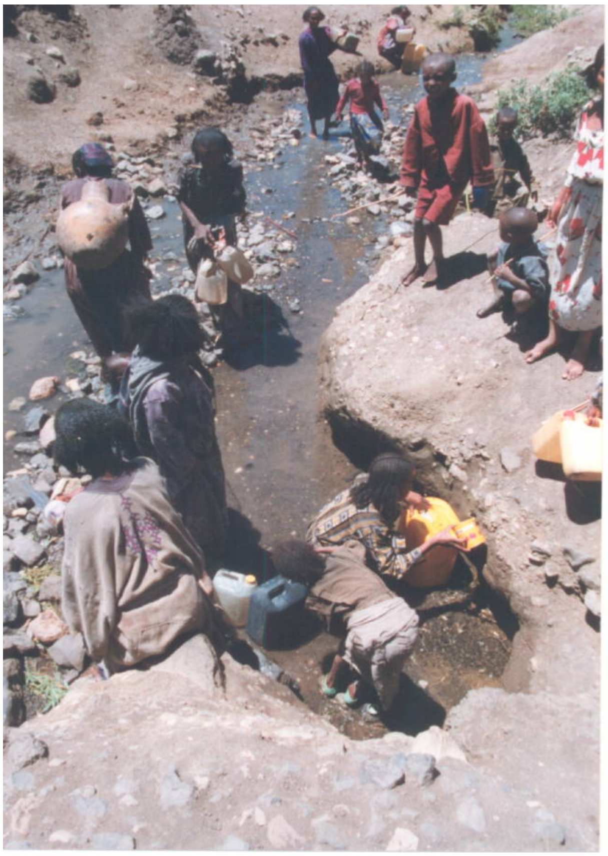
THE STRUGGLE FOR WATER
Drought, water security and rural livelihoods

Groundwater Systems and Water Quality Programme

Commissioned Report CR/02/226N



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THE STRUGGLE FOR WATER
Drought, water security and rural livelihoods

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Editor

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The daily collection of water at a spring in South Wollo, Amhara Region, Ethiopia

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This project, and BGS's previous work on drought in Africa, has forged strong bonds between institutions from different countries with an interest in drought, and those affected by it. The impact of drought on water security is an important yet neglected subject, and the commitment of those involved in developing this and previous projects is gratefully acknowledged. Ultimately, it is hoped that the work will contribute to greater understanding of the multiple dimensions of drought, of what makes certain groups of people more vulnerable, and what can be done to protect their livelihoods before lives are threatened.

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Executive Summary

Drought is a recurring event in Africa. The ongoing 2002-03 drought, affecting large swathes of eastern and southern Africa, is not exceptional. For many, drought is associated with food insecurity: rains fail; crops wither; food supplies dwindle; entitlement to food declines and people go hungry. The response, on the part of government and donors, is typically food aid 'to save lives'. Yet food insecurity is not the only concern during drought, and is not an isolated concern. One of the principal aims of this report – a synthesis of over four years research – is to show how livelihoods are affected by declining access to food *and* water, with access to both linked in a number of important ways. Implications for policy – to protect livelihoods before lives are threatened – are highlighted.

Research evolution

Since 1996, the British Geological Survey (BGS) has worked with partners across Africa on the water resource dimensions of drought. The catalyst for this work was the 1991-92 drought that affected much of southern Africa, and which left many rural people without ready access to water. Although the response to the drought was broadly successful in averting famine, it was less successful in addressing non-food priorities: institutions were confronted with a water supply crisis in some areas rather than with the early indicators of water stress; water supply interventions that did receive support were often ineffective in meeting immediate water needs; and food, water and other public health needs were treated in isolation, rather than as inter-related concerns warranting coordinated action.

Against this background, the UK Department for International Development (DFID) supported the project *Groundwater management in drought-prone areas of Africa*, with partners in Ghana, Malawi and South Africa. The focus on groundwater arose because of its importance in rural areas in Africa, especially during dry seasons and droughts when it may be the only source of supply. A key contention of the research was that some water points, and some areas, were much more vulnerable to 'groundwater drought' than others, yet potentially predictable variations were not planned for or acted upon. One of the principal outputs of the project were therefore groundwater drought vulnerability maps, highlighting differences in groundwater reliability between areas, and recommendations on drought preparedness based on a critical evaluation of the 1991-92 drought response.

In 1998 a new phase of DFID-funded work began under the title *Groundwater drought early warning for vulnerable areas*, with collaboration between UK partners BGS and the Overseas Development Institute (ODI), with the Bureau of Water, Mines and Energy in Amhara Region, Ethiopia. Drawing on village surveys and stakeholder consultations across sectors, this project evolved a broader, more holistic approach to the study of drought and water supply. Rather than focus exclusively on drought and water availability, therefore, constraints on household access to and use of water were explored through the lens of water security. This, in turn, highlighted links between the household water economy (across seasons; between good and bad years) and wider livelihood strategies, particularly in relation to interdependencies between food *and* water security.

Report structure

The report begins with a description of the evolution and scope of the project 'Groundwater drought early warning for vulnerable areas', and the rationale for working in the Amhara Region of Ethiopia. Chapter 2 then reviews key lessons learned from the 1991-92 southern Africa drought and, in particular, discusses which measures and policies were effective in meeting the water needs of rural populations. The Ethiopia study is described in more detail in Chapter 3, in terms of the methodology used for site selection, mapping and fieldwork exercises. Background

information on the physical and socio-economic characteristics of the area is also presented. Chapter 4 then discusses key findings, focussing on the mapping approach to water reliability-availability differentiation, and the village-level survey approach to water security analysis. Policy implications for water supply development and drought planning in Ethiopia are also discussed. Chapter 5 then pulls together (a) findings from the Ethiopia study, with (b) lessons learned from the 1991-92 southern Africa drought, and (c) more recent work on water and sustainable livelihoods, to make recommendations on drought planning, early warning, and development programmes more generally.

Key messages

Key messages emerging from this research concern (a) the impact of drought and the nature of livelihood vulnerability; (b) interdependencies between food and water security; and (c) the need to incorporate an understanding of both into drought preparedness and early warning:

(a) Droughts affect livelihoods in a number of different ways, cutting across sector perspectives and disciplines. Yet in many countries drought management – or more typically relief – focuses almost exclusively on the question of food needs. Other dimensions of vulnerability, including the water availability, access and use constraints that determine household water security - receive much less attention, despite evidence that access to safe water can be a major problem. This reflects the organisation and remit of government and donor bureaucracies, rather than livelihood realities.

(b) Food and water security are related. Food security, for example, is an outcome of a set of vulnerabilities, dependent on how people gain access to production and exchange opportunities. This, in turn, is influenced by the broad expenditure, in time, labour or money, invested by households in gaining access to water. In many rural environments, moreover, 'domestic' water is a production input, in garden irrigation, livestock watering, brewing and brick-making. Water insecurity can therefore affect - directly and indirectly - wider household production and income earning opportunities, as well as the quality and quantity of water consumption.

(c) Maps depicting groundwater availability during drought developed on the project provide useful awareness raising and planning tools. At a national scale, however, they cannot provide the kind of local-level information on water availability, access and use that is necessary to plan water supply projects, or identify vulnerable groups. Investment in regional mapping, combined with local water security assessment, would provide both. By widening the scope of existing local-level food and/or poverty assessments to include simple indicators of water security, a clearer picture of livelihood security, and the interventions needed to support it, could be gained at little extra cost. Water supply interventions – rehabilitation, repair, well deepening, help with water transport – coordinated with food security/asset rebuilding efforts, could help sustain income, production and consumption in the early stages of drought, or in the aftermath of a bad year.

1 Introduction

1.1 PROJECT EVOLUTION AND SCOPE

Project evolution

Since 1996 BGS has worked with partners across Africa on issues concerning drought and water security. The initial impetus for the work was the 1991-92 drought that affected much of southern Africa, and which not only affected food security, but also left many rural people without access to water (Clay et al., 1995; Calow et al., 1997; 1999). Although the response to the drought was successful in averting famine, it was less successful in addressing non-food priorities: institutions were confronted with a water supply crisis in some rural areas, rather than with the early indicators of a worsening situation; relief focused mainly on food needs, treating vulnerability as one-dimensional; and water supply activities that did receive support were often ineffective in meeting immediate water needs.

Against this background, DFID supported the project ‘Groundwater management in drought-prone areas of Africa’(R6233) with partners from Ghana, Malawi and South Africa. A key contention was that some water points, and some areas, were much more vulnerable to ‘groundwater drought’ than others, but that potentially predictable variations were not planned for or acted upon. One of the principal outputs of the project were ‘groundwater drought vulnerability maps’, highlighting these variations, and a series of wider recommendations on drought planning.

The Ethiopia Study

In 1998 a new phase of work began under the title ‘Groundwater drought early warning for vulnerable areas’ (R7125), this time involving collaboration between UK partners BGS and ODI, and the Amhara Region Bureau of Water, Mines and Energy. The work was ably facilitated in the UK and Ethiopia by SCF. The project was again funded by DFID, and ended in October 2000.

The Amhara Water Bureau has a pivotal role in water resources development, management and planning in the Amhara region, and was keen to play an active part in the project and share experience. The decentralised nature of governance in Ethiopia means that water resources management and development is a regional subject; there is a federal Ministry for Water Resources at the central level, but it has no line-management function over the regional water bureaus. SCF has a number of water projects in Ethiopia – including at the time of the study the South Wollo study area – and has a wealth of experience in drought relief, and in the assessment of food security. Both organisations were keen to investigate the impacts of drought on water security, and to explore wider links with livelihood vulnerability.

1.2 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 in groundwater-dependent rural areas. More specifically, guidance is aimed at:

a) Identifying broad areas where groundwater sources currently play, or could play, an important role in providing (buffering) water during drought or, conversely, areas of relative unreliability that are more susceptible to drought-induced water supply problems; and

b) Identifying appropriate policies and interventions that would help prevent crises developing, drought-proofing communities, and protecting rural water supplies and livelihoods.

A main output of (a) above has been the development of a groundwater availability map for Ethiopia, identifying areas of low to high reliability during drought. Knowledge of groundwater reliability can play an important role in helping to target water supply programmes, and in highlighting critical monitoring areas at a broader level. They can also help catalyse discussions around water security – food security links.

The mapping concept has been developed in tandem with an approach for assessing water security at a local (district, or woreda) level, based around an analysis of water availability, access and use. The relationship between these factors was examined along a highland-lowland transect in South Wollo, highlighting the role they play in influencing water security, household vulnerability to drought and income generation. This forms the principal output from (b) above, supporting a wider series of recommendations (drawing also on other work) on drought preparedness, relief and recovery. These are discussed in Chapter 5. Key outputs and project outcomes are summarised in Appendix 1.

1.3 TERMS

During the course of the project, the term *water security* came to the fore as an organising idea encompassing water availability, access and use. Its preferred use over the term 'groundwater drought' was agreed during the project, reflecting a shift in thinking away from a resource-based analysis of drought problems, to a more people-centred approach. This change of emphasis has parallels with the food security debate, and the shift in focus to access and entitlement to food, as well as its absolute availability.

Water security is defined in this report as:

> *"Availability of, and access to, water sufficient in quantity and quality to meet the livelihood needs of all households throughout the year, without prejudicing the needs of other users".*

The term *vulnerability* is also used widely in this report. Here, we use the term to describe the exposure and susceptibility to loss of a household or community arising from a drought hazard. It can be considered to have two dimensions: sensitivity to the shock of drought itself; and the capacity, or resilience, to bounce back to a pre-drought state (Davies, 2000). Risk can then be defined as being the product of hazard and vulnerability. The vulnerability of a household, in a broad sense, is influenced by its ability to draw on different capital assets, including financial, human, social, physical and natural capital, in order to offset perceived and anticipated risks. Considerable evidence of these relationships was found during the Ethiopia field work.

1.4 REPORT STRUCTURE

This report focuses mainly on the approach and findings of the Ethiopia study. In order to provide context, however, and to synthesise generic conclusions on drought management of relevance to other countries in the region, the report also includes (a) lessons learned from an evaluation of the 1991-92 drought that affected much of southern Africa; and (b) findings from other (related) research work, including ongoing DFID-KaR projects such as Secure

Water – Building Sustainable Livelihoods for the Poor into Demand Responsive Approaches (R8034).

The report begins by reviewing the key ‘water’ lessons learned from the 1991-92 drought, in particular which measures and policies were effective in relieving water stress, and which were not (Chapter 2). The Ethiopia study (Chapter 3) is then discussed, in terms of (a) the methodology used to prepare the site selection, mapping and fieldwork approaches, and institutional, governance, physical and socio-economic background. Chapter 4 then discusses key findings, focusing on (a) national and regional-level mapping approaches; and (b) local water security analysis in the South Wollo zone. Policy and practice implications for water supply development and drought planning in Ethiopia are then discussed. Chapter 5 draws together findings from Ethiopia with related work (past and present) to develop recommendations for drought planning and preparedness.

Appendices 1 to 6 provide additional background information, as well as a concept note for developing the work further in Amhara, and a list of DFID-funded projects related to drought.

2 Lesson learning: previous drought experience in Southern Africa

2.1 THE IMPORTANCE OF GROUNDWATER

In rural areas it is frequently groundwater - water stored below the surface in aquifers - that provides the only affordable way of meeting dispersed domestic demand. The development of groundwater has, therefore, underpinned efforts to reduce poverty and promote sustainable livelihoods, particularly in sub-Saharan Africa. One of the key advantages of groundwater is its reliability: when surface rivers and streams have dried up, groundwater can still be accessed through wells, springs and boreholes. This buffering capacity has limits, however: in certain areas, and under some conditions, groundwater sources can fail, and the search for water can become long and arduous.

Much of sub-Saharan Africa (approximately 40%) is underlain by ancient crystalline rocks which form low yielding, though widespread, aquifers. These rocks tend to have low permeability, are generally thin so that transmissivity is also low and, where unaltered, they have low potential for water supply. Fortunately, much of the crystalline basement in Africa is weathered, with a mantle commonly 10–30m thick of more permeable material known as the basement aquifer. Although minor in hydrogeological terms, it is this basement aquifer that provides water for millions of people in rural areas.[1]

Many factors determine the degree of rock weathering and aquifer properties can vary significantly, even at a local scale. This makes careful siting and design of boreholes and wells important, especially in drought-prone areas, but difficult to accomplish.

2.2 THE IMPACTS AND CAUSES OF WATER SUPPLY PROBLEMS

Drought-induced failure of groundwater sources may force people, often women and children, to walk long distances in search of alternative sources. Such was the case in Malawi when, by the end of the 1991-92 drought, normally reliable groundwater sources began to fail leaving some three million mainly rural people without adequate water supplies. One consequence was the use of unprotected sources for drinking, and outbreaks of diarrhoea, cholera and dysentery claimed many lives. In Zimbabwe, South Africa and Lesotho, severe water shortages affected large areas of the country and emergency relief programmes were hastily organised. With the exception of South Africa, these relied heavily on external assistance channelled through government or intermediary agencies and NGOs. Despite the broad success of relief efforts in averting famine, many weaknesses in drought preparedness and emergency response were exposed, particularly in relation to rural water supply (Clay et al., 1995; Calow et al., 1997, 1999; Waterkeyn, 1998).

[1] Approximately 220 million people in sub-Saharan Africa live in areas underlain by basement aquifers. The remaining 215 million people live in areas underlain by sedimentary and volcanic rocks (MacDonald and Davies, 2000)

Box 2.1 Drought definitions and concepts

There are almost as many drought definitions as there are disciplines and professional standpoints. Meteorologists, for example, define drought as a sustained period of deficient precipitation with a low frequency of occurrence; hydrologists link this to the effect on surface and sub-surface water resources; and agriculturalists link drought to soil water deficits and impacts on crops. Social scientists take drought as a relative phenomenon, which varies according to the demand placed on the resource by different uses; hence drought in a semi-arid or arid area where water use is mainly for livestock watering is likely to be substantially different to a drought in a humid area which relies on rainfed agriculture. Central to all definitions is the (relative) shortage of water.

The term groundwater drought has also been used to describe a situation in which groundwater sources fail as a direct consequence of drought (e.g. Calow et al., 1997). In this report, we adopt the broader concept of water security as a more people-centred term, able to capture the access and use, as well as absolute availability, dimensions of water scarcity in relation to household livelihoods.

Source and resource problems

Although there is generally an increase in the failure of wells, springs and boreholes during drought, the link between drought and source failure is not always obvious. Regional depletion of an aquifer is rarely a problem on the African basement as abstraction from individual sources is low (10-15 m^3/day), and sources are sufficiently few in number, that overall abstraction does not usually exceed long term aquifer recharge from rainfall. As a consequence, the amount of water that can be withdrawn from the aquifer is largely a function of the number of access points (wells and boreholes) to the resource.

Localised depletion, resulting in falling groundwater levels in the immediate vicinity of a well or borehole, or group of sources, may be a problem. This is most likely to occur where the demands being placed on a groundwater source are high, and where the transmissivity of the aquifer is low. In these circumstances, insufficient groundwater is transported to the well or borehole to replenish the water being withdrawn, and a dewatered zone may form around the source. The most likely time for this to occur is at the end of the dry season when demand for groundwater reaches a peak.

Increased stress on a groundwater source during drought also makes a failure of the pump more likely. Prolonged pumping throughout the day can put considerable strain on the pump mechanism leading to breakdowns, especially if water levels are falling and pumping lifts increasing. The result may be increased demand on a neighbouring source, and thus increased stress (and probability of failure) on that source as well. The problem may be exacerbated by the cessation of maintenance activities as relief drilling programmes take priority. In South Africa, many of the water supply failures experienced during the 1991-93 drought were blamed on maintenance problems made worse by the drought (Hazelton et al., 1994; du Toit, 1996).

A preliminary conclusion is that the failure of wells and boreholes during drought is a function of both increased demand on low yielding sources and reduced recharge to the aquifer. This may cause some sources to dry up altogether, and precipitate mechanical breakdown in others. Identifying hydrogeological zones that have low permeability, wells and boreholes that are low yielding, and areas of high population density with few alternative water sources, is therefore important in supporting a more proactive approach to groundwater management and drought preparedness.

2.3 POLICY RESPONSES AND THE OBJECTIVES OF INTERVENTION

> *"The performance of non-food assistance (in southern Africa) including that in the agricultural recovery, emergency water programmes and health sectors, was less impressive. The major part of the water and health assistance failed to yield benefits to the target population(s) until after the 1992-93 rains had begun and the crisis had passed (Clay et al., 1995).*

In countries such as Mozambique, Zimbabwe, Malawi and South Africa, the failure of groundwater sources - seemingly at random - led to crisis water management: emergency water supply programmes were organised, relief structures set up, equipment imported, international expertise and funds mobilised, and large sums of money invested. Such relief was often ineffective, certainly in terms of meeting immediate water needs. Indeed the evaluation of the Overseas Development Administration's (ODA)[2] response to the southern African drought (Clay et al., 1995) concluded that the only actions which were effective before the October rains were water tankering operations and rehabilitation and improvement measures; emergency drilling programmes, which received the bulk of support, had no effect whatsoever. This implies that, of the £2.7 million spent on drought-related emergency water supplies in southern Africa, around 80% (£2.2 million) was spent on activities which failed to address immediate water needs.

Why was this the case, and what lessons can be drawn from the southern Africa experience of 1991-92? Drawing on the evaluation of ODA's response and on other donor, NGO and government reports (see Calow et al., 1997), the main issues are summarised below.

Needs assessment, planning and prioritisation

Underpinning the problems of timeliness and targeting was a lack of information on availability and access to potable water, and on groundwater conditions generally.

In South Africa, for example, where the government embarked on two drought relief programmes, lack of pre-drought monitoring and groundwater management was identified as a severe constraint on programme effectiveness (Hazelton et al., 1994; du Toit, 1996). Indeed du Toit (ibid) noted that "… despite the fact that 80% of the rural areas are totally dependent on groundwater, virtually no monitoring of water quality, abstraction or water levels was done in any of the rural areas". The result was what both authors describe as 'crisis management'.

The South African experience of 1991-1993 was mirrored elsewhere. In Lesotho for example, the Drought Relief Implementation Group set up to coordinate drought relief identified a "critical lack of information available with which to plan, prioritise and introduce relief measures before serious problems arise", and noted that "too much action is reactive and retrospective". In Malawi, Mozambique and Zimbabwe similar problems were also encountered, leading Clay et al.(1995) to conclude:

> *"According low priority to monitoring and reporting is in the end a false economy in relation to the magnitude of resources otherwise allocated."*

It is tempting to assume that that lessons have now been learnt and incorporated into drought contingency plans. That this has not occurred tells us a lot about the stop-go approach to drought management that prevails: once a crisis is perceived to be over, systems are frozen or dismantled until next time around, data are lost or fragmented, post-drought monitoring of target populations and interventions is not carried out, and institutional memory is lost. At the

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[2] The UK ODA is now called the Department for International Development (DFID).

same time most groundwater development continues to be ad hoc and project-based, with little or no attempt made to monitor resource conditions and develop contingency plans.

Timeliness and appropriateness

For an activity intended to alleviate water stress in a drought affected population, timeliness is the principal criterion against which actions should be judged. Yet as the evaluation of ODA's response makes clear, most support was targeted at the installation of new capacity (and emergency drilling programmes in particular) and failed to yield benefits until after the crisis had passed (Box 2.2).

In contrast, stop-gap measures (e.g. water tankering operations) and improvement and rehabilitation prog–rammes (e.g. pump repair or relocation; well deepening; well re-excavation) were generally successful in meeting immediate needs. They were also more cost-effective as emergency measures. In addition, well re-excavation was frequently carried out on own-household initiative, emphasising the importance of understanding – and building off – existing coping strategies.

Not all these measures are universally applicable though. Tankering operations work best where water can be delivered to temporary storage, population densities are high, road networks good and money is available for fuel and vehicles. In Lesotho, butyl rubber water bags (bladder tanks) were used as reservoirs, facilitating rapid turnaround of (South African) tankers. Well deepening and re-excavation programmes work well with large diameter shallow wells, but less well with narrow boreholes. The advantages and limitations of different drought relief interventions are summarised in Table 2.1.

Box 2.2 Problems with the installation of new capacity

Problems encountered in trying to install new water infrastructure in response to drought included:

- Lack of realism over the length of time required to install new capacity;
- Delays in submissions and approvals of proposals, especially those involving the purchase and import of equipment and expertise;
- Use of emergency funds by some agencies to accelerate and expand their conventional programmes, where funding was more readily available for 'emergency' than for 'developmental' activities;
- Difficulty in striking the balance between measures to improve water supplies quickly, and measures that would be of benefit in the long term, or if the drought were to continue;
- Donor and government wishing to put in politically visible infrastructure;
- The lack of baseline and early warning information needed for planning and prioritisation, noted previously.

Targeting

It is difficult to judge whether activities were directed towards the worst affected populations when so little information was available on needs and priorities before and during the drought. Nevertheless, the evidence that is available suggests that targeting was often poor, with resources directed toward existing agency programmes

Box 2.3 Water insecurity - scale issues

Water stress can be a much more localised problem than food insecurity.

Required amounts of food can be transported further and more easily than those of water in areas where there are no piped networks. Moreover, the nature of the basement aquifer underlying large parts of Africa means that large local variations in groundwater yield and reliability are common. The need to identify the worst affected communities at district or sub-district level highlights the importance of decentralised monitoring and decision-making to local institutions that have knowledge of the immediate area.

irrespective of drought status. In Lesotho, the evaluation of ODA's response concluded that "…overall, the lack of logic in targeting decisions, the concentration of efforts on borehole drilling and the slow implementation raise questions about the effectiveness of the water programme and drought related operations" (Clay et al., 1995). Similar concerns were raised in South Africa, Zimbabwe and Malawi.

The need for better targeting of relief is reinforced by the localised nature of water security problems, at least in areas with highly heterogeneous aquifers. Box 2.3 discusses scale issues further.

Table 2.1 The advantages and limitations of different drought relief interventions in water scarce rural areas – experience from 1991-92

	Time to implement	Costs and benefits	Applicability	Remarks
Drilling boreholes	Long: generally >6 months from proposal to implementation	Not cost-effective as emergency measure. Long term benefits compromised by lack of community participation	Depends on geological environment, availability of local drilling capacity and vehicle access	Most frequently funded emergency response New infrastructure politically attractive to governments and donors
Development of alternative sources (e.g. small dam construction)	Medium-long: depends on approach and use made of local labour and materials	Not cost-effective as emergency measure. Longer term benefits will depend on level of community involvement	Depends on availability and quality of alternatives	Possible food for work benefits during drought. Pools behind dams can become breeding ground for mosquitoes and pose serious health hazards to neighbouring communities
Well deepening/ excavation	Short-medium: depends on environment and methods used	Cheaper than drilling boreholes, with short and longer term benefits	Existing water points only Generally most useful for large diameter wells rather than boreholes. Depends on geological environment and original well construction	Deepening can be speeded up if extra materials left on site when well first dug Scope for community involvement, especially building-on existing household and community initiatives
Pump repair/ relocation	Short-medium: depends on availability of spares and local expertise	Maintaining or repairing water points is much cheaper than building new ones	Only works where pumps are the main problem. If the borehole is damaged or the yield of the borehole is low, maintenance or repair will not work	Some scope for community involvement
Water tankering	Short if infrastructure and equipment already in place	High cost, but can be organised quickly. Stop-gap measure only: no longer term benefits	Feasibility and effectiveness depend on population density, transport network, availability of money and vehicles, and temporary reservoirs. Need reliable sources of potable water to tanker from	Used to good effect in Lesotho during 1991-92 drought. Less appealing to government and donors as permanent infrastructure not put in place

Cost-effectiveness and sustainability

The failure of most water assistance to realise benefits in the short term raises the question of whether long term benefits from supply improvement can be assumed. This is a difficult question to answer with any confidence because of the lack of post-drought beneficiary monitoring, but it is clear that "…longer-term benefits could have been achieved more cost-effectively had the activities been undertaken in a carefully planned way as part of a normal development programme rather than as an emergency intervention" (Clay et al., 1995).

The long term sustainability of relief infrastructure must also be questionable in view of the fact that rushed programmes leave little time for community mobilisation and participation. Moreover, the preoccupation with crude water delivery led, in some cases, to the neglect of complementary activities. In Lesotho, for example, no water quality testing was carried out on recently completed boreholes and many structures were poorly finished, increasing potential health risks and maintenance problems. In addition, no attention was to paid to hygiene education.

2.4 THE NEED FOR NEW APPROACHES

Drawing on this experience, and insights emerging from the current 2002-03 drought in eastern and southern Africa (e.g. Oxfam, 2002), there is a need for a less compartmentalised approach to drought planning to protect livelihoods, as well as lives. This implies a more developmental approach to assistance than currently exists, with policies and interventions that would increase community resilience to drought through a combination of food and water measures. Drought vulnerable areas, and communities, need to be explicitly targeted for assistance. In addition, there is a need for information systems that can detect the symptoms of livelihood insecurity, rather than the symptom of food insecurity alone. In the chapters that follow, we examine how such an approach could be developed.

Figure 2.1 Children in Northern Province, South Africa, collecting water. Northern Province was severely affected by the 1991-92 drought

3 The Ethiopia study

3.1 STUDY SCOPE AND ORGANISATION

The project 'Groundwater drought early warning for vulnerable areas' began in August 1998 as a development of previous DFID-funded work examining the water sector impacts of drought. Ethiopia was chosen as the core focus for research because of its predisposition for rainfall variability and recurrent drought episodes. The Amhara Region was selected because of (a) its recent experience with drought in 1984-85, and more recently 1998; and (b) strong partner presence in the area.

Fieldwork took place over a period of three weeks in the South Wollo zone of Amhara, and meetings were held with a range of stakeholders in Addis Ababa (federal level), Bahir Dar (regional level), Dessie (zonal level) and Ambassel and Worebabu (woreda level), as well as at the community - household level. In addition, project planning/study visits to the UK were held for the Amhara Region Bureau and Water, Mines and Energy, the principal project partner, and SCF staff from Ethiopia involved in water supply projects in the region. SCF staff from both Ethiopia and London played a key role in facilitating the study. The project ended in October 2000, following a three month extension.

Key project events are summarised below. Further details on study approach and methodology are contained in the project Inception Report.[3] A summary of project outputs and outcomes is contained in Appendix 1.

August 1998 -	Project approval from DFID-KaR
July 1999	Meetings with SCF and government partners in Ethiopia
	Development of groundwater availability mapping concept and methodology; collection of secondary data
August 1999	Project planning workshop, BGS, attended by government and SCF (UK and Ethiopia) representatives. Training in GIS techniques and application
December 1999	Field visit: government, donor and NGO consultations; field work in South Wollo; project workshop in Addis Ababa; draft of groundwater availability map produced
May 2000	Inception Report published; development of maps continues
July 2000	Original project end date. Extension to October 2000 because Ethiopia-Eritrea war prevents visits
October 2000	Final project workshop in Addis Ababa, attended by government, donor and NGO stakeholders

[3] Calow RC, MacDonald AM and Nicol AL 2000. Planning for Groundwater Drought in Africa: Towards a Systematic Framework for Assessing Water Security in Ethiopia. BGS Technical ReportWC/00/13.

Partners and stakeholders

The principal study partner was the Amhara Bureau of Water, Mines and Energy, a regional level government institution with responsibilities in both groundwater development (including drilling) and management. The study was facilitated by SCF in the UK and Ethiopia, through the East Africa Regional Desk and federal and regional offices in Ethiopia, respectively.

During the project, efforts were made to involve a wide range of both water resource and food security stakeholders in project discussions. This was reflected in attendance at in-country workshops by, amongst others:

Federal and regional government representatives, for example from the DPPC;

NGOs, including WaterAid, CARE, Oxfam and SCF;

Donors involved in, or supporting, water supply and drought planning and relief work, including UNDP, UNICEF, WFP, the World Bank, DFID, the EU’s Food Security Unit and USAID.

Approach

The study adopted a two-tier approach for examining the causes, patterns and consequences of water insecurity:

At the federal level, *groundwater availability mapping* was employed to identify areas of greater or lesser groundwater reliability, drawing together secondary data on rainfall and geology. Guidance on how to construct maps was prepared and published, and their potential use discussed with stakeholders at federal, regional and zonal levels.

At local zonal and woreda levels, *community and household surveys* were conducted along a highland-lowland transect in South Wollo to investigate the nature of water insecurity – patterns of availability, access and use - across seasons, between good and bad years, between different agro-ecological zones, and between households. Responses to water insecurity, and in particular experiences of past drought events, were discussed.

The process of developing the groundwater availability map is discussed in Section 3.2 below. This is followed in Section 3.3 with background information on the South Wollo zone where fieldwork took place, and a summary of the survey approach. Survey checklists and forms are presented in Appendix 3.

3.2 GROUNDWATER AVAILABILITY MAPPING – FEDERAL LEVEL

A key contention of our research is that groundwater availability during drought can be predicted and mapped. This subsection describes how national (federal) maps were developed in Ethiopia. Higher resolution regional maps could not be prepared because of lack of data.

3.2.1 Base data

Two main factors control the amount of groundwater available during drought: rock type (geology) and rainfall (aquifer recharge). Below, we provide a short summary of concepts and discuss the process through which the final map was constructed. Further detail on concepts and methods can be found in Calow et al., 1997, and Calow et al., 1999.

Geology. Groundwater is stored within pore spaces and fractures in rocks. Where the pores and fractures are interconnected, groundwater can flow easily and the rocks are said to be permeable. Rocks which contain significant groundwater are called aquifers. Hydrogeologists classify rocks according to permeability to produce hydrogeological maps. Figure 3.1 shows a simplified hydrogeological map for Ethiopia. To ensure groundwater availability during drought, the ease with which groundwater flows through the rocks (permeability) and the volume of water stored within the rocks are both important. Since the volumes of water required by dispersed rural communities are low, groundwater storage is less important than permeability.

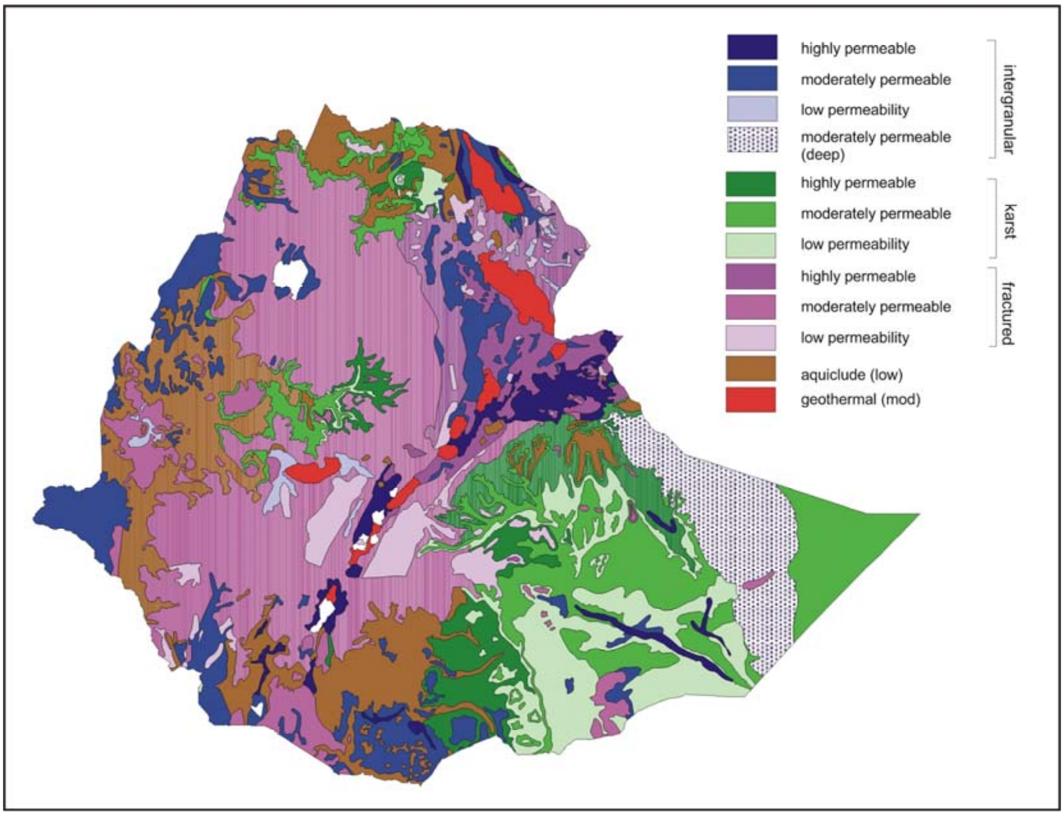

Figure 3.1 Simplified hydrogeological map of Ethiopia.
Adapted from Ethiopian Institute of Geological Surveys (1988)

Recharge. Recharge to groundwater is also important in controlling the availability of groundwater during drought. Recharge to groundwater usually occurs annually and depends on a number of factors, including: total annual rainfall; distribution and intensity of rainfall events; connection to streams and rivers; soil type; and land use. Aquifers react slowly to changes in rainfall and long term average rainfall is more important in controlling recharge to aquifers than short term variations. Groundwater sources can therefore bridge surface water deficits. The average annual rainfall for Ethiopia is shown in Figure 3.2.

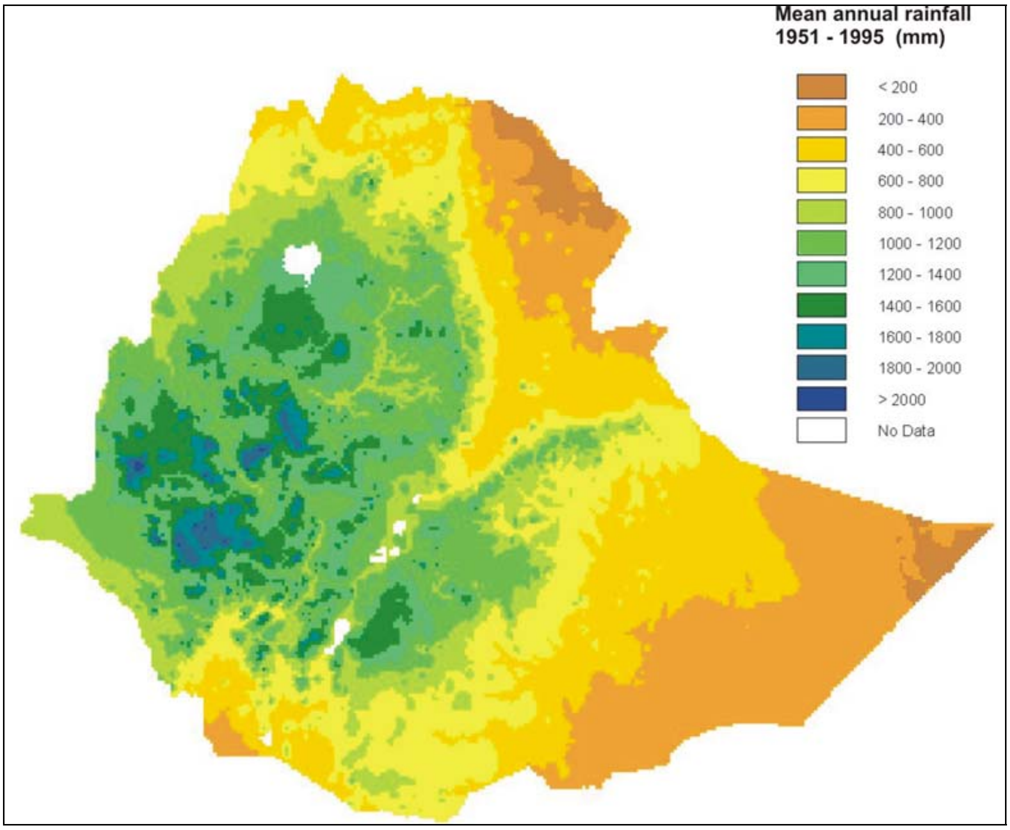

Figure 3.2 Average annual rainfall for Ethiopia.
Data from New and Hulme (1997)

3.2.2 Constructing a map for Ethiopia

A map showing groundwater availability during drought for Ethiopia was developed by interpreting existing published information (MacDonald et al., 2001). The methodology and weights used here could easily be applied to other areas. The data sets used to construct the map are also widely available. Hydrogeological maps are made to an international standard (Struckmeier and Margat, 1995) and are available for most countries. The rainfall data set is available for all Africa. The weighting system has been developed primarily for Ethiopia and may need to be modified and tested before applying elsewhere.

The map was developed by combining three factors:

a) rock permeability (derived from the hydrogeology map);

b) the ability of the rock to store water (from the hydrogeology map);

c) recharge to the groundwater (estimated from rainfall data).

Areas of high permeability, high storage and high recharge have most groundwater available during drought.

Rock permeability and groundwater storage factors are generally shown on hydrogeology maps. Hydrogeology maps divide geology into three separate classes of permeability: high, moderate and low. These were given a weight of 6, 4 and 2 respectively.

On hydrogeological maps, rocks are also divided into those with inter-granular flow and those with either fractured or karstic flow. Intergranular aquifers store water in pore spaces and have a large storage capacity. Fractured or karstic aquifers store groundwater only in fractures and therefore have much lower storage capacity. Intergranular aquifers were given a weight of 4 and fractured/karstic aquifers a weight of 2.

Recharge to the aquifer has been estimated from rainfall data for Ethiopia. To build a sophisticated recharge model demands much data and calibration which is beyond the scope of this project. Using solely rainfall data is a simplification, but the broad classifications used in making the maps make any errors less significant.

Rainfall data were taken from a 3 minute monthly climate grid for Africa for 1951 - 1995, constructed by New and Hulme (1997). To take into account rainfall variability, the coefficient of variability (*V)* was calculated along with the annual average (R_{MEAN}) for each grid cell. The average annual rainfall for below average years (R_{LOW}) was then calculated using the formula:

$$R_{LOW} \quad = \quad R_{MEAN}\,(1-V)$$

The final map showing groundwater availability during drought was then constructed by adding the various weights together. The matrix below (Figure 3.3) shows the possible combinations of physical characteristics that make up each weight, and the colour scheme used for the final map. The weights for each characteristic were chosen to reflect the relative importance of each of the factors in controlling groundwater availability during drought. A summary of the final map is shown in Figure 4.1, Chapter 4.

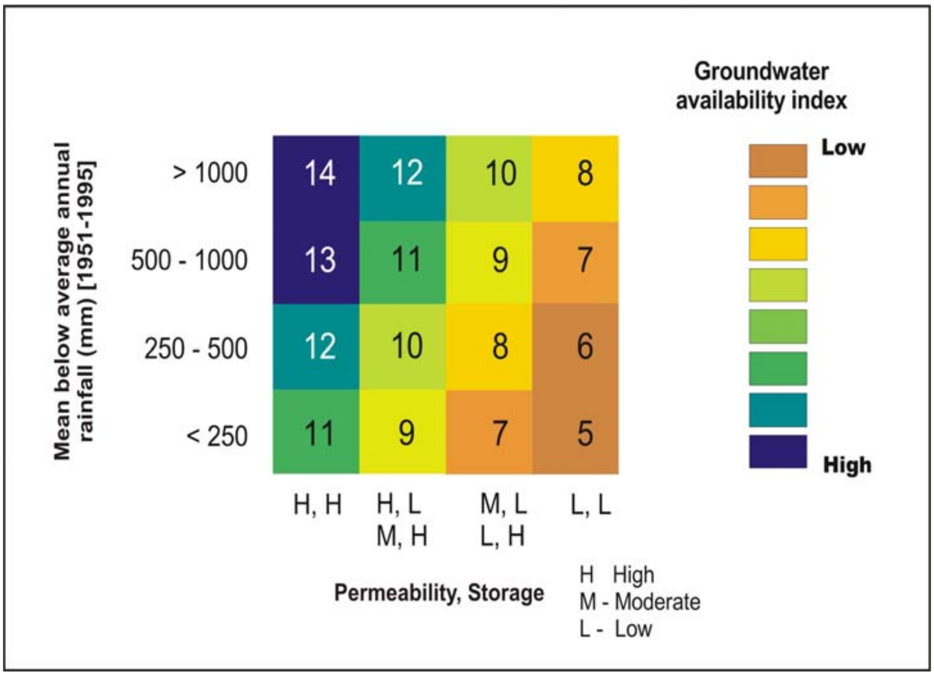

Figure 3.3 Matrix used to evaluate groundwater availability during drought

To give an overall impression of the demand for groundwater and the population at risk during drought, the population density can be overlain as a stipple on the map (see poster, Appendix 6). This information was taken from the 1995 census and also the Environmental Systems Research Institute world data set (ESRI, 1996). An indication of where groundwater quality could be poor was also shown on the map.

3.3 WATER SECURITY ANALYSIS – LOCAL LEVEL

3.3.1 Study area and background

South Wollo zone lies within the south-east corner of Amhara ethnic region, or state. The zone covers the three main agro-ecological areas, namely: *dega*, above 2,500m; *weyna dega* between 1,600 and 2,500m; *kolla*, from 1,300-1,600m within 17 rural woredas and two urban woredas. The agricultural practices in these agro-ecological zones are in part determined by characteristics such as soil type, rainfall distribution and variability, surface water distribution, vegetative cover and temperature. In most of the areas rainfall is bimodal, with short *belg* rains from March to April and longer *keremt* rains from July to September. Most of the study area came under *belg*-dependent production.

The study area in South Wollo cuts across two woredas - Ambassel and Worebabu – and was selected in consultation with SCF and the Amhara Region government (Figure 3.4). 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 to transport (given 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.

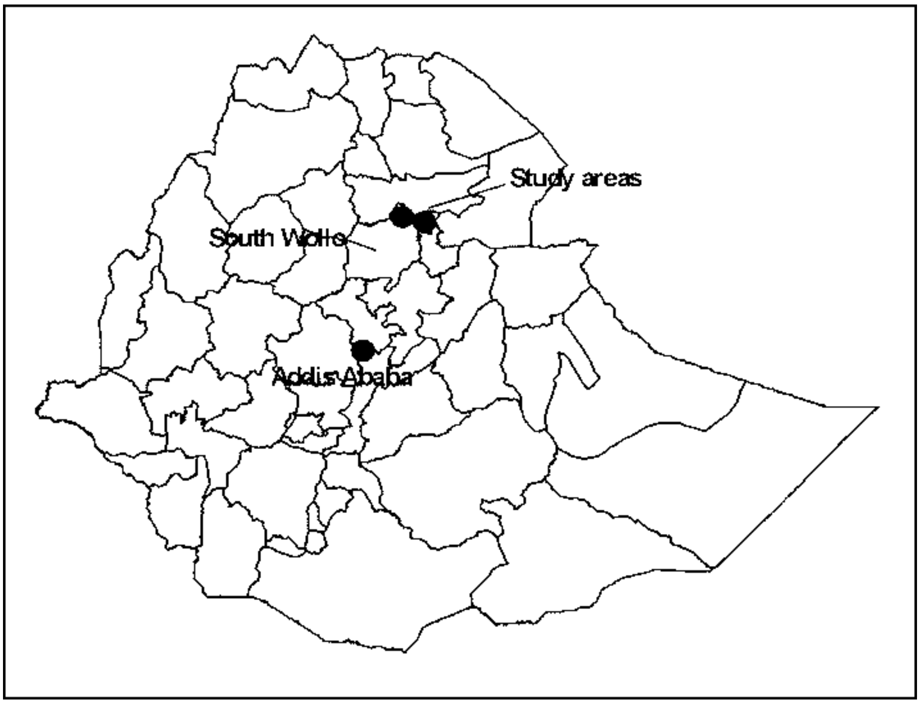

Figure 3.4 The location of the Ambassel and Worebabu woredas, South Wollo, selected for study

3.3.2 Physical background

The landscape of South Wollo is dramatic. There are high mountains (over 4000 m) in the west, and an escarpment falling into the Awash River plains to the east. The rainfall of the area is controlled by the variation in topography. In the highland areas, average annual rainfall can be in excess of 2000 millimetres (mm); in the lowland areas it declines to below 750 mm.

South Wollo is underlain by relatively young volcanic rocks. These were formed in three phases of activity during Tertiary 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 fossil soils (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 are within the river Awash basin. The only perennial river in the study area is the Mille, and this is sustained in the dry season by groundwater. Most water sources used by communities are springs, wells or boreholes.

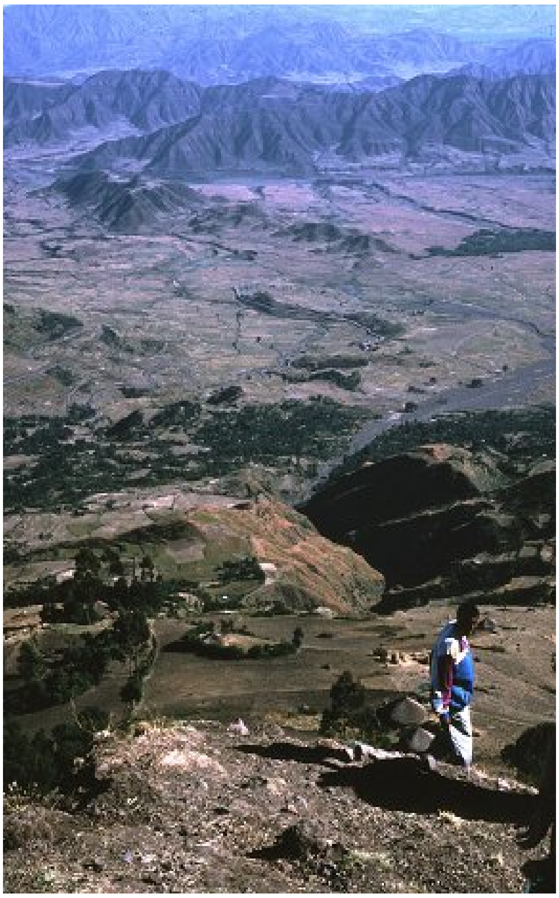

Figure 3.5 The River Mille viewed from Abbot village, Ambassel Woreda

3.3.3 Socio-economic background

South Wollo exhibits many of the key stresses and strains 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, exacerbating loss of topsoil. This contributes to a near 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 (July – September). The area of South Wollo chosen for study represents all three agro-ecological zones, ranging from *dega* to *kolla* and, as such, provided a transect-view of the highland escarpment.[4]

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 trade in goods from coastal regions via the lowlands to highland areas (Bokaksa PA was one notable trading community visited). The relationship between the livelihood systems of *dega*, *weyna dega* and *kolla* agro-ecological zones in this area is complex and, in drought years, can come under considerable stress, leading to disputes and sometimes violent conflict over access to resources. Water,

[4] For further information on the socio-economic situation of South Wollo, refer to SCF 1993 and 1998.

along with food and transport, is a key variable in this transactional relationship and in the vulnerability of communities.

3.3.4 Institutions

a) Government

Since 1991 the government of Ethiopia has pursued a federal system of government based on the development of ethnic regions. There are now nine regional governments vested with authority for self-administration, namely Afar, Amhara, Benishangul-Gumuz, Gambela, Harari, Oromiya, Southern Nations Nationalities and Peoples' Region, and Somali and Tigray regions. In addition there are two chartered cities: Addis Ababa and Dire-Dawa. Amhara Region is the second largest in the country, after Oromiya, and has a total area of some 170,000 km^2, roughly 11% of the whole country.[5]

This process of decentralisation seeks to empower lower tiers of government, leading ultimately to woredas (districts) becoming the key location for, and agent of, development activities. This ideal is some way from realisation, however, because of wide variations in capacity between woredas within different regions, and even across zones in the same region. Under the woredas there are PAs (or kebeles in urban areas) which have development committees charged with establishing community development priorities and channelling these to the woreda development committees. The idea is that bottom-up planning from the PAs/kebeles upwards takes place each year from December to April, culminating in an annual region plan in May/June. In practice, whilst there is a channelling of demands – for instance for new water points – to higher levels, there is little connection between the consolidation of these demands and the budgets devolved by regional government. Coordinating the planning and budgeting process in Ethiopia remains a key development challenge. At present regional governments have the powers to plan, direct and supervise social and economic development programmes and hold line authority over zonal departments.

In tandem with the executive government role in the development process, there is a political structure based on regional, zonal and woreda councils. These councils are the law-making bodies within a system based on popular participation and the establishment of 'direct democracy'. This concept envisages that communities will make claims on their representatives who, in turn, will act on their behalf with the executive authority at each level. It is the antithesis of centralised planning.

At present most financing for development comes from central government although, in theory, sources also include (a) revenue collected from taxes allocated to regional governments, and (b) domestic borrowing. One of the key governance challenges lies in establishing more effective local-level systems of taxation that increase links between taxation and the financing of local development projects.

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[5] The *dega*, *weyna dega* and *kola* parts of Amhara Region constitute 25%, 44% and 31% of the total area of the region, respectively.

b) Water resources management

Management structures have been similarly devolved. The federal Ministry for Water Resources is largely a regulatory and policy-making body – except with respect to major national projects and issues of transboundary water – and has no line-management control over the regional water and mines bureaus.

Water bureaus in each region have under their control zonal water departments. In 1999, a woreda-level water officer was established on respective woreda executive committees. The woreda level generally 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.

The development of the water officer position has relied on the appointment of relatively young and inexperienced personnel, given the major skills shortage in water supply and sanitation. Nevertheless, the establishment of this professional tier has enabled water bureaus to increase their reach to the local level where, increasingly, development activities are being focussed. Other ministries with an established presence at this level include health (via health assistants) and agriculture (via extension agents).

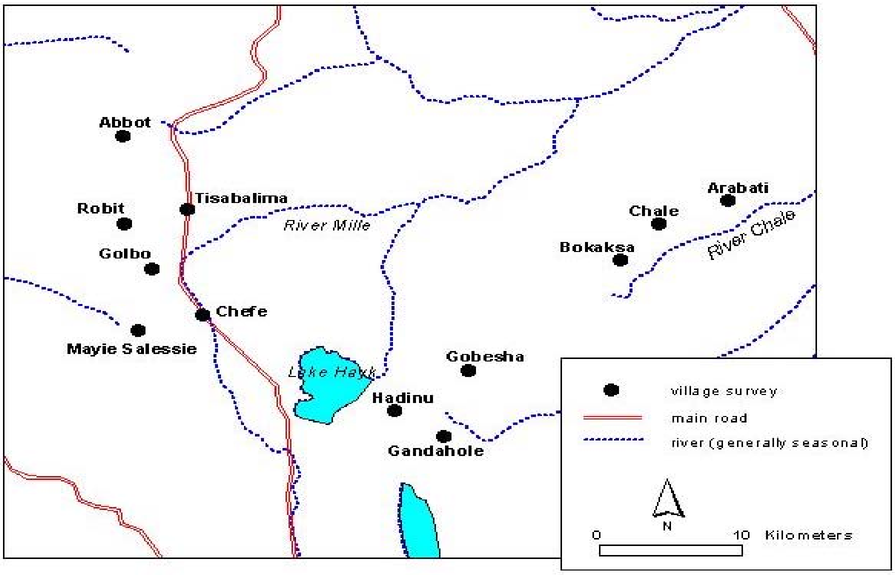

Figure 3.6 Location of villages surveyed in South Wollo

3.3.5 Field survey

The field survey consisted of interviews with a structured sample of communities arrived at 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 the team to assist in accessing the communities. Figure 3.6 shows the location of villages surveyed in the South Wollo area.

A checklist of questions (see Calow et al., 2000 and Appendix 3 of this report) 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 questionnaire covered baseline information on:

- The community itself, and its physical, administrative and socio-economic setting;
- Water sources used, including patterns of access and use across seasons, yields, quality, distance, collection times and preferences;
- Water use, and relationships with source information above;
- The community's experience of drought, particularly in relation to patterns of water access and use, and coping strategies employed.

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, who 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. Physical data are presented in Appendix 4.

4 Key findings

4.1 GROUNDWATER AVAILABILITY MAPPING

4.1.1 Interpreting the groundwater availability map

Ethiopia has diverse geology and complex rainfall. Producing an interpreted map of groundwater availability allows the water situation in Ethiopia to be presented concisely and visually to a diverse audience that does not necessarily require significant hydrogeological expertise. A summary of the map is shown in Figure 4.1. The full map, with explanatory notes, is contained in Appendix 6. The methodology used to prepare the map is described in Chapter 3.

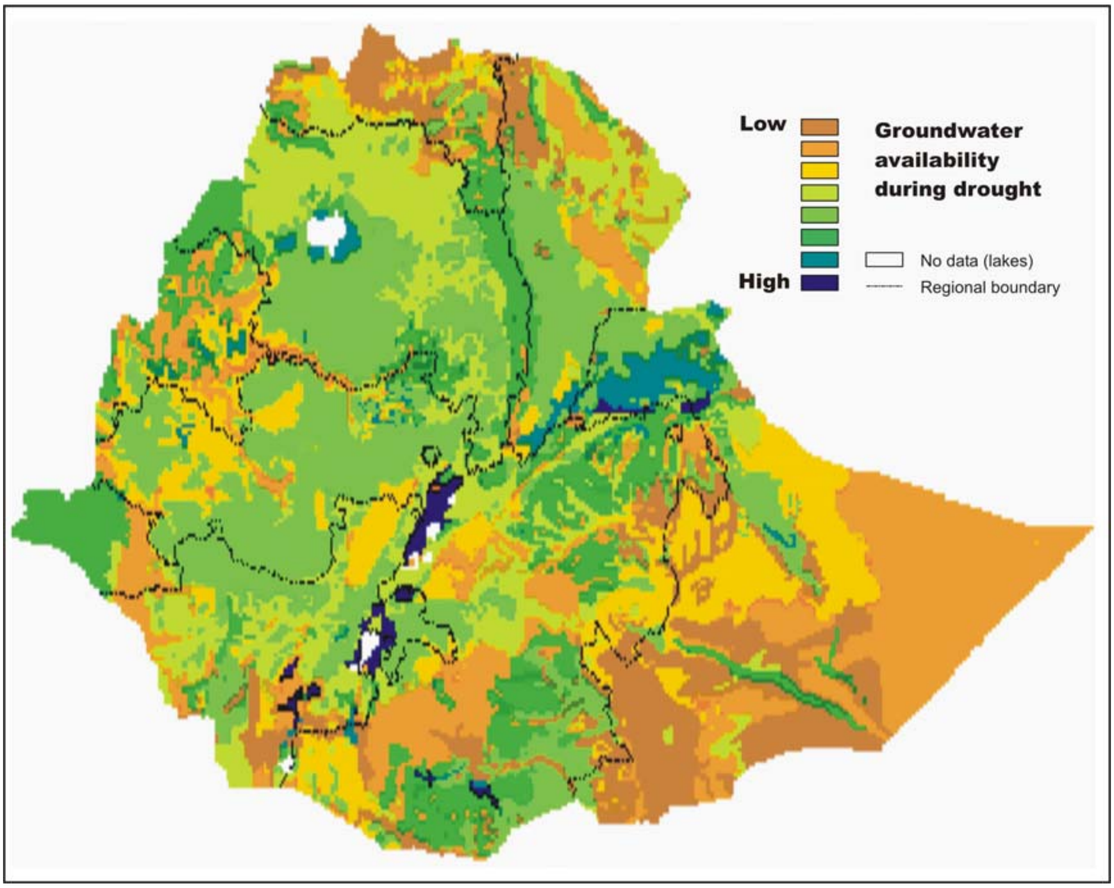

Figure 4.1 Summary map - groundwater availability during drought

The interpretation process highlights the scarcity of water in the Somali Region. This area receives little reliable rainfall, and has few significant aquifers. Any groundwater found in the area is often of poor quality (frequently saline). The most reliable groundwater is found in the alluvial deposits along the major river valleys. Other regions of concern are Tigray, northern Afar and Beni Shangul. In these areas the problem of unreliable rainfall is exacerbated by generally poor aquifers. Locally, groundwater availability is improved by the presence of highly permeable fractured rocks and alluvial deposits.

The regions with the most availability of groundwater during drought are likely to be central areas (Amhara Region and much of Oromiya Region) where rainfall is generally reliable, and there are extensive aquifers. Water insecurity in these areas is likely to be more a function of high demand and poor access rather than absolute scarcity of water, even in years of low rainfall. Increasing access to groundwater in these areas may have a considerable impact on overall water and livelihood security during drought.

4.1.2 The use and impact of mapping

A clear conclusion from the field visit research and the consultation with stakeholders and partners was that the map, and its transparently set out components, serves to indicate *broad* areas of (a) groundwater development potential; and (b) relative drought vulnerability, in terms of the likely availability of groundwater and its reliability. At their existing resolution and stage of development they can be used at the federal level, *in combination* with other tools and information sets, to help the following activities:

Target groundwater-based sector development programmes to areas with high socio-economic vulnerability (defined, for example, through food security assessments and mapping), and relatively high groundwater resource potential. Programmes could include elements of both domestic supply, livestock watering and small-scale irrigation to support livelihoods, and reduce vulnerabilities. Interestingly, requests for maps (or additional maps) since project completion have come from a range of sector stakeholders in Ethiopia, including the DPPB and SERA (food security), the Amhara Region Department of Agriculture (irrigation potential), and regional and federal planning departments (coordinating roles in development planning). Strong demand for maps has also come from outside Ethiopia, for example from UK NGOs involved in drought planning/relief in other countries, and donors.

Target more explicit drought-proofing measures to vulnerable zones in terms of, for example, water point rehabilitation and repair, well deepening and spring protection/excavation, to ensure that in the more vulnerable hydrogeological areas, access to water that *is* available is not compromised by the poor state of infrastructure. In addition, maps could be used to help prioritise zones where strategic 'drought-relief' boreholes could be drilled in the most favourable (reliable) hydrogeological areas (e.g. for emergency tankering operations).

Highlight critical monitoring areas, in terms of the more vulnerable (less reliable) areas where groundwater sources may dry up during drought, and where the remit of existing food security assessments, supported by government, donors and/or NGOs, could be widened to include indicators/reports of water stress.

In addition, the process of development and the presentation of drought-water information in map form has some more subtle benefits. For example:

Constructing the map brings together useful data that is often fragmented within, and between, different institutions and levels, in a form which is understandable to non-specialists, and is attractive;

The map helps to highlight the importance of groundwater, and especially groundwater reliability, in the context of drought. Groundwater is not a 'black box', with uniform properties and a uniform 'water table'. The role groundwater *could* play in providing a reliable source of supply in some areas, where resource access rather than availability may be a constraint, is also highlighted;

The map provides a useful catalyst for discussion between disciplines and sectors. For example, symmetries with food economy or food security areas can be explored, beginning a process of thinking and discussion around water-food links under the broader umbrella of livelihood vulnerability. Food security maps cover the walls of donor, support agency, NGO and government offices in Ethiopia, even though most cannot be used directly, or by themselves, as planning tools. In some offices, at least, there is now a groundwater availability map.

In terms of their wider uptake and use, it is significant that 'groundwater drought vulnerability mapping', a term used to describe first generation maps developed by BGS and partners, forms a core component of the World Bank – GEF funded project 'Protection and Strategic Use of Groundwater Resources in the Transboundary Limpopo Basin and Drought Prone Areas of the SADC Region'. The project is part of the Groundwater Management Programme for the SADC Region, and has been approved by all SADC countries.[6] In addition, groundwater drought vulnerability maps developed by BGS appear in recent publicity material for the establishment of a new International Drought Centre for Southern Africa (UNESCO, 2002)

4.1.3 Development potential

National maps cannot be used to provide anything other than an indication of where targeting should take place, in conjunction with other tools. Regional mapping, however, could provide a much more powerful tool for targeting the kind of activities described above to water insecure woredas, especially if linked to the kind of local level water security analysis described below. Investment in higher resolution maps, linked with training in the use of map information, can generate significant (and quantifiable) benefits (Reedman et al., 2002).

4.2 WATER SECURITY ANALYSIS

A useful interdisciplinary framework for analysing the causes and consequences of water security is through the lens of (a) availability-quality; (b) access; and (c) use, or demand (Calow et al., 1999). An understanding of the influences on each, and of the relationships between them, is vital for policy, project and programme development:

The *absolute availability and quality* of water resources, for example the presence of large aquifers, or perennial springs and rivers, of acceptable (for the intended purpose) quality. The groundwater availability map (see above) depicts availability on a national scale and also, in its more detailed form (Appendix 6), gives a crude indication of potential quality concerns. For the local South Wollo transect, the evaluation of water availability/quality was based on direct observation and inference (e.g. discussions at water points about yield; taste, preferences, health etc). High availability can still be associated with water insecurity if quality is poor, or if access to the resource is constrained (see below);

The ability of households to *access this water* through springs, boreholes and wells. In a broad sense, this is influenced by (related) technical and socio-economic factors: (a) technical factors such as coverage and the state of repair of infrastructure; and (b) the ability of individuals, households and communities to draw on various types of asset, including social capital (e.g. to gain customary rights to sources managed under common property); financial capital (e.g. for water payment); human capital (e.g. to

[6] Further details are available on the World Bank's website. BGS is involved in the project.

release labour for water collection); and physical capital (e.g. for transport and storage of water, including pack animals for water transport);

Patterns of *water use and demand*, in part the outcome of availability and access above, but also influencing it through demand related to seasonality and drought, and use related to the opportunities available to use water as a production input;

The *returns to different livelihood activities* through increased access to water at a household level, for example in increased capacity to water livestock, to trade in water locally or to use water in household production activities (see ODI, 2002).

In the subsections below, we discuss availability, access and use along the highland-lowland transect separately, and then examine the relationships between them. Implications for policy and practise are then discussed.

4.2.1 Water availability and quality

In terms of *surface water* sources, all rivers in the study were reported as seasonal with the exception of the River Mille, which joins the Awash, and is sustained by groundwater over the dry season. Water quality of surface sources was clearly a problem, not just through human and animal contamination, but also through industrial pollution. Tannery discharge into the river caused visible contamination to a source used for both animal and human consumption downstream. During the dry season, some communities also excavated pits in dry riverbeds to access water, a practice observed in many countries at times of water stress (Calow et al., 1997; ODI, 2002).

In terms of *groundwater* resources, availability in the volcanic rocks that characterise the area depends largely on the presence of fractures. The top and bottom of lava flows, particularly where they are associated with fossil soil horizons, are often highly fractured and weathered; towards the middle of the lava flows, the basalt tends to be more competent and less fractured. The interconnected fractures and cavities provide rapid, discrete flow paths, with groundwater often discharging as springs at impermeable boundaries (Figure 4.2).

In *dega* (mountain) areas, aquifers are relatively small and cannot store large quantities of groundwater; in *weyna dega* and *kolla* areas, catchment and aquifer size increases. Most access to groundwater in these environments is through springs. Springs are, however, generally 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 deeper into the aquifer they are less susceptible to such changes, though technical problems with pumps can preclude access, even if water is available (see below).

Community discussions revealed that *some* groundwater was available in all environments throughout drought periods, indicating that there was no *absolute* shortage of water. However, access to water in some locations was severely constrained by other factors, described below.

The quality of water also changed along the transect. In *dega* areas, the quality of groundwater is generally good with total dissolved salt (TDS) content low. However, TDS increases markedly with decreasing altitude and in *kola* areas, groundwater can be noticeably salty. Quality can also vary significantly between sources in a single village. For example, two springs at Bokaksa village had markedly different chemistry, indicating flow from different groundwater bodies in the area. More usually, local quality variation is caused by point source contamination.

4.2.2 Access

Access to groundwater in the study area is via a combination of springs, wells and boreholes. The relative importance of each as a source of reliable supply varied considerably along the transect:

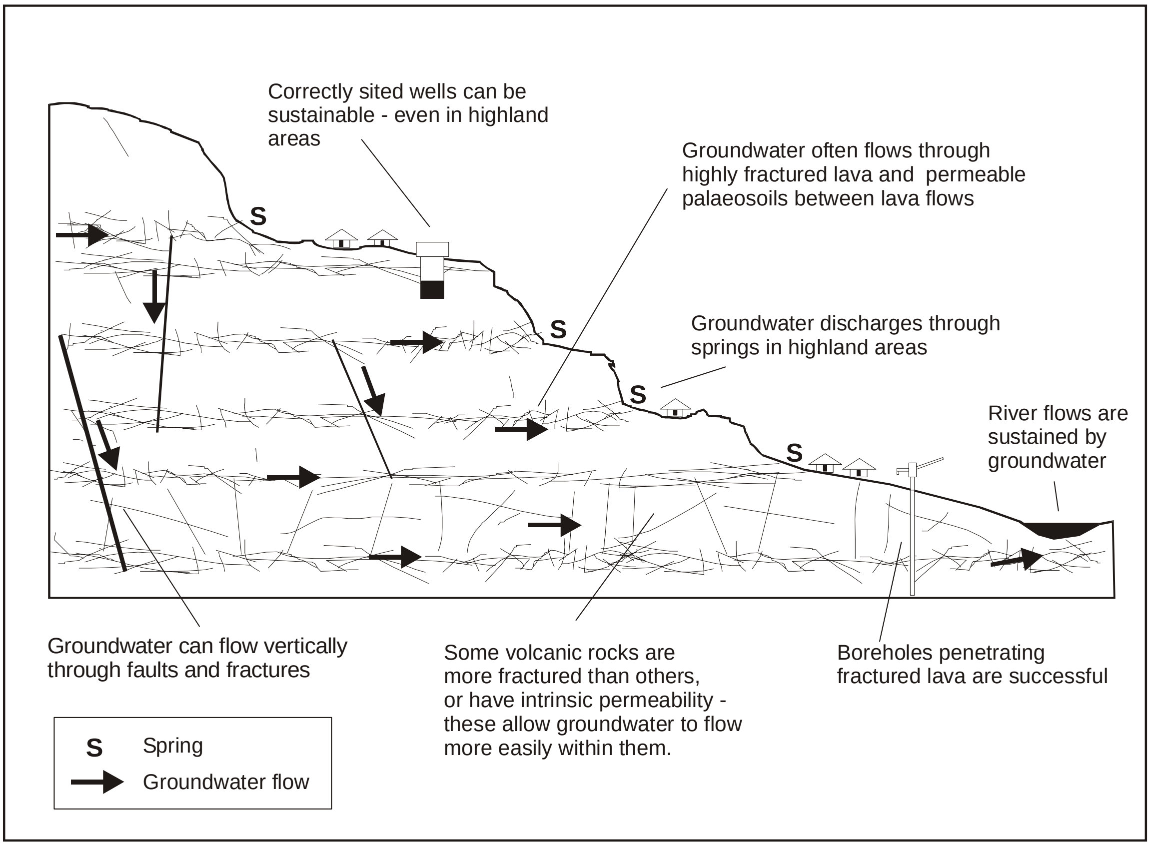

Figure 4.2 Cross-section of groundwater flow in highland volcanic areas

In *dega* and *weyna dega* areas, where rainfall is highest and rock fractures and channels are found close to the land surface, springs are the most common source of supply. In *dega* areas, where rainfall is at its maximum, communities (e.g. in Abbot village) generally have access to three or more sources in the wet seasons, as well as small (rain-fed) streams. Highland springs have relatively small catchments, however, and in the dry season, spring access declines: some springs dry up altogether, whilst yields in others decline to less than 0.5 l/s (May-June). Nonetheless, the numbers of springs available in the highlands means that access to (good quality) spring water is not viewed as a major problem by most households, though domestic water collection times (for women and children) can increase to around one hour in communities such as Abbot and Gobesha (see Appendix 4).

Box 4.1 Relationships between water point design, siting and groundwater access

In *weyna dega* areas such as Mayie Selassie with relatively shallow water tables, correctly sited and designed hand-dug wells could provide sustainable supplies of water when springs dry up. However, the majority of wells visited in South Wollo had been sealed and handpumps fitted. Although such a system helps protect the source from contamination, it makes it vulnerable to malfunction and impossible for the community to deepen. Moreover at a number of the villages, handpump selection was inappropriate, with high-lift pumps fitted to very shallow wells. The result was that pumps had broken down or provided only a very low yield. Ironically, the 'protected' wells in Mayie Selassie had been sited in swampy areas and abandoned because of the taste and smell of the water, and reported incidences of diarrhoea.

In lowland *kolla* areas such as Arabati, groundwater potential is high and other sources limited. Groundwater could provide high quality, drought-proof supply, but the practice of installing expensive and difficult to maintain (submersible) pumps has proved inappropriate given the inability of government to maintain them. No working pumps were found during the field visit, leaving communities dependent on poor quality, and often distant, river sources. Cheaper and more reliable pumps and boreholes could be installed for a fraction of the cost, with positive impacts on health and labour availability.

> In Mayie Selassie (*weyna dega*), both river, spring and shallow well sources were *potentially* accessible to the community of 900. However, the two shallow wells had been abandoned because of poor water quality (see Box 4.1). The local river was preferred for domestic use and livestock watering because of its proximity, but it was only seasonal. During the dry season and drought, more distant spring sources were used. Household water collection time could increase to over five hours per day, with long queues forming even at night.
>
> In *wena dega – kolla* areas, where rainfall is lower and springs fewer in number, people are more reliant on boreholes (when working) and rivers (when flowing). In some communities, for example Arabati in the *kolla* area and at the margin of pastoral-highland cultivation production systems, river water was often the only available source for both human and livestock use. This was because the generator used to pump water from the borehole was unreliable, though it did function and maintain supply during the 1984-85 drought. The quality of water at the River Burka – a seasonal river, accessed through excavation of deep pits in the dry season - was likened to animal urine by one interviewee.

In addition to these technical - water availability related access issues, a number of other influences were highlighted by communities. For example, although most households indicated that sources were 'open access', in some cases higher quality spring water was difficult for a neighbouring social sub-units (referred to as a '*gote*') to access because of issues of customary rights, or ownership (e.g. in Gandahole - *weyna-dega).* Although this was not explored in detail, it appeared to be significant in some areas, and at some times. During drought, for example, when there are significantly fewer springs, some households reported this as a source of inter-village, or inter-*gote*, conflict.

> **Box 4.2 Drought and seasonality**
>
> The droughts 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 the 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 such stress include longer time taken to collect water (over 5 hours in some cases) due to reduced yield combined with increased demand, the use of poorer quality sources, either due to absolute unavailability of other sources or the closer proximity of poorer quality sources, and reduced consumption of water within the household. These behaviour patterns all impact on the livelihoods of households.

The existence of water markets in some villages may reflect other types of coping mechanisms in more water insecure areas, and the purchase by richer households of the labour power of poorer households to collect water. In Bokaksa (*weyna dega/kolla*), for example, women and children used donkeys to transport water for their own households, and for others. These households would retain a certain amount and sell the rest. 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 (higher prices were reported in drought years and dry seasons, reflecting greater time taken to collect), and of prevailing wage labour rates. Clearly those households with access to their own animal power for transporting water could collect more water, make fewer visits, and save themselves time. Dry season collection times in Borkaksa were reported as 3 hours/day *without* transport, rising to 5 hours/day during drought because of heavy demand (and therefore queuing) at the source.

4.2.3 Use and Demand

Patterns of water use and demand along the transect were influenced by the broad agro-ecological transition and related livelihood strategies, and by factors such as seasonality, water quality variation, distance to sources, construction/design of sources, and their mechanical reliability. Key relationships included:

> Where a variety of sources were available and accessible (e.g. in some *weyna-dega* areas), springs were generally favoured for drinking purposes, with livestock use of poorer quality rivers if close by. Otherwise, there was multiple use of single sources. For example with protected springs, there was domestic collection from taps, whilst animals used waste/excess water collected in surrounding areas and, where properly constructed, to troughs which received excess drainage water;
>
> In some villages with high yielding springs, drainage was also used for small scale irrigation using traditional methods. In Chefe (*weyna dega – kola*), for example, two springs were used to irrigate 58 hectares of land. In the 1984-85 drought, spring yields declined dramatically and although irrigated area was maintained, reduced use of water meant lowered crop yield, with insufficient food for the whole village;

There is some trade-off between distance (collection time) and quality. Communities had clear ideas about the quality of alternative sources (e.g. in Mayie Selassie - see Box 4.1), 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. Greater collection time for households could impact on wider household activities which, at certain times of the year, might not be flexible enough to release sufficient labour time 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 activities such as water collection may fall disproportionately on children;[7]

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 through changes in water availability or mechanical breakdown.

4.2.4 Understanding relationships – summary

Drawing on the discussion above, it is clear that the water security of households is influenced by the availability of water, the ability to access to this water, and patterns of water use and demand, including socio-economic values attached to the latter. Figure 4.3 summarises these relationships.

In highland areas the aquifer containing the groundwater is smaller, though recharge is higher and streams more numerous. Water security is generally higher, however, because access to groundwater via the many springs is high, and demands (from people and livestock) are lower. In lowland areas the aquifer is larger, but water security is compromised by limited (and poor quality) surface water, restricted access to the aquifer via boreholes (few in number), and greater demands. The type of boreholes constructed in *kolla* areas also made them vulnerable to malfunction, compromising access. Large increases in demand can put stresses on individual groundwater sources, but are unlikely to affect the resource as a whole.

While a general trend in highland-lowland water security emerges, significant local variation also occurs. For example, access to water at the household level is also influenced by access to labour and animals for water carrying, money for water purchase and social capital for securing customary water rights.

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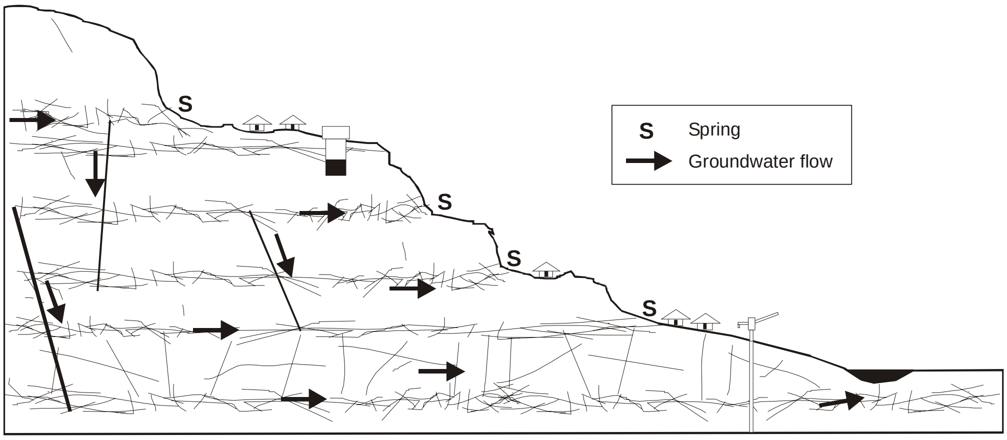
[7] The issue of labour availability and migration and its relationship to relief food distribution under food for work schemes might increasingly impact on water security in certain areas. As indicated in an SCF document on food security in South Wollo "…in terms of a policy towards the provision of 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, 1998)



	Dega (mountain)	Weyna Dega (intermontain)	Kolla (plain)
Availability	Small resource base but high recharge	Moderate resource base but less recharge than Dega. More surface water (fed by groundwater)	Large resource base but low rainfall Fewer surface sources (all groundwater fed)
Access	High: multiple access mainly springs	Moderate: multiple access through springs wells and boreholes (often widely spaced)	Low: few boreholes no springs
Demand	Low - mainly household consumption	High demand from people and livestock (most populated)	Human population less dense, but greater demand from livestock

Figure 4.3 Summary of availability, access and use relationships

4.2.5 Links with policy and practice

The project has shown that there are different patterns of access and availability in different 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 aquifer 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 targeting and design of water supply interventions.

One of the key findings of the study is that this level of understanding far exceeds that achieved by relying on coverage figures (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 this data has to be questioned since many water points were not working at the time of the visit, and the seasonality of yield at many water points is not addressed. An important aspect of coverage figures in Ethiopia is that they probably underestimate access in some areas (e.g. in the *dega* region where many springs have not been improved), and over-estimate it in others (e.g. in the *kola* areas where boreholes are not working).

Hence, whilst coverage data are easily created (and perhaps as a result attractive to users) they can also be misleading, overestimating and underestimating real access to water in different areas, and failing to differentiate between human and animal consumption. At this level of generality it is therefore questionable whether such coverage data should be used at all.

Planning processes

The results of the research suggest the need for a systematic approach to identifying and monitoring water insecure communities. As bottom up planning develops in Ethiopia, 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 have 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 of water security through existing monitoring exercises could, with little additional effort, prove very cost effective in gathering basic planning data.

Developing projects

The fit of technology choice with use function of a water source is important. For NGOs, zonal water departments and, increasingly, woreda water officers, the research indicates the importance of analysing the impact of drought and seasonality on likely demand at particular sources. This could be 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 particular times of the year should influence 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 downtimes in remoter areas. A greater number of lower yielding handpumps could provide a community dependent on a single source with much greater water security and insurance against drought. Hence a knowledge of the aquifer properties, in combination with levels of demand and seasonal patterns of usage, is invaluable in planning the appropriate level of technological choice.

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. This might include the development of rudimentary resource maps around which group discussions could take place.

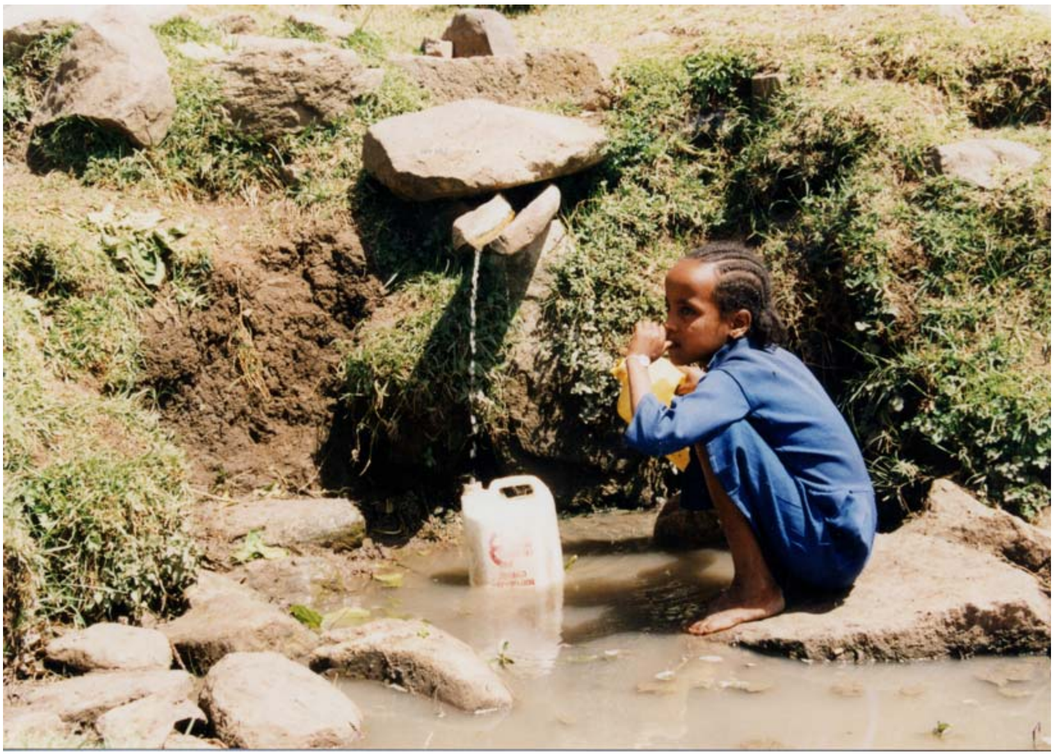


Figure 4.4 Collecting water from a spring on the escarpment, South Wollo

Monitoring

The findings point strongly to a substantial impact on households, and livelihood security, of reduced access to water during dry seasons and drought years. The sense from local and regional level officials, and from those attending the workshops in Addis Ababa, was that the monitoring of water security would be very useful if sourced via existing monitoring systems in place already 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 security issue and 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 can lead to populations staying put, leading to increased demand on remaining water points. This may create unusually acute problems of water shortage, and increased stress (and probability of failure) on remaining access points.
>
> Secondly, maintaining access to water can play an important role in protecting livestock and small-scale irrigation and, for some households, in releasing labour for more productive activities. Timely water supply interventions (water point rehabilitation; repair; help with water transport etc), coordinated with food security/asset rebuilding efforts, could therefore improve both water and food security during drought. Mapping and monitoring 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. Of particular importance for households is the quantity of labour time consumed in collecting water, and the opportunity cost 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. These issues are explored further in Chapter 5.

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[8]) may also necessitate follow-up surveys.

Clearly, accurate and informative baseline data in any case would assist woreda officials in helping to plan responses to felt demands at 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 and plan development programmes. At present there is an evident lack of basic planning data at woreda level on water sources, their behaviour and their use by communities.

[8] 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).

5 Synthesis

The aim of this chapter is to synthesise (a) results from the Ethiopia study, with (b) the evaluation of drought impact and response to the 1991-92 drought discussed in Chapter 2; and (c) findings of related work on water and sustainable livelihoods. To meet the last objective, the authors draw on recent research on food security and vulnerability analysis, and on household water economy analysis, highlighting links between the two.

The synthesis is broken down into three sections. Firstly, we argue for a change in the scope and level of drought vulnerability analysis, and an end to the current segregation of disciplines, perspectives and policies (Section 5.1). Secondly, we discuss implications for policy and practice, in terms of information systems and early warning, and in terms of 'pre-drought' development assistance in the water sector (Section 5.2). Thirdly, we present some overall conclusions (Section 5.3).

5.1 SHIFTING THE PERSPECTIVE – DROUGHT AND LIVELIHOOD SECURITY

Evolution

Over the course of two 'drought and water' projects funded by DFID, covering South Africa, Malawi, Ghana and Ethiopia, our thinking about the nature of the problem has evolved. In 1996, the focus of attention was very much on the resource: the impact of drought on water availability, and policies and measures which could lessen the impact of a 'groundwater drought'. This was based in large part on drought experience in Malawi which indicated that, in areas such as the southern escarpment, drought resulted in the drying up of shallow wells and problems, therefore, resulting from the absolute scarcity of water. In many other areas, however, groundwater *was* available within the aquifer (*resource)* but could not be accessed because of *source* problems: many boreholes were out of operation prior to the drought; heavy demand on remaining, reliable sources caused mechanical breakdown; and some sources dried up during peak demand even though the aquifer surrounding them still contained water (Robins et al., 1997; Calow et al., 1999). The picture was therefore more complex: both water availability and *access* to water were clearly important, with similar findings emerging from studies in South Africa and Ghana. The term *water insecurity* was coined to reflect this.

At the same time it was clear that, whatever the cause, drought-induced water insecurity was perceived as a problem by many rural communities, contributing to temporary migration (Malawi), ill-health and disease (Ghana, South Africa and Malawi) and, in all countries, to major investments in time and effort by those affected to find and collect water. Across southern Africa, however, the response to the 1991-92 drought focused on availability and access to food, largely ignoring the water dimension. Measures which did attempt to relieve water stress, and other health and sanitation interventions, were largely ineffective in addressing immediate needs (too late; poorly targeted) and seldom coordinated to address the multiple dimensions of household vulnerability (Clay et al., 1995; Calow et al., 1999).

It would be tempting to think that the lessons from 1991-92 have been learnt, and that responses to the current drought in southern Africa, and now in the Horn of Africa, have changed. This would be to over-estimate the institutional memory of the actors involved, and underestimate the institutional and political rigidities that force a separation of food security –

seen in isolated, one dimensional terms[9] - from other aspects of household vulnerability. As recent reports from Oxfam and others make clear, *"This is not just a food deficit – this is a wider public health emergency with key problems relating to HIV/AIDS, sanitation and the quality and quantity of water."*(Oxfam, August 2002.)

A livelihoods perspective

Recently, the work of this project and others (e.g. Nicol, 2001; ODI, 2002) has begun to flesh out a wider picture of household vulnerability in relation to drought. This livelihoods perspective examines the broad expenditure invested by households in gaining access to water, and at the impact this has on household consumption, production and income. Links between water and food security are therefore highlighted under the umbrella of livelihood security, challenging the contrived compartmentalisation of drought policy that distinguishes as entirely distinct livelihood activities that are interdependent.

The questions we now need to address are "where are the links?", and "what impact does water insecurity have at the individual and household level?". Below, we highlight some of the major water dimensions of *livelihood* vulnerability, identifying ways in which water insecurity can affect the household economy and its resilience, or vulnerability to, drought. Figure 5.2 – a model of the household water economy – highlights these links and tradeoffs.

Firstly, lack of access to adequate water supplies for domestic uses, in terms of both quantity and quality, can be a major cause of disease. This is a well rehearsed argument, but it is worth repeating in the context of drought when availability and access to clean water can decline significantly. In particular:

> Numerous epidemiological surveys have shown that in drought – famine related disasters, preventable infectious diseases such as measles and diarrhoea are the primary causes of death (Moore et al., 1993);
>
> The nutritional status of individuals and groups, a commonly used indicator in food security analysis, is an outcome of, not an explanation for, food insecurity. Apart from food consumption, nutritional status is also influenced by factors such as access to health care *and* access to clean water and sanitation, determinants of individual well-being (and vulnerability) that are additional to conventional food security indicators (Devereux, 2001b).

Secondly in many rural environments, 'domestic' water is also a production input, for example in small-scale irrigation, livestock watering, brewing and brick-making. This production supports either home consumption/use, production/income exchange, or both, contributing a significant proportion of (water-dependent) household income. The role water plays in supporting household livelihoods in this way is typically missed in the compartmentalisation of sectors, policies and institutions.[10] This is one reason why

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[9] Food insecurity is not the only concern during drought, and is not an isolated concern (Swift and Hamilton, 2001). It is an *outcome* of a complex arrangement of vulnerabilities, dependent on how people gain access to production and exchange opportunities. This, in turn, is influenced by the ability of a household, or an individual, to access water by drawing on assets such as labour and money.

[10] Domestic water supply may fall within the purview of the Department of Water Supply; water for irrigation within the Department of Agriculture; and water for livestock within the Department of Livestock and Fisheries, or equivalent, if at all. Coordination between sectors is often non-existent.

investment in collector wells – large diameter open wells that support a range of uses including garden irrigation – has proved difficult to scale up under line ministries in Africa.[11]

Thirdly, households in rural Africa are increasingly being asked to contribute to the capital and/or recurrent costs of water infrastructure, such as a new village well or borehole. The ability of poorer households to meet these costs across seasons and between years, *without* compromising their resilience to shocks, is questionable. Recent work in Kenya, for example, suggests that water tariffs may be a barrier to livelihood diversification (ODI, 2002). Direct payment for water also occurs through (typically informal) water markets, such as those found in the Highlands of Ethiopia (see Chapter 4). In Hambantota District in Sri Lanka, recent fieldwork showed how in times of acute water stress, men[12] had to leave the fields and travel to peri-urban areas to buy water from standpipe operators (ODI, 2002). This incurred a direct financial cost - including bus fare - and an indirect opportunity cost in terms of land preparation foregone.

Fourthly, and following on from the above, the time taken to collect water can incur significant expenditure. The burden of water collection has been well documented in this study and many others (e.g. Robins et al., 1997; Nicol, 1998a, 1998b; ODI, 2002). Collecting water in some areas of South Wollo, for example, can take over 5 hours per day in drought periods; in many other areas of rural Africa, collection times of 2-5 hours per day in a *normal* dry season are not uncommon.

Figure 5.1 The daily queue for water in Robit village, South Wollo

There are also important gender and age specific issues involved in the division of labour for water collection. In rural Africa, where most agricultural labour is undertaken by women, productive impacts can be significant. For households and economies relying on the sale of

[11] Collector wells have been piloted in countries such as Zimbabwe, and have provided reliable water supplies for domestic and agricultural uses during drought. They are more expensive than simpler wells and boreholes, however, and defy easy classification and line ministry ownership.
[12] It was not considered safe for women to travel into town alone to collect water.

labour, the cost of losing a day's labour can be exceptionally high at particular times of the year (ODI, 2002). A key question in water collection, therefore, concerns the opportunity cost of this time - within and between households, across seasons, and between good and bad (e.g. drought) years. This question is taken up again in Section 5.2 below.

The opportunity cost of water collection can have social, as well as economic, dimensions. For example if the burden of water collection falls disproportionately on children, the result may be lost education. Important too are health, nutritional and safety dimensions. Carrying water exacts a heavy burden on women and children, with the potential for injury, and collecting water at night[13] can be both exhausting and unsafe.

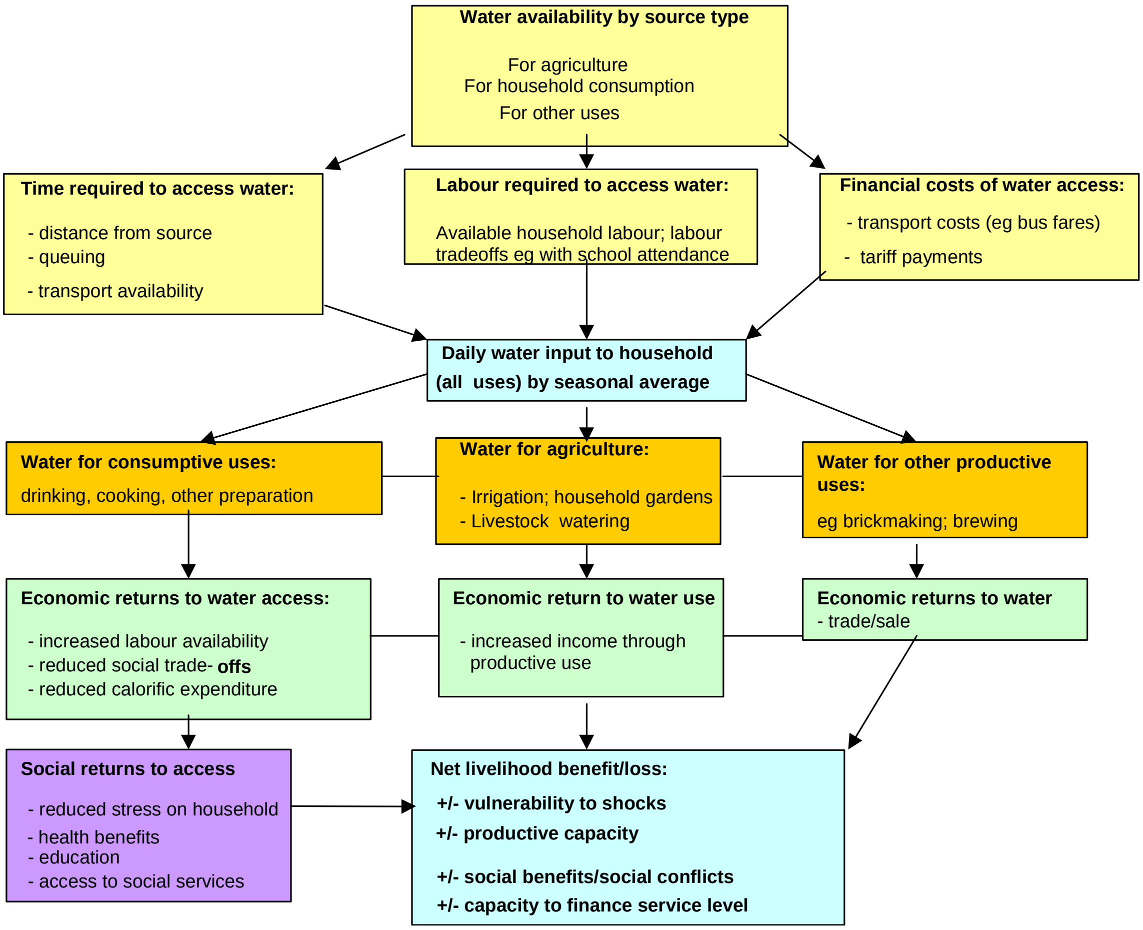

Figure 5.2 Schematic diagram of the household water economy.
Source: ODI 2002.

The discussion above has drawn attention to (a) the influences water insecurity - an outcome of the availability – access – use relationship discussed in previous sections - can have on the wider household economy; and (b) specifically, how food and water insecurity may be interwoven. Table 5.1 summarises the main points of departure between a food-first perspective, and a livelihoods perspective, in relation to drought impacts and needs.

[13] Collecting water at night is common practice at times of acute water stress. During the day, heavy demand at remaining (reliable) wells and boreholes can cause localised drawdown of the water table surrounding the source. Yields decline, queues increase, and the source may even dry up. At night when demand is less, the water table recovers.

Table 5.1 Shifting the perspective - differences between a narrow 'food-first' approach and a wider 'sustainable livelihoods' approach to drought and household security.
Source: adapted from Davies (1996) and Maxwell (2001).

Livelihood	Food-first approach	Sustainable livelihood approach
Objective	Access to food	Secure and sustainable livelihood, maximising access to assets (including water) to support production, income and consumption
Priorities	Food at the top of a hierarchy of needs	Food one part of a jigsaw of (inter-related) livelihood needs, including water for consumption and income generation
Entitlements	Narrow entitlement base (current and past consumption)	Broad entitlement base (future claims, access to common pool resources such as water)
Vulnerability	Lack or want of food	Insecurity; exposure to risks, shocks and stress, including water insecurity resulting from availability-access constraints
Vulnerable groups	Based on social, medical criteria	Based on wider set of livelihood security indicators, including water availability, access and use
Coping strategies	Designed to maximise immediate consumption	Designed to preserve livelihoods. Tradeoffs between expenditure on accessing water (direct; indirect) and preserving consumption, production and income
Measurement and monitoring – problem definition	Narrow: food availability, access and consumption. National and local assessment.	Broad: livelihood security and sustainability, including water security indicators. More emphasis on local assessment
Supporting interventions	To increase access to food: food aid, food-for-work, food stamps etc	To protect livelihoods and assets: coordinated and sequenced food and water interventions

5.2 PROTECTING LIVELIHOODS – POLICIES AND INTERVENTIONS

> *Evidence from communities under drought-induced pressure suggests that the first consideration is to protect productive assets, such as breeding livestock, tools and land. One of the main requirements is for people to remain in their villages and often the first problem faced is not access to food, but rather availability of water (Eele, 1993)*

In this final section, we examine ways in which improved understanding of the multiple, inter-related dimensions of drought vulnerability can improve drought planning. Specifically, we look at:

- How the potential impacts of drought shocks on areas, communities and households might be better predicted, drawing on the tools developed by this project;
- How this knowledge can be used to improve drought preparedness, and to trigger timely and appropriate responses.

5.2.1 Identifying vulnerable areas and vulnerable groups

Groundwater availability mapping

Groundwater availability maps of the type described in this report can help provide a *starting point* for discussions about (a) groundwater development potential; (b) broad areas of potential vulnerability, in terms of the likely availability/non-availability of groundwater during drought; and (c) the 'fit' between water security/insecurity and food security/insecurity zones. At this (national) resolution, and in combination with other tools and information sets, they can be used to:

> Begin the process of targeting groundwater-based sector development programmes to areas of high socio-economic vulnerability (defined, for example, through food security assessments and mapping; poverty assessments; history of insecurity; low water supply coverage; etc), and relatively high groundwater resource potential. Programmes could include elements of both domestic supply, livestock watering and small-scale irrigation to support livelihoods, and reduce vulnerabilities. Highlighting the role groundwater *could* play in providing a reliable source of supply in some areas is important in itself;
>
> Begin a process of targeting more explicit, water security based drought-proofing measures to vulnerable zones. Measures could include water point rehabilitation and repair, well deepening and spring protection/excavation, to ensure that in the more vulnerable hydrogeological areas, access to water that *is* available is not constrained by, for example, by the poor state of infrastructure;
>
> Highlight 'critical monitoring areas', in terms of the more vulnerable (less reliable) areas where groundwater sources may dry up during drought, and where the remit of existing monitoring and information systems, which may focus on narrow food needs, could be widened to include indicators/reports of water stress.

As this report makes clear, however, for most countries in Africa the maps can only be developed at a national scale using existing data. Regional mapping would provide a much more powerful tool for informing the kind of decisions described above, especially if linked to local level water security analysis. Investments of this sort, linking improved knowledge of the resource base and access constraints, with capacity building for using new knowledge in development planning, can bring major (quantifiable) benefits[14] (Reedman et al, 2002).

Monitoring and information systems

While mapping at national or even regional level can tell us about the likely availability of water resources during drought, it tells us nothing about the *local* interaction of availability, access and use that determines village-household level water security. As we have observed in previous sections it is this local-level information, beyond flawed coverage data, that adds most to an understanding of water insecurity, as insecurity may vary considerably over short distances (e.g. along the South Wollo transect discussed in Chapter 4 of this report).

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[14] In addition to developing national maps depicting groundwater availability during drought, BGS has also developed local maps illustrating groundwater development potential in countries such as Nigeria (Davies and MacDonald, 1999). The investment in hydrogeological knowledge, combined with training in the use of maps and water point siting techniques, can bring major benefits. A cost-benefit analysis of data acquisition and use in the Oju – Obi district of Nigeria, a drought-prone and water-insecure area, indicated significant net benefits in terms of costs avoided (Reedman et al, 2002).

To identify the most vulnerable areas *and* communities (following through the arguments of Section 5.1), there is a need for local information on livelihood vulnerability which captures both water and food security dimensions. From a broad poverty perspective, we know the rural poor may include marginal and undiversified resource-poor farmers; female-headed households; landless labourers; pastoralists and displaced people, but that the particular manifestation of livelihood insecurity is likely to vary between groups. From a food security perspective, information about access to production and exchange capabilities is required, and the impact this has on access to food. From a water security perspective, information about water availability, access and use is needed. From an inter-related 'livelihoods' perspective, information about both is needed. How could this be achieved, and what are the implications?

Firstly, a decentralised system of monitoring and response, at the lowest level where capacity exists, is required. In many countries such systems already exist, at least on the monitoring side. However, their remit is often narrowly food-focused and, partly as a consequence, they are located within sectors and individual departments (if government supported) that follow narrow agendas. By widening the scope of existing information systems, and locating them outside traditional line ministries, a clearer picture of livelihood security, and of the interventions needed to support it, could be gained at little extra cost (Box 5.1).

This kind of shift in the level of analysis (national to local), in the scope of analysis (food-first to livelihoods-based) and in the assessment of vulnerability (more participatory; wider indicator set) presents some difficult challenges. For a start, it implies a heavier institutional burden on the institutions involved, making definition of 'the problem', and potential responses, more complex. It also requires better collaboration across sectors, disciplines and institutions at a time when, despite initiatives such as the World Bank's Comprehensive Development Framework (CDF), and the introduction of Sector Wide Approaches (SWAPs) and Sector Investment Programmes (SIPs), governments and donors continue to programme resources and deliver services vertically through sector ministries, coordinating and focusing efforts within, rather than across sectors (Maxwell, 2001).

Box 5.1 Widening the remit of existing information and response systems

Since the 1980s, there has been a huge increase in the number and quality of early warning information systems in Africa. However, while second-generation systems have moved towards multi-indicator approaches, including demand side as well as supply side variables, their remit is still narrowly food focused. By widening the scope of existing local-level assessments to include simple indicators of water security (based around the availability/quality, access and use framework discussed earlier and including, for example, evidence of absolute scarcity – yield, quality; access constraints – time and labour availability, financial cost, transport; and consumption/production impacts – domestic rationing, reduced/non use for production and income generation), a clearer picture of livelihood security, and of the interventions needed to support it, could be gained at little extra cost.

This information could help generate more flexible, and more appropriate (to livelihood needs), responses. For example, in protecting the livelihood assets of households in the early stages of drought, or rebuilding them in the aftermath of a bad year, a key constraint may be access to water, both in increasing labour availability, and in protecting livestock, garden irrigation and non-agricultural income from cottage industries. This may indicate a need for targeted, timely water supply interventions (water point rehabilitation; repair; well deepening; help with water transport etc), coordinated and carefully sequenced with food security/asset rebuilding efforts, rather than just food *or* water interventions alone.

Nonetheless, significant advances have been made in recent years, with some movement towards the kinds of livelihood-based information systems proposed by this project. For example, considerable progress has been made in participatory monitoring and poverty assessment, and livelihood surveys/monitoring systems are an increasing feature of development programmes. These could become integrated with existing food security information systems owned, ideally, by both government and donors to encourage early warning *and* response (Buchanan-Smith and Davies, 1995; Devereux, 2001b). In addition, independent (of line ministry) food security monitoring units have been established in some countries (e.g. Ethiopia), with some (e.g. in Turkana District, northern Kenya) operating at local levels and using a range of indicators linked explicitly to interventions. NGOs have also set up independent information systems, often running in parallel with (sometimes in competition with) government systems. A key challenge is to translate progress in these areas into livelihoods-based drought preparedness and response actions, based around multidisciplinary, and multisectoral, planning teams.

Whatever progress is made towards the development livelihoods-based monitoring and information systems, it is important to recognise that good information does not guarantee a timely, and flexible, response (Buchanan-Smith and Davies, 1995). In short, better information on the impact of drought on water *and* food security will make vulnerability easier to understand and predict, but better institutions are needed before crises become easier to prevent. Obstacles that need to be addressed include:

> *Ownership and politicisation of data*. With so many actors involved in the early warning industry, and in the chain that runs from information to action, relationships – and data – can become heavily politicised. This can cause serious delays in responding to information. For this reason, a key recommendation by Buchanan-Smith and Davies (1995) is that famine early warning systems should be jointly owned by government and donors, maximising the transparency, credibility and effective use of information. This recommendation is equally valid for the broader-based, multi-indicator systems recommended in this report;

Divisions between relief and development; the organisation of bureaucracies. For many governments and donors, early warning is still about aggregate food supplies – harvest forecasts, food balance sheets and food aid requirements – and responses are only forthcoming once evidence of a crisis has already emerged. In part this reflects the persistence of (false) divisions between relief and development inherent in government and donor bureaucracies. It also reflects a problem of 'fit' between the recommendations emerging from 'livelihoods thinking', and the bureaucracies charged with taking them up. Arguably, institutions continue to separate famine from other drought impacts, and emergencies from more general development activities, on organisational grounds;

Lack of institutional memory and lesson-learning. Once a crisis is perceived to be over, systems are frozen or dismantled, data are lost or fragmented and post-drought monitoring of target populations and interventions is not carried out. The outcome is an inability to learn from past mistakes, preventing the improvement of response (Calow et al., 1999).

5.2.2 Project and programme planning

A key lesson from this project is that drought is not an abnormal event, with its own pattern of one-dimensional food impact. It is an extension and intensification of seasonal stress, associated with heightened, inter-woven vulnerabilities. Drought can and should be planned for, and there are ways in which pre-drought development activities in the water sector can be improved to provide better insurance against drought.

In this section, we examine the policies currently shaping the way projects are designed and implemented, and suggest 'drought-proofing' improvements.

Improving the selection, design and siting of water points

The findings of the Ethiopia study, of other country studies, and of the evaluation of the 1991-92 drought, all highlight the importance of groundwater availability during drought, when all but the most major surface sources dry up. What they also emphasise is the problem of accessing available groundwater during drought, when demands on wells and boreholes increase dramatically. In many cases, access is constrained by preventable problems: pumps break down because inappropriate technologies have been used; water points dry up even though groundwater is locally available; and water supply projects gravitate towards less vulnerable areas. These problems are not necessarily solved through better community participation, or financing arrangements. They often stem from the way in which policy is implemented on the ground, leading to unintended outcomes. Below, some examples are discussed and recommendations made for improvement.

Firstly, there are weak links in the execution of DRA[15] that can exacerbate, rather than reduce, drought vulnerabilities. In particular, the objectives of those charged with delivering services, often private contractors and NGOs, may differ from those attempting to manage the implementation process (often local government, in conjunction with regional authorities). A private contractor, for example, may be paid according to the number of successful boreholes drilled, with 'success' defined by the number of boreholes that meet minimum yield and quality requirements. An NGO, keen to demonstrate success in terms of improving coverage

[15] Under demand responsive approaches (DRA), consumers are engaged in the process of selecting, financing, implementing and managing water and sanitation services according to expressed user demand.

within a limited project period, may employ similar reasoning. The outcome in both cases can be the 'cherry-picking' of easier environments where groundwater can be found with little investigative effort, and success rates are higher. Wells and boreholes are developed in less vulnerable areas already enjoying high coverage; more difficult, water insecure areas, are ignored. Recent field work in Ghana (MacDonald et al, 1999) and Nigeria (Davies and MacDonald, 1999) supports this conclusion. How could this problem be addressed in order to pull back investment into more vulnerable, drought-prone areas?

A key issue is the management and oversight of the private contractors, NGOs and CBOs that increasingly dominate service delivery, straddling state and civil society. In terms of 'who' manages the activities of these actors, responsibilities need to be clarified. Decentralisation and the promotion of DRA implies new ways of doing business for all sector stakeholders, including communities, NGOs, the private sector, government and international agencies. In many cases, oversight functions *seem* to rest with local government, but specific responsibilities and lines of accountability remain unclear. Capacity building at this level (if appropriate) would therefore seem important, especially as the people charged with oversight functions may have few specialist skills in the monitoring and oversight of water projects. For example, guidance could be provided on how to set and monitor performance targets, including criteria for the evaluation of 'success', and how to draw up water supply contracts.

Secondly, much can be done to improve the selection process through which water supply choices are made. In particular, the knowledge base that influences the particular 'menu' of service options offered to communities needs to be strengthened, so that the likely effects of drought on the availability of water, and on access to and use of water at times of peak demand, is factored into menus and community-level discussions. A key constraint here is the lack of coordination between projects and programmes, another unintended outcome of DRA. While wistful tribute is paid to the notion of integrated resource management, DRA can encourage a 'scattergun' approach to resource development, with little lesson-learning between individual projects (Calow et al., 1999). For example, the pooling and use of 'public good' hydrogeological data between projects would provide useful insights into the reliability of different technologies and siting decisions under drought conditions. However, valuable hydrogeological data that could be cheaply acquired during drilling for use by others is often not collected, or stays with individual drilling companies and NGOs who may have little incentive to pass it on (Davies et al., 2001; MacDonald et al., 2002; Robins et al., 2002).

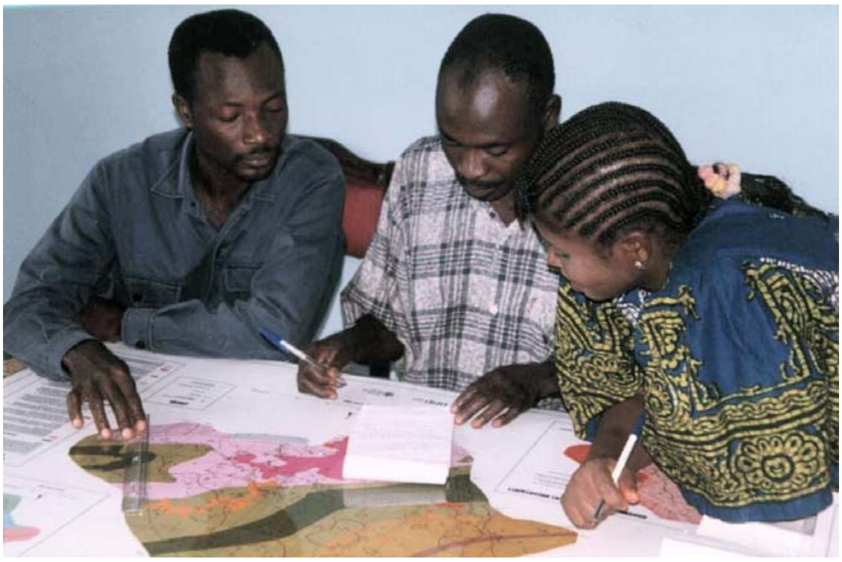

Figure 5.3 Local government staff in Nigeria consulting a groundwater development map

Here again, building capacity in the local government institutions charged with overseeing such operations could pay dividends, ensuring that better technical - more 'drought-proof' – choices are offered and made. Box 5.2 summarises some drought-proofing measures that could be implemented in 'normal' years to increase the reliability of water supply.

In terms of water access and use, there is also a need to ensure that discussions with communities on service provision levels and options fully consider the likely impact of drought on different households. For example, can all households afford access to water at difficult times, and what forms of expenditure are used up to maintain use? Valuable work is currently being carried out in this area, exploring links between the household economy and expenditure on water (see Box 5.3).

Box 5.2 Drought-proofing measures

The findings of this and other studies highlight the importance of designing water supply systems with a capacity to cope with drought. Measures that can be implemented in pre-drought periods to sustain groundwater supplies include:

Ensuring that the service options offered to communities are sensitive to local hydrological and hydrogeological conditions, and can provide a reliable source of supply during drought.

Ensuring that wells or boreholes are located in the most productive parts of the aquifer. Modest investment in resource assessment and siting techniques can pay dividends in terms of higher drilling success rates and higher yielding (more reliable) sources (van Dongen and Woodhouse, 1994; Reedman et al., 2002; MacDonald et al., 2002). Simple tests can also be carried out to assess the performance of a well or borehole once it has been constructed, providing valuable information on how the source will behave during drought. If a single source cannot meet peak dry season or drought demand, further village sources may need to be developed (see below).

Constructing sufficient sources in a village to meet peak demand. In the longer term, this is more cost-effective than attempting to develop extra capacity when additional water is required. Alternatively, extra materials can be left on-site to make future rehabilitation easier. In northern Ghana, for example, extra concrete rings are cast and left at the well head to facilitate deepening at some time in the future should the need arise.

Sinking deep 'relief' boreholes in the most favourable hydrogeological locations – perhaps away from villages - which can be uncapped and used in emergency situations. Such boreholes could be used by households from different villages should local sources dry up, or could be used to provide water for tankering operations.

Box 5.3 Towards a deeper understanding of community demand for water

The DFID-funded project SecureWater (see ODI 2002) uses household economy analysis as the basis for understanding aggregate community demand for water. Why and how do communities need water in particular quantities and at particular times of the year? How is demand for the resource articulated to local government and other agencies? SecureWater's main premise is that water remains fundamental to a range of livelihood activities that go far beyond demands expressed on the basis of perceived health needs. Thus, demand reflects values attached to the resource by particular households and groups of households engaged in certain livelihood activities.

SecureWater assessment involves the analysis of data on basic household characteristics, the dynamics of principal livelihood activities, the structures and characteristics of wealth groups based on a selection of livelihood assets (including land, labour and livestock), and the mapping of availability, access and use of water from multiple sources. The construction of a dynamic model of the household economy in terms of food and non-food income, through 'good', 'normal' and 'bad' years, then allows examination of key issues such as seasonality of income and expenditure flows, the value of time and changes to water availability and access in relation to their impact on disposable income. This includes income that may or may not be available to cover cash payments for a new water scheme. In this way, the model can help the user gather a basic data set enabling, on the one hand, the impact of changes in water availability, access and use on poor households to be understood more fully over time and, on the other, greater understanding of relative community capacity to finance particular water supply interventions, including the likely range of capacities to contribute particular sums and pay particular tariff rates.

5.3 CONCLUDING REMARKS

Drawing on the discussion above, and on the findings presented in previous sections of this report, we can summarise briefly as follows.

Drought vulnerability – impacts on livelihoods

Firstly, we have argued that *drought affects livelihoods in various, inter-related ways*. Food insecurity is one symptom of livelihood vulnerability; water insecurity is another. Both are related, with links illuminated through a broad livelihoods lens, rather than through separate food *or* water lenses. For example, the nutritional status of households is determined not only by food intake, but by health care, sanitation and access to water of sufficient quantity and quality. Declining access to water, experienced in the dry season and most acutely during drought, can affect the consumption, production and income earning opportunities of households.

Instead of a discussion concerned largely with national food supply and price, or with local access and entitlement to food, therefore, we need one concerned with the *complexities of livelihood strategies in difficult and uncertain environments, and with how people themselves respond to the risks and uncertainties associated with drought.* This report has attempted to provide such insights, highlighting the main points of departure between a narrow 'food-first' approach, and a wider 'sustainable livelihoods' approach to drought vulnerability analysis and monitoring. We have argued that prevailing (compartmentalised) approaches to drought mitigation and relief reflect the organisation and remit of government and donor bureaucracies, rather than livelihood realities.

Information and response – widening the perspective

Information on *water availability, access and use* – the key determinants of water security - is limited in many countries. Coverage data, if they exist, are a poor indicator of water security. Information on water availability *alone* provides only partial insights, though groundwater availability maps – now promoted by SADC - provide useful awareness raising and planning tools. Their development at regional and district levels is constrained by limited data, however. Water security can vary significantly over short distances, for example along the South Wollo transect described in this report. In contrast to food, water is difficult to move over distance unless households have access to transport of some kind, or can buy water from others.

Local-level information on the water security status of areas and communities is therefore needed to (a) identify vulnerable areas/groups; and (b) trigger appropriate responses, protecting livelihoods *before* lives are threatened. In this report, *we argue for an extension of existing early warning systems – beyond a narrow food focus – rather than the creation of new monitoring systems specific to the water sector*. By widening the scope of existing local-level 'food' and/or poverty assessments to include indicators of water security and its determinants, a clearer picture of livelihood security, and of the interventions needed to support it, could be gained at little extra cost. For example, water supply interventions (water point rehabilitation, repair or deepening; help with water transport), coordinated with food security/asset rebuilding efforts, could help sustain income, production and consumption in the early stages of drought, or in the aftermath of a bad year.

These recommendations bring significant challenges, however. For example, *existing food-based early warning systems are often located within sectors and departments with narrow agendas. And the protection of livelihoods is more complex, in terms of problem definition and response, than saving lives through food aid*. Progress can and has been made, however. Independent (of line ministry) food security monitoring units have been set up in some countries, with locally defined indicators of food insecurity linked directly with responses. In addition, significant progress has been made with participatory monitoring, with livelihoods-based poverty assessments an increasing feature of development programmes. A key challenge is to bring progress on both together.

Resource assessment and drought proofing

A key lesson from this project is that *drought is not an abnormal event with its own pattern of impact*. Rather, it is a normal process in many African countries associated with heightened, interwoven vulnerabilities. In terms of water security, it is an extension and intensification of the seasonal water shortages experienced by many communities. An important policy implication is that *drought can be planned for within 'normal' development activities*. How can this be achieved?

Firstly, we have argued *for investment in water resource assessment* at regional and sub-regional levels as a logical development of the national groundwater availability mapping described in this report. Higher resolution maps, available as public goods to all sector stakeholders, would provide a powerful tool for targeting water supply programmes and monitoring initiatives to vulnerable areas, especially if combined with food security-food economy mapping. Investment in resource mapping, when combined with training in the use of new information (e.g. for local government, NGO and private sector stakeholders), can generate substantial - and quantifiable - returns.

Secondly, we have argued that the *theory and practice of water service provision under DRA can diverge*. Unintended outcomes include the 'cherry-picking' of more favourable geological areas where drilling success rates are higher, with more difficult (water insecure) areas ignored. Strengthening the capacity of local government institutions to set and monitor performance targets (e.g. for drilling contractors) is therefore important. A further problem arises if the service options offered to communities are not informed by local resource conditions, and are not sensitive to the likely impact of drought and peak demands. For example, shallow wells can provide reliable water supplies in some geological environments (and may be favoured on cost or community involvement grounds), but may be unreliable in others where a borehole would be more drought-proof. Both the community, and those providing services, need to be aware of the tradeoffs.

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Glossary

Agglomerate	A volcanic rock made of angular pieces of rock from explosive volcanic eruptions
Aquifer	A rock formation that contains groundwater to be useful for water supply
Basalt	A black igneous rock, normally the major component of lava flows
Belg	The short and moderate spring rains that fall in March and April in some areas of Ethiopia, including the north-eastern highlands
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
Collector well	A *shallow well* with horizontal radials drilled through the sides of the well to increase the yield
Crystalline basement	Ancient hard rock formation that forms low yielding, though widespread aquifers, in sub-Saharan Africa
Dega	Ethiopian term denoting a highland area (above approximately 2,500 m in altitude)
Drought	A period of insufficient water initiated by reduced precipitation
Intergranular flow	Groundwater flow through the pore spaces in a rock
Karstic	The result of erosion on limestone which gives rise to underground channels and conduits and therefore rapid groundwater flow
Keremt	The major summer rain in Ethiopia that falls from July to September (also known as *meher*)
Kolla	Ethiopian term denoting a lowland area (between approximately 1,300m and 1,600m in altitude). Below the kola lies rangeland or desert
Permeability	Rate of groundwater flow through a cross-section unit area of aquifer under a unit pressure gradient. Permeability is higher where there are interconnected fractures in rock
Pyroclastic rock	Generic term used for rocks formed by explosive volcanic eruptions
Shallow well	A large diameter (usually greater than 1 m diameter) hole, usually dug to less than 20 m, to access groundwater
Transmissivity	The rate of flow of water through a vertical strip of aquifer which is one unit wide and which extends the full saturated depth of the aquifer – usually measured in m^2/d.

Weathered zone	A layer of rock beneath the soil which has been altered by physical breakdown or chemical decomposition
Weyna-dega	Ethiopian term denoting an inter-montain area (between approximately 1,600m and 2,500m in altitude)
Woreda	District-level administrative unit in Ethiopia
Yield	The volume of water discharged from a well or borehole, measured in m^3/d or l/s.

Acronyms and Abbreviations

BGS	British Geological Survey
CDF	Comprehensive Development Framework
DFID	Department for International Development, UK
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 Systems (operated by USAID)
GEF	Global Environment Facility
KAR	Knowledge and Research (DFID-funded research programme)
MWR	Ministry of Water Resources
NGO	Non-Government Organisation
ODI	Overseas Development Institute, UK
PA	Peasant Association
SADC	South African Development Community
SCF	Save the Children Fund
SERA	Strengthening Emergency Response Actions
SIP	Sector Investment Programme
SWAP	Sector Wide Approach
USAID	United States Agency for International Development
VAM	Vulnerability Analysis Monitoring (carried out by WFP)
WFP	World Food Programme

Appendix 1 Project outputs and outcomes

Publications and reports

Output	Comment on dissemination and uptake
Project flyers	Over 500 distributed UK and overseas, mostly on request, throughout project. Also available online
Project Inception Report	Published May 2000. Distributed direct to workshop participants (see Appendix B, and via local partner networks. Also via direct request from BGS and ODI
Project Poster - Ethiopia: Water Security and Drought	Final poster produced 2001 and disseminated as above (see Appendix F). Additional copies requested from range of different government departments in Ethiopia
Case Study for DFID's Sustainable Livelihoods Guidance Sheets (Section 7)	Accessible online at www.livelihoods.org; hard copies also distributed on request
Article for DFID Water Magazine – 'Use of the SL Approach in the Water Sector'	Includes case study on Drought and Water Security in Ethiopia (Issue 12, May 2001)
Conference papers	Proceedings of the International Conference on Integrated Drought Management – Lessons for Sub-Saharan Africa (September 1999)
Workshop and seminar papers	Seminar notes and summary papers from: DFID Water and Livelihoods seminar (October 2001); BGS-organised NGO workshops (July 1999; Jan 2001)
Final Project Report	August 2002 (this report). Dissemination via in-country networks, and to wider donor-NGO-government networks used by BGS and ODI

Presentations, seminars and workshops

Output	**Comment on dissemination and uptake**
Conference presentation, South Africa	Presentation to international policy-practitioner audience at: Conference on Integrated Drought Management (see above), September 1999
Project workshops, Ethiopia	Project workshops held to discuss project findings and links with related work, attended by government, donor and NGO stakeholders (see Appendix B), Dec 1998; Oct 2000
NGO workshops, UK	Presentations to UK NGO audiences at annual BGS-organised NGO workshops (see above), July 1999 and Jan 2001
DFID Water and Livelihoods Seminar, UK	Invited BGS-ODI presentation at DFID Water and Livelihoods Seminar, October 2001

Other project outcomes

Groundwater vulnerability/availability mapping developed on this and previous BGS-led drought projects now being adopted by SADC member states part of a new World Bank/GEF-funded project on entitled ‘Protection and Strategic Use of Groundwater Resources in the Transboundary Limpopo Basin and Drought Prone Areas of the SADC Region’. The project is part of the Groundwater Management Programme for the SADC Region. In addition, groundwater drought vulnerability maps appear in recent publicity material for the establishment of a new International Drought Centre for Southern Africa (UNESCO, 2002).

Organising framework for looking at water security issues (availability, access and use) adopted by other projects, e.g. ODI’s Secure Water – Building Sustainable Livelihoods for the Poor into Demand Responsive Approaches’, and the Centre for Ecology and Hydrology’s ‘Development and Testing of the Water Poverty Index’.

Drought policy and planning ideas for the water sector picked up by the UK Foreign and Commonwealth Office (FCO) for inter-governmental discussion in Middle East (EU funded)

Appendix 2 Workshop participants

Interim Project Workshop, December 1999 and Final Project Workshop, October 2000

Name	Organisation
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 3 Survey checklists

BACKGROUND INFORMATION: FEDERAL, REGIONAL AND WOREDA LEVELS

1. Federal

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? Decentralisation issues?

2. Regional

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. Woreda

Officials

What is the current status of water points in the woreda? Do you have an audit available? Maps? Coverage data? (last updated? mechanism for update?)

What is the relationship between the woreda council and the executive committee on planning water point development including engaging with outside organisations?

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? What is the nature of water problems reported?

Where are the most drought-vulnerable areas of the woreda and why? What is the nature of 'vulnerability'? Discuss in terms of both water and food security – what/where are the overlaps?

How do you prepare for emergency food aid provision and how do you respond to demands from communities? Are these all channelled through PAs?

Peasant Associations

What are the water points included in your PA? PA responsibilities? Maps? Coverage data?

What is the history of these water points?

How do you relate demands for water resource development to the woreda, and what is their response?

What have been the recent drought events affecting your PA, and how have you responded to them?

How do communities inform you of their water problems? What are the procedures for responding? What is the nature of water problems reported?

Where are the most drought-vulnerable areas of the PA and why? What is the nature of 'vulnerability'? Discuss in terms of both water and food security – what/where are the overlaps?

How do you prepare for emergency food aid provision and how do you respond to demands from communities? Are these all channelled through PAs?

South Wollo community and household survey

The tables and checklists below were used to conduct semi-structured interviews with key informants and groups at different villages along the South Wollo transect. See Chapter 3 of this report for further details.

1. Administrative, physical and socio-economic context

(Based on secondary data collected at woreda and PA levels, cross-checked with community)

Name of village/community	
PA	
District	
GPS and altitude	
Topography	
Rainfall	
Distance from main road; nearest market	
Population of village/community	
Local economy/livelihood details	

2. Village water sources and water availability

ID	Type of source: surface (eg stream; river); ground (eg spring, well, borehole)	Construction date and details (if available)	Water availability/ yield*				Taste/quality preferences and comments
			Dec	Mar	July	Last reported drought	
1							
2							
3							
4							
5							

*estimates based on based on water point observation and discussion with those collecting water

Supplement information above with:

Map of water sources – wet and dry season; drought.

Water quality testing, if feasible.

Observations on geological, hydrological and hydrogeological setting.

3. Water access

ID	Distance of community/ household from source	Type of management (eg open access; common property; private)	Type of water transport (eg head/hand; donkey; bicycle; cart)	Time to collect (round trip, including queuing); no. of trips; household members			
				Dec	Mar	July	Drought
1							
2							
3							
4							
5							

Supplement information above with:

Information on conflict and competition for water between users – across seasons; between years (dynamic management/ownership arrangements for water sources?).

Information on any cooperative arrangements (e.g. shared transport and collection).

Information on water sales/purchase arrangements.

Information on any temporary/permanent migration influenced by water availability/access constraints.

4. Water use

Complete separately for December, March, July and 'drought period' as above

ID	Drinking	Washing and cleaning	Bathing	Irrigation (describe)	Livestock watering (describe)	Other uses (eg brewing; brick-making – describe)
1						
2						
3						
4						
5						

Supplement information above with:

Information on competition for water between uses – across seasons; between years (e.g. trade-offs between time/distance and water use, water quality.

Information on productive uses of water and contribution to household economy, and how this changes across seasons and between years. Which households and communities use water for income generation and production, and why?

Information on rationing of essential uses/use of poorer quality sources. Reports of ill-health/disease related to water?

5. Experience of drought – discussion checklist

Description of most severe events

Local definitions of drought

Predictability of drought – local indicators?

Description and sequencing of events: e.g. rainfall failure; crop failure; food shortage; failure of water sources

Nature of water problems experienced – absolute scarcity (drying up of water sources – which ones; when?); access problems (e.g. heavy demand on few remaining sources; mechanical breakdowns); constraints on use (e.g. loss of productive uses, including for livestock; rationing of consumptive use); use of poorer quality sources

Scale of impact – very localised, to district, to region

Differentiation of impact – which villages and households were most affected and why? Specific impacts on different household members

Responses and coping strategies

Changing patterns of water use. Constraints on use – consumptive and productive (see above)

Distance and time to collect water; release of household labour and perceived opportunity cost, if any (e.g. impact on collection of wild foods; land preparation; labouring opportunities; school attendance etc)

Payments for water and/or markets as a response to scarcity: nature of payment and/or markets; households involved; terms and conditions

Reported conflicts over water: inter-household; inter-village

Temporary/permanent migrations?

Divestment

Timing of strategies in relation to sequencing of events described above.

Engagement with ‘outside’ organisations: were problems/specific demands communicated to PA/woreda officials? Responses? (food; water; other)

Appendix 4 Summary of survey data

ID	name	loc^n	Altitude	pop^n	economy	water source (wet)		water source (dry)		water source (drought)		chemistry[1]	Comments
						type	time (hrs)[3]	type	time (hrs)[3]	type	time (hrs)[3]		
1	Abbot	D[2]	3000	500	Mixed agriculture	springs	0.5	Springs	1	Springs	1	pH 7.5 T 16.6°C TDS 186 mg/l $CaMgHCO_3$	10 springs in the dispersed village. Yield is generally fine, but queues in dry season, drought. Some garden irrigation, but main springs below village.
2	Gobesha	D	2630	600	Mixed agriculture Chatt	spring	0.3	well spring	1 1	well spring	1 1	pH 7.5 T 19.7 °C TDS 275 mg/l $CaMgHCO_3$	The spring was protected with a spring box. A hand dug well had been sited above spring, but pump broke since inappropriate design) - preferred hand dug well. A poor quality (but reliable) shallow well used in drought.
3	Mayie Selassie	WD-D	2330	900	Tef/mixed agriculture	spring river	0.2 0.5	Spring	>5	Spring	>5	pH 6.9 T 19.2 °C TDS 217 mg/l $CaMgHCO_3$	River preferred source since closest, but seasonal. Two hand dug wells constructed in swampy area and abandoned due to bad smell. Springs used when river dries; single distant spring used during drought – only available source.
4	Gandahole	WD	2230	1500	Tef/mixed agriculture	spring	0.3	Spring	> 1	Spring	> 1	pH 6.8 T 21 °C TDS 460 mg/l $CaMgHCO_3$	Neighbouring gohts use the source in dry season. This is the only viable source in drought and queues of 20 - 30 people form. Use sometimes contested e.g. at peak demands.
5	Hadinu	WD	2120	350	Tef/mixed agriculture	well	0.3	well	0.5	well	0.5	pH 6.9 T 22 °C TDS 590 mg/l $CaMgHCO_3$	12 m deep well with India Mk 2 hand pump. Hand pump broken (since inappropriate for shallow well), but water taken from hole in the side of the casing. This source is used by 3 other gohts in drought times.
6	Golbo	WD	1830	3500	Tef/mixed agriculture market	spring	0.5	Spring	1	Spring	1	pH 7.3 T 22 °C TDS 470 mg/l $NaCaHCO_3$	Spring water forms a small lake. Water is used to irrigate 10 Ha (even through 84/85 drought). Cattle drink from lake.
7	Robit	WD-K	1800	3000	Tef/mixed agriculture market	river spring 1 spring 2	0.5 1 1	spring 1 spring 3	>5 >5	spring 1 spring 3	>5 >5	pH 6.8 T 21.3 °C TDS 429 mg/l $CaMgHCO_3$	River used during late rains (0.5 hours) for drinking and year round for cattle. In 84/85 cattle water 8 km away in River Mille.
8	Bokaksa	WD-K	1740	4000	trade mixed agriculture	spring 1 spring 2	2 2	spring 1	4	spring 1	4	pH 7.1 T 27.3 °C TDS 1275 mg/l $CaNaMgSO_4HCO_3$	Poorest collect water in drought and sell it (20 litres - 75 cents). Normal price throughout year 20 litres = 50 cents. Donkeys make the trip since very steep track. Some children miss school because of long queues.
9	Chefe	WD-K	1730	350	Tef/mixed agriculture	spring	0.2	Spring	0.2	Spring	0.2	pH 7.4 T 28.4 °C TDS 427 mg/l $NaHCO_3$	Good source used by village and in crisis by others. This spring (and one other) used to irrigate 58 ha using traditional methods. In 1984/85 spring yield declined significantly; irrigated area maintained but reduced yield - insufficient food for whole village.
10	Tisabalima	WD-K	1640	1500	Tef/mixed agriculture	spring	0.5	borehole 2	0.5	borehole 2	0.5	pH 6.9 T 23.1 °C TDS 475 mg/l $CaMgHCO_3$	Borehole 1 owned by church (constructed 92) - only used by community during crisis. Borehole 2 submersible pump - not now working. Borehole preferred source since good quality.

ID	name	loc^n	Altitude	pop^n	economy	water source (wet)		water source (dry)		water source (drought)		chemistry[1]	Comments
11	Chale	K	1430	500?	cattle mixed agriculture	well	0.3	River	4	River	4	pH 7 T 26.3 °C TDS 1410 mg/l $CaNaMgSO_4HCO_3$	River Burka used all year round for washing clothes and for cattle 4 hour round trip. The well was only recently constructed (by digging out spring zone) so not tested in drought.
12	Arabati	K	1200	1000	cattle mixed agriculture	river rainwater	0.8 0.1	river borehole	4 0.5	river borehole	4 0.5	pH 7.1 T 28.9 °C TDS 600 mg/l $CaNaMgHCO_3Cl$	Borehole in village with submersible pump. This was working during the 84/85 drought but is now not working. The river (Burka) is seasonal, so they move up and down stream and dig 7-10 m wells in river bed. The Afar share the river in dry years.

[1] Chemistry sample taken during the dry season from the source shown in bold (details in Appendix)

[2] D - Dega; WD - Weyna Dega; K - Kolla.

[3] Time is for a two way trip for domestic water and includes walking, queuing and filling time.

Appendix 5 List of DFID-funded research projects with relevance to drought

89/19 British Geological Survey 1984-92. **Hydrogeology of regolith and crystalline basement aquifers.**

R3869 Loughborough University 1984-92. **Use of dambos in rural development.**

102/103 HR Wallingford 1986-95. **Irrigation water management.** Develop procedures for improving water distribution; develop tools for effective water resource planning; develop a planning framework prior to rehabilitation; and diagnose courses of unsatisfactory channel conveyance, impact of aquatic vegetation and recommend suitable maintenance techniques.

114 HR Wallingford 1987-95. **Environmental aspects of irrigation.** Develop tools to assist engineers to identify and avoid adverse environmental effects of irrigation projects.

R5838 HR Wallingford 1987-94. **Environmental management / Assessing impacts.** Provide tools for identifying the environmental impacts of water resources development in developing countries and to increase awareness of professionals to the adverse impacts and assist them in mitigating against such impacts.

T06055B1 Institute of Hydrology 1987. **Use of remotely sensed hydro-meteorological data for calculation of evaporation losses.**

91/8 British Geological Survey/Institute of Hydrology 1989-92. **Development of techniques for hydrogeological mapping and the siting of boreholes and dug wells in Zimbabwe.**

R4576 University of Strathclyde 1990-92. **Examine the effectiveness of limestone filters in the removal of iron from ferruginous groundwater.**

R4629 Robens Institute/Imperial College 1990-92. **Water disinfection techniques for developing countries.** Investigate methods for disinfection of small-scale rural water supplies as an alternative to chlorination.

R4647 Centre for Development Planning Studies 1990-92. **Produce a manual to facilitate the provision of appropriate water supply and sanitation infrastructure in Third World cities.**

R5545 British Geological Survey 1990-93. **Impact of urbanisation on groundwater quality.** Investigate the impact of increasing urbanisation in developing countries on the groundwater supplies in their vicinity.

T05054S1 Institute of Hydrology 1990-92. **Estimation of effective rainfall.**

T12052K1 Institute of Hydrology 1990-93. **Impact of changing land use on surface water resources in southern Africa.**

91/ HR Wallingford 1991-92. **Assess adequacy of data and methodology for planning sustainable water resources development.**

R4428 Silsoe College 1991-92. **Rehabilitation of boreholes and tubewells.**

R4702 IMMI 1991-93. **Irrigation management improvement.** Investigate the scope for applying modern technologies for irrigation agencies to better match scarce water supplies with crop demand.

R5478 British Geological Survey. **Cost effectiveness of monitoring and maintenance options associated with groundwater abstraction.**

R5544 British Geological Survey 1991-94. **Over-exploitation of aquifers.** Study the hydraulics of two major world aquifers to determine local and regional safe yields for groundwater development.

R5844 Institute of Hydrology 1991-95. **Impact of climate change on water resources.** Identification of the likely hydrological and social effects of climate change on specific water resource systems in East Africa.

R5551 British Geological Survey/ Cranfield Institute of Technology 1992-95. **Sustainability of groundwater supply from hard rock aquifers.**

R5847 Institute of Hydrology 1992-95. **Southern African low flows.** Quantification of the magnitude and frequency of low flow events and characterisation of their variability within the SADC region.

R5850 Institute of Hydrology 1992-95. **Water balance of African lakes.**

R5848 Institute of Hydrology 1993-97. **Water resources modelling for large catchments.** As part of an integrated catchment management approach, methodologies are required to model water resources within large catchments. The project developed suitable models which take account of alterations in river flow resulting from changes in land use and climate within large catchments as well as the development of water resources.

R5561 British Geological Survey 1993-96. **Groundwater development in alluvial aquifers: groundwater management – over-exploitation, protection, drought and subsidence.** A manual which describes the need for the management of groundwater exploitation and its protection from a variety of threats.

R5846 Institute of Hydrology 1993-97. **The effect of land management on groundwater recharge.** To better understand groundwater recharge mechanisms to enable more successful siting of shallow collector wells.

R5973 British Geological Survey 1994-96. **Groundwater data management system for developing countries.** Planning the delivery of efficient water resource supply, and increasing demands for environmental monitoring require access to accurate information on the occurrence and movement of groundwater. The principal repository of information is the collated reports of the behaviour of existing wells and boreholes, both during their drilling and subsequent operation. The project reviewed contrasting groundwater data management experience from different countries, and prepared guidelines for project managers and water resource planners. The results highlighted several key elements that lead to the successful setting up of a groundwater information system. Ghana and Malawi were used as case studies.

R5974 British Geological Survey 1994-96. **Degradation of groundwater: socio-economic impacts.** To develop conceptual framework describing the inter-relationship between different socio-economic and hydrogeological environments. Investigation of the circular inter-relationships between the supply and demand for water and the socio-economic impacts of the growing degradation of groundwater resources, both in terms of quality and quantity.

R6064 Institute of Hydrology/British Geological Survey 1995-98. **Assessment of global water resources.** It is important to be able to identify countries and, within countries, regions which are most at risk of the socio-economic disruption resulting from water scarcity, and those areas which are likely to experience water scarcity in the future. A system was developed to allow planners access to detailed predictions of current areas prone to water scarcity. The basic approach relies on the use of a 0.5° by 0.5° grid, which allows the spatial variability in both the availability of water and the demands for water to be represented. The approach allows detailed considerations of future scenarios so that factors such as population growth, urbanisation, economic development and climate change that are putting increasing stress on water resources can be examined. It has so far been applied to eastern and southern Africa.

R6065 Institute of Hydrology 1995-97. **Integrated water resources simulation model for developing countries.** To provide the means for improved planning and operation of complex multi-use river basins, with the ability to include water quality and ecological objectives in such planning.

R6233 British Geological Survey 1995-97. **Groundwater management in drought-prone areas.** This project studied ways in which the impact of groundwater drought can be alleviated for vulnerable communities. Management strategies were identified aimed at alleviating the worst impacts of groundwater drought and at drought-proofing those same communities. The work involved three partners: the Ghana Water and Sewerage Corporation, the Malawi Ministry of Irrigation and Water Development and the South African Department of Water and Forestry. A major workshop on the project findings was held in Lilongwe in February 1997.

R6250 Institute of Hydrology/British Geological Survey 1995-99. **Regional groundwater recharge assessment in semi-arid areas.** To investigate geochemical methods, in particular chloride balance, for the estimation of groundwater recharge in semi-arid regions. This is part of a project on physically-based methods and their limitations. The objective is to arrive at integrated models for recharge assessment. The geochemical studies are being carried out in Zimbabwe linked to remote sensing information from hard rock areas.

R6533 British Geological Survey 1995-97. **A diagnostic method to determine aquifer susceptibility.** Assessment of groundwater degradation threats using a diagnostic methodology to assess the susceptibility of aquifers to the side effects of groundwater exploitation. These include groundwater level decline, saline intrusion and land subsidence.

R6573 Institute of Hydrology 1996-99. **Assessment of the regional impact of drought in Africa (ARIDA).** The hydrological or river flow aspects of drought have generally received less attention than the meteorological or agricultural aspects. However, the importance of river flow droughts for the planning of water resources systems, and the need to monitor river flows for management of droughts, is increasingly being recognised. The overall aims of the project are to investigate improved methods for the identification of river flow droughts in southern Africa, and to develop tools and software which hydrologists and water resources managers in the region can use to monitor droughts. The package will include maps of the flow or drought characteristics at sites across a region so that the spatial extent of the drought can be examined. Such operational software will be increasingly useful as greater volumes of near real-time flow data become available from satellite data transmission projects such as SADC-HYCOS.

R6866 Institute of Hydrology 1997-99. **International institutional co-operation in water resources assessment through FRIEND.** Establish regional hydrological databases and management procedures to enable better design of water resources projects in data deficient areas. The FRIEND project (Flow Regimes from International and Network Data) is a contribution to the UNESCO International Hydrological Programme.

R6568 WEDC/British Geological Survey 1997-99. **An integrated framework for rural water supply and sanitation in groundwater-dependent areas.** Development of procedures to prepare frameworks for rural water supply and sanitation programmes. These provide assistance in designing projects with appropriate institutional, technical and environmental sustainability. Dissemination is via guideline documents and workshops.

R6869 British Geological Survey 1997-2000. **Assessing risk to groundwater from onsite sanitation (ARGOSS).** Prepare a manual and guidelines to help ensure water quality in drinking water supply wells is acceptable by improving their design and siting in relation to on-site sanitation. A comprehensive technical report has been prepared, and is available from BGS and World Bank websites.

R6849 British Geological Survey 1998-2000. **Groundwater drought early warning for vulnerable areas.** Continuation of potable supplies during drought is essential for the well-being and health of effected communities. This project concentrates on the issues surrounding the early warning of drought to drought-prone communities and the groundwater management plans and strategies that can then be drawn into place. The concepts of drought vulnerability mapping will be tested in order to identify critical zones and a pilot study area. This will provide data on institutional and stakeholder needs as well as on groundwater availability and access so that a monitoring strategy can be devised and suitable thresholds and triggers defined. A workshop will precede preparation of early warning system guidelines.

R6867 British Geological Survey. **A decision support system for improved groundwater management.** The project aims to equip urban decision makers with the assessment and decision support tools needed to make informed choices in managing water resources. The aim is to provide guidance on how to reach decisions, highlighting technical, economic and institutional criteria and trade-offs.

R6874 Robens Institute. **Urban water supply monitoring in developing countries.** To develop a cost-effective and sustainable model for monitoring of water supplies in urban areas of developing countries which is focused on priority groups and linked to improving supply and quality worldwide.

R7131 Institute of Hydrology. **Productive water point handbook.** Handbook giving synthesis of research and development findings for planning and implementing community-based productive water points.

R7134 British Geological Survey. **Groundwater protection and management for developing cities.** Develop techniques of groundwater protection assessment and guidelines for sustainable management of urban aquifers.

R7135 HR Wallingford Ltd. **Integrated water information management system (IWIM).** Develop assessment guidelines and information system of multi-sectoral water demand, allocation and current use.

R7136 Gamos Ltd. **Exit strategies for resettlement of drought-prone populations.** Identify elements of a successful exit strategy for water programmes with resettlement of rural populations.

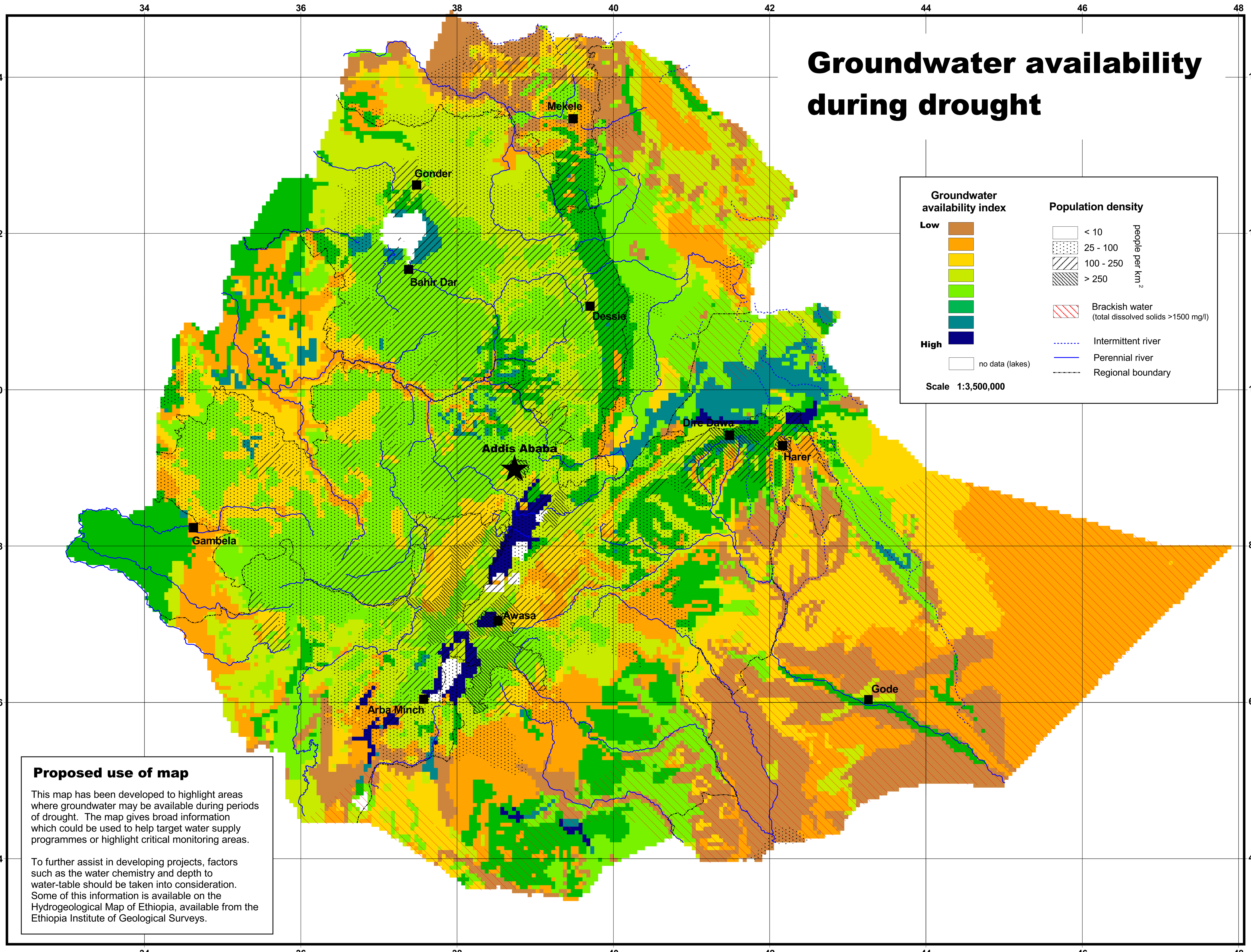
R7137 Institute of Hydrology 1998-2001. **Integrated planning and management of water resources.** Evaluate and develop guidelines from the use of belief and decision networks at the local and catchment scales.

Reading University. **Drought and flood warning in southern Africa.** Improve the capability of meteorological services in southern Africa to utilise satellite data for drought and flood warning. Specific objectives included: to evaluate the utility of satellite techniques in monitoring of drought over Zambia and Zimbabwe; and to study the best way of presenting drought and flood forecasts to assist in remedial action and the preparation of warnings.

Appendix 6 Ethiopia: water security and drought (poster)

Ethiopia: Water Security and Drought

Groundwater availability during drought



Proposed use of map

This map has been developed to highlight areas where groundwater may be available during periods of drought. The map gives broad information which could be used to help target water supply programmes or highlight critical monitoring areas.

To further assist in developing projects, factors such as the water chemistry and depth to water-table should be taken into consideration. Some of this information is available on the Hydrogeological Map of Ethiopia, available from the Ethiopia Institute of Geological Surveys.

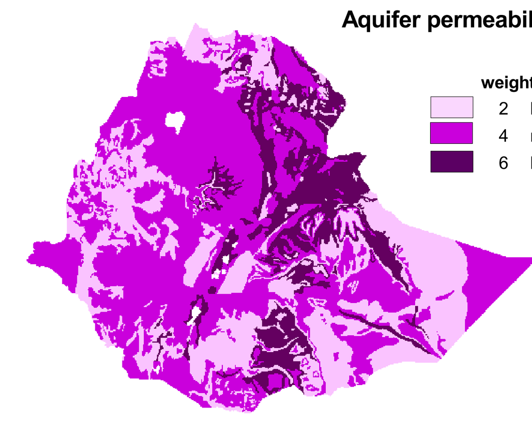
Constructing the map

The map showing groundwater availability during drought for Ethiopia was constructed by combining three factors:

(1) rock permeability (derived from the hydrogeology map)
(2) the ability of the rock to store water (from the hydrogeology map)
(3) recharge to the groundwater (estimated from rainfall data).

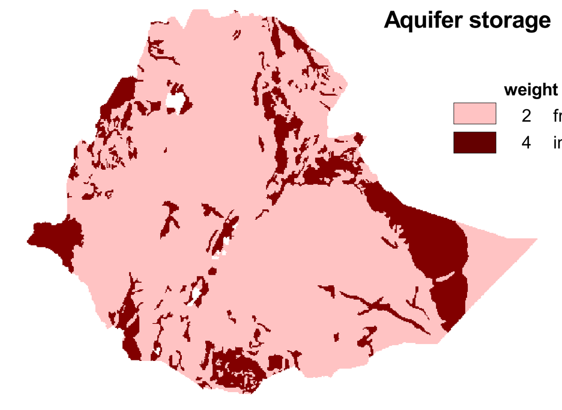
Areas of high permeability, high storage and high recharge have most groundwater available during drought (see box on "Groundwater and drought"). Rock permeability and groundwater storage factors have been derived from the published hydrogeology map for Ethiopia. Hydrogeology maps divide geology into three separate classes of permeability: high, moderate and low. These were given a weight of 6, 4 and 2 respectively.

Aquifer permeability



On hydrogeological maps, rocks are also divided into those with inter- -granular flow and those with either fractured or karstic flow. Intergranular aquifers store water in pore spaces and have a large storage capacity. Fractured or karstic aquifers store groundwater only in fractures and therefore have much lower storage capacity. Intergranular aquifers were given a weight of 4 and fractured/karstic aquifers a weight of 2.

Aquifer storage

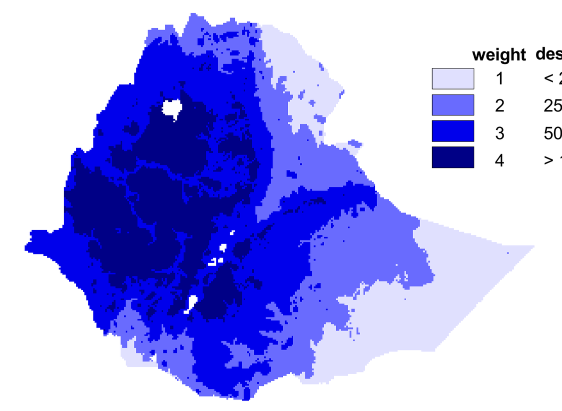


Recharge to the aquifer has been estimated from rainfall data for Ethiopia. To build a sophistocated recharge model demands much data and calibration which is beyond the scope of this project. Using solely rainfall data is a simplification, but the broad classifications used in making the maps make any errors less significant.

Rainfall data were taken from a 3 minute monthly climate grid for Africa for 1951 - 1995, constructed by New and Hulme (1997). To take into account rainfall variability, the coefficient of variability was calculated along with the annual average for each grid cell. The average annual rainfall for below average years (R) was then calculated using the formula:

R = mean x (1 - co of var) = mean - standard deviation.

Average rainfall for below average years (1951 - 1995)



Weighting and colours for final map

mean below average rainfall (1951-95)	H, H	H, L / M, H	M, L / L, H	L, L
> 1000 mm	14	12	10	8
500 - 1000 mm	13	11	9	7
250 - 500 mm	12	10	8	6
< 250 mm	11	9	7	5

permeability, storage →

H - High
M - Moderate
L - Low

The final map showing groundwater availability during drought was then constructed by adding the various weights together. The matrix (left) shows the possible combinations of physical charactersitics that make up each weight, and the colour scheme used on the final map. The weights for each characteristic were chosen to reflect the relative importance of each of the factors in controlling groundwater availability during drought.

To give an overall impression of the demand for groundwater and the population at risk during drought, the population density was overlain as a stipple on the map. This information was taken from the 1995 census and also the Environmental Systems Research Institute world data set (ESRI 1996).

The methodology and weights used here could easily be applied to other areas. The data sets used to construct the map are also widely available. Hydrogeology maps are made to an international standard (IAH 1995) and are available for most countries. The rainfall data set is available for all Africa, and likewise some rough estimates of population are also available. The weighting system has been developed primarily for Ethiopia and may need to be modified and tested before applying elsewhere.

Groundwater and drought

Groundwater (water stored below the ground in aquifers) provides the only affordable means of meeting the dispersed demand of rural communities. One of the key advantages of groundwater is its reliability, particularly during drought. After surface rivers and streams have dried up, groundwater can still be accessed through wells, springs and boreholes.

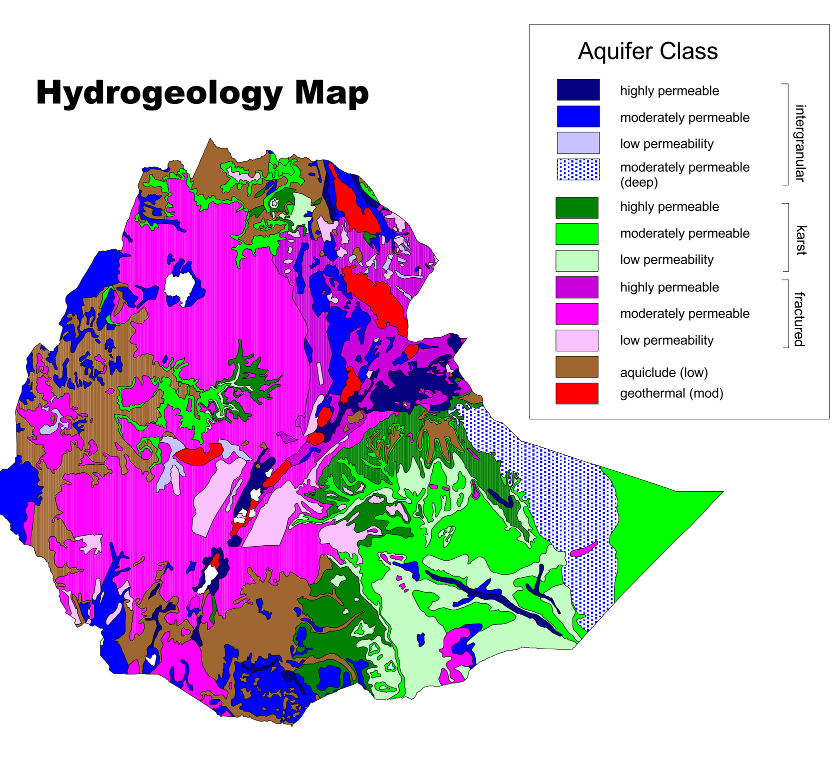
Research in Malawi, Ghana, South Africa and Ethiopia (Calow et al. 1997, Robins et al.1997, Calow et al. 2000) has shown that water security during drought is dependent on three main factors: groundwater availability (as volume stored in the aquifer), access to groundwater (via springs, wells or boreholes) and demand for groundwater during drought (dependent on livelihood strategies and the failure of other sources). The main map above addresses the first of these issues - groundwater availability during drought.

Two main factors control the amount of groundwater available during drought: rock type (geology) and rainfall (aquifer recharge).

Geology

Groundwater is stored within pore spaces and fractures in rocks. Where the pores and fractures are interconnected, groundwater can flow easily and the rocks are said to be permeable. Rocks which contain significant groundwater are called aquifers. Hydrogeologists classify rocks according to permeability to produce hydrogeology maps (see right). To ensure ground-water availability during drought, the ease with which groundwater flows through the rocks (permeability) and the volume of water stored within the rocks are both important. Since the volumes of water required by dispersed rural communties are low, groundwater storage is probably less important than permeability.

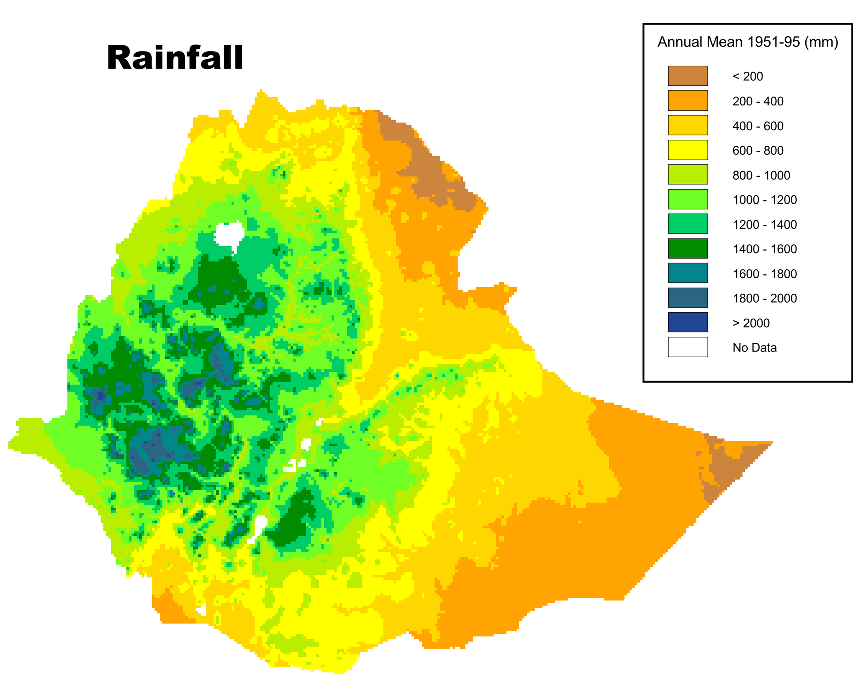
Hydrogeology Map



Recharge to groundwater

Recharge to groundwater is also important in controlling the availability of groundwater during drought. Recharge to groundwater usually occurs annually and depends on a number of factors, including: total annual rainfall; distribution and intensity of rainfall events; connection to streams and rivers; soil type; and land use. Aquifers react slowly to changes in rainfall and long term average rainfall is more important in controlling recharge to aquifers than short term variations. Therefore groundwater sources can bridge surface water deficits. The average annual rainfall for Ethiopia is shown to the right.

Rainfall



Access to groundwater and patterns of demand

Accessing available groundwater resources during drought is often more of a problem than the absolute availability of groundwater. Once surface streams have dried up, people are reliant on whatever groundwater sources are present. Where these are few in number, the demands placed on individual water points may lead to mechanical failure or reductions in yield. In some circumstances the groundwater source, though not the aquifer, may dry up altogether. The result may be severe water stress as consumption declines, and people and animals are forced to use the same deteriorating sources.

Household livelihoods may be impacted in other ways too. For example, income generation as well as direct consumption may suffer if the watering of livestock and small scale irrigation are affected. Similarly, time spent finding and collecting water may carry a high opportunity cost because of lost production, income, and food gatheriing through reduced labour time, as well as missed eduction for children.

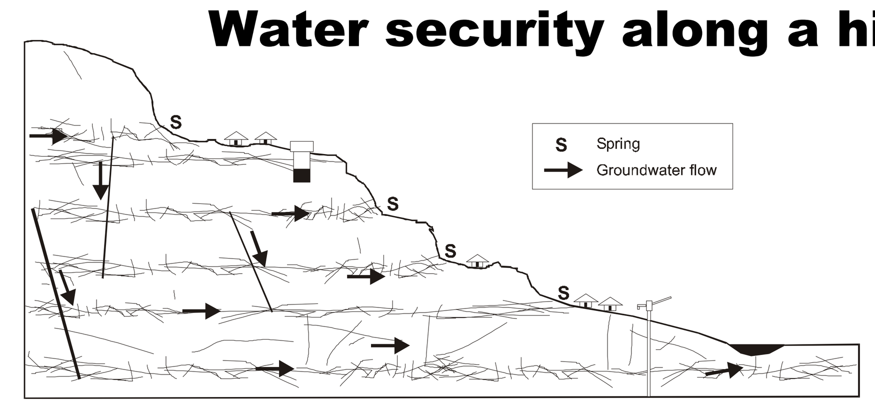
Links with policy and practice

PROGRAMME DEVELOPMENT. Maps could be used to target water supply programmes to areas which are vulnerable to drought, but which contain reliable sources of groundwater. Maps could also be used to highlight areas where the monitoring of water availability and access is important, perhaps through widening the scope of existing food security assessments. Regional maps could be used to identify water insecure woredas, but cannot be developed at present because of insufficient data.

PROJECT DEVELOPMENT. An understanding of water security at a local level, and of the factors that influence it, is needed to respond effectively to community 'demand' for projects. For example in areas of high water demand, where few other options for water supply exist, it may make more sense to install several lower yielding handpumps rather than a single deep borehole which may fail under stress.

DROUGHT PLANNING. A broader approach to drought mitigation, focusing on food and water security (and the links between them), could be developed. Water security analysis could be combined with existing vulnerability/ profiling exercises (which focus on food security) to gain a clearer picture of livelihood security, and of the interventions required to support it. For example, in protecting the assets of households in the early stages of drought, or rebuilding them in the aftermath of a bad year, the key variable may be access to water, both in increasing labour availability and in protecting and increasing livestock production. This may indicate the need for targeted water supply interventions, coordinated and carefully sequenced with food security/asset rebuilding efforts, rather than just food or water interventions alone.

Water security along a highland-lowland transect



	Dega (mountain)	Weyna Dega (intermontain)	Kolla (plain)
Availability	Small resource base but high recharge	Moderate resource base but less recharge than Dega. More surface water (fed by groundwater)	Large resource base but low rainfall Fewer surface sources (all groundwater fed)
Access	High: multiple access mainly springs	Moderate: multiple access through springs wells and boreholes (often widely spaced)	Low: few boreholes no springs
Demand	Low - mainly household consumption	High demand from people and livestock (most populated)	Human population less dense, but greater demand from livestock

The water security of households is influenced by the availability of water, the ability to access this water, and patterns of water demand. The diagram on the left shows how the relative importance of these factors varies along a highland-lowland transect in the Amhara region of Ethiopia. The transect falls within a single geological unit.

The availability of water for different uses depends on resource characteristics such as storage and reliability. In highland areas groundwater resources are limited since the aquifers are small, although recharge is high and streams more numerous. Water security is generally higher however, as springs are more numerous and demand (from people and livestock) is relatively low. In lowland areas the aquifer is larger, but water security is undermined by limited (and poor quality) surface water, restricted access to the aquifer via boreholes, and greater demands. Boreholes are also subject to mechanical failure. Large increases in demand can put stresses on individual groundwater sources, but are unlikely to affect the resource as a whole.

While a general trend in highland-lowland water security emerges, significant local variation also occurs. For example, access to water at the household level is also influenced by access to labour and animals for water carrying, money for water purchase and social capital for securing customary water rights.

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