Dire Dawa	Total
1	Hand dug well (community) Av. depth 10m	33,239	195	146	139	1,677	30,218	3,410	278	414	26	**69,745**
2	Modern hand dug well av. depth 15m	16,622	583	257	98	2,409	11,820	3,224	1,585	1,819	151	**38,568**
3	Spring on the spot	1,459	86	87		1,345	1,763	9,685				**14,426**
4	Spring development (with motor or gravity system)	210										**210**
5	Motor driven stream						90					**90**
6	Gravity system stream						325					**325**
7	Medium stream							438				**438**
8	Shallow well		623	160		3,602		4,516	258	553	25	**9,737**
9	Shallow well (with hand pump)	4,275					5,235					**9,510**
10	Shallow well (with motor pump)	14					1,557					**1,570**
11	Deep well	680		3	28	113	1,012	676	59	410	6	**2,986**
12	Others (treated surface water)	18							1	1		**20**
13	Large spring 1							1				
14	Large spring 2							1				**1**
15	Shallow well (with solar pump)					3	33					**36**
16	Shallow well (wind mill)					1	18					**18**
17	Cistern (with wall)					57						**57**
18	Pond (with hand pump)						565					**565**
19	Cistern (with plastic lining)								303	3,882	29	721
	Total	**56,117**	**1,488**	**653**	**265**	**9,208**	**52,635**	**21,952**	**2,484**	**3,586**	**236**	**149,024**

Source: Universal Access Plan (2006)

Achieving and groundwater development needs to be put in a larger perspective than the development of groundwater systems. Several macro-policies stand out that will support water-centred development (1) integrating groundwater development into land use planning (2) integrating groundwater development and management into other water related investment programmes and (3) selecting priority areas and (4) encouraging private sector funding.

Integrating groundwater development with land use planning

With respect to land use planning, efforts to place groundwater development in the context area development are afoot in Oromia, Amhara, Afar and Somale Regional States – and are being discussed in others. This is taking the shape of land use planning where on the basis of regional strengths and weaknesses a comprehensive plan for an area is developed – water-resource development but also the planning of supporting infrastructure – such as roads and markets. The same is done in the Growth Corridor Plans that are being developed for several high potential sub-basins or larger watershed areas. The land use planning methodology makes it possible to bring several claims on land and water resources together and create synergy with the development of other infrastructure.

At the same time there is scope to further strengthen land use planning not only on the water demand side, but also on the supply side, as different both land use and infrastructure, such as roads, determine run-off and infiltration patterns and hence contribute to sustained groundwater availability.

Link in with other water resources policies
It is also important to link groundwater management with other water resources investments – to create more efficient and resilient water resource systems, in particular:

- Promoting groundwater based watershed programmes – with specific attention to local characteristics and implementing recharge programmes appropriate them. In particular with respect to climate change a better match with watershed management is required. A special annex in this Volume describes the effects of climate change, the recharge mechanisms in different parts of Ethiopia and the most appropriate response in terms of groundwater management.
- Promoting conjunctive use of groundwater and surface water in surface irrigation systems – so far surface irrigation development has focussed on developing either the surface resources or (increasingly) groundwater, but not the co-management of both.
- Explore scope for more intense use of groundwater in areas that now face drainage problems. The accelerated use of shallow groundwater – provided it is of useable quality – can ameliorate water logging problems;
- Enhancing the productivity of flood recession farming – for instance around Lake Tana and in the Baro floodplains in Gambela. This can be done by promoting the development of shallow wells to provide a larger degree of security in the farming systems.

Focus on priority areas
Whereas groundwater development for drinking water supply is required everywhere, groundwater development for agricultural development may focus on a number of priority areas. Some areas have high potential for growth because of their location and connectivity and because of their resources. There are three categories of areas that have a particular high potential and would need to be developed.

The first category of high potential areas for growth and sustainable groundwater use are pocket areas with ultra shallow groundwater and ample recharge. Such areas have all the ingredients for high value small holder farming – particularly if located within reach of urban centres. Such areas occur in several places in Oromia, Amhara and SNNPR among others – with favourable hydrogeology close to catchments or inside minor river valleys. In many of these areas high productivity farming has not taken off, but could be triggered by the introduction of high value horticulture – supplied by simple lifting technology and sustained by ensuring adequate local recharge.

Second target areas are the lowlands. The areas where most substantial unused groundwater is suspected and partly already explored are in the lowlands of Amhara, Tigray, Afar and Somalia. These areas are relatively empty and managed groundwater development would need to be included in a large perspective of developing essential infrastructure. Combined with spate irrigation several of these areas have the potential to transform to productive agricultural areas.

Third priority categories are the areas that are already very productive but that suffer from climate variability – excarbated by climate change. Providing supplementary irrigation to overcome in particular the unpredictability in the rainy season (no rains in the belgh season, delayed arrival of the kimret rain, dry spells in the rainy season) can be overcome with supplementary groundwater irrigation. An example for instance is in the coffee producing areas, where the late start of the rainy season has a marked effect on flowering and in the end coffee production.

Promote private sector financing
In countries where groundwater has taken off – particularly in Asia - it has usually initially been triggered by public investment but subsequently taken over by private financing, including investment by small farmers. The role of the government changed from investor and instigator to regulator and provider of public services. In Ethiopia in groundwater it is also important to develop this private sector category of financing – tapping also into the investment potential of small farmers:


Private sector promotion of rope pump

- Providing for private sector concessions in providing groundwater for drinking water supply
- Small farmer loan systems for low cost pumping systems – from rope pumps to low capacity diesel pump sets
- Creating a conducive environment for the development of a private service sector. This can be done in contract management

Regulatory improvement
Until recently groundwater use beyond drinking water was limited in Ethiopia. With the drive towards more intense groundwater use developing regulation becomes more important – to safeguard the source and guide the allocation of groundwater.

At present there is no encompassing institutional framework for groundwater management, but the principles of the Water Resource Management Policy (WRMP) of 1999 may be taken as a guideline. The objectives of the WRMP that are particularly relevant for managed groundwater development are the integrated management of water; the recognition of water as a scarce and vital resource that needs to be managed on a strategic planning base; the integration of water resources development in the overall national economic development framework; adopting basins as fundamental planning units; participation of the private sector in water resources management and conducive environment for linkages between the Federal and Regional States on the basis of the Constitution. The general principles of allocation and apportionment of water in the WRMP may also hold true for managed groundwater development:

- Basic minimum requirement for essential human and livestock needs and environment
- Highest priority to water supply and sanitation an the remainder to use with higher socio-economic benefits
- Encourage efficient use of water resources
- Water allocations to be made not permanently but on the basis of agreed time horizons.

Regulatory responsibilities for groundwater management are not clearly defined as yet, which is understandable given the limited extent of groundwater development until very recently. The main challenge in regulation is clarity and effectiveness. It is important to avoid creating laborious regulatory systems that hinder rather than guide development. Several regulation provisions exist on groundwater management but they are not widely known and implemented. Another shortcoming is that they are limited to licensing individual wells – particularly with an eye to water quality – but are not geared to the sustainable management of groundwater.

The priority actions in regulations hence are: (1) clarifying the institutional framework, (2) activating existing regulation, (3) developing groundwater management plans for priority areas and (4) developing standard drilling procedures.

Clarify institutional and legal framework

In developing better groundwater regulation the responsibilities of the different parties need to be clarified. Table 3 is a proposal in this regard. It is understood that the mandate to formulate and implement the basic policies, strategies and plans as well as law making rests with the federal government and any subsequent policies, strategies, plans and laws issued at the respective regional levels must be consistent with those issued at the federal level. The federal government also assumes responsibility for water bodies that concern more than regional state. The table below suggest responsibilities in regulation, capacity building and development.

Table 3 Proposed institutional responsibilities in managed groundwater development

Institutions	Responsibility
Ministry of Water Resources	Develop policies, standards and criteria – among others for groundwater management plans, drilling standards and well designs, fluoride/ iodine treatment Maintain information base Initiate and support interregional groundwater management plans. Oversee water allocation
Ethiopian Geological Survey	Plan and guide groundwater assessments
Federal EPA	Reviewing possible impacts of national investments on groundwater quality and quantity Selected strategic environmental assessments – linked to groundwater management plans
Regional Governments	Integrate groundwater management into other development programs
Regional Water Resources Bureaus	Adopt policies, standards and criteria Initiate groundwater management plans for selected areas Supervise quality of monitoring Licensing in low density areas
Regional EPAs	Licensing in high density areas (need to be upgraded) Reviewing possible impacts of investments on groundwater quality and quantity
River Basin Organisations (once on stream)	Coordinate surface and groundwater allocations and supplies
Water Users Association (once on stream)	Local regulation and efficiency measures – support and engagement in groundwater management plans
Well field operators	Monitoring
Universities	Courses in drilling and drilling supervision and groundwater management
TVETS, NGOs	Courses in manual drilling and pump development
Private sector educational services	Specialist courses
Public sector technical services	Design and supervision
Private sector technical services	Design and supervision
Corporate private sector drilling services	Drilling of shallow wells Drilling of deep wells (to be strengthened)
Artisanal private sector drilling services	Drilling/ development of very shallow wells (to be strengthened)

Activate current regulatory provisions in priority areas

A limited number regulatory provision exist but these are not systematically used. These provisions should be activated in the larger context of groundwater management.

The 1960 Civil Code establishes the public property nature of groundwater and sets limits to private well development. Article 1255 and 1447 mention: *Underground accumulation of water and rivers shall form part of the public domain'* and *'No person may without permission construct on his land a drilling exceeding one hundred meters of depth.'* Land is owned up to depth that is required to use it for agriculture. *'Ownership of land shall extend below the surface of the land to the extent necessary for the use of the land' article 1447.*

These provisions though mentioned in the Civil Code lead a more or less unknown existence. The same applies with the "Wells Drilling, Construction and Rehabilitation Directive", issued by the Ministry of Water Resources. The main points of the Directive are given in box 1. Though not explicit the directive seems to apply for shallow and deep well drilling – not for very shallow wells.

Box 1: Main provisions in "Wells Drilling, Construction and Rehabilitation Directive"

No person shall be engaged in the drilling or rehabilitating of water wells without a permit duly issued by the Ministry or his designee.

Any person who wants to have a water well drilled shall first acquire a permit to do so from the Ministry or his designee before entering a contract for this purpose with a water well drilling or rehabilitating contractor. Applications made to have a water well drilling or rehabilitating contractor. Applications made to have water well drilled must be accompanied with the design and specifications of such well.

All water well drillers and rehabilitators shall, before entering in to a contract to drill a water well, first ensure that the Ministry or his designee has approved that such well be drilled.

All persons who want to have a water well drilled or rehabilitated shall, before entering in to a contract to have such water well drilled or rehabilitated, first ensure that the driller or rehabilitator has a permit to undertake the drilling or rehabilitating or water wells.

A well driller or rehabilitator shall, within three months of completing a well drilling or rehabilitation, submit to the Ministry or his designee a technical report – that includes information about the drilling, construction and rehabilitation process, the geological and electrical log, yield tests, laboratory tests, problems encountered during drilling, construction and rehabilitation, pump installed.

The provisions look at individual wells and focus primarily on well quality. They do not look at groundwater planning at watershed level. In many countries similar legal provisions exists and the experience with such regulations is similar to Ethiopia (1) they are not known and hence seldom used (2) they may be useful as part of the larger framework of a groundwater management plan – that sets the criteria under which wells may be developed and used. On their own the impact of well licensing procedures is limited.

It is proposed to introduce effective licensing procedures in the selected priority areas as one useful element in management particularly in areas with shallow and deep groundwater. At present well registration is only actively practiced in Addis Ababa, where it is handled by Addis Ababa - EPA. The EPA-AA issues well drilling licenses and abstraction permits to domestic uses, industrial uses, hospitals water bottling plants, thermal water operators and real estate companies. EPA upon receiving a request for licence checks the geographic coordinates and investigates against criteria like the distance of the requested well to the municipality well field (500m) or the location in areas of high vulnerability of pollution. Accordingly a drilling permit is given first. When the drilling completion report is presented including the water quality test results, a one year permit is given assuming it will be renewed annually. The latter however is unusual.

The challenges are in case of Addis Ababa that the responsibilities between AAWSA (that used to do the licensing in the past) and AA-EPA are not entirely clear and that there have been cases where the EPA is by-passed. A second problem is the limited capacity of the Addis Ababa EPA (only one person). Related to this is that there is as yet no complete well register. There are expected to be more than 1000 wells but only less than 500 are 'known'. Well owners are also supposed to give monitoring results every year to EPA but this is done in exceptional cases only. This experience serves as a useful reality check. In activating well licensing procedures in selected areas it is important to (1) have sufficient capacity (2) make sure procedures are known broadly and (3) take action – even if on a demonstration basis – against well operators that default on these rules.

Initiate groundwater management plans in priority areas

As part of this Framework however it is proposed to prepare groundwater management plans in the regions where there is accelerated groundwater development and where overuse or pollution could become an issue. Groundwater management plans are to be linked to the land use plans and should contain:

- Estimates of overall yield and safe yield
- Regional water balances making the connection with management of surface water
- Allocation priorities as given in the WRMP
- Provisions for protecting against overuse and quality deterioration
- Registration of groundwater users
- Agreement on future use and access
- Monitoring arrangements
- Communication plans.

Annex 6 provides guidance on the development of such groundwater management plans, based on international experience. The process of plan development is as important as the content of it. The groundwater management plans should be developed jointly – with the engagement of all parties directly involved or benefitting from groundwater resource use.

Standardized well drilling procedure

Another important regulatory improvement is standardization of well and pump designs, well drilling guidelines, supervision provisions, well testing and well development standards and well head design standards. Such guidelines and standards are important tools to improve the quality of drillings and boreholes and reduce the constraints that are now experienced. Clear standards will also be cost effective as it provides a framework for drilling companies to invest in the appropriate equipment and stimulate than to submit competitive quotations. An example is the rotary reversed circulation method which is the preferred method to drill deep large diameter wells in the prevailing rocks around Addis Ababa (and elsewhere). Since only one reversed circulation rig is available, the price for using this rig is high and the use of other rigs for deep boreholes a lot of problems. Prescribing the reversed circulation method as the standard for deep well drilling will encourage other companies to invest in these types of rigs which will improve quality and encourage competition

Along with guidelines and standards, there is urgent need to improve the skills and human capacity for well drilling supervision. Adequate supervision improves the quality of the work while properly constructed and developed wells generally have a longer lifetime and lower operation cost

User engagement

Managed development of groundwater requires the active engagement of many players – both the institutional parties as described in table 4.2 and the (potential) groundwater users. Several measures are required to promote and active stakeholder roles, in particular (1) capacity building (2) strengthening private sector roles (3) making links to river basin management and (4) information sharing and communication

Capacity building

Capacity building is an overriding challenge in groundwater management. The inadequate capacity – human and material – to keep pace with the required speed and quality of groundwater development is universally noted. All around positions vacant in groundwater development[7]: in Regional Water Resources Bureaus (31%), Zonal Water Resources Offices (54%), Woreda Water Office (61%), Water Works Design Offices (34%) and Town Water Supply Organizations (25%). Annex 3 is a more detailed overview. This high proportion of vacancies is compounded by high turn-over. The largest need is for hydrogeologists, professional drillers as well as for water supply engineers.

Shortage of professional drillers and hydrogeologists

There is similarly a lack of drilling equipment and back up services. A conservative estimate based on the demand within the drinking water sector (not agriculture) puts the need for additional drilling rigs at 200. This is partly addressed with the recent procurement of drilling rigs by the Government of Ethiopia. Apart from absolute numbers there is also a need for rigs specialized to operate in different hydrogeologic settings.

[7] Ethiopia Water Technology Center (EWTEC). 2009. Training Needs Assessment Survey. Japan International Cooperation Agency (JICA). The Federal Democratic Republic of Ethiopia, Ministry of Water Resources (MoWR). Volume I, Report

In increasing capacity several activities need to be set in motion:

- University training: the capacity of universities to deliver BSc and MSc graduates in applied hydrogeology, groundwater management and water supply engineering needs to be accelerated. This is currently being done under several programmes –in particular the Ethiopian Capacity Building Project that strengthens technical training in five universities.
- Moreover under the NUFFIC IRBM project the BSc and MSc curricula in groundwater management are strengthened in five universities too. This builds on MSc courses in Addis Ababa University and Mekelle University. At the same time there is a drive to significantly increase the number of students in science studies in general – with a doubling of number in many faculties. Very specific needs are the courses in drilling techniques and drilling supervision. A course of this nature used to be provided by the Water Technology Centre in Arba Minch but in spite of the large need in drinking water supply and in groundwater irrigation the course is no longer given. It should be reinstated and the course should be provided in several universities. Also several other capacity building programmes in the water sector are on the way – including the Colorado State University Project, where groundwater also should be placed on the agenda.
- Popularizing manual drilling and related low lift techniques would need to be linked to the course offered in TVETs – especially those in high potential area. No TVET at present has curricula on groundwater exploitation techniques – with the exception of training on assembling and maintaining Afridev hand pumps. TVETS should also develop into service centres. One of the handicaps of TVETs at present is the difficulty to provide the 70% practice learning in the courses. This could be turned into an advantage by TVETs develop into service centres providing trainings to students and artisans alike and having stocks of equipment and spare parts.
- The large need for (specialized) drilling equipment is now addressed partly by government procurement. The management capacity of public sector drilling companies is limited (see annex 2) and need to be upgraded. At the same time the role of the private sector needs to be expanded. At present a limited number of high quality services are delivered by the private sector but need to be significantly upscaled (see next section)

Promote private sector roles

Though expanding, at present private sector roles in groundwater development and management are still limited and not at par with the expected increases. Interest is concentrated on developing production wells – but technologies used vary from basic and sophisticated and the absolute number of private drilling companies is limited. There is no service sector to speak off for the maintenance and operation of wells or for providing siting services. The private sector so far is also not promoted – and in fact often discriminated, for instance in access to higher education.

Recently a Drillers Association has been established and this Association could play an important role in developing a conducive environment for private sector investment in drilling, for instance in:

- Improving contract management procedures – giving more contract security and removing a disincentive to enter the sector

- Fiscal incentives, such as tax waivers, on the purchase of essential equipment
- Educational co-operation programs, for instance restart of drilling supervision programmes and provision of traineeship positions to students.

Developing links to River Basin Management

The Ethiopian Water Resources Management Plan sets out to 'recognize and adopt the hydrological boundary or "basin" as the fundamental planning unit and water resources management domain'. Eight river basins have been delineated in Ethiopia. For most of these basins River Basin Master Plans have been developed. The legal basis for the development of RBOs was created in Ethiopia with River Basin Councils and Authorities Proclamation (No. 534/2007).

The role of the River Basin Organizations concerns policy, regulation and management. The proposed functions are the coordination of planning by different stakeholders, water resources administration, knowledge functions, information exchange, capacity building and the development of integrated projects and programs. The structure of the River Basin Organizations is two-tiered: (a) a Basin High Council responsible to direct the preparation of a river basin plan, examine the appropriateness of priorities (major proposed works), setting water fees and deciding on water allocation rules and settling disputes (b) a Basin Authority to implement the different activities in coordination and information, such as submitting the river basin plan and issue permits for water works *without prejudice to the power given to the Regional States*.

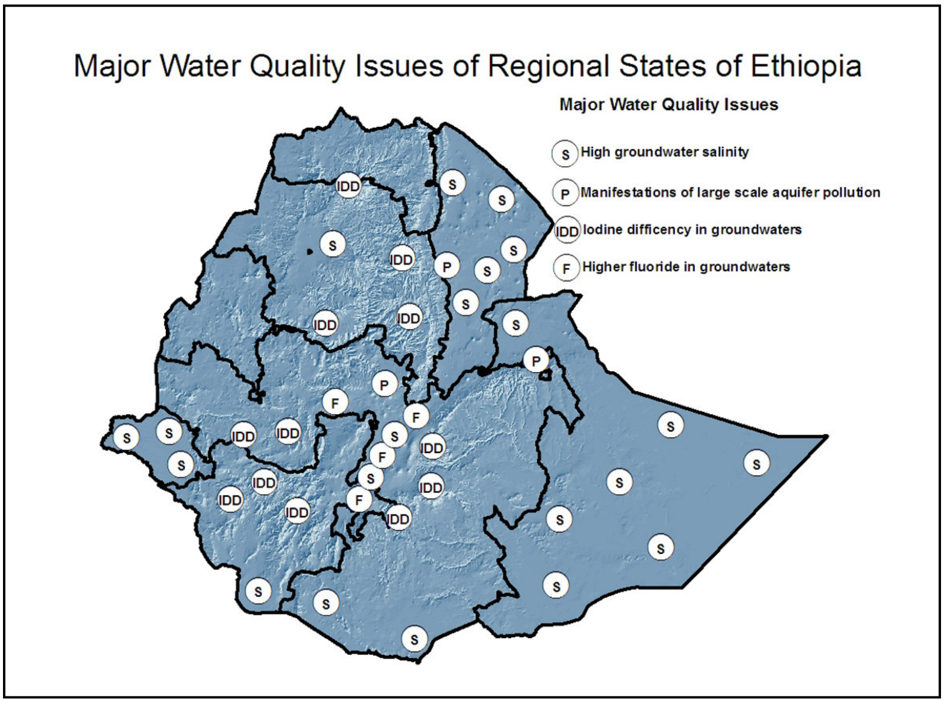
Individual RBOs – including the regulations for each of these - are to be established by decision of the Council of Ministers. This is done so far for the Abay Basin (Blue Nile) and Awash Basin and is in the making for the Central Rift Valley. The RBOs are still in incipient stage hence, but in the long run strong relations should be forged between basin management and groundwater management. Groundwater hardly figures in this now but with groundwater expected to become more important groundwater management should be become more prominent in the task lists of the RBOs. The RBOs can also function as the platform to promote conjunctive use and settle allocation issues, particular in situations involving several regional states.

Shared information basis

The ENGDA information system that was managed by EGS is currently substituted and replaced by the NGIS administered by the Ministry of Water Resources. The NGIS allows larger flexibility and more user interfaces. Introduced in the second part of 2009 NGIS is now being filled with contribution of among other Regional Water Bureaus. Groundwater still being a large 'unknown', it is important to set move groundwater out of the black box and have an information plan added to NGIS – to inform a large audience on the groundwater potential of the country. This will serve to attract a larger interest and at the same avoid unrealistic opinions.

Quality measures
The main issues in groundwater quality in Ethiopia are the natural groundwater quality – in particular the high fluoride levels in part of the country and iodine deficiencies else where in Ethiopia as well as salinity of groundwater. Figure 5 gives an overview of the most important natural quality issues and the areas where they are reported to occur

Figure 5 Water quality issues in different areas



Source: Seifu Kebede

The second groundwater issue is the point pollution, particular in intensively used areas – such as Addis Ababa and Mekelle. Several quality measures are required: (1) iodine and fluoride policy (2) pollution risk mitigation strategy (3) standardization of well head protection (4) risk assessment based solutions

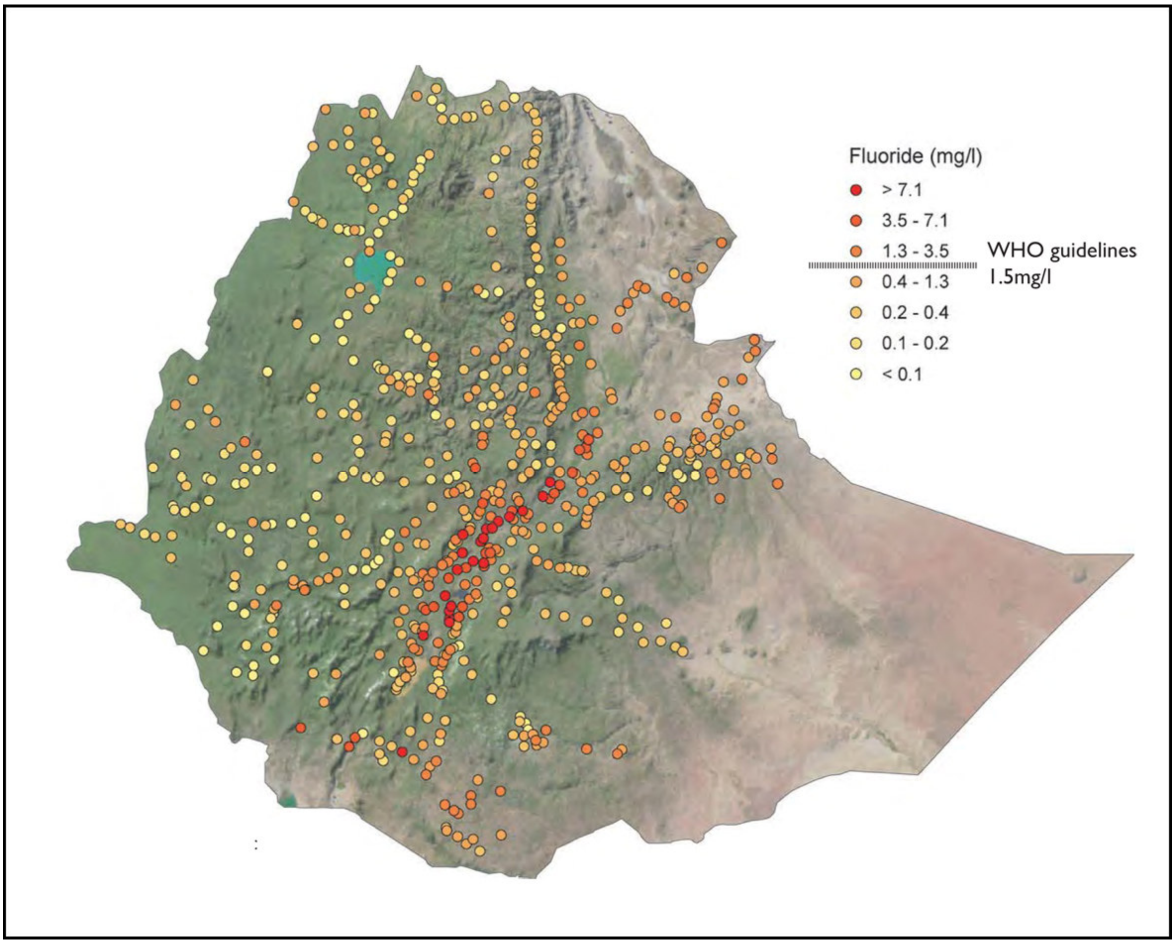
Fluorosis and iodine policy
Fluorosis is assessed as a risk for a population of close to 8.5 Million in Ethiopia. On the whole nearly 40% of deep wells and 20% shallow wells of the Rift Valley yield fluoride levels between 2 mg and 7 mg/l. Outside the Rift Valley fluoride levels are high in the Jimma Region (see figure 6) The problem is increasingly recognized and the Ministry of Water Resources is hosting the National Fluorosis Mitigation Project (NFMP). The NFMP aims to develop guidelines on fluorosis mitigation – in terms of safe sourcing and treatment methods. It is also co-ordinating mitigation trials, using the Nalgonda and bone char methods and doing research – among others on the link between fluorosis and nutrition.

Dental fluorosis in the Central Rift Valley

Observations from some districts in Ethiopia for instance suggest that high fluoride levels do not always go hand in hand with high incidence of fluorosis and that it makes most sense to concentrate prevention and mitigation efforts on areas with high fluorosis levels rather than high fluoride levels per se.

One field with much potential for improvement is in more sophisticated drilling techniques – placing screens in aquifers that have low fluorosis levels. There are for instance indications that some of the deep aquifers have lower fluoride levels. A targeted and differentiated approach appears most promising – focusing on highly problematic areas and using locally appropriate solutions – safe sourcing where feasible or otherwise treatment.

Figure 7 Occurrence of fluoride in groundwater in different areas



Source: RiPPLE (BGS, EGS, Gararbet, MetaMeta, Unicef)

A second groundwater quality issue receiving little attention but of serious nature too is the iodine deficiency in large part of the country. According to Ministry of Health and UNICEF, 42 million people (78%) of the total population of Ethiopia are exposed to iodine deficiency, 35 million (62%) are iodine deficient, Lack of adequate iodine in foods and drinking water could lead to Iodine Deficiency Disorder (IDD). This causes goiter, cretinism, poor pregnancy, still birth, mental retardation and infant mortality. Iodine deficiency is the world's most common cause of mental retardation and brain damage and goiter incidence. 14 million (26%) have goiter and at least one in 1000 people is cretin; with about 50,000 prenatal deaths. Medical sciences research in Ethiopia have previously recognized that risks of IDD is associated with a) living in high altitudes, b) cassava and millet consumption and 3) leaching of iodine from top soil by erosion and flooding. Recently Kebede, 2009 relate high goiter incidence to geo-environmental setting—distance of rain producing air mass from the Ocean, geology (low iodine in associated with crystalline rocks and high with sedimentary and lacustrine sediments) and evaporation rates.

Pollution risk mitigation strategy

In urban and industrial areas in particular there is a risk of groundwater quality deteriorating. Likely sources of contamination of urban aquifer systems are industrial effluent, sewerage lines and contaminated surface streams, leaks from petrol stations, garages, health facilities or landfills. So far there is little regulation in effect to reduce pollution risks.

Such contamination is reported from several cities. The most substantial work on groundwater pollution risk so far has been done for Addis Ababa (Tamiru et al, 2005)[8] – identifying the pollution sources and the low, high and medium risk areas in terms of vulnerability to contamination. The resultant vulnerability map should be used (1) in land use planning – allocating potential high risk facilities to low vulnerability areas (2) in developing protection zones around vital well fields.

At the same time regulation should be introduced to prevent contamination – particularly irreversible contamination – around Ethiopia's fast growing cities, because if not in the long run water security of an increasing urban population is jeopardized. At present for instance leakage from petrol pumps and garages occurs from corroded storage containers and pipelines, from old unprotected land fills or from effluent disposal in sewers. These different issues need to be addressed on priority basis.

Well head protection

The Civil Code explicitly mentions the protection of groundwater quality. Article 1235 mentions the protection of wells*: Whoever is entitled to use a well , spring or other water, whether running or still, may object to the construction of any work such as a sewer or latrine, capable of polluting the water used by him"* and '*He may require that any such work done in disregard of his rights be destroyed'.*

As groundwater is increasingly developed the protection of well heads is important – both in urban and in rural areas. In Addis Ababa groundwater contamination has increased and there are indications that this is related to inadequate well head protection. Well head protection needs to be standard part of the development of wells – and as such included in the standard well design that are currently developed. The existence of a large number of essentially unregistered wells (more than 50%) in Addis Ababa is of large concern in this regard. Well registration and licensing needs to be strictly enforced not only for concerns on water abstraction but equally for the development of safe protected wells and in the future the capping of abandoned wells.

[8] Tamiru Alemayehu, Dagnachew Legesse Tenalem Ayenew, Yirga Tadesse, Solomon Waltenigus,Nuri Mohammed (2005). Hydrogeology, Water Quality and the Degree of Groundwater Vulnerability to Pollution in Addis Ababa, Ethiopia. UNEP/ UNESCO/UN-HABITAT/ECA.

Well head protection should consist of:

- Well siting away from sources of pollution
- Proper well construction – not allowing pollutants to enter inside or around the outside of the casing
- Keeping possible contaminants – for instance from storm water run-off away from wells
- Regular testing of well water quality.

Well head contamination is not exclusive to urban areas but is also a serious issue in the rural areas where dug wells generally lack basic protection. Situated at ground level there is nothing that prevents run-off and drainage water to wash into open wells. A campaign is required to ensure that the development of small protection mounds or concrete ring protection is standard component of dug well development or alternatively that very shallow manually developed tubewells become common place.

Well head protection problematic in rural areas too

Demand management measures

Raise awareness on groundwater development and management

As mentioned at present areas with intense groundwater development (for instance the northern border of Lake Ziway) co-exist with areas with very little groundwater use at all (for instance Butajira) even though in both cases the potential is the same. It is important in each area to bring groundwater development in line with local priorities (livestock, irrigation) and develop plans around these. At the same time it is important to build up awareness on the potential for high value small scale farming using groundwater and is part of local planning stimulate the supporting infrastructure for this.

Promoting use of rope pumps on shallow aquifer in Tigray

Rural electrification

Considerable investment is being made in hydro-power generation in Ethiopia. Current shortfalls have already been reduced with the commissioning of Upper Tekeze, Gilgebe II and Beles. In the medium and long term the abundant electricity may be used for agricultural pumping – especially where single block aras are developed. For relatively small lifting systems in ultra shallow aquifers, manual lifting or diesel-operated prime movers are the best option – as maintenance systems are relatively easy. However for the newly planned well fields electrification should be considered, as in deep well systems electric prime movers require least maintenance.

Experience from elsewhere suggest that it may be useful to consider dedicated supply lines, as this makes it possible to regulate supply and ensure its reliability which is a major factor in wise groundwater use. The cropping systems and market infrastructure needs to be brought in line with a realistic water price – covering at least the operational costs.

Increase drilling capacity

Measures to improve drilling capacity for shallow and deep aquifers were discussed in section 4.3 already. There is a need not only for additional capacity in human resources and equipment but also a need for more sophistication.

The same applies for very shallow wells. The most common technique used currently in areas with very shallow groundwater in Ethiopia are dug wells. Even so even in areas with constantly recharged the density of dug wells is relatively low. Ultra shallow tubewell development – using a range of techniques depending on the shallow hydrogeology (alluvial only, or interspersed with stones) – is uncommon. The advantage of very shallow tubewells over dugwells is that they are more reliable and less to prone to fluctuation as they penetrate the water bearing strata deeper. It is proposed to popularize manual well drilling around area with high yielding very shallow aquifers. In areas where the very shallow aquifer is fragile it should not be encouraged, but these are general not alluvial aquifers.

As discussed in section 3.2.3 there is an important role for TVETS here. To meet the sector's demand for intermediate level human resources, eight Technical and Vocational Training Centers have been established already in Afar, Somali, Oromia, Amhara, SNNPR and Tigray states where training of professionals in water techniques is underway. Preparations are being made to open a similar training center in Benishangul Gumuz. These will provide a sustainable, yearly increasing number of trainees and is believed to have a significant contribution to planning and implementing water development activities at woreda level.

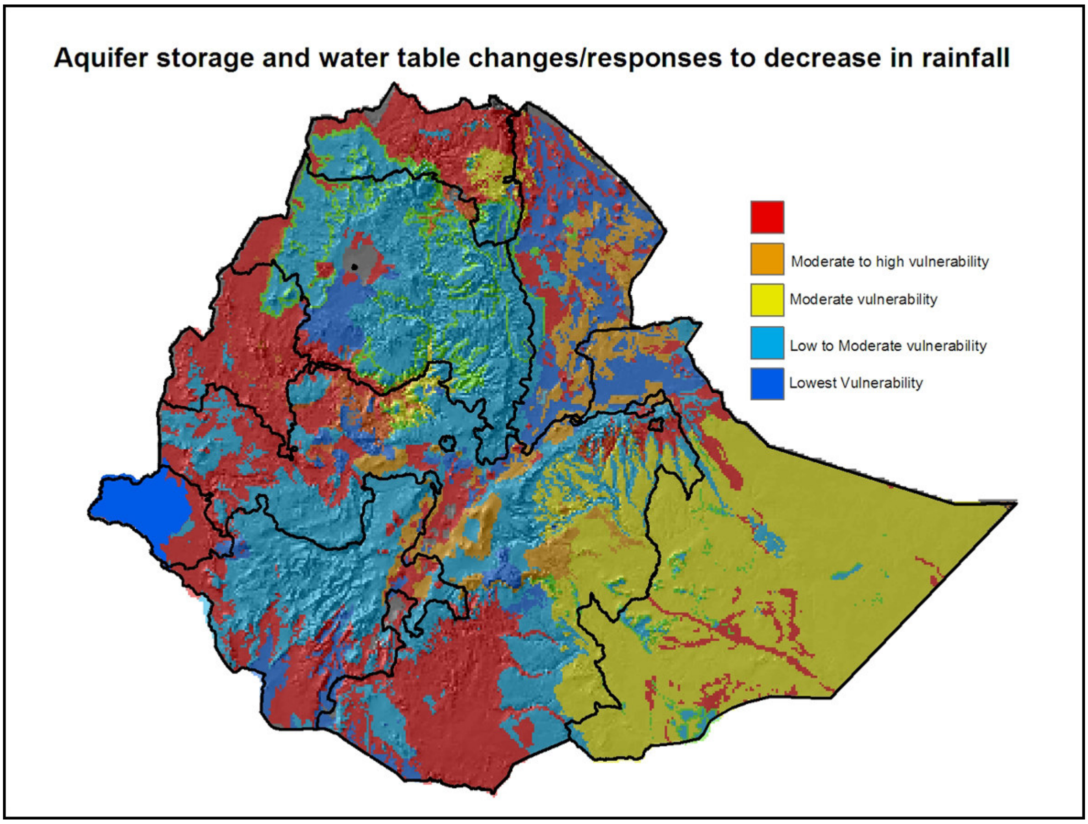
In order to carry out community level minor construction and maintenance services on a broad front, training of artisans who could enter into work after short-term training needs to be carried out extensively. As a result, these artisans will carry out manual digging of wells, minor spring development, digging of ponds for *kebeles* and basic maintenance of these facilities.

Introduce water saving techniques
In particular in areas where there is no reusable return flow the use of water saving techniques is important to achieve high water productivity. This applies to areas with shallow and deep groundwater – where water will be lifted at considerable cost, which is only justified if used for efficient high value agriculture. There is fortunately in Ethiopia already a strong move towards the use of drip and sprinkler systems. These systems bring apart from water saving benefits in terms of ease of use or reduction of pest and diseases. They should be part and parcel of the envisaged new groundwater irrigation projects. In addition there are other improvement in water saving – that should be systematically promoted – improving soil moisture retention capacity through the use of organic material, particularly in newly developed areas, considering efficient irrigation agronomy, such as SRI for paddy or sugarcane or alternate wetting and drying. At same time in such areas groundwater quality should be protected by the controlled use of pesticides – through integrated pest management measures.

Supply side measures
As groundwater use moves more centre stage supply sides measures should do as well. Particularly in ultra shallow groundwater systems water availability can be influenced by supply side measures, in particular (1) promoting recharge and storage and (2) promoting conjunctive management.

Promoting recharge and storage
There is a need and scope to more effectively recharge groundwater. The watershed management programmes that are implemented in Ethiopia have been intensively concerned with erosion control – but less with groundwater recharge and storage. There is a need to systematically include recharge and storage in shallow aquifers – where possible – into watershed programmes. This is not possible everywhere but depends on the local hydrogeology – the storage capacity and the recharge mechanism. Some areas are more vulnerable to rainfall fluctuations – figure 7 provides an overview. Particularly in the areas that are vulnerable to fluctuation – such as the Tigray, the West and Borana - the buffer functions should be improved by investment in water harvesting structures.

Figure 7 Aquifer storage and response to rainfall in Ethiopia



Source: Seifu Kebede (AAU)

Furthermore annex 5 gives a tool sheet linking aquifer characteristics with buffer management strategy. As climate change will affect rainfall patterns and temperatures maintaining the buffer characteristics of shallow groundwater becomes more important.

An important requirement is to work at scale – as is already being done in parts of Amhara Region for instance, and align all concerned development programmes – including the Productive Safety Net. There is also scope to apply several recharge and storage techniques on a much larger scale and 'buffer' entire areas. It is also noted that some managed aquifer recharge techniques are applied only sporadically in Ethiopia, whereas the scope for their productive application is high: sand dams, subsurface dams, contour trenches and others techniques. It is important to mainstream these and build capacity, because as with other techniques proper planning and implementation is important and some of these – particularly sand dams – are vulnerable to design and siting errors.

Promoting conjunctive use of groundwater in surface irrigation systems

As discussed before, conjunctive management will greatly increase the productivity of surface irrigation development, as return flows are reused. This avoids drainage problems and turns excess water into an asset. Conjunctive management of large irrigation systems requires the careful planning of surface water deliveries and proper siting of command area – on top of aquifers that allow reuse - so that a conjunctive balance is achieved. As there is a considerable thrust to develop new irrigation systems there is a large opportunity to plan in conjunctive use from the beginning.

Priority actions for managed groundwater development in Ethiopia

Based on the above the following priority actions are singled out. These are activities that can be undertaken immediately and serve as a reality test for the strategic framework and managed groundwater development in general:

- prepare and implement groundwater management plans for selected areas of high intensity use – linking to local land use plans and introducing monitoring and quality protection measures. Annex 6 provides a guidance for the preparation of such plans.
- integrate groundwater development in larger programmes – agricultural development, irrigation development, watershed protection or road planning – making sure to maximize the benefits of groundwater use within these programme
- accelerate the development of capacity – human and material, public as well as private sector.

4. PRACTICAL FRAMEWORKS FOR REGIONS

The strategic framework for the whole country should be used to define regional management frameworks for Regional States or for example for river basin or areas of intensive groundwater development. The national framework identifies the actions to be taken at national level – in terms of enabling frameworks and national policies as well as resolving the transboundary and interstate nature of groundwater management issues. The practical frameworks for regions on the other hand describe the issues to be attended to at the level of the regions or subbasins.

The issues in the national strategic framework are the starting point to formulate a regional action plan. This should be done in close consultation with the main stakeholders and will lead to issues which are more focused on the specific management issues in the region and result in a practical framework with for concrete actions for managing the groundwater development. Annex 7 contains preliminary frameworks for four regions in the country – Amhara, Oromia, SNNPR and Tigray. These preliminary frameworks are meant as an input for a more extensive discussion that will make it possible to finalize them. For Addis Ababa this process is already completed and is discussed next.

4.1 Applying the framework in the Addis Ababa Region

A Practical Framework was developed for the Addis Ababa region – following the same format as the National Framework. The framework was finalized with a core team from Addis Ababa and the Oromia Regions.

Well field on border of Oromio (left) and Addis Ababa Administration (right)

As in other comparable cities groundwater contributes increasingly to the water supply of Addis Ababa. The most current estimate is that surface water provides 195 Ml/day and groundwater 90 Ml/day of the municipal water supply provided by AAWSA. In addition there is private pumping. The quantity of this is unknown. Well licensing is not done systematically and an up to date well inventory is missing. The Addis Ababa Environmental Protection Agency estimates that there are close to 1000 wells in Addis Ababa – yet has a register of 500 wells only. This picture is not different from other fast growing cities where in recent years groundwater resources are being developed as an important complement to earlier surface supplies. In for instance Nairobi, Lusaka and Dar-us-

Salam groundwater development is recent and taking care of at least 15% of urban water supply and regulation of private wells in incomplete.

Compared to other parts of the country, the groundwater potential in Addis Ababa region is relatively well-investigated. All of four categories (see annex 8) of aquifers occur in Addis Ababa: the very shallow aquifer (below 30 meter), the shallow aquifer (30-100 meter), the deep aquifer (100-250 meter) and the very deep aquifers (beyond 250 meter)

The most intensively used aquifers are the shallow and deep aquifers. These serve as the source of water for AAWSA, but at the same time are also increasingly used by private parties – such as industries and horticultural farms. For the moment the shallow aquifer contributes importantly to the water supply of Addis Ababa – through the Akaki well fields and through wells drilled in different parts of the city. The shallow aquifers underlay both Addis Ababa and Oromia Region. There are no conflicts yet – but in the near future the intensified use for agriculture requires more coordination and regulation.

Groundwater exploration is continuing. Reconnaissance studies and extensive geophysical surveys (VES and Magnetic) in the greater Addis Ababa area revealed five potential areas for further study: the Legedadi-Lega-Tefo-Ayat well field location; the South Ayat-North Fanta-Yerer well field location; the South West and West of Akaki well field location; the Milka-Kunture well field location; and the Sebeta-Tefki well field location. The Legedadi area and the West/South west Akaki area were selected for further exploration studies because these well field locations are close to existing water supply infrastructure. Initially eight wells were drilled (two in Legedadi and six in Akaki). The wells in Legedadi were only partly successful due to technical problems during drilling but also because of the seeming absence of productive aquifers resulting in a low yield of the wells (20 l/sec). Although there may be more productive layers at greater depth (>600 m), it was decided to focus on the exploration works in the Akaki area first. Contracts for another eight explanatory wells were signed in 2009 and this work is still ongoing. The first wells drilled in the Akaki area show a high productivity of the deeper aquifer. From two of the tested wells, a rate of 90 l/sec was pumped with drawdown of only 6-10 meters.

There are now also strong indications that of the presence of a very deep aquifer (with depths above 250m) with an expected high potential. The recharge zone of this aquifer is expected to extend to the Abbay Basin. Based on the preliminary results, designs are made for deep production wells (500 m) which are expected to yield 100 l/sec. A drilling program for 15 deep production wells (500 m) is prepared and under implementation.

Implementation is afoot to develop groundwater for irrigation – particularly in the Ada/Becho plain. In general an increase in demand for groundwater is highly likely both from the shallow aquifer and the recently discovered deeper aquifer. In the latter case pumping costs are manageable because of artesian pressure – making well development attractive particular when the capacity to drill at this level increases.

There are quality concerns on the very shallow and shallow aquifers. The vulnerability of groundwater to pollution is a factor of the local subsurface infiltration and the nature of the multi layered aquifers. The subsurface infiltration condition of Addis Ababa area is governed by the thickness and hydraulic conductivity of the unconsolidated sediments overlying on the weathered and fractured volcanic rocks. These sediments are classified into three groups: alluvial, residual and lacustrine clay deposits Engeda 2001[9]). The alluvial deposits - mainly composed of clay - are found along the Akaki River and its tributaries. The high elevation, ridges and steep sloped areas of the city on the other hand are covered by thin layer of residual clay soils while watershed divide and plain areas of the town (central and upper part of the town) are covered by thick residual clay soils. The southern part of the town (Akaki and Aba Samuel area) is covered dominantly with very thick lacustrine deposits. The lacustrine deposits are black cotton of highly plastic clays with thickness up to 40 meters. Infiltration is particularly high in alluvial and thin residual deposits.

Where the aquifer is unconfined and groundwater depth is less than 80 meters pollution risk is high[10]. Areas with semi-confined aquifers are considered as low vulnerability because the semi-impermeable strata prolongs the travel time of the contaminants. The confined zone of the groundwater of Addis Ababa area is considered negligible vulnerability to pollution due to the high confinement of the groundwater with impermeable strata.

Because of these settings the relatively shallow aquifers to the south of Addis Ababa are most prone to contamination discharge from Addis Ababa – whereas the pollution risk for the very shallow aquifer to the north of the city is less. For the deep and very deep aquifers the reverse is true. Here the largest contamination risk comes from the northern part of the city , whereas because of the protection from thick clay beds the contamination risk of the deep aquifers is less in the southern part of Addis Ababa.

At present the highest pollution is measured around the Merkato Area The high nitrate and chloride observed at Merkato Area corresponds to the maximum population density within Addis Ababa. The contamination is most probably due to:

- Poor well construction of boreholes and improperly abandoned wells
- Septic tanks and latrine pits closely located to wells that provide contaminate pathway as a short and through the unsaturated zone

There are indications that water quality in the Akaki well field deteriorated after the well field came in operation insufficient well head protection in particular appears an important factor. In addition no groundwater protection is in effect in Addis Ababa at the moment.

[9] Engida (2001), Groundwater Study of Addis Ababa Area. Report 01/1993.
[10] Beyond this level pollution is relatively minimal.

4.2 Management approaches and measures

Figure 8 is the Practical Framework for Managed Groundwater Development for the Addis Ababa region. In spite of the importance of groundwater now and in the future, institutions in managing groundwater are weak in the Addis Ababa Region. This is a point of concern as one would expect in the country Addis Ababa to be a front runner in this field. Monitoring – either of water levels or water quality is not taking place at the moment. The regulatory framework arrangement concerns mainly well licensing by EPA and the OWRB. The capacity of EPA in this respect is very limited and in fact the wells that are licensed are the ones developed by AAWSA. With a few exceptions privately developed wells are 'out of sight'. A more intensive use of groundwater would require a commensurate development of groundwater management institutions.

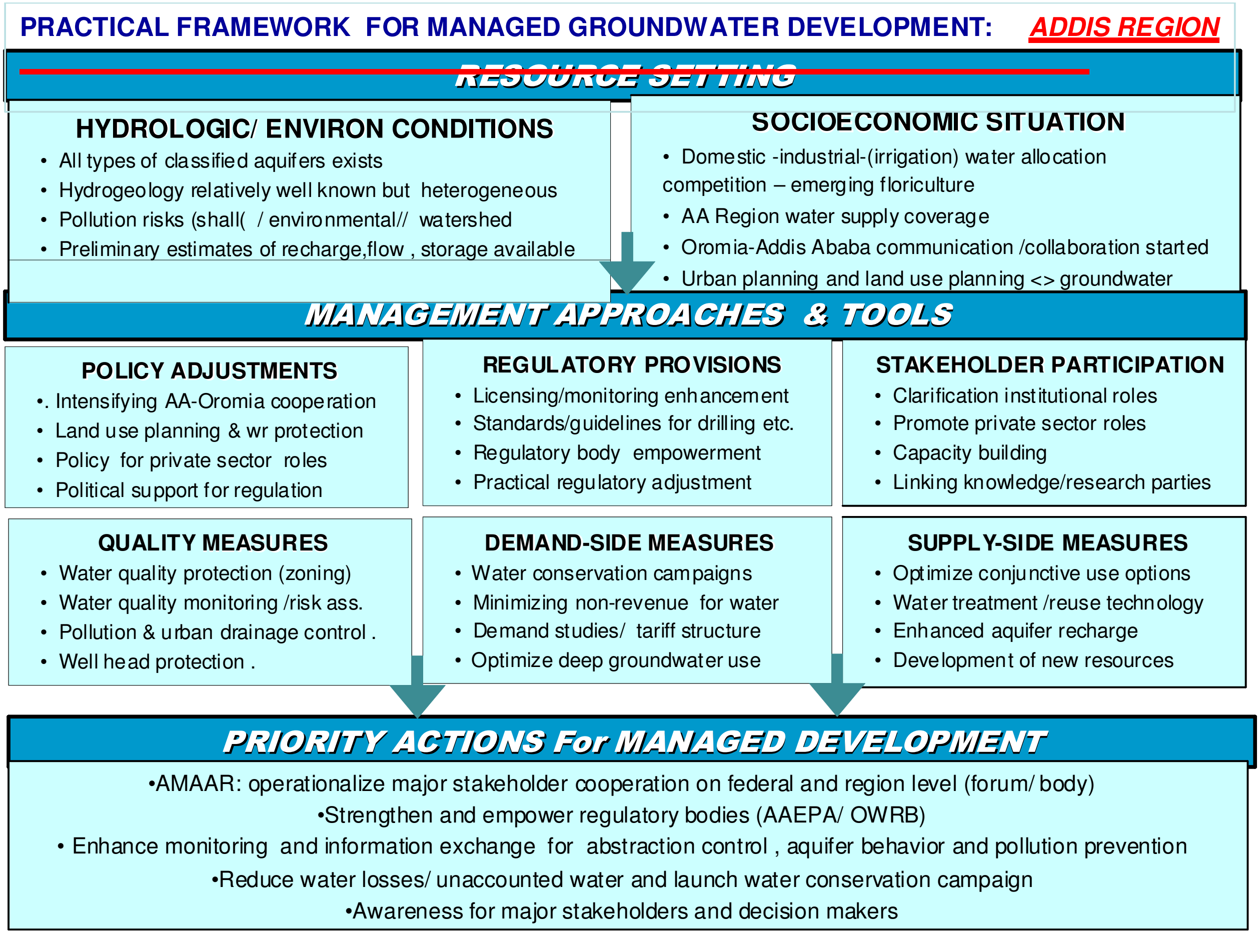


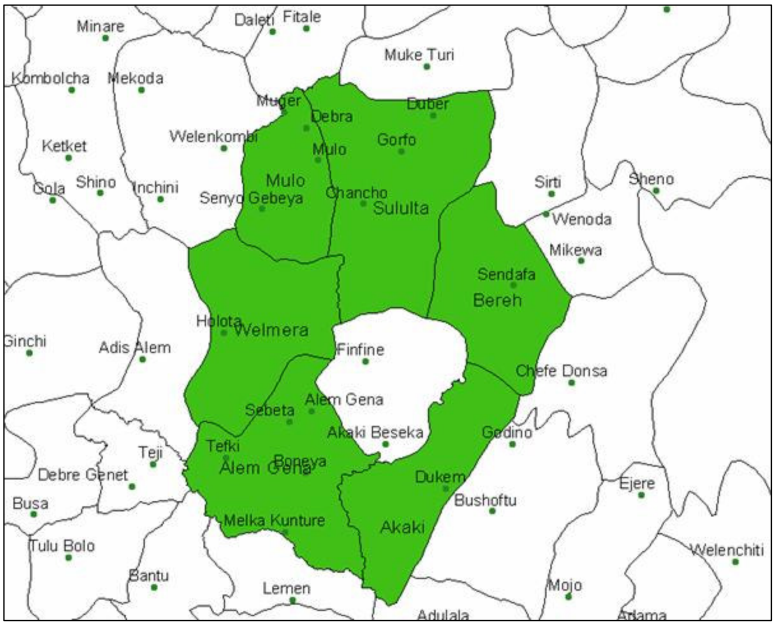
Figure 8 Practical framework for managed groundwater development in Addis Ababa region

Below the approaches in terms of policy adjustments (4.2.1), regulatory provisions (4.2.2) and stakeholder engagement (4.2.3) are described as well as the groundwater quality measures (4.2.4) and the supply and demand measures (4.2.5 and 4.2.6). This leads to priority actions that are described in the next section.

4.2.1 Policy adjustments

Cooperation between Oromia and Addis Ababa

An encouraging development is the cooperation between Addis Ababa and Oromia Regional State with respect to land use planning and regional development. Cooperation between Oromia Regional State and the Addis Ababa Administration needs to be further elaborated, since the aquifer is shared between the two regions. The Oromia Special Zone Surrounding Addis Ababa consists of six woredas surrounding Addis Ababa (see map). Integrated land use plans have been prepared for these woredas and the eight major towns located in these. Part of the land use planning is the preparation of a Green Belt. The Special Zone constitutes a large part of the recharge area for the shallow aquifer. Cooperation between the Addis Ababa Administration and the Oromia Special Zone



Administration should be intensified to include the management of surface and groundwater.

Figure 9 Oromia Special Zone (in green)

Linking land use plans and groundwater management

Land use plans are being prepared and near completion for the Oromia Special Zone. In the land use plan prime land is allocated for agriculture and horticulture, whereas land that is less suitable is allocated to industry, housing, quarrying and others. The development of new heavy industry is planned in the South East of the Special Zone, away from the shallow aquifer recharge area. Environmental protection zones are planned around the urban centers, stretching for 3-5 kilometers. Along perennial and intermittent streams and around reservoirs buffer strips of 50 to 100 meters have been designated. The land use planning could be further expanded to include managed recharge – retaining run-off in recharge zones, dovetailing road design and urban design with recharge.

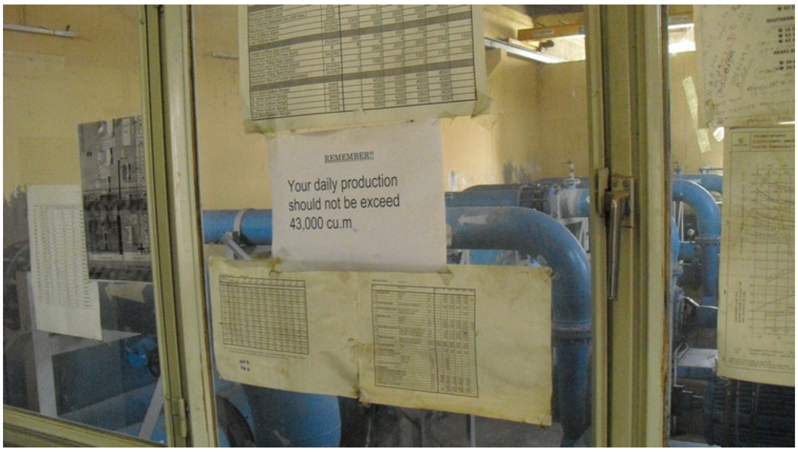
Policy for private sector roles
As described in the National Framework, where groundwater has taken off it has been through private sector investment and services. This requires both a facilitating environment and a regulatory regime. There needs to a clear vision on how to engage the private sector in groundwater development and management in the Addis Ababa region, including:

- Clarity on regulatory procedures
- Opportunities to develop private sector role and capacity in drilling, well operation, monitoring compliance and communication.

Support for regulation
The reverse side to enlarged private sector involvement is better regulation. Currently regulation is weak and has no priority, as is clear to the meager manpower dedicated to it, the logistical means and the political support for enforcement. If groundwater use is to intensify and extent to agro-economic use, regulatory activities need to be better resourced both in Addis Ababa and in Oromia. This should start by enforcing the regulations that are there by making the minimum required resources to do so available.

4.2.2 Regulatory provision

Enhancing monitoring capacity
Monitoring – even on the Akaki well field – is non existent. Basic information on groundwater levels or total number of functioning wells for instance has not been recorded, making it difficult to make an assessment of the sustainability of groundwater extraction – by AAWSA and by other groundwater users . It is proposed to develop the monitoring and management of the Akaki well field – also to set an example nationally (see chapter 3.2). AAWSA already has a field unit that records abstraction and sees to it that the estimated safe yield is not exceeded. Recording water table depths and water quality should be added to its workload. A monitoring plan for Addis Ababa region should be developed and implemented.



Abstraction monitored in Akaki wellfield

Well development guidelines

It is proposed to develop national well drilling guidelines and the Ministry of Water Resources has made a start of this (see also chapter 3). The urgency of these guidelines is particularly high in the Addis Ababa region where intense exploratory and exploitation drilling is taking place. In the drilling of the test wells a large variation in quality and techniques is observed. The well drilling guidelines would help to set quality standards in well development and to protect the well drilling sector against unfounded complaints. The well drilling guidelines should make use of standardized well designs – in the case of Addis Ababa in particular the diameter of the wells should be revisited, as the wells that are currently drilled are over dimensioned which adds to the cost.

Strengthen regulatory body

Groundwater regulation should be strengthened. Licensing is now done by Addis Ababa EPA and Oromia Water Resources Bureau[11], but the effort is piecemeal and incomplete. There is a large backlog particularly in the Addis Ababa city limits with many wells unregistered. Any effort in groundwater regulation should start with reconstructing an up-to-date data base of production wells – privately and publicly owned. There have been cases of the EPA being overruled moreover by the major stakeholders – when it objected on the development of some new AAWSA wells. Rather than overruling it is better than adding an objection clause to the current regulation. All in all regulatory enhancement should be practical with licensing and after licensing requirements being at par with the capacities of the regulatory bodies and the well owners.

4.2.3 Stakeholder involvement

Clarify institutional roles

There are a large number of organizations who activities have a bearing on the sustainable use of groundwater – from both regulation, abstraction, recharge and quality point of view. It is encouraging that groundwater has already moved into the realm of land use planning – opening the scope to manage groundwater beyond the water domain, yet there is no organization that masterminds the management or development of groundwater.

At federal level the main stakeholders are the Ministry of Water Resources, the Federal Environmental Protection Agency, the Ministry of Mines and Energy - in particular the Ethiopian Geological Survey, the Ministry of Agriculture (as it concerns land use), the Ministry of Urban Planning and Ministry of Health and in the private sector the Drillers's Association. At regional level the stakeholders are the Oromia Water Resources Bureau, the Addis Ababa Water Supply and Sanitation Authority, the Addis Ababa Environmental Protection Agency, the Oromia Land and Environmental Protection Bureau, Housing Bureaus and Regional Urban Bureaus – apart from private sector service providers and users. The activities of all organization have a bearing on groundwater use and management. Roles should be clarified – between federal/regional organizations and

[11] These are both suitable short and medium term arrangements of convenience – in the long run a dedicated licensing office under the regional government maybe more appropriate – as in OWRB there is a conflict of interest as the OWRB also commissions well drilling and AA-EPA mandate is on overall environmental management.

between regional organizations – as well as the mechanism to coordinate the different interests. Section 3.2.2 is a proposal for a better definition of roles at national level. The same should be done for the Addis Ababa area. Several of the organizations mentioned above undertake activities that have a bearing on sustainable groundwater management – but so far have no explicit program in the field.

Capacity building

As the use of groundwater intensifies, the need for trained staff and informed users increases. This point was also made in the discussion of the national framework (section 3.2.3 and annex 3). The large need is for drilling supervisors, hydrogeologists and groundwater development and groundwater management. As the region is well endowed with educational institutes educational programmes and in-house training should be dovetailed (see also next)

Linking knowledge and research parties

The complaint from practioners and policy makers vis-à-vis the knowledge institutes is that (a) groundwater development and management gets very scant attention and (b) the attention is often far from practical. There is a need to reengage – by having trainee ships, guest lecturers, discussion on the curriculum and engaging university staff and students in studies. This is possible with the universities and vocational training centres in the region. A mechanism that can be utilized in this respect is the University Water Sector Partnership that aims to bridge this gap and coordinate activities in this respect.

Private sector roles

Private sector roles in groundwater development need to expanded and intensified – among other with the help of the Drillers Association that is being developed. Incentive structures should be created for private well developer to expand their business – both through contract arrangements and through financial incentives. At present focus has been on strengthening public sector for instance through procurement of drilling rigs – but more incentives should be created by strengthening private sector capacity. This can be done by a number of activities:

- License companies for drilling in shallow to very deep aquifers
- Carry out regular audits of work done by drillers and consultants, and link extension of permits to performance
- Design guidelines and schedules, standards and norms for borehole drilling project implementation
- Include borehole siting specifications in standard contracts as well provision for failed drillings
- Closer monitoring of NGOs and enforce implementation procedures according to standard documents
- Introduce engineer’s estimates for drilling and siting
- Review taxation framework for the sector and introduce incentives such a the waiving of import duties and VAT and special loans – as is being considered now for public enterprises

- Facilitate access to credit for drillers and consultants
- Set up training programmes (collaborate with private sector) and courses
- Improve compliance and enforcement of water laws, permits and licensing conditions for drillers and consultants.

4.2.4 Quality measures

Water quality protection through zoning

The importance of protecting the quality of the vital groundwater resources in view of rapid urbanization and industrial development in the Addis Ababa region is imperative for long term sustainable development.

An elaborate study[12] undertaken with the help of UNEP and UNESCO has mapped the risk of groundwater contamination in the area and is still valid. This should be the basis of zoning regulation, that would regulate the siting of potentially polluters – petrol stations, industries, waste disposal plants and the investment in sanitation measures. In addition protection zones based on pollutant travel time around critical assets – in particular large well fields – should be enforced. Maps should be produced that make the zoning visible in a single overview. Sustainable abstraction rates of well field shall be determined through integrated methods.

Water quality monitoring and risk assessment

Monitoring of groundwater quality should start to be able to assess the degree of contamination. At present groundwater quality monitoring is being done fragmentarily. This should also be tied to drinking water provision for the city and the surrounding towns and become a routine activity on given production and observation wells.

Well head protection

Insufficient well head protection has been identified as a cause of deteriorated water quality in the Akaki well field. Part of the well design standards proposed to be developed as part of the National Framework would be to include well protection. Observations around Akaki for instance show that there are sources of seepage from drain water surrounding some of the wells. This needs to be corrected.

Scope for improving well head protection

[12] Tamiru Alemayehu, Dagnachew Legess, Tenalem Ayenew, Yirga Tadesse, Solomon Waltenigus and Nuri Mohammed (2005), Hydrogeology, water quality and the degree if gorundwater vulnerability to pollution in Addis Ababa, Ethiopia. UNEP, UNESCO.

4.2.5 Demand side measures

Reduce unaccounted for water

Though water availability has not reached the critical levels it has in several other fast growing third world cities water sources is precious and needs to be saved. In Addis Ababa city the figure for so-called unaccounted for water are in the order of 30-40%. Clearly such figures are at variance with the high costs of exploring and developing water resources in the larger Addis Ababa area: particularly as the city depends on sources outside the municipal borders it is difficult to accepts such large losses.

There are two categories of unaccounted for water – the water that is supplied but does not show up in the financial records and the water that is lost due to leakage. From a water resource management point of view it is very important to control the second category of loss. This goes beyond water saving. Leaks are also a major reason for the contamination of the water supply systems – with sewage entering into the pipe network. This is a major issue in Addis Ababa with the older parts of the network not well mapped and waterlines passing through areas with high water tables and nearly 'floating' latrines.

Water conservation campaigns

Water conservation is also an important issue in (future) agricultural use. Particularly as deep aquifers with large recharge times will be developed at substantial cost judicious use is important. This should be encouraged by at least full real cost pricing for agricultural consumption (i.e. O&M, investment and maybe even an assessment for the resource cost).

Looking at tariff structures

Tariff structures particularly for large consumers should reflect and should encourage efficient water use – not necessarily through paying for water consumed but also by bonus or malus system for efficient respectively wasteful water use. The current trend of including environmental cost to creat sustainable environments should be encouraged – as recently was done by adding the charges for solid waste collection to the water bill – making it also more straightforward to collect such costs.

The value of water is apparent from the difference in land prices in area with and without reliable surface. This difference in prices should also be captured by the water service provider and regulator.

4.2.6 Supply management

Conjunctive use

Several supply side measures are to be undertaken to ensure the sustainable management of the groundwater resource. Conjunctive use is an important one. In case of the Addis Ababa area the operation of surface water reservoirs and groundwater abstractions should be synchronized. This has two dimensions:

- The surface water storage is more vulnerable to dry spells. By maintaining a balance in water supply from both surface water and groundwater, the provision of water to Addis Ababa and other fast growing cities in the region is secured during cycles of dry years too.
- There is also a need to consider the sharing of water from both (newly developed) surface water and groundwater sources between the Addis Ababa Special Region and the Oromia Regional State – particularly in the Growth Zone and there is hence a case in future water resource development plans to take into account the interests of the entire urban conglomeration

Enhanced aquifer recharge

In the catchment of Addis Ababa there is scope for enhanced recharge – particularly when linking recharge to improved watershed management programs, road planning and land use planning.

Also the urban surface entire in the region increases the removal of storm water – and subsequent retention and reuse becomes more important. Storm water can be collected and spread over recharge zones – provided water quality allows.

Managing waste and storm water

Water use in the Addis Ababa area depends on both surface and groundwater and it is important that water from both sources is managed in a conjunctive manner. This concerns the water supply to Addis Ababa – where groundwater can act as a safety valve in drought years – compensating for low surface water supplies.

There is also a case to link waste water and storm water into conjunctive management. Both sources can be an opportunity as source of recharge and storage but also a threat i.e. as a source of contamination. The planning of the sewer and waste water disposal system should take this into account. The following areas are of help:

- Most sewerage water in Addis Ababa is untreated. By anaerobic or aerobic treatment waste water can be made reusable for recharge or linkage to surface storage bodies
- Related to this using natural wetland areas and lakes around Addis Ababa should be investigated for their contribution to improved water quality (the kidney function) and creating other high value amenity (recreation, attractive housing)

Develop of new groundwater sources
The development of new groundwater resources should be accelerated – following the ongoing assessment. Several promising well field location have not been explored.

On-going exploration and development of deep aquifers

4.3 Priority actions for managed development in Addis Ababa area

The following five priority actions are proposed:

- Setting up an AMAR: a forum or body for groundwater management in the Addis Ababa and Oromia as a mechanism for coordination and stakeholder cooperation
- Strengthen and empower regulatory bodies in Addis Ababa and Oromia Region
- Enhance monitoring and information exchange for abstraction control , aquifer behavior and pollution prevention
- Reduce water losses/ unaccounted water and launch a water conservation campaign
- Create awareness among major stakeholders and decision makers

AMAR – shared groundwater management arrangements
The main immediate action is the establishment of arrangements for shared groundwater management arrangements in the larger area surrounding Addis Ababa. It is proposed to strengthen stakeholder cooperation in the aquifer surrounding Addis Ababa and come to an AMAR – Aquifer Management in Addis Ababa Region. It is proposed that the Ministry of Water Resources initiates this process – and brings together the main parties from both Addis Ababa and Oromia Region.

Proposed is to link the AMAR strongly to the Oromia Special Region Administration and the Addis Ababa City Administration – preferably as a partnership initiative of both organizations. The proposed area of operations of the AMAR would be as given in figure 9. The area (measuring 12,600 km2) concerns the area of recharge and discharge of the very shallow, shallow and deep aquifer systems – and the area of discharge of the very deep aquifer.

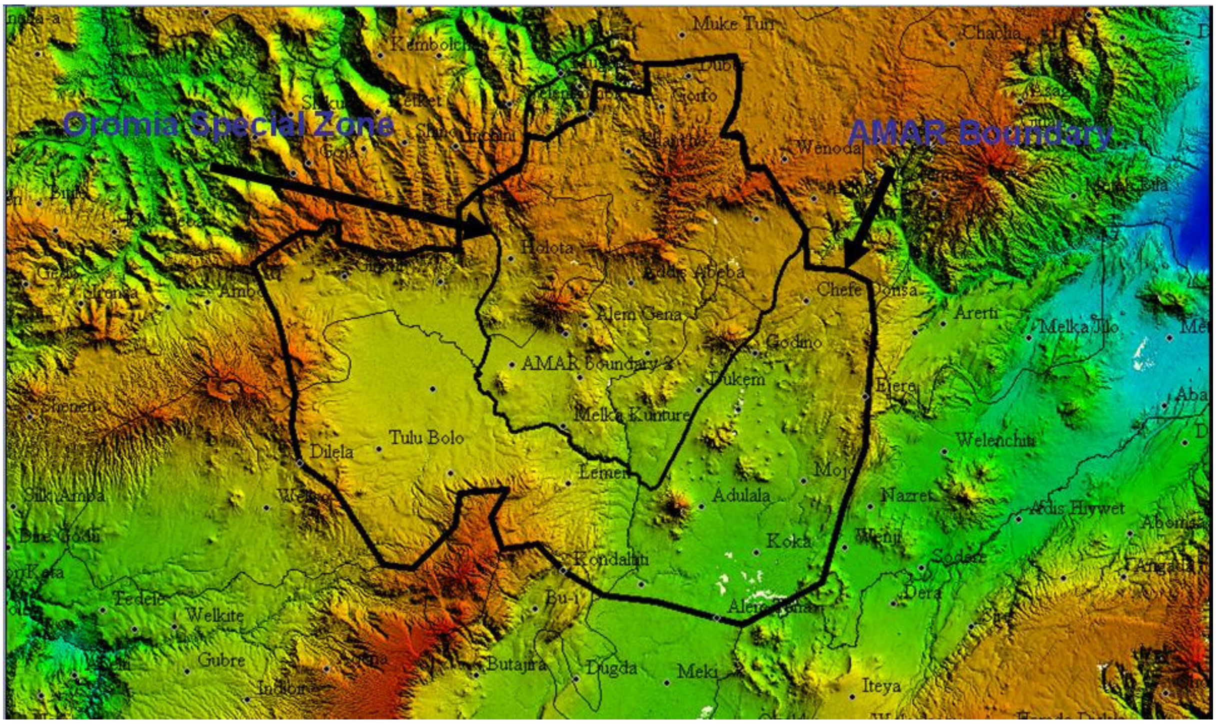


Figure 10 Proposed area of operation of AMAR (Aquifer Management in Addis Ababa Area)

The tasks of the AMAR could be:

- Coordination mechanisms between the two states on groundwater assessments, groundwater development and conjunctive water management – including urban drainage, waste water reuse and coordinated reservoir operations.
- Coordination with all parties in the two states on steps in groundwater protection – including land use planning and zoning
- Clearing house for all existing studies and information sources (including real time monitoring outcomes) with respect to groundwater
- Initiate inventory of current abstraction with Addis Ababa Environmental Protection Agency and Oromia Water Resources Bureau
  Coordinate promotion and awareness campaign both for general audience and professional/ decision making audience on aquifer characteristics and risks and opportunities of groundwater development in the larger region.

If basic agreement on the AMAR is reached the institutional setting, staffing, short-term program, establishment and operational budget can be worked out.

Improving current regulation of groundwater use

The AMAR needs to be supported by ample regulatory capacity in both Addis Ababa and Oromia Region. In both Oromia and Addis Ababa regulation of groundwater use should be strengthen and empowered. This requires:

- Increase staffing and logistical arrangements
- Widely announce licensing arrangements
- Undertake well inventory
- Retroactive licensing where appropriate, but also where necessary closing wells.

Enhanced monitoring and information exchange

Monitoring of groundwater levels and groundwater quality needs to start – preferably under the aegis of AMAR. A routine basic monitoring program should be put in place, consisting of:

- Measurement of discharge from well on the basis of water meters on selected wells. The discharge measures should be cumulated daily as well as weekly, monthly and annually
- Water quality should be sampled on production wells – preferably by the well operators and the requirement to sample quality twice a year should be part of the license
- In well field areas special monitoring wells should be established – indicatively one out of 20-40 wells. From these monitoring wells one month conductivity and temperature at different depths should be collected, as well as a full set of water quality indicators twice a year.

These data should be made available in the public domain – preferably as part of the AMAR outreach programs.

Reduce water losses and unaccounted for water

A measurement program assessing the main losses should be undertaken both in Addis Ababa and in other main settlements in the region. The first step is to single out the areas of major losses on the basis of area inflows and consumption estimated – followed by using techniques and equipments for leakage detection and control in the distribution system. Next the scope for leakage control will be elaborated focusing on pressure dependent outflow; optimal valve locations; and the design of pressure management areas.

Annexes

ANNEX 1: OVERVIEW AND STATUS OF ONGOING GROUNDWATER DEVELOPMENT PROJECTS

Introduction

Ethiopia expects to have a substantial potential of groundwater resources that can be exploited for the economic development of the country. Currently water supply requirements of towns and rural communities are partially met from groundwater and there is an understanding that this huge resource can be further utilized for the development of irrigated agriculture activities in the country. Cognizant to these resources currently the Ethiopian Government is investing on groundwater development activities in different groundwater basins in the country.

Projects under study and design

1 Ada GW development study project: (Calendars in bracket are European calendars)

- Starting & completion period 1998 – 2002 (2005/06 – 2009/10)
- Feasibility studies completed and remaining activities are expected to be completed in 2002(2009/10)
- Budget: 141Million Birr;
- Fund source: GOE

2 Aladige GW Development Study Project

- Starting & completion period 1998 – 2001 (2005/06 – 2008/09)
- Feasibility studies completed
- Budget: 90Million Birr;
- Fund source: GOE

3 Mekelle & Surrounding GW Development Study Project

- Starting & completion period 2001 – 2003 (2008/09 – 2010/11)
- Feasibility studies on progress
- Budget: 50Million Birr;
- Fund source: GOE

4 Upper Tekeze GW Development Study Project

- Starting & completion period 2000 – 2002 (2007/08 – 2009/10)
- Feasibility studies on progress
- Budget: 50Million Birr;
- Fund source: GOE

5 Teru GW Development Study Project

- Starting & completion period 2000 – 2002 (2007/08 – 2009/10)
- Feasibility studies on progress
- Budget: 40Million Birr;
- Fund source: GOE

6 Wolkite-Ambo GW Development Study Project

- Starting & completion period 2001 – 2003 (2008/09 – 2010/11)
- Feasibility studies on progress
- Budget: 40Million Birr;
- Fund source: GOE

7. Ketar GW Development Study Project

- Starting & completion period 2001 – 2002 (2008/09 – 2009/10)
- Feasibility studies on progress
- Budget: 5Million Birr;
- Fund source: GOE

8. Ogaden GW Development Study Project

- Starting & completion period 2001 – 2006 (2008/09 – 2013/14)
- Feasibility studies on progress
- Budget: 60Million Birr;
- Fund source: American Government

Projects under construction

9 Kobo Trial GW Construction Project

- Starting & completion period 2000 – 2001 (2007/08 – 2008/09)
- Construction work is completed
- Budget: 10Million Birr;
- Fund source: GOE & Hungary Government
- Developed area so far (trial plot): 30ha
- Consultant: MCE PLC
- Beneficiaries: 90HHs (households)
- In 2002 (2009/10) planned to develop 300ha

10. Kobo-Girana GW Design & Construction Project

- Starting & completion period 1998 – 2003 (2007/08 – 2008/09)
- Detailed Design work: 90% completed
- Budget: 171Million Birr;
- Fund source: GOE

- At completion expected to develop 17,000ha
- Developed area so far (trial plot): 30ha
- Consultant: MCE PLC
- Beneficiaries: 68,000HHs (households)
- In 2002 (2009/10) planned to develop 300ha
- Well Construction 86% completed

11. Raya GW Design & Construction Project

- Starting & Completion period 1998 – 2003 (2007/08 – 2008/09)
- Detailed Design work on progress and 90% completed
- Budget: 233Million Birr;
- Fund source: GOE
- At completion expected to develop 18,000ha
- Developed area so far (trial plot): 267ha
- Consultant: WWDSE
- Beneficiaries: 72,000HHs (households)
- In 2002 (2009/10) planned to develop additional 300ha
- Well Construction 80% completed

12. Fifteen Towns Water Supply and Sanitation Implementation Project

- Start and Completion Date: April 2007-April 2012.
- Budget: 36,2 M Euro
- Fund source : European Commission /grant/-16,500,000 Euro
  European Investment Bank /loan/-16,500,000 Euro

  Government of the Federal Democratic Republic of Ethiopia-3,222,100 Euro

- Project Status:
  - Draft design review and tender document preparation submitted by the consultant under review;
  - Tender document for the supervision consultancy, institutional strengthening of town water boards and town water supply and sanitation services under review;
  - Draft of concept to procure of Access to Water Facility under review;
- Implementing Agency: Ministry of Water Resources. Regional Water Bureaus facilitates the implementation in their respective regions
- Project Components:
  - Water supply and sanitation Provision;
  - Institutional capacity strengthening of Town Water Supply Services and Town Water Boards of 8 Towns.
  - Access to water facility: Provision of long term credit service for connection fee for poor households who can not afford paying connection fee at the beginning but willing to get connected to the towns' water supply system. The total number of households estimated to get this facility in 15 Towns is 40,000.

- Target Regions: Amahara, Oromia, SNNP and Tigray Regions
- Beneficiary Towns:
    - Amhara –Seven Towns -Injibara, Motta, Ataye, Mersa, Shoa Robit, Were Illu, and Kemise
    - Oromia-Four Towns -Holeta, Fitche, Gebere Guracha, and Dembidollo
    - SNNP-Two towns -Soddo and Bonga
    - Tigray-Two Towns -Machiew and Adigrat
- Expected Results
    - Water supply and sanitation systems of the towns constructed/improved to accommodated the current and future (2020) water demands;
    - Poor households have improved access to individual connection to the towns water supply services through access to water facility;
    - Public sanitation facilities constructed and become operational in the beneficiary towns;
    - Efficient and sustainable management system put in place in the beneficiary towns water supply and sanitation service enterprises and also capacitate water boards through capacity building

13. Tana Beles Groundwater Assessment

    - Assessment of conjunctive groundwater potential surrounding Lake Tana

Lake Tana sub-basin and adjacent (e.g. Beles Basin) basins have high potential soils for agriculture and livestock development. Currently the sub-basin economy is dominated by rainfed agricultural and livestock. Although the sub-basin has high rainfall and a number of perennial rivers, the potential agricultural could be further developed if more water is available. Moreover, there is already a growing competition of water use for hydroelectric power, tourism and recreation (Tis Abbay fall), irrigation and lake transportation. Groundwater potential in Lake Sub-basin and adjacent areas will complete the hydrological studies under the World Bank supported Tana/Beles IWRM Project (TBIWRDP) and provide the basis for a water resources planning and development strategy aimed optimize water uses in the basins while minimizing competition.

In addition to the above conditions, the Ethiopia Irrigation and Drainage Project (EIDP) currently under preparation with World Bank support, aims to increase irrigated area through investments that are cost effective, environmentally and socially sound, and beneficial to the rural poor. The initial identified development sites are mostly centered around Lake Tana sub-basin (Megech, Ribb etc). Because of the competing uses of water of Lake Tana and its sub-basins, an assessment of all available water resources is critical for such development.

In 2007 a ToR was prepared for an integrated groundwater assessment study under the Tana Beles IWRM project. This study is currently implemented under a consultancy contract and will be completed in 2011. The outcome of the study will be used to set up a groundwater development and management plan for the Tana Beles basin.

ANNEX 2: SUMMARY OF ISSUES IN KNOWLEDGE, CAPACITY AND MANAGEMENT

Knowledge

Issue	What is being done	What is missing
Geological surveys	- Geological maps (1:250000) 50% of the country - Hydrogeological maps 39% of the country - Based on borehole information not on test drilling information - Accelerated investment in assessment/exploration - implemented by MoWR and regions - MoWR largely engages the public enterprise WWDSE for this purpose	- Integrated groundwater exploration including test drilling for high potential areas - Lowered pace in covering the remaining area through mapping: EGS not able to live up to its mandate - Current assessment project wise and not linked to EGS set procedures

Information base	- Limited knowledge on:
	    o very shallow aquifers
	    o deep aquifers
	- Non reliable knowledge on shallow aquifers
	- Water quality has not been well defined and mapped
	- Scattered information – work on ENGDA discontinued
	- NGIS recently started
		- NGIS to be developed over coming years
		- Communication and dissemination strategy/ business plan

Monitoring	- Not done only patchy and project based – not even in high intensity area as in Akaki - Emerging uses of groundwater for irrigation and seeking deep aquifers for their high yield and lowered pumping cost demands very systematic monitoring	- MoWR to gazet priority areas for monitoring - Clear responsibility for well field operators - Link to NGIS
Sustainable yields	- First estimates for number of aquifer systems – but not for others - No water balances	- Confirmed prior to operation of well field - Level and abstraction monitoring in line with confirmed sustainable yield - Link to groundwater management plans

Capacity

Issue	What is being done?	What is missing?
Exploration	- Poor capacity to explore deep aquifers – poor supply - Public enterprises have poor capacity and management in complex well drilling - Little engagement of private sector in drilling complex exploration - Problematic contract management observed from both sides – supervision/ contract management	- No (in-country) training on deep well drilling - Limited number/no critical mass of organizations - Good supervision (arrangements) missing
Mechanical drilling	- Absolute shortage of drilling rigs (conservative estimate is 200) – partly addressed by recent procurement drive - Shortage of submersible pumps, generators and spare parts - gap in local maintenance capacity and supply of fast moving items.	- Drilling rigs – specific to conditions (deep wells/ sediments) - Maintenance of drilling rigs to ensure continued operation
	- Presumably relatively high cost of drilling compared to other African countries	- Competition and little engagement of private sector
	- Relatively high number of failed wells – 15% to 75% varying with regions	- Analysis of well failure – probably related to lack of local engagement/ technical supervision – in some areas due to water quality issues
	- Discussion on standardizing well design started by MoWR	- Standardization
	- Drilling association just set up	- Drilling association to become active partner in development of the sector
Manual well development	- Limited well development even in high potential ultrashallow aquifer - Dugwell dominate	- Very shallow borewell technology – which allows deeper penetration - TVETs engagement/ private sector training - Popularization of manual drilling – among others
Expertise in groundwater development	- Pump tests not systematically done - 25-60% vacancies (JICA report)	- Training of: chief drillers, hydrogeologists and water supply engineers - High capacity equipment for pump tests and well development
Expertise in groundwater management	- Groundwater curricula recently being strengthened in five universities	- Capacity to monitor in terms of manpower and equipment - Centres of Excellence in Groundwater development

Management

Issue	What is being done	What is missing
Managed development	- Accelerated highly ambitious exploitation plans/ concept for growing number of areas	- Groundwater management plans – with stakeholder engagement
Interlinkage with other sectors on demand side	- Land use planning process – based on started in Oromia, Amhara, Somale and Afar - Growth corridors plans - UAP	- Need to expand and need to broaden and put implementation perspective/ EGRAP Plus
Interlinkage with other sectors on supply side	- Watershed improvements programs exists but no focus on recharge - Irrigation development but not conjunctive	- No systematic linkage and not all buffer techniques used - Conjunctive management
	- Integration with land use planning on supply side	- Harmonize watershed programs with buffer management – differentiated approach
GW protection	- Not there - No specific guidelines for point or non point pollution	- Protection zones in selected areas (legal backing?) - Regulation around high priority point pollution
Regulation	- Licensing procedure for well development in place but not known nor systematically followed - Civil code set the limit for regulation at 100 meter depth	- Activation of licensing procedure – especially in selected areas
Groundwater management plans	- None existent	- Would be required in areas of intensive development
Monitoring	- See above (knowledge section)	-
Basin management	- RBO ordinance promulgation - One RBO in place (Abay), two under preparation - Mechanism for allocation - Groundwater does not figure importantly	- In future ground water management plans linked in to river basin management

ANNEX 3: ASSESSMENT OF THE LABOUR MARKET GAPS IN GROUNDWATER DEVELOPMENT AND MANAGEMENT

In this annex a short overview is given of the missing capacity in groundwater development and management. It is based on: "Ethiopia Water Technology Center (EWTEC). 2009. Training Needs Assessment Survey. Japan International Cooperation Agency (JICA). The Federal Democratic Republic of Ethiopia, Ministry of Water Resources (MoWR). Volume I, Report."

This training needs assessment was based on a sample survey of different water sector organizations. The results in the tables below hence are extrapolations from the sample survey – not the results of a full inventory. Below the capacity needs for the different categories of water sector organization are given.

(1) Regional Water Resource Development Bureaus (RWB)

The current human resource situation in RWB is generally characterized as follows:

- About 31% (281 out of 895) of job positions are currently vacant or planned to be filled in the future (*future recruitment plan of RWB in SNNP was not provided, therefore the percentage of vacant position (31%) is considered minimum)
- Among the professionals, the requirement of hydrogeologists (category no.1), and water supply engineers (category no.4), are relatively higher (Figure 1).

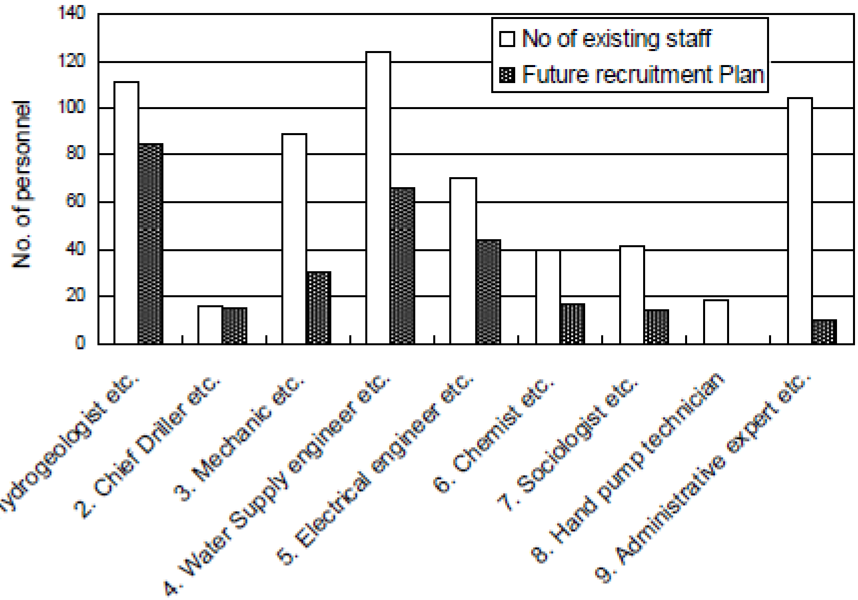


Figure 1: Existing staff and vacant/future recruitment plan in Regional Water Bureaus (RWB)

(2) Zonal Water Resources Development Office (ZWRO)

The current human resource situation in ZWRO is generally characterized as follows:

- About 54% (579 out of 1,076) of job positions are currently vacant or planned to be filled in the future.

- Among the professionals, the requirement of hydrogeologists (category no.1), and water supply engineers (category no.4), are relatively higher. Especially, the requirement of water supply engineer (category no.4), is triple of the existing manpower (Figure 2).

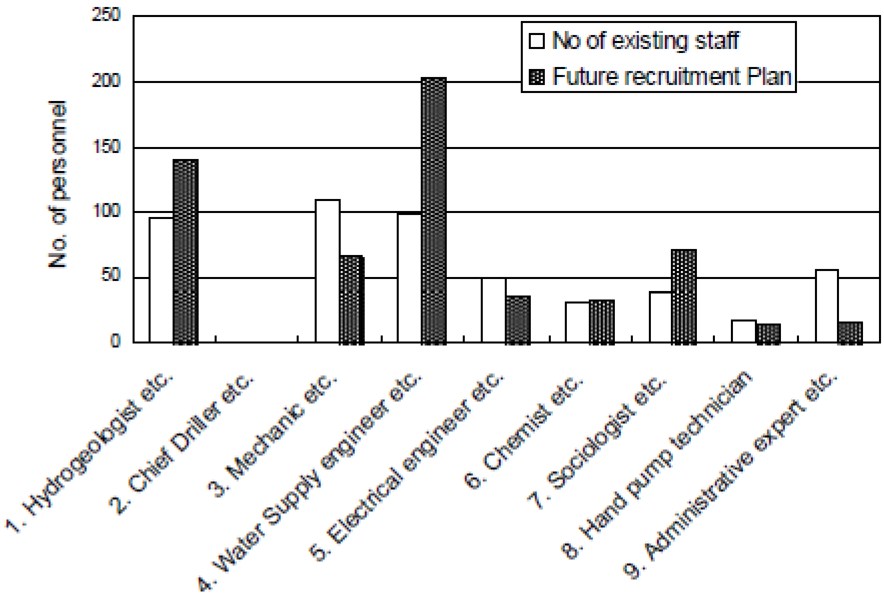


Figure 2: Existing staff and vacant/future recruitment plan in Zonal Water Resources Development Office (ZWRO)

(3) Woreda Water Office (WWO)

The current human resource situation in WWO is generally characterized as follows:

- About 61% (7,447 out of 12,140) of job positions are currently vacant or planned to be filled in the future.
- Among the professionals, the requirement of hydrogeologists (category no.1), and water supply engineers (category no. 4), are relatively higher. Especially, the number of hydrogeologists category no.1), shows an outstanding gap (Figure 3).

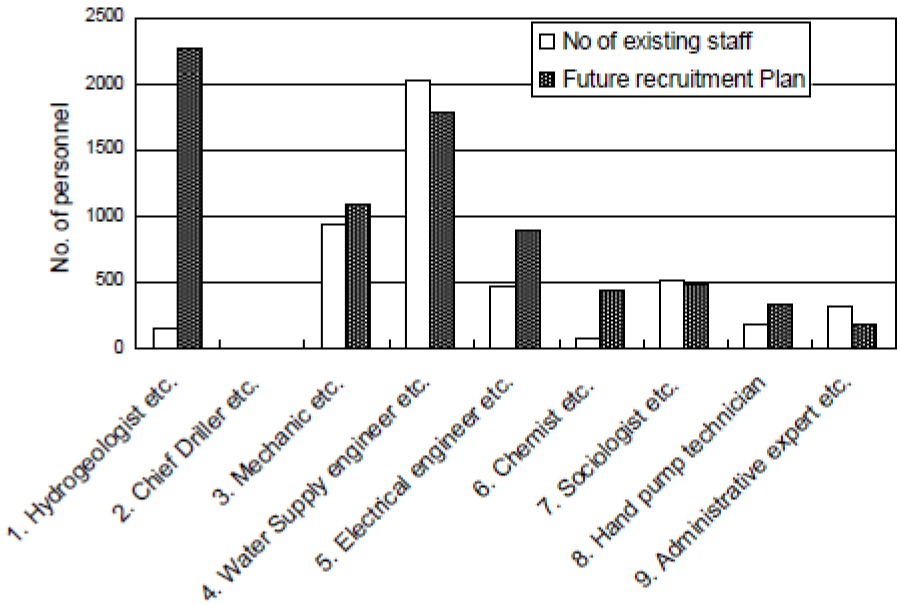


Figure 3: Existing staff and vacant/future recruitment plan in Woreda Water Office (WWO)

(4) Town Water Supply Service (TWSS)

The current human resource situation in TWSS is generally characterized as follows:

- About 25% (1,002 out of 3,740) of job positions are currently vacant or planned to be filled in the future.
- Among the professionals, the requirement of water supply engineers (category no.4), is relatively higher (Figure 4).

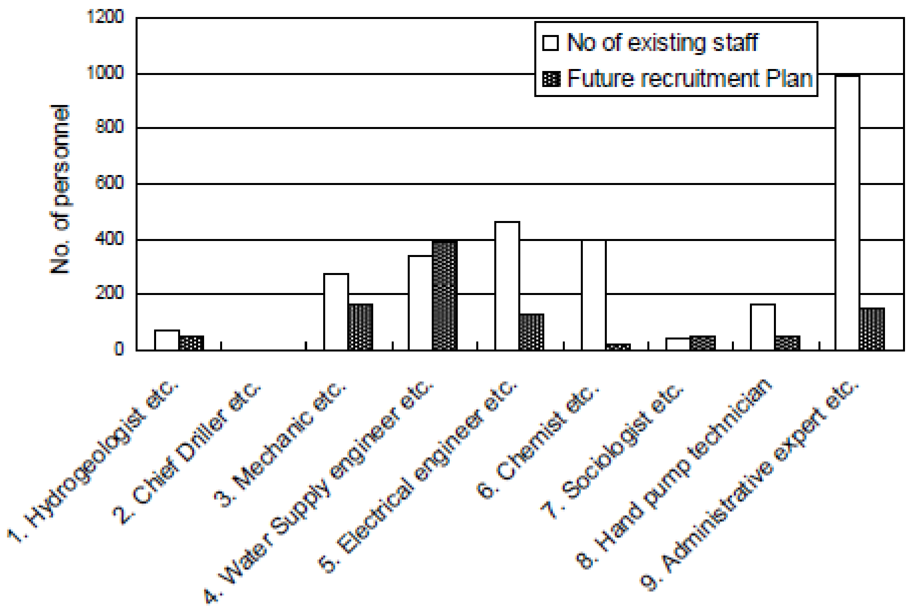


Figure 4: Existing staff and vacant/future recruitment plan in Town Water Supply Service (TWSS)

(5) WWCE, WWDSE, WWDE

The current human resource situation in public enterprises (WWCE, WWDSE, WWDE) is generally characterized as follows:

- About 34% (512 out of 1,503) of job positions are currently vacant or planned to be filled in the future.
- Among the professionals, the requirement of hydrogeologists (category no.1); chief drillers (category no.2); mechanics (category no.3); and water supply engineers (category no.4), are equally high (Figure 5).

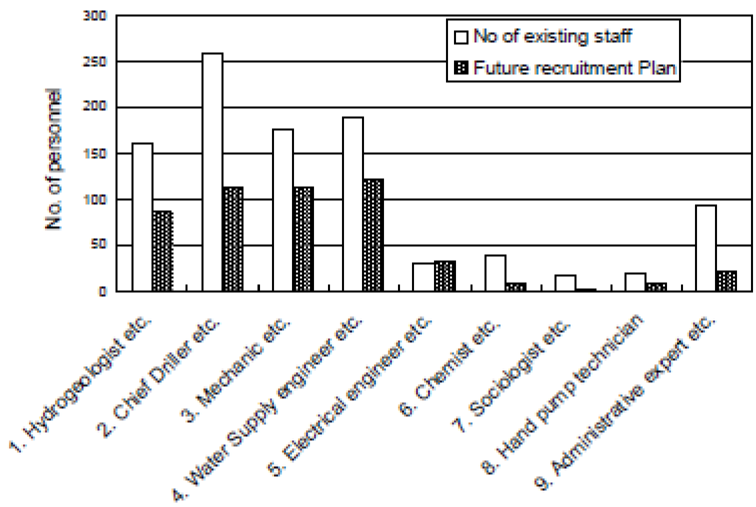


Figure 5: Existing staff and vacant/future recruitment plan in public enterprises (WWCE, WWDSE,WWDE)

(6) Drilling/Water works construction companies

In looking over the technical staff requirement of the studied 12 private drilling companies, the requirement of drillers (chief drillers, drillers, assistant drillers) are very high which is followed by relatively equal high requirement of hydrogeologists, electricians and mechanics.

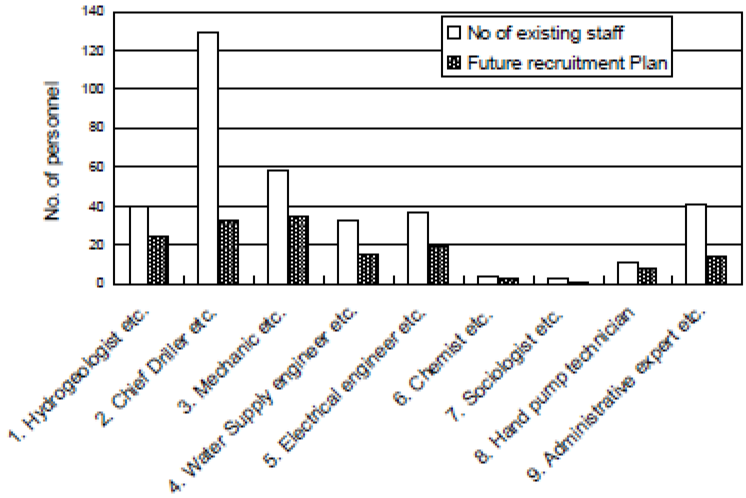


Figure 6: Existing staff and vacant/future recruitment plan in private drilling/water works construction companies (result of 9 companies)

(7) Consulting firms

Among the technical staff requirement of the studied 12 consulting firms, the requirement of water supply engineers (category no. 4), is very high which is followed by Hydrologists (category no. 1)

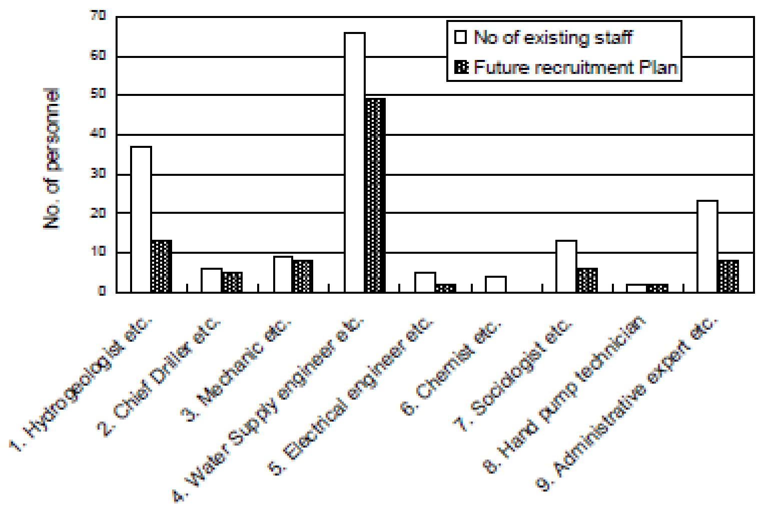


Figure 7: Existing staff and vacant/future recruitment plan in private consulting firms (result of 12 firms

ANNEX 4: STATUS AND ISSUES IN THE REGIONS

Region	Groundwater status	Ongoing exploration	Reported issues
Afar	- High potential expected in Western Afar – adjacent to the Kobo-Raja belt - Salinity issues in Eastern Part	- Deep borehole exploration in Western Afar - Aladige GW Exploration	- Very suitable soils but so far interest in irrigated agriculture among local population is limited – yet high demand to use groundwater for rangeland development.
Amhara	- Large variety of hydrogeological regimes: fractured basalt with little areas of alluvial deposits in the valleys - Regional aquifers expected underneath the alluvial deposits - Promising shallow groundwater resource in flood plains around Lake Tana and in Kobo, Achafer and Bati - Kobo-Girana (about 650l/s) for developing 550ha is operational and 120 wells are on completion to develop 1500ha. The design work for the 1500ha is at its completion phase and construction will be soon awarded. Other ongoing abstraction is limited to the usual water supply for both rural & urban centers. Potential of Kobo well field is 17000ha.	- Exploration afoot in Kobo, Kobo-Chefu and Teru Graben - Groundwater study started in Tana - Six growth corridors identified largely conjunctive use with surface runoff. Reconnaissance study for the eastern growth corridor is expected to be completed in June 2010	- Gojam high potential but being fast degraded - In urban areas water mgt.is insufficient – erosion and lack of conjunctive use - Scope of conjunctive use in newly developed irr.ystems - Plans to develop shallow grw. for irr. on shores of Lake Tana - Groundwater irrigation development started in Kobo - In Bihar-Dar and Kombolcha areas, industrial influents are currently water quality issues
Benishangul Gumuz	- Alluvial deposits - Weathering part of the basement, and fractures zones may yield some water		- Wells being undermined by excavation of gold pits among indigeneous people.
Gambela	- Shallow groundwater potential within alluvial and lacustrine sediment deposit – recharged by annual flooding	- Local studies to develop shallow wells	- Need to understand buffer mechanisms following annual flooding
Oromia (Central Highlands and Rift Valley)	- Shallow groundwater in North Shewa, West Shewa, SW Shewa and Northern shore Lake Ziway - Basalt aquifer in Ada'a Becho plain with indications of regional aquifer	- Regional WWDSE is planning valley development works to have conjunctive use with the surface WRs and also to use GW resources alone especially in the lowlands): Five years plan indicate to drill a total of 6484 BHs in five years out of which: 1950 for rural water supply, 75 for Urban water supply and the balance for agriculture. Plan for irrigation 5000ha per zone (Oromia has 17	- Increased use of shallow GW for irrigation around lake Zeway, Koka, and along perennial & semi perennial rivers - Fluoride occurrence throughout Rift Valley – though low fluoride levels expected at larger depth

		zones) at a rate of 100ha/year - Ada'a-Becho Grw, Dev. study - well fields at detailed feasibility study - Ketar Grw. Dev. Study Project - Addis Ababa Water supply development	
Oromia (Southeast)	- The Mesozoic sedimentary & Tertiary volcanic rocks act as good aquifers - Very shallow aquifer in Harraghe	- See above - Ramis_ Mojo, Shenen- Dhungeta and Borena GW investigation projects	- Studies are showing very encouraging results - GW development for pasture development in Borena
Oromia (West)	- Shallow GW with moderate yield is being developed for domestic use (in parts of Jima, Iluababora and Wellega - Characteristics deeper aquifers not well known	- See above - Wolkite-Ambo GW Development Study Project	- Need for supplementary irrigation to coffee plantations
Somali State	- High groundwater resources expected in northern part of the State, - GWI project has been launched by the SRS	- Ogaden Groundwater Development Study Project	- Plans for 250,000 ha sugar estate - Pilot project to irrigate land of small holder farmers (200 ha) has been started
SNNPR	- Large variation of groundwater situations - Groundwater forest in Nech Sar - Salinity in Omo valley - Potential to use very shallow water in river valleys towards Konso and in Butajira - Almost no groundwater irrigation	- Woreda maps on Fluoride levels - Only 3-4% of area is explored - Groundwater study in Butajira	- Public company can drill shallow wells – not deep ones; not much interest from private parties - 30-40% of SNNPR in Rift Valley: fluoride is a main issues here - Salinity in groundwater in Omo region - Industrial effluent from ceramics factory
Tigray	- Fractured basalt in the highlands, sandstone aquifer in the west areas, and (high potential) alluvial deposit in the south eastern part (Raya-Azebo Well-field) - Structurally controlled valleys are important - Very shallow groundwater in Wukro - Anyelem well field for Mekelle town - In Mekele, hardness is the major issue, in Adwa industrial influent	- Exploration in Raya, Upper Tekeze and Mekelle and surrounding areas - In Raya two well field areas identified: (i) Alemata Basin with potential of about 70,000ha at an abstraction of 87500m^3/hr; and (ii) Mohone basin with a potential of 176315ha and expected abstraction of 169520m^3 - Only small areas developed (in hundreds of ha)	- Overuse and depletion concerns in smaller valleys – affecting river base flows - EPA has institutional problem, - housed in the Bureau of Agriculture and Rural Devt, but this is one of the offices to be regulated by EPA - Raya Valley Development Project started 1996 now accelerated - Food Security Project started 2009 – aims at developing 175000 ha part of which under groundwater irrigation

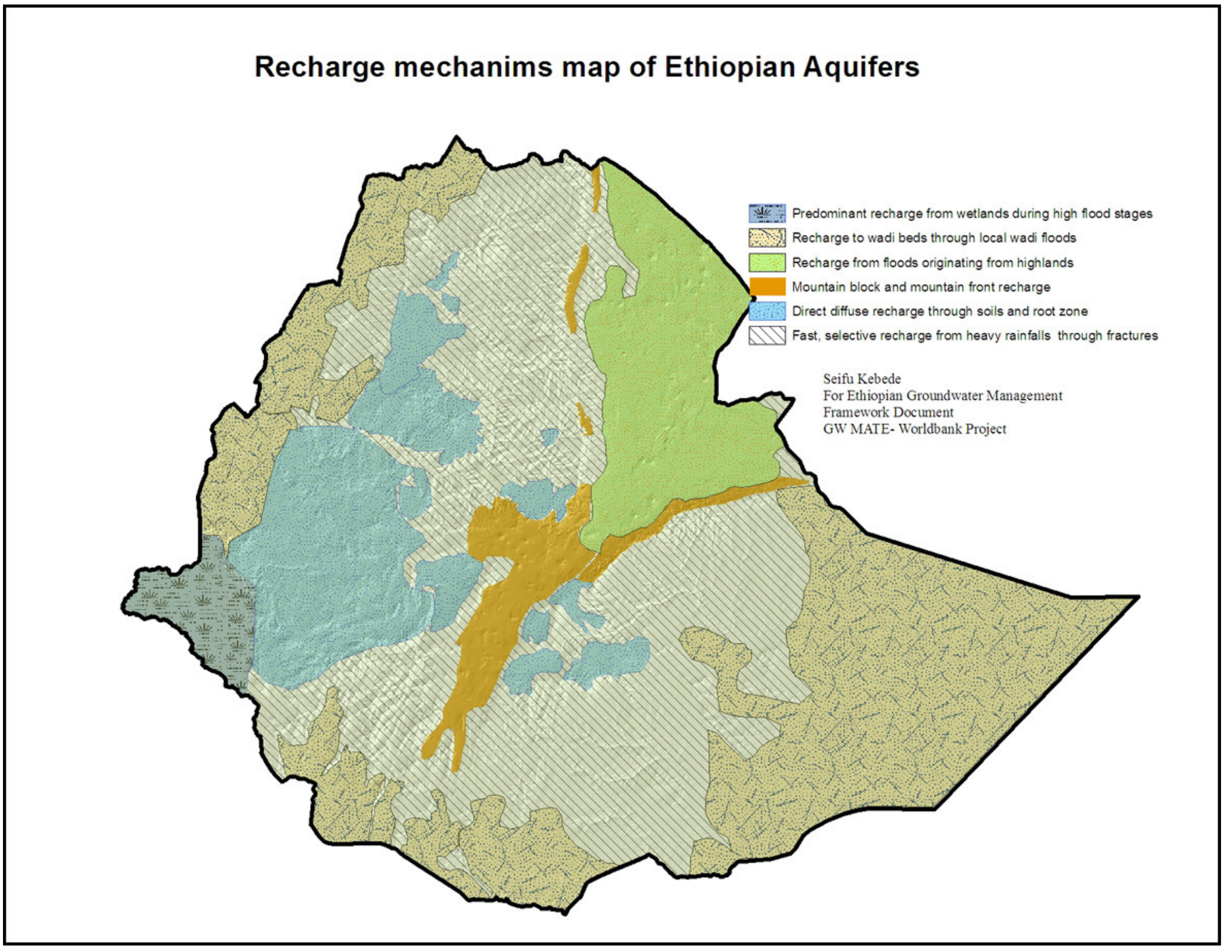
ANNEX 5: MANAGING CLIMATE CHANGE EFFECTS AND GROUNDWATER IN ETHIOPIA

The impact of climate change effects on groundwater depends on a number of factors – but an important factor concern the recharge mechanisms. These recharge mechanism are shown in table 1. Higher intensity rainfall – an important expected effect of climate change will in areas with hard rocks and thin soils led to more rainfall infiltration and recharge. Also in lowlands ephemeral rivers will receive more water and recharge more in case of more intense rainfall. In areas with thick soils high rainfall will not result in more infiltration – but in less recharge.

Table 1

Expected climate change effect	Impact	Response
More extensive drought periods	Drought particularly immediately impacts: - unconfined aquifer - small aquifer systems - dissected aquifer systems (tectonic)	Local buffer techniques – - local storage based on shallow aquifer characteristics
	Drought has less short term impact on: - large confined aquifers (large catchment/rare)	Regional buffer techniques: - watershed management - river management
Higher temperature	More non beneficial ET from areas with shallow GW	Accelerate development of small scale irrigation
	Less percolation – no standing water	Fast percolation techniques – contour trenches etc
	Salinization risks for shallow gw in arid areas (Tana)	Lower gw table Crop pattern
Higher intensity rainfall **(see map of recharge mechanisms)**	Erosion > gullies lower gw table which accelerated further erosion	Gully control, moisture holding capacity etc
	Higher infiltration in areas with thin soils and fractured rocks	
	Lesser infiltration and more run off in areas with thick soils	Investment in buffer techniques, retention.

	Drainage problems in high land areas (relate to above)	Drainage
	More flooding in lowlands > more recharge Salt mobilization	Flood spreading techniques such as spate irrigation
	Damage to groundwater infrastructure	Adjustments in design and siting for flood protection
Unseasonality	Little overall impact but buffer functions become more important	Invest in groundwater development and recharge
More rainfall	Depending on pattern but in general more recharge	Increase capacity to store


Recharge mechanims map of Ethiopian Aquifers
Predominant recharge from wetlands during high flood stages
Recharge to wadi beds through local wadi floods
Recharge from floods originating from highlands
Mountain block and mountain front recharge
Direct diffuse recharge through soils and root zone
Fast, selective recharge from heavy rainfalls through fractures
Seifu Kebede
For Ethiopian Groundwater Management
Framework Document
GW MATE- Worldbank Project

ANNEX 6: TENTATIVE FRAMEWORKS FOR SELECTED REGIONAL STATES

PROVISIONAL FRAMEWORK FOR MANAGED GROUNDWATER DEVELOPMENT: Amhara Region

RESOURCE SETTING

HYDROGEOLOGIC CONDITIONS

- General hydrogeological features known
- Detailed knowledge resource base limited
- Pollution risks in bigger towns
- General environmental concerns (degradation)

SOCIOECONOMIC SITUATION

- Demand increasing in agriculture (irrigation, floriculture)
- Both rural and urban drinking water coverage low;
- Six Growth Corridors Identified
- Accelerated development in Kobo valley and possibly Tana

MANAGEMENT APPROACHES & TOOLS

POLICY ADJUSTMENTS

- Enhance planning of gw developm
- Guidelines for private involvement;
- Link groundwater recharge to watershed management/protection

REGULATORY PROVISIONS

- Establish licensing procedures;
- Establish standards for drilling, well developent
- Establish common platform/ management bodies for selected areas

STAKEHOLDER PARTICIPATION

- Establish regulatory responsibilities
- Start involving private sectors
- Capacity building
- Bridging gap practioners –researcher

QUALITY MEASURES

- Water quality investigation in bigger towns;
- Establish monitoring system
- Pollution control in selected areas
- Wellhead protection strategy

DEMAND-SIDE MEASURES

- Combine groundwater development with efficient use;
- Study conditions for self administering water organizations;

SUPPLY-SIDE MEASURES

- More attention to deep groundwater use;
- Focusing on conjunctive use (Tana)

ACTION PLAN for MANAGED DEVELOPMENT

- Establishing good resources knowledge base and data bases;
- Establish guidelines for developing licensing procedures, standards
- More investment on groundwater resources development especially in promising areas;
- Establish monitoring and regulation activities;

PRELIMINARY FRAMEWORK FOR MANAGED GROUNDWATER DEVELOPMENT: *SNNPR*

RESOURCE SETTING

HYDROGEOLOGIC CONDITIONS

- Regional groundwater resources not yet known
- Water supply well data compiled
- Fluoride in Rift Valley (already mapped)
- Salinity South Omo

SOCIOECONOMIC SITUATION

- No groundwater irrigation = actual or planned
- Rural and urban drinking water coverage low;
- Groundwater not planned as part of regional devt planning
- Local shallow aquifers but unutilized

MANAGEMENT APPROACHES & TOOLS

POLICY ADJUSTMENTS

- Enhance planning of groundwater development
- Link groundwater recharge to watershed management/protection
- Stimulate local investment

REGULATORY PROVISIONS

- Start monitoring and licensing;
- Establish standards for drilling, well development

STAKEHOLDER PARTICIPATION

- Align institutional interests in groundwater development
- Promote private sector roles in shallow and deep well drilling and pump servicing
- Capacity building

QUALITY MEASURES

- Fluorosis mitigation in areas with endemic problems
- Pollution control in selected areas
- Wellhead protection (rural areas)

DEMAND-SIDE MEASURES

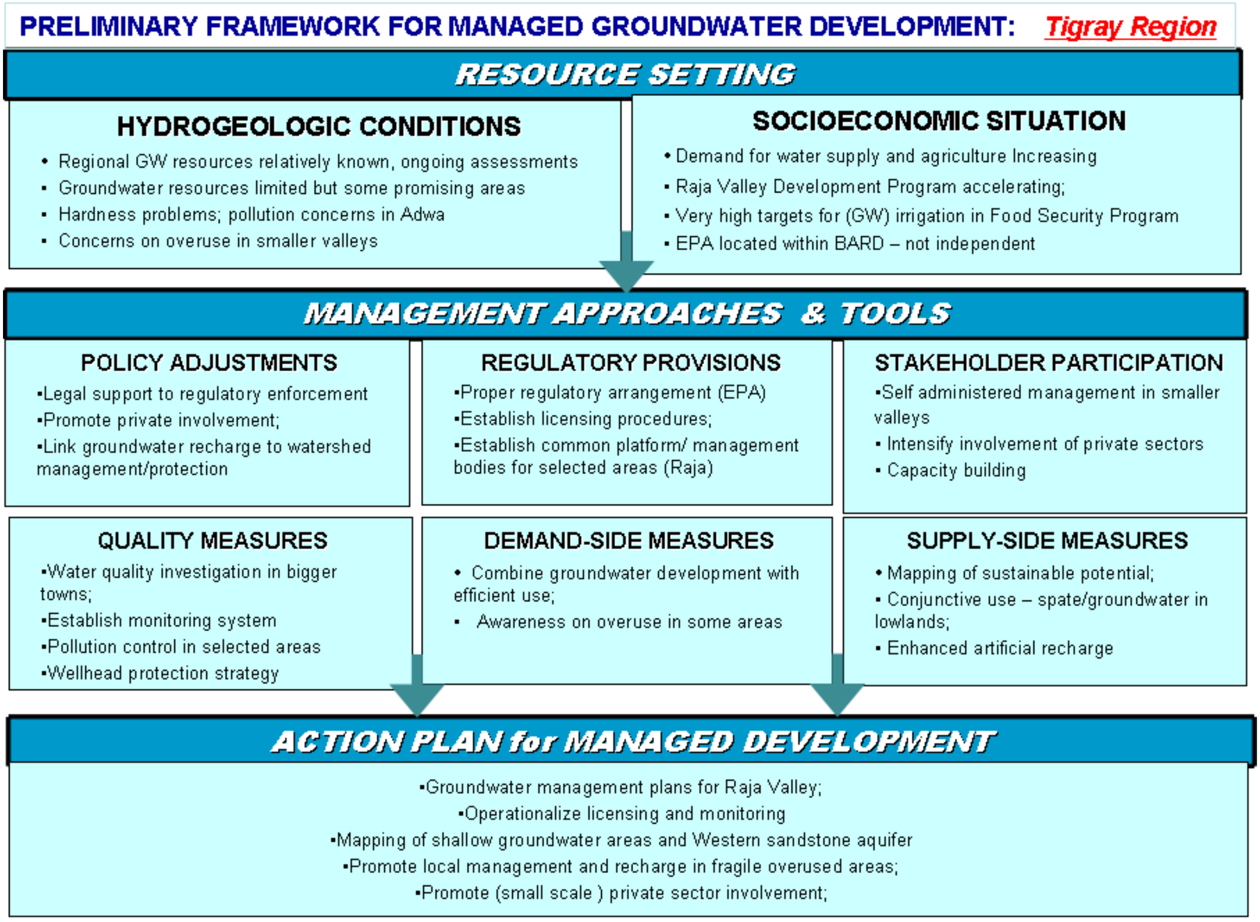
- Create interest in (supplementary) groundwater irrigation
- Introduce efficient conveyance methods
- Better servicing of drinking water systems

SUPPLY-SIDE MEASURES

- Systematic groundwater assessment
- Buffering methods in dry areas (sub surface dams, sand dams)

ACTION PLAN for MANAGED DEVELOPMENT

- Accelerated assessment and mapping of groundwater potential;
- Fluorosis mitigation – including safe sourcing
- Develop shallow and deep well drilling and pump maintenance capacity;
- Start monitoring and regulation activities;


PRELIMINARY FRAMEWORK FOR MANAGED GROUNDWATER DEVELOPMENT: Tigray Region
RESOURCE SETTING
HYDROGEOLOGIC CONDITIONS
• Regional GW resources relatively known, ongoing assessments
• Groundwater resources limited but some promising areas
• Hardness problems; pollution concerns in Adwa
• Concerns on overuse in smaller valleys
SOCIOECONOMIC SITUATION
• Demand for water supply and agriculture Increasing
• Raja Valley Development Program accelerating;
• Very high targets for (GW) irrigation in Food Security Program
• EPA located within BARD – not independent
MANAGEMENT APPROACHES & TOOLS
POLICY ADJUSTMENTS
•Legal support to regulatory enforcement
•Promote private involvement;
•Link groundwater recharge to watershed management/protection
REGULATORY PROVISIONS
•Proper regulatory arrangement (EPA)
•Establish licensing procedures;
•Establish common platform/ management bodies for selected areas (Raja)
STAKEHOLDER PARTICIPATION
•Self administered management in smaller valleys
• Intensify involvement of private sectors
• Capacity building
QUALITY MEASURES
•Water quality investigation in bigger towns;
•Establish monitoring system
•Pollution control in selected areas
•Wellhead protection strategy
DEMAND-SIDE MEASURES
• Combine groundwater development with efficient use;
• Awareness on overuse in some areas
SUPPLY-SIDE MEASURES
• Mapping of sustainable potential;
• Conjunctive use – spate/groundwater in lowlands;
• Enhanced artificial recharge
ACTION PLAN for MANAGED DEVELOPMENT
•Groundwater management plans for Raja Valley;
•Operationalize licensing and monitoring
•Mapping of shallow groundwater areas and Western sandstone aquifer
•Promote local management and recharge in fragile overused areas;
•Promote (small scale) private sector involvement;

PRELIMINARY FRAMEWORK FOR MANAGED GROUNDWATER DEVELOPMENT: *Oromia Region*

RESOURCE SETTING

HYDROLOGICAL CONDITIONS

- Several groundwater assessments – incl deep aquifer - underway
- Pockets of productive very shallow aquifers
- Pollution risks in bigger towns
- High fluoride in Central Rift Valley and Jimma

SOCIOECONOMIC SITUATION

- Increased demand for irrigated agriculture/ livestock watering;
- Rural and urban actual drinking water coverage low;
- Groundwater increasingly integrated in development planning
- No strong link with watershed management

MANAGEMENT APPROACHES & TOOLS

POLICY ADJUSTMENTS

- Cooperation on trans regional aquifers
- Legal support to regulatory works
- Stimulate private sector investment
- Combine groundwater recharge and watershed management

REGULATORY PROVISIONS

- Enforce licensing procedures
- Systematic monitoring
- Standards for drilling/ well development
- Establish common platform/ management bodies in selected areas

STAKEHOLDER PARTICIPATION

- Establish organizational responsibilities
- Private sector capacity in well development and maintenance
- Capacity building in all fields – including deep drilling and manual well development

QUALITY MEASURES

- Fluorosis mitigation – incl safe sourcing
- Establish monitoring system
- Pollution control in selected areas
- Wellhead protection

DEMAND-SIDE MEASURES

- More attention to deep GW use;
- Combine groundwater development with efficient use;
- Better servicing of existing drinking water systems

SUPPLY-SIDE MEASURES

- Promote conjunctive use in valley development programs;
- More attention for water buffering techniques

ACTION PLAN for MANAGED DEVELOPMENT

- Integrated groundwater development in high potential areas
- Establish guidelines for developing licensing procedures, standards
- Strengthen private sector capacities;
- Establish monitoring systems and enforce regulation activities;

ANNEX 7: STEP WISE CHECKLIST FOR GROUNDWATER MANAGEMENT PLANNING/ACTION

With reference to GWMATE Briefing Notes (BN)

Step	Issue	BN
1 **Groundwater status**	**Resource assessment** - Describe local hydrogeology in regional context with simplified maps/ profiles - Estimate aquifer balances, including surface water interactions - Appraise hydrogeological uncertainty and groundwater historical trends - Describe links to surface water and waste water (resource and thread) - Assess options for water buffering and application of 3R technologies **Quality characteristics** - Assess natural water quality variations and presence of saline/brackish grw. - Evaluate evidence for extent and possible causes of current pollution - Assess potential pollution risks form land use & aquifer pollution vulnerably **Monitoring networks** - Status of abstraction metering and estimation - Status of waste water discharges affecting groundwater - Arrangements for aquifer water level and water quality monitoring **Water use and abstraction** - Assess current water use for different sectors (incl grw dev. plans) - Assess policies and subsidies affecting groundwater abstraction - Summarize current water allocation positions by sector graphs of historical trends - Establish water –user profiles and water well inventory	**2** **14** **9**
2 **Current management arrangement**	**Institutional provisions** - Appraise legal framework, customary arrangements and water permit system - Assess responsibilities of all relevant organizations (incl RBO) - Identify groundwater allocation criteria and priorities - Review resource-fee policy and enforcement **Institutional capacity** - Assess enforceability of water, land use and environmental law - Scope of user and other key stakeholder participation	**4,5**
3 **Required services -**	**Required services** - Discuss socioeconomic scenarios with political leaders and water users - Predict future water demands over planning period (10 years) - Assess aquifer target yields, allowing for environmental discharges - Draft options for aquifer stabilization or rational mining	**15** **11,3**
4 **Future options**	**Economic analysis** - Estimate groundwater economic value - Assess feasibility of implementing direct or indirect groundwater pricing - Assess consequence of modifying macro-economic policies	**7**

for management development	- Undertake systematic cost benefit analysis of options **Climate change impacts** - Appraise main impacts of climate change to consider in the definition of options **Definition of options** - Describe management options to achieve stated aquifer services - Consider con. use/ compare demand mgt. options to supply-side augmentation - Conclude on preferred option to pursue - Seek support and consensus for preferred option from main stakeholders	**3**
5 **Implementation program**	**Defining the tasks and responsibilities** - Identify key tasks, responsible institutions, financial needs and impl. time table Appraise improvements in user/stakeholder participation required - Define action plan for their engagement **Capacity building** - Appraise cap.building & training needs for water users/institutional stakeholders - Prepare program for training, communication and publicity **Monitoring and review requirement** - Define improvement in monitoring for management plan - Define responsibilities (incl. self monitoring) and implementation arrangements - Install improved management monitoring network - Propose time table and process for evaluation of plan effectiveness	**6** **9**

ANNEX 8: PROPOSED AQUIFER CLASSIFICATION AND MANAGEMENT TABLES

Below is a proposed new classification of aquifers in Ethiopia – prepared to make a distinction between the different shallow aquifers. Different forms of groundwater management would apply to the different classes of aquifers as described next.

Proposed name	Depth (meters)	Characteristics	Use	Intensity of use	Rock type	Aquifer type	Location
Very shallow aquifer	0 – 30	Hand dug wells Phreatic aquifer Low yields Bacteriological pol.	RWS SCI	Medium	A		
					B		
					D		
Shallow aquifer	30-100	Dug & drilled wells Phreatic & confined Low/medium yields Pollution hazards	RWS (UWS)SC I	Medium to High	A		
					B		
					C		
					D		
Deep aquifers	100-250	Drilled wells Main aquifers Medium yields Pollution hazard	UWS LSI	Medium	A		
					B		
					C		
					D		
Very deep aquifers	>250	Drilled wells Medium/high yields Recent development	UWS LSI	Low	B		
					C		

Rock type

A Precambrian metamorphic basement rocks (cover about 23% of the country).
B Mesozoic sedimentary rocks (cover about 25%)
C Tertiary volcanic rocks—largely flood basalts— (cover about 25%)
D Quaternary volcanic rocks—largely ignimbrites—and sediments (cover about 17%)

Aquifer type: fissured (secondary porosity) (Fis) <<> sedimentary (primary porosity) (Sed)

Use Small scale irrigation (SCI), Large scale irrigation (LCI), Urban WS (UWS0 or rural WS (RWS)

Location : distinction between physical environments: H: highlands, M: midlands , L: low lands

Different groundwater scenarios and proposed management issues for different classes of aquifers

	Intensively used	Not intensively used
Very shallow aquifers	• Develop conjunctive use • Promote local management • Develop integration with watershed programmes, surface irrigation and land use planning • Quality protection	• Improve capacity for manual drilling • Develop integration with watershed programmes, surface irrigation and land use planning • Promote user participation
Shallow and deep aquifers	• Groundwater management plan incl land use and allocation of uses • Safeguard groundwater quality • Standardize well technology and well head protection • Activate regulation and monitoring	• Improving capacity for deep well drilling and maintenance services • Map natural groundwater quality and consider distance sourcing • Water allocation plan
Deeper aquifers	• Not existing yet	• Improved drilling technology and capacity • Introduce water management plan