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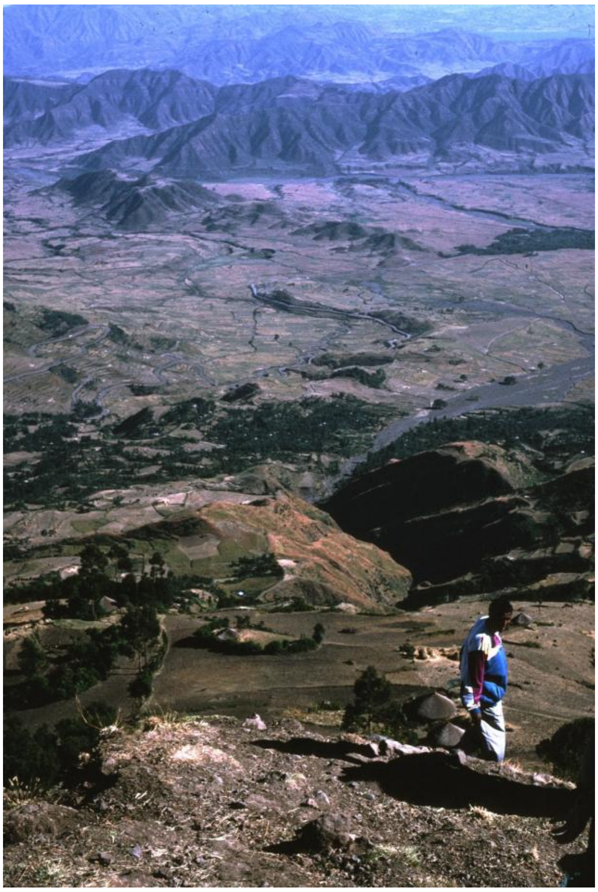
Project report on visit to Ethiopia, November-December 1999



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PLANNING FOR GROUNDWATER DROUGHT IN AFRICA: TOWARDS A SYSTEMATIC APPROACH FOR ASSESSING WATER SECURITY IN ETHIOPIA

Project report on visit to Ethiopia, November-December 1999

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Front cover illustration: Looking down onto the River Mille from Abbot Village, Ambassel Woreda.

Keyworth, Nottingham, British Geological Survey, 2000

Contents

List of Figures

List of Tables

Acronyms and Abbreviations

DPPC	Disaster Prevention and Preparedness Commission
DPPD	Disaster Prevention and Preparedness Department
ESRDF	Ethiopian Social Rehabilitation Development Fund
EWWCA	Ethiopian Water Works Construction Authority
FDRE	Federal Democratic Republic of Ethiopia
FEWS	Famine Early Warning System (operated by USAID)
MWR	Ministry of Water Resources
NGO	Non-Governmental Organisation
PA	Peasant Association
SERA	Strengthening Emergency Response Actions
USAID	United States Agency for International Development
VAM	Vulnerability Analysis Monitoring, carried out by WFP
WFP	World Food Programme

Technical Glossary

Aquifer	A rock formation that contains groundwater.
Borehole	A cylindrical hole, usually greater than 20 m deep and 100 mm in diameter, constructed by a drilling rig to allow groundwater to be abstracted from an aquifer.
Geophysics	Techniques which measure the physical properties of rocks without the expense of drilling boreholes. In certain circumstances results from geophysics surveys can be used to infer the presence of groundwater.
Porosity	The ratio of void space in rock to the total rock volume - expressed as a percentage. Rocks with high porosity can store greater volumes of groundwater than rocks with low porosity.
Permeability	A measure of the relative ease with which an aquifer can transport groundwater. Permeability is higher when there are interconnected fractures.
Pumping test	A test that is conducted to determine aquifer or borehole characteristics.
Shallow well	A large diameter (usually greater than 1 m) hole, dug to less than 20 m depth to access groundwater.
Success rate (borehole drilling)	Imprecise term, normally taken as the number of successful boreholes divided by the total number of boreholes drilled – expressed as a percentage. Different organisations have different measures for denoting a successful borehole.
VES	Vertical electric sounding, a widely used geophysical method for siting boreholes.
Weathered zone	A layer of rock beneath the soil zone which has been altered by physical breakdown or chemical decomposition.
Yield	The volume of water discharged from a well or borehole, measured in m^3/d or l/s.

EXECUTIVE SUMMARY

Meeting our objectives

The visit met its main objectives The range of interested parties consulted before and after the field survey enabled the researchers to focus the study questions for the research and to receive helpful feedback on the preliminary results at the end of the trip. [1] A high degree of interest was shown in the study at all levels. The early findings were disseminated widely to donors and agencies at the federal level. The feasibility of constructing and using vulnerability maps and of establishing monitoring mechanisms was assessed.

Partners and stakeholders

The project partners – namely Save the Children (UK) (SCF) and the Amhara Region Water Bureau – participated fully in the study visit. Their assistance and facilitation in all matters is gratefully acknowledged, particularly the work of Ben Foot (Director) and Wendy Fenton (Deputy Director) of SCF, and Ato Fekadu Debalkie (Head) and Ato Shumet Kebede (Hydrogeologist) of the Regional Water Bureau.

Meetings were held with a range of stakeholders in Addis Ababa[2] (federal level), Bahi Dar (regional level), Dessie (zonal level) and Ambassel and Worebabu (woreda level), and at the community level. Those consulted included NGOs, bilateral donors, UN agencies and government and community leaders. Two workshops were held, an initial zonal-level planning workshop in Dessie prior to the field survey and an end-of-trip workshop in Addis Ababa.

Key findings

Water security

This was recognised as a key organising idea which encompasses water availability, access points and the demands placed on sources by humans and animals. Its preferred use over ‘groundwater drought’ was agreed during the visit. The general pattern of water security appeared to be moving from a smaller resource base, but greater access in the highlands, to a larger resource base, but more limited access in the lowlands. Moreover, drought impact was really only an acute version of annual seasonal shortages. Groundwater is a key resource in times of scarcity, but only where access could be made available. Access was a major problem in terms of the number of source points, distance to them, yield variability (hence queuing) and other social factors serving to restrict access.

Mapping approach

Constructing new maps requires a level of data which does not exist at present, and would be expensive to gather. Nevertheless, the maps already drafted were acknowledged by many (particularly donors) as important and useful national-level planning tools. The mapping process, in conjunction with water security analysis carried out at lower levels, could provide an important methodology for systematising the information required to make informed decisions on drought planning and preparedness. It would also assist in the planning of rural water supply investment more generally.

[1] See appendices for full itinerary and list of people met.
[2] Principal amongst which were other agencies engaged in early warning and/or vulnerability mapping: notably USAID-FEWS, WFP-VAM and the DPPC.

Monitoring

Existing early warning systems (e.g. woreda vulnerability profiles by SERA within DPPC) could be extended to providing simple community-level data about water availability, access and demand, and could be combined with other processes of data collection to provide some rudimentary form of monitoring. The project has drawn up a list of questions that could be asked (see Appendix B). In short, rather than establish new mechanisms, the systems are in place (or being developed) which could serve to establish a simple form of water security mapping amongst communities.

Feedback from partners and stakeholders

- The difficulty posed by the lack of capacity to act on information – in whatever form – was mentioned. This suggested the need for information to be time and cost effective in how it is presented and used.

- The need to work at many levels and to bring the federal level into data collection, analysis and use is important. Issues of ownership over resources should be addressed at all levels, and a clear understanding of exactly what is being done at a national level by government, agencies and communities should be established.

- Systematising information acquisition and analysis is an essential part of planning responses. Decentralising development requires a more sophisticated capacity by local government tiers to respond to increasing demands and to prioritise responses. Information could be systematised in such a way as to achieve this objective at all levels. Information on the resource base should be complemented by socio-economic data and political data (for instance on relations between different local-level groups).

Action points

- Redesign vulnerability maps on the basis of research findings and feedback from partners and stakeholders prior to final visit and workshop.

- Build findings into vulnerability analysis of SERA/DPPC.

- Develop proposal for technical assistance to Amhara Region on water resources planning and development, acting on the findings and feedback given above. Develop the proposal with the existing approach to vulnerability mapping in selected woredas, seeking collaboration and partnership with the Regional Water Bureau and the Regional Food Security Unit.

- Organise follow-up visit in June 2000 (provisional) to review study during the dry season, to present full findings and vulnerability maps, and to discuss opportunities for future co-operation with Amhara Region.

1. INTRODUCTION

1.1 Visit Objectives

The objectives of the visit were threefold:

(i) To develop a systematic approach for identifying water insecure areas through:

- analysing existing map data, and conducting a survey of water access and availability problems within selected woredas (districts), including an investigation of the social and physical aspects of water demand and supply;

- a retrospective analysis of community drought experiences, including seasonal responses to resource scarcity and associated coping strategies at both community and household levels.

(ii) To evaluate the effectiveness of a mapping approach as a tool for responding to water security problems, including drawing up guidelines on constructing maps (incorporating use of different information formats and types of 'hard' and 'soft' data); and drafting guidelines for the 'drought-proofing' of rural water supply programmes in the Ethiopian context, with possible application to other water-scarce areas in Africa.

(iii) To seek complementarities with existing approaches to vulnerability mapping and early warning in Ethiopia through discussions with regional and local-level stakeholders, and to plan for a follow-up visit and regional workshop for June 2000 (provisional) in consultation with project partners and stakeholders.

1.2 Visit Background

The visit formed part of a two year KAR[3] project 'Groundwater Drought Early Warning for Vulnerable Areas' which builds on earlier research carried out in Africa since 1994. Underpinning the research is the experience that groundwater may be the only source of year-round supply for rural communities, hence when such sources fail a 'groundwater drought' may result forcing communities to seek water from distant, often poor quality, sources.

Anticipating and planning for groundwater drought can, therefore, help to lessen the negative impacts on communities. A key contention of the research to date - drawing on the drought experience in Malawi and South Africa in the early 1990s - is that some groundwater sources, and some areas, are much more vulnerable to groundwater drought than others. These potentially predictable variations are seldom planned for, or acted upon, however, and the result in the southern Africa example was crisis management, with activities such as emergency drilling programmes organised far too late and targeted incorrectly. This also reflects a predisposition among policy makers and donors to separate food insecurity from related drought emergencies, and to ignore other (non-food) aspects of vulnerability.

Ethiopia was chosen as the core focus for the research, reflecting both its predisposition for rainfall variability and recent history of drought events. The Ethiopian example presents a particularly important case study for assessing the water resource impacts of drought and, in general, for developing a broader approach to drought planning in Africa. Draft groundwater drought vulnerability maps were constructed for the country using available hydrogeology maps, rainfall and socio-economic data (see Figure 1).

[3] DFID Knowledge and Research budget line.

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Figure 1 Map of Ethiopia showing physical vulnerability to groundwater drought (draft).

Note: a low 'hydrogeology coefficient' (low storage; low permeability) indicates greater vulnerability to groundwater drought.

Save the Children Fund (UK) has a number of water supply projects in Ethiopia - including in the South Wollo study area – and agreed to facilitate the research visit. The Amhara Region Water Bureau became a project partner in late 1998 and participated in the visit. A UK workshop held in July 1999 brought together SCF, the Amhara Region Water Bureau, BGS and ODI to discuss the draft vulnerability maps developed prior to the workshop based on earlier data gathered from a variety of international and in-country sources. The workshop was also an opportunity to plan for the initial field visit to the country.

1.3 Project Aims and Outputs

The overall objective of the project is to reduce the social and economic consequences of drought by providing guidance on drought vulnerability and early detection of problems and appropriate responses, particularly in relation to community water supplies. More specifically, guidance is aimed at:

(i) Improving the ability to predict when and where groundwater failures are likely to occur during drought;

(ii) Identifying and triggering appropriate policies and interventions to help prevent crises developing, and to protect livelihoods.

A main output of (i) above is the development of drought vulnerability maps[4] combining physical and socio-economic data on water access and availability. These maps can help to:

(i) Target drought-proofing measures in pre-drought periods, such as well deepening and the drilling of strategic boreholes in the most reliable geological locations;

(ii) Inform water source selection, siting and construction choices so that water supply programmes are designed with drought in mind from the outset, and are capable of withstanding high demand by humans and livestock;

(iii) Identify areas where the monitoring[5] of groundwater availability and access is particularly important, possibly as an addition to an existing early warning system.

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[4] Drafts of which were prepared for discussion at the workshop in the UK.

[5] Monitoring information may include data on groundwater availability (water levels, underground storage), data on groundwater replenishment from rainfall and data on groundwater access and demand (e.g. water supply coverage and type).

2. THE STUDY AREA: SOUTH WOLLO

South Wollo zone lies in the south-east corner of Amhara Region (Figure 2), and includes 17 rural woredas (districts), and two urban woredas.[6] The zone covers the three main altitude bands of *dega*, *weyna dega* and *kolla*. Ethiopians commonly describe locations in these terms because altitude, and its influence on temperature, rainfall, crop choice and livestock, is the principal determinant of livelihood strategies and population densities. Specifically:

Dega: above 2500m, with rainfall varying from 600mm/a to over 2000mm/a. Barley and wheat are the principal crops, and sheep and goats the main livestock.

Weyna dega: warmer middle altitudes (between 1600m and 2500m), with rainfall ranging from about 500 - 900mm/a. This band contains most of the population and the greater part of agricultural land, with all regional crops grown including *tef*, a pinhead sized grain unique to Ethiopia as a staple. Cattle, sheep and goats are the main livestock.

Kolla: the hotter and more sparsely populated lowland area, between about 1300m and 1600m, with rainfall of around 300-450mm/a. Sorghum, maize and *tef* are the main crops. Here, more land is given over to livestock: goats replace sheep; some camels are kept for transport; and cattle breeding is the single largest economic activity.

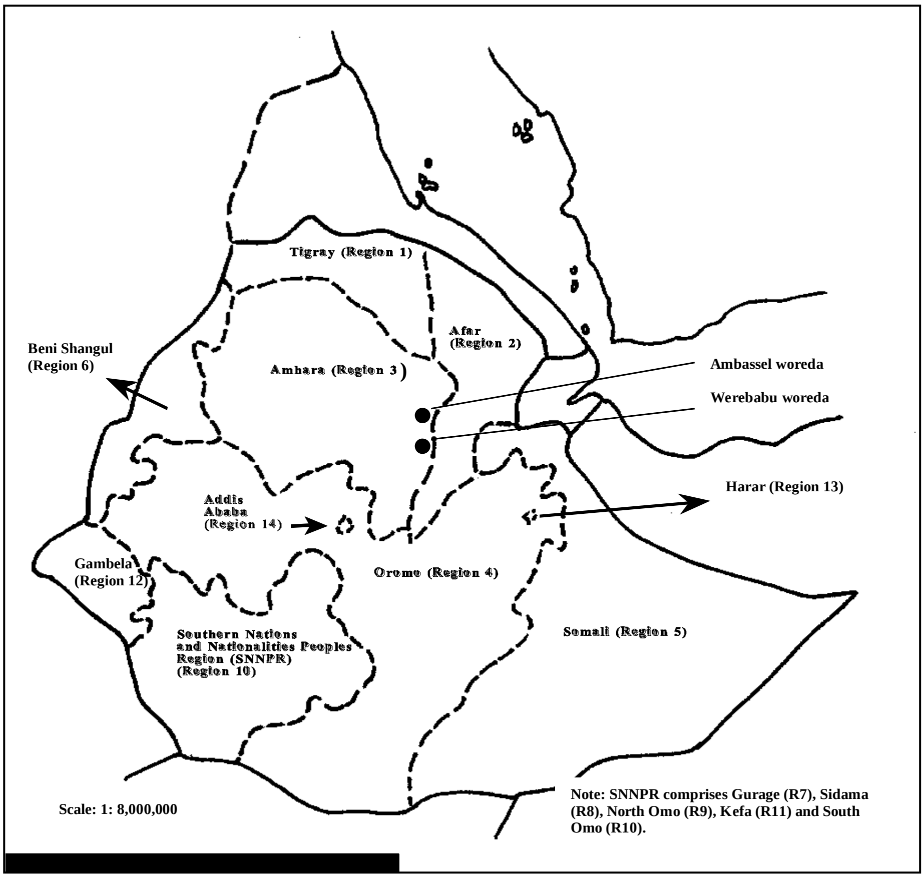

Figure 2 The location the two woredas (Ambassel and Worebabu, South Wollo Zone) chosen for study.

[6] The population of a woreda is normally in the region of 100,000.

In most areas rainfall is bimodal, with short *belg* rains from March to April, and longer *keremt* rains from July to September. Most of the study areas came under *belg*-dependent production.

2.1 Selection Criteria

The project emphasis is on collaborative development with government and NGOs involved in rural water supply planning and management. Hence, the study area in South Wollo was selected in consultation with SCF and the Amhara Region government. A number of criteria were used to select the two specific woredas: namely, that they were in a drought-prone area of the north-east highlands; they were accessible within the short duration of the field visit; some previous mapping work had been undertaken (the results of which were available); and that they encompassed a variety of water source types and agro-ecological zones. The workshop held in the UK helped to identify potential study woredas which were then discussed in more detail during the initial days in Addis Ababa.

2.2 Physical Background

There are high mountains (over 4000 m) in the west of South Wollo, and a lowland plain in the east. The rainfall of the area is influenced by variation in elevation. In the highland areas, average annual rainfall can be in excess of 2000 millimetres per annum (mm/a); in the lowland areas average rainfall falls to below 750 mm/a. South Wollo is underlain by relatively young volcanic rocks. These were formed in three phases of activity during Palaeogene and Quaternary times, associated with the opening of the East African rift valley. These events gave rise to a thick, complex sequence of lava flows, sheet basalts and pyroclastic rocks such as agglomerate and ash. Thick basalt lava flows are interbedded with ash layers and palaeosoils. The volcanic rocks are exposed in the highland areas. In the valleys and plains, however, the volcanic rocks are often overlain by unconsolidated sediments.

The rivers on the tablelands in the west of South Wollo form the headwaters of the Blue Nile. An escarpment forms the edge of the highland massif. The escarpment is dissected by deep valleys, which lead down to the lowland plains of the Awash valley. The two woredas selected are located on the escarpment, and both lie within the river Awash basin. The only perennial river in the study areas is the Mille – and this is sustained in the dry season by baseflow (groundwater). Most water sources used by communities are springs, wells or boreholes.

2.3 Socio-economic Background

South Wollo exhibits many of the key stresses of the wider Ethiopian agricultural economy, principal amongst which is the ever-increasing population pressure on highland agricultural land. This is exhibited in decreases in per capita yields and increasing movement of sedentary agriculture down the escarpment into *kolla* regions. There is also severe land degradation in some areas through over-cultivation leading to the loss of topsoil. This contributes to what some regard as a chronic emergency situation in many parts of the zone. Most of South Wollo's farmers are *belg* dependent, relying on the shorter *belg* rains (March-April) for cultivation rather than the longer *keremt* season (August-October). The area of South Wollo chosen for study represented all three agro-ecological zones ranging from *dega* to *kolla* and, as such, provided a transect-view of the highland escarpment.[7]

There are important transactional relationships across this escarpment including the exchange of livestock – principally cattle – by lowland pastoralists for highland agricultural produce (Bati market is particularly important in this respect), and the trade in goods from coastal regions via the lowlands to highland areas (Bokaksa was one notable trading community visited). Hence the relationship between *dega*, *weyna dega* and *kolla* livelihoods systems in this area is both complex and mutually significant in terms of the livelihood strategies adopted by households within this vulnerable social,

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[7] For further information on the socio-economic situation of South Wollo, refer to Holt and Lawrence (1993) and SCF-UK(1998) (see references).

economic and natural environment. Water, along with food and transport, is a key variable in this transactional relationship and in the vulnerability of communities (see below).

2.4 Institutions

2.4.1 Government

Since 1991 the Ethiopian government has been decentralised on the basis of ethnic regions. South Wollo zone lies within the Amhara ethnic region (or State). The guiding idea behind this process is the empowerment of lower levels of government to undertake development tasks. Ultimately, the woredas are envisaged to become the ‘engines of development’. Between the woredas and the regional government lie zones; there are 10 in Amhara Region. At present the zonal level is strong in South Wollo. Beneath the woredas are the PAs (peasant associations), the development committees of which establish community development priorities and channel these through development agents to woreda development committees. The planning process takes place between December and April, culminating in the region announcing its annual plan in May/June. However, at present there is little effective bottom-up planning taking place.

The relationship between the levels of the executive is mirrored by levels of elected government, with regional, zonal and woreda councils. These councils are the law-making bodies. The foundation of the system is the idea of popular participation and the establishment of direct democracy, and it is envisaged that communities will make claims on their representatives and on the executive authority at the woreda level for development projects. It is the antithesis of centralised planning. The main disjunction is between the regional government and the federal state. At the federal level, whilst there are still ministries, increasingly their function is to develop policy and guide development, though having no actual line-ministry control over regional bureaux. Regional governments themselves have the powers to plan, direct and supervise social and economic development programmes and have line control over zonal departments (of which there are 13 in South Wollo).

Sources of finance for development projects include: a) revenue collected from taxes allocated to regional government (only slowly becoming significant); b) grants given by central government (the most important); c) domestic borrowing (negligible); and d) other sources of income (this might include donor grants).

2.4.2 Water resources management

Management structures reflect the institutional set-up described above. Whilst at the central level there is a federal Ministry for Water Resources, it has no line-management function over the Regional Water and Mines Bureau. Representatives of the water bureau exist as departments at the zonal level and recently the water bureau has extended to the woreda level with the establishment of woreda-level officers within the woreda council. This reflects concern amongst the water bureau that a lack of reach into the woreda level might hamper their ability to influence development decisions made at this level. Other ministries with an established presence within woredas include health (via health assistants) and agriculture (via extension agents). The woreda level has been described as the 'missing link' in relations between communities and the implementation of water resources policy, and is increasingly important as a focus for development activities.

3. APPROACH

3.1 Stakeholders and Partners

Given the institutional set-up described above, the project sought to work at the regional level and below in terms of water resources development, but to be aware of the federal-level activities already underway in early warning and vulnerability mapping. A key concern was to avoid duplication of existing work. To this end the field visit undertook to be as participatory as possible in the time available, engaging project partners and stakeholders in decision making at each stage. Ahead of the visit, the objectives were circulated to all levels of government in the designated study area in order to raise awareness of the project's aims and objectives.

The first two days of the visit were spent following up comments on the objectives with government, agency and NGO staff at the federal level. These initial discussions served both to brief donors, NGOs and government on visit objectives, and to identify areas of mutual interest and concern, including possible complementarities with existing work. Previous agreement to participate in the project had been reached with the Amhara Region Water Bureau. The field visit, therefore, began at the zonal level with meetings and a short workshop with officials in South Wollo zone. This meeting helped to identify the key woredas both accessible within the timescale of the visit and potentially fruitful in terms of the information available. Whilst the original intention had been to only cover one woreda, the Regional Water Bureau requested that three woredas were included. However, following discussion at a zonal level, two woredas – Ambassel and Worebabu – were selected. In both cases letters of introduction were provided and discussions held with woreda officials on the most suitable and accessible PAs to visit. Details of the field research are described in 3.2 below.

The preliminary findings were discussed with partners and stakeholders at the regional level following the study visit. The meeting also covered possible future collaboration on the project and Regional Water Bureau confirmed its continued support for the project. The Food Security Unit of the regional council was separately informed of the project and a discussion held on the possible future linkage between the study results and the regional-level food security strategy.

An end of visit briefing workshop was held in Addis Ababa to discuss initial findings, and to incorporate comments and insights from attendees. From feedback at all levels a number of key points emerged:

- the need for systematised understanding of groundwater resource availability, access and demand across seasons and good and bad years;
- the need to incorporate such a systematised understanding with existing early warning/vulnerability mapping systems;
- understanding the rainfall / recharge / surface water availability relationship as the key to being able to plan responses;
- the difficulty of institutional incapacity;
- the need to incorporate experience from management elsewhere in Africa; and
- the cost of the mapping exercise and hence the question of capacity to replicate in other areas.

3.2 Field Survey

The field survey consisted of interviews with a structured sample of communities selected in consultation with woreda officials. The sample was structured around the need to cover some 12 sites, a range of types of source and a range of different agro-ecological areas. Woreda water officers were assigned to our team to assist in accessing the communities.

A checklist of questions (see Appendix B) was prepared pre-visit to ensure that interviews covered the range of objectives of the country visit and incorporated both socio-economic and physical data. Broadly, the survey covered baseline information about the community (including detailed information on the water points in existence) and the community's drought experiences.

In each community semi-structured interviews were conducted with a range of individuals at water points. At most sites group interviews and participant observation were also carried out. Where feasible, the views of women were actively sought. The range of informants included the elderly (whose longer memories could recall past drought events), local PA officials, women and children.

The team undertaking the interviews in each community consisted of three researchers, two translators, a woreda water officer and, where available, members of the local PA. Interviews were conducted with two separate groups to allow different question lines to be followed and to facilitate cross-checking.

Some physical data were also collected for the major water source of each community. The basic chemistry of the water was tested, including major ions, pH and electrical conductivity. The physical setting of the water source was examined, for example the altitude, geology and topography. The yield of the source was measured, and interviews used to assess the variability of the yield and quality throughout the year and during drought periods.

Survey data, including village profiles based on questionnaire results, are held at BGS. They will be included as an appendix in the final project report.

4. PRELIMINARY FINDINGS

The research results indicate a complex interrelationship between the physical and social environments in South Wollo based on seasonal and annual variability in resource availability, access and demand. Data on the presence or absence of water resources needs to be combined with an understanding of seasonal patterns of demand, households strategies for gaining access to water supplies seasonally and between years, and the different physical and socio-economic barriers households face in gaining access to different sources of water.

4.1 Water Sources

In all, 18 water points were visited in 11 communities, across the three agro-ecological zones. It was found that communities rely on a variety of sources in all agro-ecological zones and access different sources according to availability and water use function. Key findings were the continuity between seasonality and drought, and the more localised effects of water insecurity as compared with food security.

4.1.1 Springs

In *dega* areas springs are the most common water source. They display some seasonality with yields varying throughout the year, being typically at their lowest in May-June. Discharge at these springs ranged up to 5 l/s and commonly declined to less than 0.5 l/s in the May-June period. Most of the *dega* sources were unprotected. A number of agencies have provided varying degrees of spring protection including facilities such as cattle troughs, tapstands and washing bowls in *weyna dega* areas. A number had been rehabilitated in the last few years. The availability of springs declined from *dega* to *kolla* due to the changing topography. This had significant implications for access to water during the dry season. In *dega* areas communities generally have access to three or more springs. These springs, however, have small catchments, and flow can reduce or even stop in the dry season. However, the *dega* areas tend to have high rainfall, so the small aquifers are frequently replenished. Communities in *weyna dega* areas have fewer springs - generally less than three per community - but these springs are often high yielding. In *kolla* areas there are few springs, although groundwater does discharge into the rivers.

4.1.2 Hand-dug wells

Frequently it was difficult to distinguish hand-dug wells from springs, given the siting of wells on or near springs. At a number of sites hand-pump selection was inappropriate (high lift pumps had been installed on shallow boreholes) with the result that pumps had broken down or provided a low yield. It appeared that the yield from hand-dug wells was more reliable than from springs, although this was difficult to corroborate given the small sample size. Some hand-dug wells were inappropriately sited (e.g. in swamp areas) and had ceased to be used by the communities due to poor water taste and smell.

4.1.3 Boreholes

Few boreholes were visited, largely due to the few in existence in the woredas chosen. According to informants most had been sited using geophysics (VES) and drilling had been carried out by EWWCA during the previous government. In general, yields from boreholes were fairly consistent throughout the year. Only one borehole with a hand-pump was visited (in Tis Abalima). Boreholes are found in both *weyna dega* and *kolla* regions and, in the latter, are particularly important since the only alternatives are rivers and occasionally rainwater cisterns. Most boreholes have been equipped with electric submersible pumps, which require a generator and fuel to run. These systems are expensive to construct and difficult to maintain by a community (more than five boreholes with community handpumps could be installed for the same price). Communities with submersible pumps are highly vulnerable in times of drought. No working submersible pump systems were found on the field visit. It is surprising that there are so few boreholes with community handpumps, considering their low cost and reliability.

4.1.4 Rivers

Nearly all rivers are seasonal, with the exception of the Mille which is perennial downstream of Tis Abalima. During the dry season most river flows are sustained by groundwater. In many cases water quality is a problem in rivers, not just through human and animal contamination, but also through industrial pollution. Tannery discharge into the Mille south of Haik caused visible contamination to a source used extensively by human and animal populations downstream. During dry seasons some communities also used shallow hand-dug wells in riverbeds to access water.

4.2 Hydrogeology

The potential for groundwater in volcanic rocks depends largely on the presence of fractures. The top and bottom of lava flows, particularly where associated with palaeosoils, are often fractured and weathered; towards the middle of the lava flows, the basalt tends to be more competent and less fractured. A transect from highland to lowland areas showing the hydrogeology of volcanic rocks is illustrated in Figure 3. Fractured lava flows can be permeable and have properties like karstic limestones. The interconnected fractures and cavities found in the lava flows provide rapid, discrete flow paths for groundwater, which often discharge as springs at impermeable boundaries. The important factors for the development of aquifers within volcanic rocks are noted below:

(i) Thick paleosoils or loose pyroclastic material between lava flows are often permeable.

(ii) Joints and fractures caused by the rapid cooling of lava flows provide important flow pathways.

(iii) Contacts between lava flows and sedimentary rocks or volcanic material, such as domes, are often fractured and contain some groundwater.

(iv) Gas bubbles within lava flows, and porosity within ashes and agglomerates, can provide significant groundwater storage.

(v) The quality of groundwater from lava flows can be poor, since minerals within the volcanic rocks are easily taken into solution.

In *dega* areas, the aquifers are small and cannot store large quantities of groundwater; in *weyna dega* and *kolla* areas, the catchment and aquifer size increases. Highland aquifers have been poorly studied; therefore, not much is known about how much groundwater is available in *dega* areas. Most access to groundwater is through springs. Springs, however, are sensitive to changes in water level within an aquifer: small decreases in water level can lead to dramatically reduced yields. Since wells and boreholes penetrate deep into the aquifer, they are less susceptible. Groundwater flows from the highland areas to the lowland areas. However, the proportion of groundwater in *kolla* regions that originates in the highlands, rather than infiltrating directly within *kolla* areas, is uncertain. The electrical conductivity (and hence salinity) is higher at low altitudes (Figure 4). More chemical analysis is currently being undertaken in the laboratory at BGS.

4.3 Uses of Water Sources

The use of sources is affected by season, quality, distance and construction type, and mechanical reliability. Where a variety of sources are available, springs are generally favoured for drinking and excess drainage water for irrigation, with livestock use of poorer quality rivers if close by. Otherwise, there is multiple use of single sources. For example with protected springs, there is domestic collection from taps whilst animals use waste/excess water collected in surrounding areas and, where properly constructed, to troughs which receive excess drainage water.

In some communities visited, for instance Arabati in the *kolla* area and at the margin of pastoral-highland cultivation production systems, only one source was being used by both humans and livestock due to the failure of the borehole. Even when working, the generator required maintenance every 5-6 months and last broke down in September 1999. Since the breakdown, both animals and livestock have used the river Burka (a 45 minute round trip). The quality of water at the river (which is seasonal and, in the dry season, is only accessed by digging into the river bed) was likened to animal urine by one interviewee. Some rainwater harvesting was being carried out around the community through the construction of cisterns.

There is some trade-off between distance and quality. Communities had clear ideas about the quality of alternative sources, but nevertheless used poorer quality but closer sources where a higher quality source was (significantly) further away, or where distance was affected by the issue of access 'rights'. Although most communities said that all sources were 'open access', in some cases higher quality spring water was difficult for a neighbouring social sub-unit (referred to as a '*gote*') to access because of the 'ownership' issue between communities. This was not explored in much detail, but it appeared to be significant in some areas and, at times of great water insecurity, could be a source for conflict between communities.

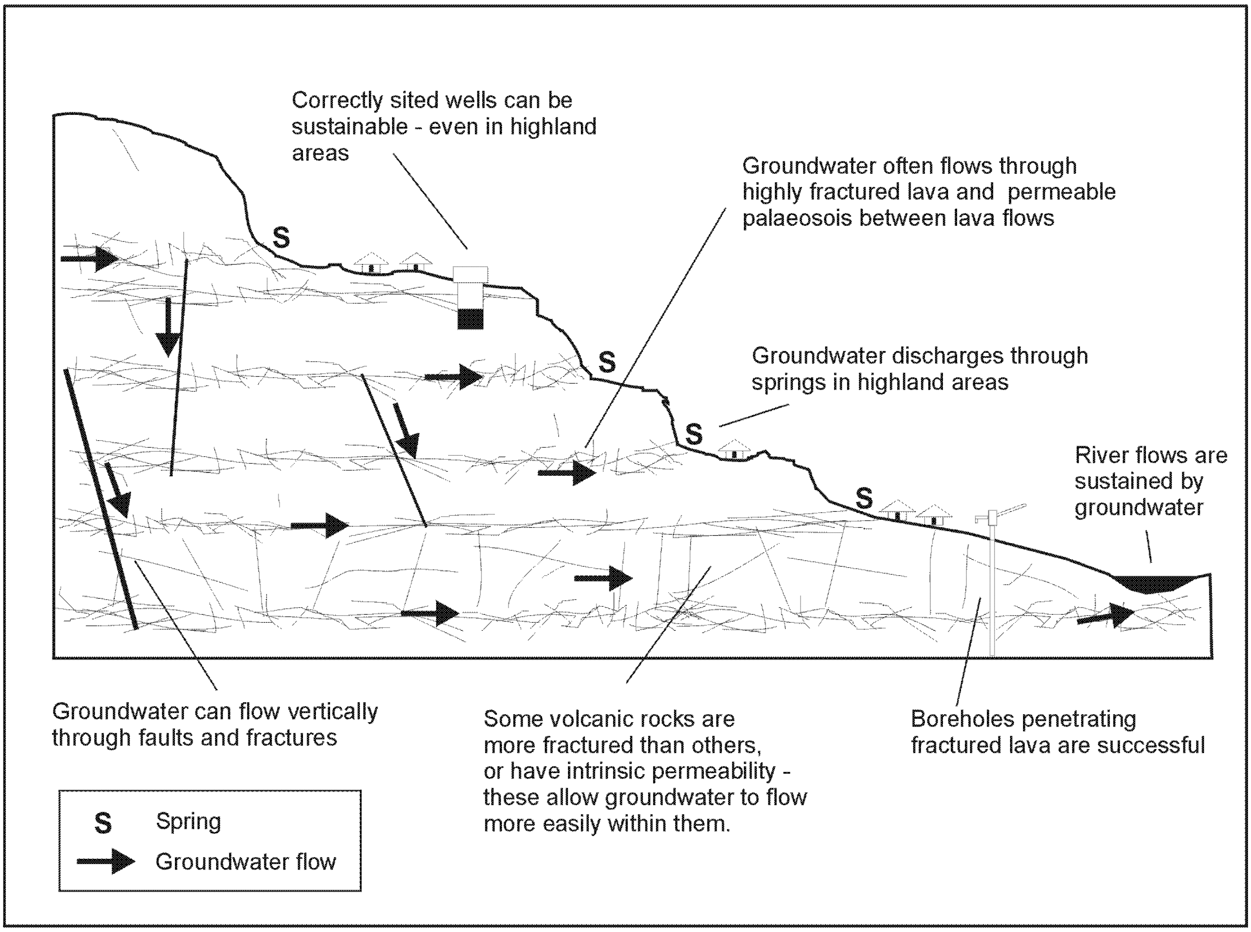

Figure 3 Cross section of groundwater flow in highland volcanic areas.

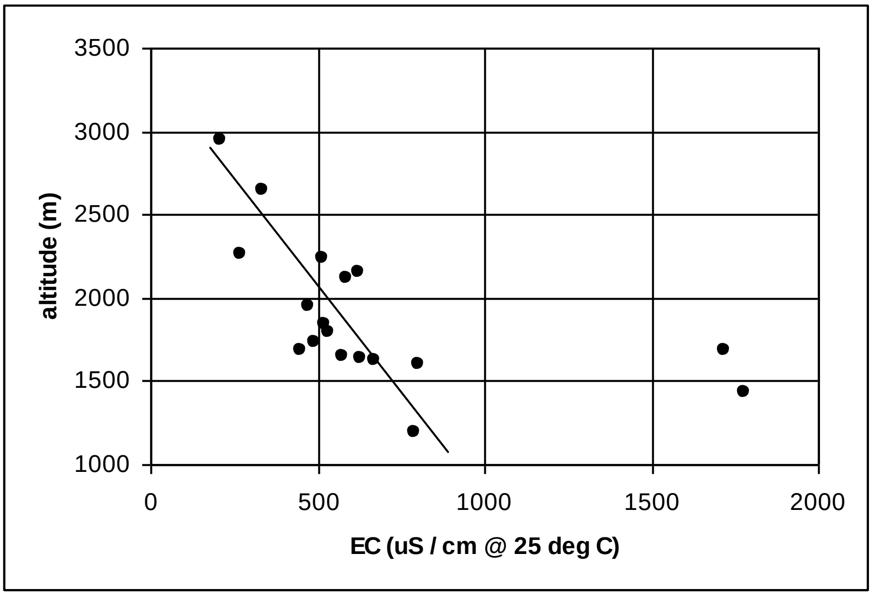

Figure 4 **The variation of electrical conductivity (related to salinity) with altitude.**

Quality also affects choice. In the village of Mariye Selassie (*weyna dega*), inappropriate shallow well construction and capping with handpumps on swampy ground had led to water quality deterioration and the abandonment of the pumps in favour of other sources, including a river and springs.

4.4 Water Security

The importance of looking at groundwater vulnerability under the umbrella term 'water security' became apparent because the complex resource-household relationship encompassed issues of availability (as volume and storage capacity) of groundwater; resource access (via springs, boreholes and/or wells); and demand (failure of other sources).

4.4.1 Drought and seasonality

The droughts[8] of 1973, 1984/85 and 1998 were identified by communities as being particularly severe. Though the level of rainfall in 1998 was reported to be as low as that in 1984/85, impacts on communities - particularly their food security – were not as severe due to greater preparation for food shortages by government. Interviews with a range of informants suggested that drought is an extension and intensification of seasonal water shortages in most communities, rather than an event with its own pattern of shortage. It is, in effect, an acute version of the chronic water insecurity felt by households during dry season periods. Indicators of water stress include greater time taken to collect water (queuing for water took from 2-4 hours in some cases) due to reduced yields and increased demand, the use of poorer quality sources, due either to absolute unavailability of other sources or the relative proximity of poorer quality sources, and reduced consumption of water within the household. These behaviour patterns all impact on the livelihoods of households.

4.4.2 Availability

Availability of the resource depends on the size of the aquifer and catchment area. Results showed that some groundwater was available in all environments throughout drought periods, indicating that

[8] Defined for project purposes in terms of negative rainfall departure from the norm.

in these areas there is no absolute groundwater drought. Aquifer size was smallest in *dega* areas, and largest in *kolla*, with evidence that groundwater flows from high areas to lowland areas. Interviewee replies suggested that groundwater levels within aquifers fluctuated seasonally, and in response to extended periods of low rainfall, resulting in less groundwater discharging to springs and rivers. However, it is unclear at present how the absolute volume of groundwater stored within the aquifers (especially the small *dega* aquifers) is affected by drought. The origin of groundwater in the *kolla* region is unclear in terms of, whether it is mainly direct recharge or flow from highlands, or a combination of the two.

4.4.3 Access

Access to groundwater is via springs, wells and boreholes. Since the yield of springs depends on groundwater levels within an aquifer, they are most susceptible to rainfall variability and some clearly dried up in drought years. However, since communities relying on springs generally had more than one source, a number of springs could often provide some water throughout drought. In many cases local[9], international or government agencies had constructed spring boxes which helped regulate supply, and hand dug wells which could increase yields. Deep groundwater accessed via boreholes was less susceptible to drought. Such boreholes are not reliant on ‘overflow’ (unlike springs), hence fluctuations in groundwater levels will have less effect on yields. Nevertheless boreholes are vulnerable to malfunction, and a working pump is required to access the groundwater resource. The practice of installing expensive and sophisticated electrical submersible pumps is not recommended. Cheaper, easier to maintain boreholes and pumps could be installed for a fraction of the price of the more sophisticated systems.

Where water levels are shallow, hand dug wells provide good access to groundwater. Correctly sited wells are generally more sustainable than springs. Pumps are not required to abstract water from the well – a simple rope and bucket will generally suffice. However, most of the wells visited in South Wollo had been sealed and a hand pump installed. Although this protects the source from possible contamination, it makes it vulnerable to malfunction.

4.4.4 Demand

The interrelationship between demand and supply has significant implications for the sustainable livelihoods of households in many of the areas studied. The nature of constant demand (practically the survival level of water demand) meant dependence on poorer quality and more distant sources in some cases where other access points either reduced in yield or suffered mechanical breakdown. This apparent trade-off between quality and distance appeared to be time-related. Greater collection time for households could impact on other household activities which at certain times of the year, might not be flexible enough to release sufficient labour for collection from more distant sources. Questions of the opportunity cost of time relate to wider labour markets in agriculture (i.e. whether there is a surfeit or deficit of available labour), and to the relative scarcity of labour between different agro-ecological levels, and different household strata. Where other essential labour-consuming activities (e.g. land preparation, foraging, other income generating activities, food for work activities, taking cattle to water and pasture, housework) create excessive demands on adult labour, the burden of water collection may fall disproportionately on children.[10]

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[9] Mainly ‘Mekana Yesus’, a local NGO linked to the evangelical church.

[10] The issue of labour availability and migration and its relationship to relief food distribution under food for work schemes might increasingly impact on water security in certain areas. As indicated in an SCF document on food security in South Wollo “…in terms of a policy towards the provision of smaller or larger quantities of relief food in ‘normal’ years, the net benefits of discouraging migration (temporary or permanent) through provision of relief food must be weighed against encouraging people to remain in an area which cannot sustain the numbers of people now living there.” (SCF-UK, 1998).

The existence of water markets in some areas may reflect other types of coping mechanisms in water insecure areas and the purchase by richer households of the labour power of poorer households to collect water. This suggests that the time savings for richer households can be combined with other assets to increase income or other capital stocks, such as human capital (education) or social capital (community-level networks and relationships). It may also, of course, reflect a simple status-related transaction. The cost of water in such markets provides both an indication of the opportunity cost of time for buyer and seller (with higher prices in drought years and dry seasons, reflecting greater time taken to collect), and of prevailing wage labour rates. The level of demand and the opportunity cost of time can also lead to reduced consumption for washing and cleaning, with longer-term implications for hygiene and health at the household and community level.

The matrix below summarises the key access, availability and demand issues in the main agro-ecological zones.

Table 1 Matrix of water security by ecological zone (assuming similar geology).

	Access	Availability	Demand
Dega	Multiple access, mainly springs.	Small resource base. Seasonal differences large, though tempered by increased rainfall.	Household consumption, some small stock.
Weyna dega	Multiple access: springs, wells, boreholes.	Moderate resource base (larger than *Dega*), but less rainfall. More surface water sources (fed by groundwater).	High demand from human and livestock populations (most populated).
Kolla	Few boreholes, no springs. Some surface water harvesting.	Larger resource base in aquifer, low rainfall. Fewer surface sources (all fed by groundwater).	Human population less dense, but greater demand from livestock.

5. IMPLICATIONS FOR PROJECT

The project has shown that there are different patterns of access and availability in each of the agro-ecological zones. This is determined in part by demand, and in part by the nature of access points which the physical properties of the groundwater system help create (such as the high number of springs per capita in *dega* areas). This suggests that there is some scope for using agro-ecological zones as a surrogate for access, at least in the absence of direct knowledge of access properties in a particular area. This would help, in broad terms, to begin the process of addressing different water security issues facing communities in different regions, and developing a basic typology of availability and access to assist in the construction of vulnerability maps.

One of the key findings of the study is that this level of understanding far exceeds that achieved by relying on ‘coverage’ data (normally water points per capita). Whilst figures for coverage exist in Ethiopia and are used to some extent in the WFP Vulnerability Analysis Monitoring (VAM), the utility of these data has to be questioned since many water points were not working and the seasonal problems of yield are not addressed. It is important to note that coverage figures in Ethiopia probably underestimate access since only improved sources are included. For example, the *dega* region sources may not be improved (and so are reported as low coverage), but in fact have many high quality springs providing high access.

Hence, whilst coverage data are easily created (and perhaps, as a result, attractive to users), they can also be misleading in so far as they may overestimate real access to water, underestimate the problem of sustainability, and fail to differentiate between human and animal consumption. At this level of generality it is, therefore, questionable whether coverage data should be used at all.

5.1 Linkages with Policy and Practice

5.1.1 Planning processes

The preliminary results of the research suggest the need for a systematic approach to identifying and monitoring water insecure communities. As bottom up planning develops, community ‘demand’ will increasingly trigger government and agency responses. Against this background, the nature of resource use patterns across the range of *dega, weyna dega and kolla* agro-ecological zones is important to understand, given that different use patterns are likely to generate different needs in times of acute scarcity. In addition, an understanding of the resource base, and groundwater availability in years of low rainfall and after cumulative low rainfall years, and how communities access the resource, is needed to respond effectively to bottom-up demands. Linking an approach to increasing knowledge through existing vulnerability monitoring could, with little additional effort, prove cost effective in gathering basic planning data on water security at a local level.

5.1.2 Developing projects

The fit of technology choice with the use of a water source is important. For NGOs, zonal water departments and, increasingly, woreda water officers, the research indicates the importance of a retrospective analysis of past drought impacts on likely demand at particular sources combined with existing local level data to assist in targeting appropriate technologies to particular agro-ecological zones. The level of demand in particular years and at times of the year should dictate in part the type of technology used. A high level of demand on a submersible pump where few other options for water supply exist can cause breakdown and long outages in remoter areas. Perhaps a greater number of lower yielding handpumps could provide a community with greater water security. Hence a knowledge of aquifer properties, in combination with levels of demand and seasonal patterns of usage, is invaluable in planning the appropriate level of technological choice. In *weyna dega and dega* areas, for instance, springs are the main source of water and can be vulnerable in times of drought. It is important, therefore, to study how groundwater occurs in the mountains, and to assess the effectiveness of less drought susceptible sources such as wells and boreholes.

5.1.3 Assisting communities

Given current moves towards community-based maintenance and management, the ability of a community to understand the resource base and articulate changes in patterns of access over time would seem important, especially in service level decision-making with woreda and zonal level authorities. The development of rudimentary resource maps around which group discussions could take place might be useful in this respect.

5.2 Vulnerability Mapping

A clear conclusion from the field visit research and the consultation with stakeholders and partners is that vulnerability maps serve to indicate broad areas of vulnerability, but only at a country level with existing data. At their current resolution and stage of development, they could possibly be used to: target supply programmes to areas with high socio-economic vulnerability but low physical vulnerability; and to highlight ‘critical monitoring areas’ (for instance areas where the remit of existing monthly food security assessments could be widened to include water security indicators). However, two major gaps in knowledge would need to be filled: (a) the lack of understanding of highland aquifer characteristics; and (b) the critical relationship between livestock and household water use, and how this affects levels of demand on different access points, and on decisions by households to move in times of acute scarcity.

However, the key question to ask is: who are the users of vulnerability maps? Clearly at a federal level the process of decentralisation limits their use by national government although they only exist at a national level at present. Their main potential use is, therefore, as part of the sectoral development programme, where they could help in targeting donor-funded development/rehabilitation programmes in water supply. Demand is needed from donors and/or regional government to take this forward, and it is, therefore, important that awareness of project activities and outcomes is increased.

Further development of vulnerability mapping would have to form part of another project, the elements of which could include the development of regional-scale hydrogeological maps; integration with existing early warning systems at a national and regional level; and increasing data quality on water supply status in different areas (by level of coverage, status, technology type, etc). If a critical level of resolution is reached, they could then become useful in helping to identify water insecure woredas under decentralised planning.

5.3 Monitoring

The initial findings point strongly to a substantial impact on household livelihoods of reduced access to water during dry seasons and drought years. The need to monitor groundwater availability, therefore, depends on two things: firstly whether scarcity is more a function of lack of access than lack of availability (i.e. access points versus absolute groundwater levels); or secondly, whether water is a more critical determining factor in water-scarce years than concurrent problems of food availability. The sense from local and regional level officials was that some element of monitoring could be useful if sourced via existing monitoring systems which, at a woreda level, look at food security.

A number of implications of the current emphasis on food availability relate indirectly, but critically, to the water availability issue, and may indeed necessitate a closer look at monitoring and managing access to groundwater more effectively. Firstly: increasing the efficiency of food aid delivery in a drought year (when rainfall is the greatest determinant on non-availability of food) can lead to populations staying put and increasing stress on existing (and fewer) water points. This may create unusually acute problems of water shortage and demand on remaining access points. Secondly, in rebuilding the livelihood assets of households after a bad year, the key variable may in fact be water availability, both in increasing labour time availability and in improving livestock production. This indicates the need for drought impacts to be followed by more focused and targeted water supply interventions. Monitoring and mapping can help to establish the most appropriate areas for drought mitigation and post-drought rehabilitation.

Nevertheless, the links between household food and water security, and the ability of households to generate income in drought periods, requires further detailed research (beyond the scope of this project). Of particular importance for households is the labour time involved in collecting water, and the opportunity cost (if any) of this time. The initial (tentative) conclusion of this project is that monitoring, combined with greater understanding of the household water economy in drought-affected areas, would assist in developing a broader approach to drought mitigation than at present exists, at least in those areas where there is little access to perennial groundwater.

In some areas a one-off retrospective survey might provide a reasonable alternative to the establishment of ongoing monitoring mechanisms, though it is recognised that water security varies across seasons and between years. Longer term trends in agricultural, livestock or domestic use (through population growth, changes in crop types and animal type/number[11]) may also necessitate follow-up surveys.

Clearly, accurate and informative baseline data can assist woreda officials in helping to plan responses to demands from the community level. With the current process of decentralised budgeting and planning extending down to the woreda level, woreda officers will have to be more aware of the overall pattern of demand and supply (access and availability) within their woredas in order to prioritise development programmes. At present there is a lack of basic planning data at woreda level on water sources, their behaviour and their use by communities.

[11] For instance in recent years the camel population in *weyna dega* areas of Ambassel Woreda has been increasing for use as a pack animal (personal communication with woreda chairman).

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APPENDIX A: VISIT DETAILS

Itinerary

29/11	Arrive Addis Ababa
2/12	Arrive Dessie, South Wollo Zone, Amhara Region
4/12	Ambassel woreda
	- Robit
5/12	- Abat
6/12	- Tis Abelima / Mariye Selassie
7/12	- Golbol / Chefe
8/12	Worebabu woreda
	- Arabati / Chale
9/12	- Bokaksa / Golbisa
10/12	- Asalel
11/12	Depart South Wollo
12-14/12	Bahi Dar, Amhara Region capital
15/12	Addis Ababa
16/12	Workshop
17/12	Depart Addis Ababa

People Met (chronological order)

Peter Middlebrook	EU Food Security Unit
Alemtsahay Admas	EU Food Security Unit
Dr Nicholas Taylor	DFID
Ben Foot	SCF (UK)
Wendy Fenton	SCF (UK)
Colin Davis	UNICEF
Dr Assefa Woldegiorgis	Farm Africa
Florence Nararro	UNDP
Jim Boreton	UNDP – EUE
Yusuf Abdella	USAID – FEWS
Birhane Gizaw	DPPC
Gebretsadik Eshete	Geological Survey
Paul Barker	CARE
Ato Yunis	CARE
Girma Erkie	Water Department
Ato Tesfaye	South Wollo Planning Department
Ermias Guta	Zonal Administration, South Wollo
Shimelis Haile	Planning Department
Said Ali	Water Department
Teshome Zegeye	ESRDF
Assefa Haile	Interpreter
Ashebir Mohammed	DPPD
Ato Abebe	Ambassel woreda, executive committee
Ato Eshetu	Ambassel woreda, executive committee
Ato Mesfin	Ambassel woreda, Water Officer
Ato Fekadu Debalkie	Water Burerau
Ato Shumet Kebede	Water Bureau

Ato Abol	Woribabu woreda, Executive Committee
Ato Said	Woribabu woreda, water officer
Woletau Hailemariam	DPPC
Yohannes Mekonnen	Regional Council Food Security Unit

Addis Ababa Workshop

Gebretsadik Eshete	Ethiopian Institute of Geological Surveys
Wendy Fenton	SCF (UK)
John Fox	Farm Africa
Bayush Tsegaye	USAID/FEWS
Yibrah Hagos	DPPC
Beres Abdulkadier	EC/LFSU
Tefese Hailemichael	SCF (UK)
Elham Monsef	SCF (UK)
Teshome Assefa	SCF (UK)
Yitbarek Tessema	World Bank Country Office
Lydia Workineh	DFID
Abi Masefield	DFID
Tomisat Mulu	Oxfam
Anteneh Tesfaye	UNDP-EUE
Akalwolde Showakena	SCF (UK)
Jonathan McKee	SCF (UK)
Salvador Baldizon	CARE
Mathewos Tamiru	WFP
Mesfin Lemma	UNICEF

APPENDIX B: SURVEY FORMS AND QUESTIONS

B1. Background information - different levels

1. National Context

- At present is there any drought mitigation/preparedness? If so, how is the system established? Is there monitoring of critical areas
- How does food early warning relate to drought early warning, if at all? what is the DPPC's role at a national level and at the regional/zonal level
- Who are the major stakeholders in water: government, civil society; private sector National Meteorological Agency: what is the present state of rainfall monitoring and how does the national system work within the regions? strengths/weaknesses – issues of decentralisation?

2. Regional Context

- Region – zone – woreda – PA relationship: how is it defined in terms of food aid; what does this tell us about water relationship?
- How does the Ethiopian Social Rehabilitation Development Fund (Govt/World Bank) engage in water and what is its relationship to Water Department/Bureau
- Regional water policy – where does audit of water points fit into planning; is there monitoring of yield, capacity and, if so, how and why is this carried out? By whom?
- What is the process by which bottom-up planning takes place? Is there a conflict between Community Based NRM and Decentralisation?

3. Ambassel Woreda

a) Officials

- What have been the recent drought events affecting your woreda and how have you responded to them?
- How do communities inform you of their water problems? What are the procedures for responding?
- Where are the most drought-vulnerable areas of the woreda and why?
- What is the current status of water points in the woreda (do you have an audit available?)
- How do you prepare for emergency food aid provision and how do you respond to demands from communities? Are these all channelled through PAs?
- What is the relationship between the woreda council and the executive committee on planning water point development including engaging with outside organisations?

b) Peasant Associations

- What are the water points included in your PA?
- What is the history of these water points?
- How do you relate demands for water resource development to the woreda – what is their response like?

c) Communities

- how many water points do people use in your community? differentiate by surface/groundwater?
- who constructed the water points / who financed construction and why?
- is use affected by seasons?; by drought years? If so which are used more/less and why?
- have all the sources dried up in a particularly bad year? if so, what did people do?
- do people prefer groundwater or surface water sources?
- in a drought year what are the main impacts on your use of water? do you differentiate sources by human/animal use and if so how is this affected in a drought year?
- when was the last serious drought?
- what were the reactions of households in your community? what were the main negative impacts on household members – women, children (quantify impacts – e.g. physical example of time/distance effects)
- what actions were taken by government to help alleviate the problem, if any?
- were private individuals involved?

d) Monitoring

- what are the early physical signs of water shortage?
- what are the early social signs of water shortage (problems of farm labour? exhaustion?)
- which water points are more reliable/unreliable?
- is quality affected in water-scarce years?
- do you inform the PA / woreda of water shortages – is there a response?

South Wello: community questionnaire

A BASELINE INFORMATION

Administrative, Physical, Socio-economic

Name ……………………………PA ………………………… District ……………………...

GPS ………………………………… Altitude ………………………………….

Topography ……………………………………… Rainfall ………………………………..

Distance main road …………Market ………………………….. Population …………………

Area of community/village ……………………………………………………………………….

Local economy/livelihood ……………………………………………………………………….

Water points

ID	Type	Distance	Constructed	Yield			Taste
				Dec	Mar	July	
1							
2							
3							
4							
5							

ID	Managed	Used (for what, how much, taste, preferences)
1		
2		
3		
4		
5		

Information sources ………………………………………………………………………….
Drought ………………………………………………………………

ID	Yield	Time to collect
1		
2		
3		
4		
5		

B EXPERIENCES OF DROUGHT

How many very water scarce years in life time ?

……………………………………………………………………………………………………….

Name
Age

Description of most severe events

Was the drought anticipated

Crop failure

Food shortage

Sequence of events; sequence of any water source failures

Time from rain failure to any water failure

Coping strategies

Water consumption (livestock; human)?

Distances walked to collect water?

Payments and/or markets? Inter-village conflicts?

Temporary/permanent migrations?

Divestment?

Timing of strategies?

B3. Community questionnaire – hydrogeology/hydrology

Local hydrogeology /hydrology: prompts for discussion

Community name ………………………………………………

Geological description:

Hydrogeological setting:

Map of water sources:

Water points

ID	type	Distance	Constructed	Yield			Taste
				Dec	Mar	July	Ec
1							
2							
3							
4							
5							

Drought ………………………………………………………………

ID	Yield	Time to collect
1		
2		
3		
4		
5		

Water conductivity of streams