ground water

Issue Paper/

Ground Water Security and Drought in Africa: Linking Availability, Access, and Demand

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Abstract

Drought in Africa has been extensively researched, particularly from meteorological, agricultural, and food security perspectives. However, the impact of drought on water security, particularly ground water dependent rural water supplies, has received much less attention. Policy responses have concentrated on food needs, and it has often been difficult to mobilize resources for water interventions, despite evidence that access to safe water is a serious and interrelated concern. Studies carried out in Ghana, Malawi, South Africa, and Ethiopia highlight how rural livelihoods are affected by seasonal stress and longer-term drought. Declining access to food and water is a common and interrelated problem. Although ground water plays a vital role in buffering the effects of rainfall variability, water shortages and difficulties in accessing water that is available can affect domestic and productive water uses, with knock-on effects on food consumption and production. Total depletion of available ground water resources is rarely the main concern. A more common scenario is a spiral of water insecurity as shallow water sources fail, additional demands are put on remaining sources, and mechanical failures increase. These problems can be planned for within normal development programs. Water security mapping can help identify vulnerable areas, and changes to monitoring systems can ensure early detection of problems. Above all, increasing the coverage of ground water–based rural water supplies, and ensuring that the design and siting of water points is informed by an understanding of hydrogeological conditions and user demand, can significantly increase the resilience of rural communities to climate variability.

Drought in Africa

Historically, about 20% of the earth's land surface experiences drought at any one time. This has now risen to 28%, and is set to rise to 35% by 2020. Over the last 10 years, areas affected by the most severe droughts have risen from 1% to 3% of the planet's landmass, and the situation is likely to get worse (Hulme et al. 2000; Burke et al. 2006; Sheffield and Wood 2008). Despite considerable uncertainty surrounding the future of Africa's climate as reported in the Intergovernmental Panel on Climate Change (IPPC) Fourth Assessment Report, several patterns emerge (Christensen et al. 2007): decreasing rainfall in northern and southern Africa, increasing rainfall over the Ethiopian Highlands, and (most notably) an increasing frequency of floods and drought.

Droughts affect communities in different ways. In this paper, the term *vulnerability* is used to describe the exposure and susceptibility of a household, or community, arising from the hazard of drought. It has two dimensions: sensitivity to the hazard itself, and the capacity, or resilience, to return to a predrought state (Davies 2000). Risk is the product of hazard and vulnerability. The vulnerability of a household, in a broad sense, is influenced by its ability to draw on different assets, including financial, human, social, physical, and natural capital. Clearly a household that barely subsists on rain-fed agriculture or on livestock rearing in a normal year is likely to be more vulnerable than a household with more

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diversified livelihood options and which is less dependent on water as a production input.

Drought is Africa's principal type of natural disaster and (historically at least) the most common trigger for episodes of acute household insecurity. Moreover, poverty and food insecurity are increasingly "Africanized" because of the continent's persistent vulnerability; sub-Saharan Africa is expected to account for roughly 50% of the world's poor by 2015, compared with 19% in 1990 (Devereux and Maxwell 2001). In these circumstances, drought can mean the difference between coping and not coping. Such was the case in Ethiopia when, in 2002–2003, a combination of drought and economic shocks left more than 13 million people in need of emergency assistance (OCHA 2004). Most of this assistance, as with previous responses, was delivered as food aid. Wider public health and income support needs to protect livelihoods and save lives received much less emphasis, with funding "critically slow in meeting essential non-food requirements for medicines, veterinary drugs, seeds and water and sanitation needs" (OCHA 2004), despite repeated calls for more "balanced" assistance from agencies such as Oxfam (Oxfam 2002).

This state of affairs was repeated again across the Horn of Africa in 2005–2006, the region's worst drought in a decade, with pastoral livelihoods particularly hard-hit in Afar and eastern Amhara regions. The bias of early warning and needs assessment toward food, and the difficulty in attracting donor support for wider livelihood interventions, was again highlighted (ODI 2006).

What are the impacts of drought on water supplies, and what evidence is there that a rebalancing of assistance would reap rewards? This paper highlights the importance of ground water for rural water supply in Africa and considers the impact of drought on water availability, access, and use, drawing on research experience from four different countries, particularly Ethiopia. Links between water, food security, and livelihoods are highlighted. The prevailing "food-first" approach to drought assistance is reviewed, and it is argued that the privileging of food aid over nonfood assistance, including water supply interventions, reflects the organization and remit of government and donor bureaucracies rather than livelihood realities. Policy recommendations emphasize the need to shift away from ex post disaster relief to ex ante risk management as the preferred response to emergencies, with a strong focus on reducing underlying vulnerabilities through ground water supply.

The Importance of Ground Water

At least 44% of the population in Africa—some 320 million people—do not have access to clean, reliable water supplies (WHO/UNICEF 2007). Faced with this reality, the international community set ambitious targets in the form of Millennium Development Goals (MDGs) to reduce, by half, the number of people without clean water by 2015. In Africa, progress has been slow and patchy; and at current rates, the target is not expected to be met until 2050. In Ethiopia, for example, only 11% of the population are estimated to have access to safe water (WHO/UNICEF 2007), although the government has put in place highly ambitious plans for universal access by 2012.

In this context, the need for affordable, safe, and reliable supplies is paramount. In rural Africa, it is ground water that normally meets these criteria (Calow et al. 1997; Foster et al. 2000). There are several reasons: ground water is generally cheaper to develop relative to alternatives; aquifers are able to offer natural protection from contamination (although anthropogenic pollution is a growing concern and naturally occurring fluoride [F] and arsenic [As] can cause significant problems); and ground water offers reliability of supply and a buffer against drought (Calow et al. 1997). For irrigation, the benefits of controllability are also significant, allowing efficient and flexible in-field application on demand. This is a key reason why yields from ground water irrigated areas are typically much higher than under surface water schemes (Burke et al. 1999).

Exactly how important ground water is as a source of rural water supply is difficult to gainsay. Coverage figures do not easily distinguish between surface and ground water sources, and coverage figures themselves can be unreliable (Morris et al. 2003). However, Robins et al. (2006) suggest that ground water is the only practical means of meeting rural community needs in the arid and semi-arid regions, and note that ground water also supplies many urban centers, including Lusaka, Windhoek, Kampala, Addis Ababa, and Cairo, as well as contributing to the supply of others such as Lagos, Abidjan, Cape Town, and Pretoria. There is significant country to country and local variation, however, and in some countries (e.g., Botswana, Namibia, and Zimbabwe) ground water dependence is critically high.

The importance of different ground water environments can be gauged by looking at geological maps. Figure 1 portrays a simplified hydrogeological map of sub-Saharan Africa based on a synthesis of various studies and mean annual rainfall across Africa (Foster 1984; UNTCD 1988, 1989; Guiraud 1988; MacDonald et al. 2005a). The potential of each hydrogeological province to contribute to rural water supply can be indicated by the rural population living in each area: for crystalline basement 220 million, sedimentary rocks 110 million, unconsolidated sediments 70 million, and volcanic rocks 45 million (MacDonald et al. 2008a).

Lessons from African Droughts in the 1990s

Research in the 1990s looked at the impact of drought on the availability of ground water in rural areas (Robins et al. 1997; Calow et al. 1997, 2002). The catalyst for this was the 1991–1992 drought, which affected much of southern Africa and left many rural people without access to water. In Malawi, for example, some 3 million people were left without access to water, and the use of unprotected sources (shallow traditional sources that are open to contamination) led to outbreaks of diarrhea,

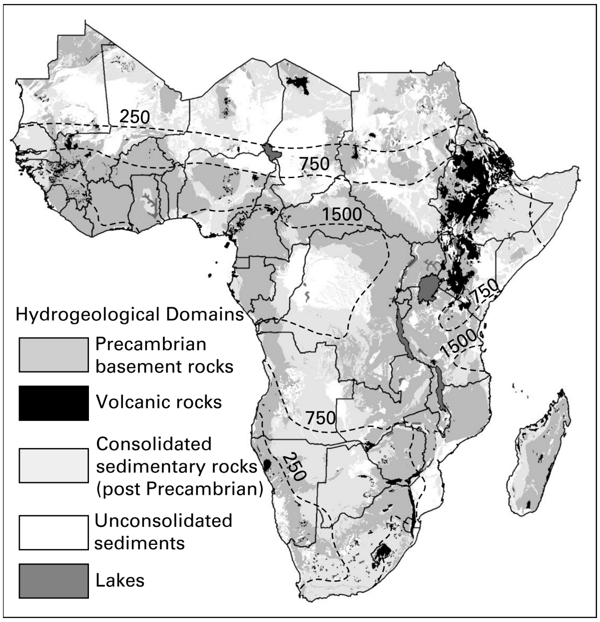


Figure 1. Hydrogeological provinces and rainfall in sub-Saharan Africa (adapted from MacDonald et al. [2005a]).

cholera, and dysentery. In Zimbabwe, South Africa, and Lesotho too, water shortages affected large areas and emergency relief programs were hastily organized. Despite broad success in averting famine, however, the performance of nonfood assistance, including water interventions, was generally poor. Measures that did attempt to relieve water stress, and other health and sanitation measures, were largely ineffective in addressing immediate needs (too late, poorly targeted) and poorly coordinated with other relief activities (Clay et al. 1995; Calow et al. 2002).

More recently, evaluations of emergency responses during the Ethiopian drought of 2002–2003, and the wider Horn of Africa drought in 2005–2006, have echoed previous criticisms. But what exactly is the nature of the water supply problems reported? Are they, as OCHA (2004) suggests, the result of wells and boreholes drying up on a massive scale and the "desiccation" of land and water resources more generally, or is the situation more complicated?

Experience from Malawi in 1991–1992 indicated that in areas such as the southern escarpment, prolonged drought resulted in the drying up of shallow wells and problems, therefore, resulting from the absolute scarcity of water. In other areas, however, ground water was available within aquifers, but could not be accessed because of problems with individual sources (Calow et al. 1997). A key conclusion, supported by later work in Ethiopia (see subsequently), was that both availability and access to water were important, and that although there was generally an increase in the failure of wells, springs, and boreholes during drought (and often beyond), the link between drought and source failure was not clear-cut. In particular:

Regional (aquifer scale) depletion of an aquifer was rarely a problem. In much of rural Africa where hand pumps are the norm, abstraction from individual sources is very low (5 to 15 m^3/d), and sources are widely dispersed. As a result, overall abstraction rarely exceeds long-term recharge where there is >250 mm rainfall. Studies in the Sahel, for example, have indicated an active recharge of greater than 14 mm/a (Edmunds et al. 2002), which is greater than the amount (>5 mm) required to support a hand pump (Foster et al. 2000; MacDonald et al. 2008a). In larger villages and towns, however, ground water depletion may be an issue. For example, in the Northern Province of South Africa, large village communities of several tens of thousands locally overdraw the available ground water resource during the dry season, although contamination of the aquifer is normally the more critical hazard where population densities are high and sanitation is poor.

Localized depletion, resulting in falling ground water levels in the immediate vicinity of a well or borehole, or group of sources, was more common. This is most likely to occur where the demands being placed on a ground water source are high and where the transmissivity of the aquifer is low. For generally low yielding rural water supplies equipped with hand pumps, transmissivity is the most significant factor in controlling drawdown for a certain pumping rate, and well losses are minimal (MacDonald et al. 2008b). In Zimbabwe, for example, the droughts of the 1990s caused individual boreholes and wells to fail, but more sophisticated sources such as collector wells (which exploit more of the aquifer) were reliable (Wright 1992; Macdonald et al. 1995).

Mechanical failure caused by increased stress on a ground water source during drought was also common. 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 rising demand on a neighboring source and thus increased stress—and probability of failure—on that source. And so the cycle continues. In South Africa, for example, many of the water supply failures experienced in 1991–1993 were blamed on maintenance problems exacerbated by drought rather than on regional or local depletion (Hazelton et al. 1994; du Toit 1996).

Lessons from Drought in Ethiopia

Further work in Ethiopia in 2002 confirmed the earlier lessons (Calow et al. 2002). It also demonstrated that an understanding of water use and livelihood strategies was important in the assessment of drought impact as well as an understanding of availability-access relationships. The term *water security* was coined to describe the outcome of the relationship between the availability, access, and use relationship. Water security is defined 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."

Figure 2 and Table 1 summarize findings from a survey of 12 villages along a highland-lowland transect in

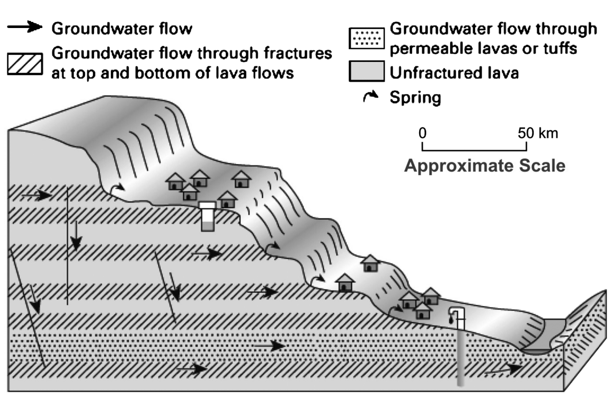
South Wollo, Amhara Region (more details in Calow et al. [2002]). Significant transactions of goods and services occur along the escarpment, including the exchange of livestock by lowland pastoralists for highland agricultural produce. The relationship between different livelihoods types is a complex one and, in drought years, can come under increasing stress. Violent conflict over land and water resources is not uncommon, particularly between pastoralists from Afar and arable groups from Amhara.

In terms of water availability, ground water is the most important source of water (across seasons, between good and bad years) both in mountain (*Dega)* and intermontane (*Weyna Dega*) zones. In highland areas aquifers are smaller, though recharge is higher. Water security is generally higher, however, because access to ground water via the many springs is good and demands (from both people and livestock) are lower. Only in the most severe droughts were problems reported, with intercommunity conflicts over access to the remaining shared springs to meet basic water needs. In some villages at lower elevation, however, poor siting of wells in swampy areas created localized problems, with villagers reluctant to use poor quality water for drinking and unable to water cattle easily from the protected well head when surface sources dried up, whereas in villages with higher yielding springs, water was available for small-scale, village irrigation. Another consistent finding was that water sources used at the end of the dry season were also generally those used during drought (Table 1); hence water insecurity during drought can usually be treated as an extension of the seasonal stress experienced in a "normal" year.

In lowland (*Kolla*) 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. Moreover, the type of boreholes constructed in Kolla areas also makes them prone to mechanical failure, with difficult to maintain (and expensive) submersible pumps. In this zone, increases in demand could put stresses on individual sources, but would be unlikely to affect the resource as a whole.

Although a general trend in highland-lowland water security emerges, significant local variation also occurs. For example, access to water at the household level was also influenced by access to labor and animals for water carrying and money for water purchase. Better-off households were able to transport in bulk and sell water, or employ others to do so on their behalf. Poorer households did not have these options and, at busy times of the year, faced difficulties in releasing labor for more productive activities (e.g., land preparation, foraging, paid labor) that could increase income or production and consumption.

Overall, a key conclusion is that absolute availability of water was not a key constraint. Rather, access to water was critical, particularly for poorer households, with access determined by the coverage and functionality of water infrastructure and by the ability of a household to draw on labor and other assets to secure supply. Moreover, water was used to generate income in both upland and lowland areas through small-scale irrigation and livestock rearing, respectively. Access to water clearly has a direct bearing on livelihood security beyond the satisfaction of basic needs.



	Dega (mountain)	Weyna Dega (intermontane)	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 through 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 2. Water security along a highland-lowland transect in South Wollo, Ethiopia.

A Livelihood Perspective

The discussion so far has touched on the links between water and livelihood security. In this section the relationships are examined further, looking specifically at links between water, health, production, and income.

First, lack of access to adequate water supplies for domestic uses, in terms of both quantity and quality, can be a major cause of disease. Numerous epidemiological surveys have shown that in drought and famine related disasters, preventable infectious diseases such as measles and diarrhea are the primary causes of death (e.g., Moore et al. 1993). Also, 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 and is influenced by factors such as access to health care and access to clean water and sanitation (Devereux and Maxwell 2001).

Similar conclusions were drawn by a government and donor team evaluating the impact of the 2002–2003 drought in Ethiopia (OCHA 2004). A key recommendation was that government should give priority to increasing access to year-round potable water supplies and sanitation as part of a food security strategy, noting that low access of rural Ethiopians to both potable water and sanitation

Table 1
Summary of Access to Different Water Sources (including Unimproved Sources) across the Seasons

						Water Source (wet)		Water Source (dry)		Water Source (drought)	
ID	Name	Loc	Altitude	Pop	Economy	Type	Time (h)	Type	Time (h)	Type	Time (h)
1	Abbot	D	3000	500	Mixed agriculture	Springs	0.5	Springs	1	Springs	1
2	Gobesha	D	2630	600	Mixed agriculture	Spring	0.3	Well	1	Well	1
					Chatt			Spring	1	Spring	1
3	Mayle	WD-D	2330	900	Tef/mixed agriculture	Spring	0.2	Spring	>5	Spring	>5
	Selassie					River	0.5				
4	Gandahole	WD	2230	1500	Tef/mixed agriculture	Spring	0.3	Spring	>1	Spring	>1
5	Hadinu	WD	2120	350	Tef/mixed agriculture	Well	0.3	Well	0.5	Well	0.5
6	Golbo	WD	1830	3500	Tef/mixed agriculture	Spring	0.5	Spring	1	Spring	1
7	Robit	WD-K	1800	3000	Tef/mixed agriculture	river	0.5	Spring 1	>5	Spring 1	>5
						Spring 1	1	Spring 3	>5	Spring 3	>5
						Spring 2	1				
8	Bokaksa	WD-K	1740	4000	Tef/mixed agriculture	Spring 1	2	Spring 1	4	Spring 1	4
						Spring 2	2				
9	Chefe	WD-K	1730	350	Tef/mixed agriculture	Spring	0.2	Spring	0.2	Spring	0.2
10	Tisabalima	WD-K	1640	1500	Tef/mixed agriculture	Spring	0.5	Borehole 2	0.5	Borehole 2	0.5
11	Chale	K	1430	500?	Cattle/mixed agriculture	Well	0.3	River	4	River	4
12	Arabati	K	1200	1000	Cattle/mixed agriculture	River	0.8	River	4	River	4
						Rain water	0.1	Rain water	0.5	Rain water	0.5

D – Dega; WD – Weyna Dega; K – Kolla

(6%) contributes to high levels of childhood malnutrition through repeated illness, particularly during drought.

Second, domestic water is often a production input, for example, in small-scale irrigation and livestock watering as well as in activities like brewing and brick-making (Nicol 2001; Moriarty and Butterworth 2003; Calow et al. 2002). Such production supports home use, production-income exchange, or both. Yet the role domestic water sources play in supporting household livelihoods in this way is typically missed in the compartmentalization of sectors, policies, and institutions. This is one reason why investment in collector wells (large diameter open wells that support a range of uses, including garden irrigation [Lovell 2000]) has proved difficult to scale up under line ministries in Africa. Pastoralists, dependent on access to grazing and water for livestock, are particularly vulnerable to water insecurity. ODI (2006) highlights the devastating impact of the 2004–2005 drought on pastoralists in the Horn of Africa, citing livestock losses of up to 70% and mass migration of people in search of water, food, jobs, and relief aid.

Third, the time taken to collect water can incur significant expenditure. The burden of water collection has been well documented (e.g., Robins et al. 1997; Nicol 1998; ODI 2002; WHO 2004) and, on the Ethiopian escarpment discussed previously, collection to meet drinking water needs can take more than 5 h per day in drought periods and in a normal dry season (Table 1). Moreover, the burden of water collection often falls disproportionately on women and children, particularly girls, for whom educational opportunities can be lost. Carrying water exacts a heavy toll with the potential for injury, and collecting water at night (a common practice when water is scarce) can be both exhausting and unsafe. For households and economies relying on the sale of labor, the cost of losing a day's labor can be very high at particular times of the year (ODI 2002).

Finally, in a global study of the costs and benefits of improved water supply and sanitation, WHO (2004) concluded that the health and wider socioeconomic benefits of safe water and adequate sanitation provided a compelling argument for further resource allocations to improving access. Achieving the MDG target for water and sanitation, WHO estimates, would bring economic returns ranging from US$3 to US$34 per US$1 invested, depending on the region, with the highest returns in Africa.

Implications for Policy and Practice

There are several ways in which improved understanding of the interrelated dimensions of drought vulnerability can improve drought planning: specifically, (a) how the potential impacts of drought shocks on areas, communities, and households might be better predicted; and (b) how this knowledge can be used to improve drought preparedness and trigger timely and appropriate responses.

Identifying Vulnerable Areas and Vulnerable Groups

Ground water availability maps can provide a starting point for discussions about (a) ground water development potential; (b) broad areas of vulnerability in terms of the likely availability or nonavailability of ground water during drought; and (c) the fit between water security-insecurity and food security-insecurity zones. It is important that these maps move beyond traditional hydrogeological maps, to capture the attention of policy makers. Figure 3 illustrates a national water availability map developed for Ethiopia, combining data on geology, hydrogeology, and rainfall to highlight areas of differing ground water reliability during drought (see MacDonald et al. 2001; Calow et al. 2002). At this resolution, and in combination with other tools and information sets, they can be used to do the following:

- Begin the process of targeting ground water–based sector development programs to areas of high socioeconomic vulnerability and relatively high ground water resource potential.
- Begin a process of targeting more explicit, water security based drought-proofing measures to vulnerable zones (e.g., water point rehabilitation and repair, well deepening, and spring protection/excavation).
- Highlight critical monitoring areas, for example, less reliable areas where ground water sources may dry up during drought, and where the remit of existing monitoring and information systems (e.g., for food security) could be widened to include indicators and reports of water stress.

For most countries in Africa, maps can be developed only at a national scale because of data availability, although there is a growing acknowledgment of the need for hydrogeological and ground water information for both ground water development and integrated water resources management (Adelana and MacDonald 2008). Regional mapping provides a more powerful tool for informing the kind of decisions described previously, especially if linked to the kind of local level water security analysis described subsequently. Ongoing work in Ethiopia, supported by the UK Department for International Development (DFID), is exploring ways in which local-level mapping, based on some additional collection of primary data, could be used to support rural water supply programs and drought preparedness.

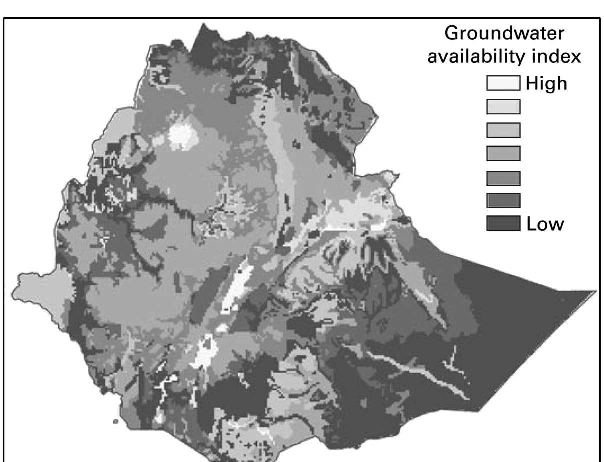


Figure 3. Ground water availability during drought: A mapping approach for Ethiopia.

Early Warning and Response

Early Warning

Although mapping at national or even regional levels can tell us about the likely availability of water resources during drought, it tells us nothing about the local relationship between availability, access, and use. As noted, it is this local-level information, beyond flawed coverage data, that adds most to an understanding of water insecurity, because insecurity may vary considerably over very short distances (e.g., along the South Wollo transect in Ethiopia highlighted in Figure 2).

To identify the most vulnerable areas and communities, there is a need for local information on livelihood vulnerability that captures both water and food security dimensions. In many drought-prone countries, such systems already exist, at least on the monitoring side. However, their remit is often narrowly food-focused because of the food-first culture that continues to dominate emergency assessments. By widening the scope of these existing information systems, a clearer picture of livelihood security, and of the interventions needed to support it, could be gained at little extra cost. Drawing on the water security analysis presented in this paper, key questions and indicators would need to focus on the symptoms and causes of water stress.

Symptoms. Questions here relate to evidence of water-related disease, broad expenditure on securing water access, and impacts on production and income at the household and community level. Key indicators of stress are, therefore, likely to include incidence of disease and ill health (particularly diarrhea); rationing of basic needs (for consumption and hygiene); time taken to collect water and its costs; distress use of poor quality sources for potable needs (e.g., ponds, excavation in dry river beds); migration to other areas; conflicts over water (e.g., between villages); and constraints on production and income earning opportunities (e.g., irrigation, livestock watering, livestock deaths).

Causes. Questions here relate to the availability-access issues discussed elsewhere in this paper, and whether symptoms can be traced back to problems of absolute scarcity or access problems. Key indicators are, therefore, likely to include yields from wells, springs, and boreholes in relation to demands; water quality problems; availability and access to water transport and storage; the functionality of water infrastructure; the availability and cost of spare parts that might be necessary for repair; and the availability and cost of fuel for running electric or diesel pumps.

Response

Table 2 provides a summary of the advantages and disadvantages of different emergency interventions. Not all of the responses listed are universally applicable. For example, tanker operations work best where water can be delivered to temporary storage, population densities are

Table 2
Some Advantages and Disadvantages of Different Drought Relief Activities

	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 labor 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 neighboring 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	Deepening can be speeded up if extra materials left on site when well first dug.
			Generally most useful for large diameter wells rather than boreholes. Depends on geological environment and original well construction	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 organized 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 water to tanker from	Less appealing to government and donors as permanent infrastructure not put in place

high, road networks are good, and money is available for fuel and vehicles. Similarly, well deepening and re-excavation measures work better with large diameter shallow wells, but less well with narrow boreholes. A basic knowledge of hydrogeology and ground water development potential and constraints is therefore needed for sound decision-making.

Figure 4 illustrates how responses can break the downward spiral of water and livelihood insecurity. A key point relates to the timing of different types of intervention. For an activity intended to alleviate water stress in a drought affected population, timeliness is the principal criterion against which actions need to be judged. For example, attempting to install new capacity through an emergency drilling program may have a long-term attraction but is very unlikely to meet immediate water needs (Calow et al. 2002). In contrast, stopgap measures (e.g., tankering) and improvement and rehabilitation programs (e.g., pump repair or relocation, well deepening) are likely to give quicker results and may be able to draw on local labor (with cash payments) and expertise.

Challenges

The kind of shifts outlined 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) does present some difficult challenges, however. They imply a heavier institutional burden on the institutions involved, making definition of the problem, and potential responses, more complex. They also require better collaboration across sectors, disciplines, and institutions at a time when governments and donors continue to program resources and deliver services vertically through sector ministries, coordinating and focusing efforts within rather than across sectors (Devereux and Maxwell 2001).

Nonetheless, significant advances have been made in recent years, with some movement toward the kind of livelihood-based information systems that are proposed. For example, progress has been made in participatory monitoring and poverty assessment, and livelihood surveys and monitoring systems are an increasing feature of development programs. These could be 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 and Maxwell 2001).

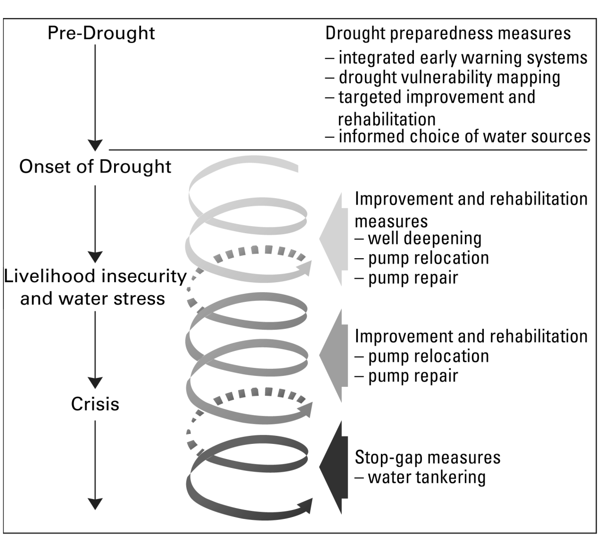


Figure 4. Breaking the drought spiral.

Whatever progress is made toward the development livelihood-based monitoring and information systems, it is important to recognize that good information does not guarantee a timely, flexible response (Buchanan-Smith and Davies 1995; ODI 2006). 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.

Particular obstacles that need to be addressed include the following:

Ownership and politicization 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 politicized, causing serious delays in responding to information.

Divisions between relief and development; the organization of bureaucracies. For many governments and donors, early warning is still about aggregate food supplies, with famine still separated from other drought impacts and emergencies from more general development activities.

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 improvement of response in the future.

Project and Programme Planning

Drought and its pattern of food impact are not an abnormal event. They are an extension and intensification of seasonal stress, associated with heightened, interrelated vulnerabilities. Drought can and should be planned for, and there are ways in which "normal" development activities in the water sector can be improved to build resilience and adaptive capacity:

1. Improve water coverage and prioritize vulnerable areas. The impact of drought on livelihoods, both pastoral and arable, would be lessened if water supply coverage were generally improved so that there is less reliance on individual sources and reliable water points are closer to the point of need.
2. Increase reliability of sources. In many cases, access is constrained by preventable problems: pumps break down because inappropriate technologies have been used; water points dry up even though ground water is locally available; and water supply projects gravitate toward less vulnerable areas with higher success rates.

Building these two aims into water programs is not trivial. One problem is that the incentives of those implementing rural water supply projects (often private contractors and nongovernment organizations [NGOs]) may differ from those attempting to manage the implementation process (e.g., 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 within a limited project period, may employ similar reasoning. The outcome in both cases can be the cherry-picking of easier environments where ground water can be found with little investigative effort and where success rates are highest. Wells and boreholes are developed in less vulnerable areas already enjoying high coverage; more difficult, water insecure areas are ignored (such as mudstones, on which 70 million people live in rural Africa [MacDonald et al. 2005b]).

To help build the environment in which drought proofing could be built into projects, the management and oversight of the private contractors and NGOs that increasingly dominate service delivery (straddling state and civil society) need to be clarified and improved. Decentralization and the promotion of bottom-up planning processes imply 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 would therefore seem important, especially because 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 the drawing-up of water supply contracts (MacDonald et al. 2005a).

Much can also 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, are factored into discussions. A key constraint is the lack of coordination between different projects and programs. Although wistful tribute is paid to the notion of integrated resource management, the norm is often a scattergun approach to resource development, with little lesson-learning between individual projects. 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 acquired cheaply during drilling are often not collected or stay with individual drilling companies and NGOs with little incentive to share (MacDonald et al. 2005a; Robins et al. 2003, 2006).

In terms of policies toward service delivery in rural areas, it is also worth noting that households in rural Africa are increasingly being asked to contribute to the capital or recurrent costs of water infrastructure such as a new village well or borehole. The arguments for this lie principally with the inability (or unwillingness) of government to fund water supply programs, and the commitment a financial contribution implies in terms of final ownership and upkeep of systems. However, the ability of poorer households to meet costs across seasons and between years, without compromising their resilience to shocks, is questionable. Work in Kenya by ODI, for example, suggests that water tariffs may be a barrier to livelihood diversification (ODI 2002).

In light of these issues, measures that could be implemented in predrought periods to sustain ground water supplies and improve access may include the following:

- Ensuring that the service options offered to communities are sensitive to local hydrological and hydrogeological conditions and are likely to provide a reliable source of supply even during drought.
- Ensuring that domestic water supply programs account for the needs of productive uses as well as drinking water hygiene needs.
- Ensuring that contribution systems—cash, materials, or labor—are sensitive to the needs of poorer community members, including the seasonality impacts of cash availability and labor release and the potential need for cross subsidies from wealthier to less wealthy households.
- 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; MacDonald et al. 2005a). 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.
- 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.
- Sinking deep relief boreholes in the most favorable hydrogeological locations—perhaps away from villages—that can be uncapped and used in emergency situations. Such boreholes could be used by households from different villages should local sources dry up, could be used to provide water for tankering operations, or could be used as emergency watering points in pastoral areas, with complementary livestock interventions (e.g., destocking).

Conclusions

Key messages emerging from the research described in this paper 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 planning. These are summarized here in the context of ground water dependent rural environments, recognizing the vital role ground water plays—and will continue to play—in meeting dispersed rural demand for much of Africa's population.

First, drought and seasonal water stress affect livelihoods in a number of different ways, cutting across sector perspectives and disciplines. Yet in many countries, policy responses focus 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 critical problem.

Second, food and water security are linked. 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, labor, or money invested by households in gaining access to water. In many rural environments, moreover, domestic water is a production input. 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. A key conclusion of this paper is that restricted access to ground water to meet these needs, rather than physical water scarcity, often determines whether households are water secure or insecure.

Third, it follows that drought planning needs to focus more on livelihoods analysis and integrated responses, including activities that complement food inputs, address wider public health needs, and prevent crises occurring in the first place. These include efforts to droughtproof ground water sources, identify water insecure areas and communities, and target relief measures to secure water for domestic and productive needs. The development of ground water availability maps would provide valuable planning support, particularly at subnational levels. Combined with local level assessment of food and water security, a clearer picture of livelihood security, and the interventions needed to support it, could be gained at little extra cost.

Finally, a more general conclusion. Extending affordable access to water is central to building household resilience to climate variability, particularly to the natural storage provided by ground water aquifers. However, an acceleration of ground water development depends critically on sound water resources assessment and a much better understanding of geology and recharge processes than currently exists. The challenges are significant, but not insurmountable.

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