Research-inspired Policy and Practice Learning in Ethiopia and the Nile region

Water Economy Baseline Report

Water and livelihoods in a highland to lowland transect in eastern Ethiopia

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List of Acronyms

BGS	British Geological Survey
DRMFSS	Disaster Risk Management and Food Security Sector
GPS	Global Positioning System
HEA	Household Economy Approach
HWEA	Household Water Economy Approach
LARS	Long-term Action Research
LIU	Livelihoods Integration Unit
LPCD	Litres per Capita per Day
LTM	Long-Term Mean
NGO	Non-Governmental Organization
RiPPLE	Research-Inspired Policy and Practice Learning in Ethiopia and the Nile Region
SAP	Shinile Agro-Pastoral Livelihood Zone
SCUK	Save the Children UK
SMC	Sorghum, Maize and Chat Livelihood Zone
SPHERE	Humanitarian Charter and Minimum Standards in Disaster Response
RHVP	Regional Hunger and Vulnerability Program
TDS	Total Dissolved Solids
WBP	Wheat, Barley and Potato Livelihood Zone
WELS	Water Economy for Livelihoods
WIAS	Water Impact Analysis Sheet
WSS	Water and Sanitation Sector

Executive Summary

The study is one component of RiPPLE's Growth Long-term Action Research Project (Growth LARS), which focuses on how investments in the Water and Sanitation Sector contribute to poverty reduction, sustainable livelihoods and pro-poor growth. One component of the Growth LARS focuses on investigating how best to build resilience of communities and households vulnerable to climate change hazards by strengthening policy, planning, and implementation on water-based climate change adaptation measures. The Water Economy for Livelihoods Systems (WELS) – previously known as the Household Water Economy Assessment (HWEA) – action research falls within this component of the Growth LARS and aims to provide both baseline data on household access to water and how this impacts on livelihoods systems, as well as a dynamic set of analytical tools that allows for scenario-based assessment of risk and prescriptive assessment of the impact of hazards.

Water Economy for Livelihoods (WELS) is a new approach to water and livelihoods that was developed to bring analytical rigour to understanding the inter-linkages between water security and food security. Designed to build on approaches and methodologies that have already achieved buy-in and skills/capacity development, it also aims to link to and inform the livelihoods monitoring and early warning systems in place in Ethiopia.

Ethiopia's Disaster Risk Management and Food Security Sector (DRMFSS) and its Livelihoods Integration Unit (LIU) currently use the Household Economy Approach (HEA) as the analytical framework by which to assess food and livelihoods-based needs of populations affected by a range of shocks such as those related to weather, markets, policies, or health. The premise behind both HEA and WELS is that an understanding of how people will be affected by shocks or hazards in a bad year is only possible if an understanding is achieved of how people piece together their livelihoods – and in the case of WELS, secure access to sufficient water to meet livelihoods needs – in normal years.

Access to safe water in drought – one of the most common hazards in Ethiopia – is consistently a major problem. Integration of water security into traditionally food-centred assessments contributes to the formulation of more effective and creative multi-sectoral responses. Until recently, livelihoods analysis has under-appreciated how crucially water contributes to production, and to the ability of households to secure the resources they need to survive. In reality, access to food, income and water are linked in important ways, particularly during drought. WELS aims to link household economy with access to water at household level – and strengthen our understanding of livelihoods and our responses to threats to livelihoods.

The WELS approach has three components:

a) Water Baselines – which address both water availability and water access within each geographical unit of analysis, or livelihood zone.

b) Hazards Analysis – which is based on seasonal or other assessments and which quantifies shocks or hazards and translates them into quantified economic and water access consequences at household level.

c) Outcome Analysis – which projects the impact of the hazards against the baseline in relation to survival and livelihoods protection needs, or thresholds.

For piloting the WELS approach, a highland to lowland transect was chosen so that watershed level resource transfers and flows, both natural and human-induced, could be included in the assessment. Within this transect, 3 Livelihood zones were selected: Wheat, Barley & Potato (WBP) (highlands), Sorghum, Maize & Chat (SMC) (midland), and Shinile Agro-Pastoral (SAP) (lowlands). Eight kebeles were selected through purposive sampling in each livelihood zone. Key informant interviews, focus group interviews, and water source site visits have been conducted in each sampled kebele.

WELS can, combined with information on population and livelihood strategies that exert pressure on water sources, provide information that enhance our understanding of the linkages between how seasonal water availability affects water access at household level during different periods of the year, and how these impact on livelihoods opportunities and constraints and vice versa. Seasonal variability in water sources is important to the ability of households to access adequate water because it impacts which sources of water are available, the time and labour required for collection, and water quality. In highland WBP and midland SMC Livelihood Zones, springs – which are used by the vast majority of the population as the main water source for domestic and productive water needs – as well as scattered streams, show marked seasonal variations, or seasonality.

Water quality varies along the transect, generally decreasing with lower altitudes. Groundwater quality as measured by total dissolved solids (TDS) and the perception of users is generally good. However, the presence of recurrent water-borne diseases in the three livelihood zones indicates pollution at the source and during transport and storage in homes. This is most often associated with insufficient sanitation practices, including sanitation of water containers, and source protection (e.g. unprotected springs and excavated riverbed pits that do not separate human and livestock uses).

Using the WELS methodology, we are able to analyse the inter-relationships between water availability, access to water at household level, and livelihoods in each livelihood zone along the transect. A comparison of livelihoods and population across the transect reveals important differences in wealth, livelihoods strategies, and population density that all impact on demand for water and resources. Total income levels (food and cash income) in all livelihood zones are below regional averages. Households in highland WBP Livelihood Zone have the highest average overall total income levels out of the three transect livelihood zones.

Highland Wheat, Barley & Potato (WBP) Livelihood zone

Water-based livelihoods in highland WBP Livelihood Zone are limited mainly to livestock rearing, a strategy taken on most significantly by middle and better off households who are able to secure a large enough herd and higher value animals. Very poor and poor households rely heavily on agricultural labour to generate cash to meet food needs not met through their own crop production. Agricultural labour income makes up 50 % and 25 % of very poor and poor household baseline cash income, respectively.

In highland areas, springs are the most common water supply source for humans and livestock alike. Due to the small storage capacity of aquifers in the highlands, however, springs are sensitive to changes in rainfall, and yields decline very quickly after rains end. Availability of good quality spring water is not especially constrained during normal years, particularly for securing adequate water for human consumption. Conflicts do arise, however, over securing and allocating water for productive uses, and irrigation in particular, due to the lack of clear and enforceable water use and allocation rules and institutions for managing undeveloped spring sources.

In the dry season, decreased yields and increased demand from the population at a smaller number of sources leads to a climb in average collection times at those sources. Collection times (round trip plus queuing) at unprotected springs average around 1 to 1.5 hours during the wet seasons, increase to roughly 3 to 4 hours during the dry seasons and can reach 5 to 6 hours during drought.

Just as for access to food and cash income, access to water for all uses – human consumption (drinking and cooking), hygiene and sanitation, and productive activities (in this case, livestock production) – is found to increase with wealth. Reasons behind these wealth-based trends lie in the social, economic, and human asset bases, or 'entitlements' that different households are able to access. Poorer households have fewer household members to release for water collection, own no donkeys for transport and fewer and smaller jerry cans. They also confront conflicts over labour and time allocation that are more significant than for wealthier households due to their smaller household sizes and income diversifying strategies which require labour to be allocated elsewhere.

Although climate variability affects highland WBP zone and erratic rainfall places uncertainty on the timing of crop planting and harvests from time to time, rainfall levels are substantial enough that water stress rarely characterises the livelihood zone. During dry years, yields in some lower yielding, typically perennial spring sources falls to levels unsuitable for water collection, and water quality at all unprotected springs continues to deteriorate from dry season levels.

Midland Sorghum, Maize & Chat (SMC) Livelihood zone

Households in midland Sorghum, Maize & Chat (SMC) Livelihood Zone have the lowest total income levels out of the three livelihood zones. Livestock rearing, which is water-dependent, is more central to livelihoods in the midland zone than in the highland zone. In SMC, unlike in WBP, it is not only the wealthier but the poor as well who depend on livestock sales for a significant proportion of their cash income. Poor households generate over a quarter of reference year cash income from livestock sales, compared to less than 10% for poor households in the highlands.

In midland areas, as in highland areas, seasonal and perennial springs are the most common form of water supply and are used by a majority of households for human consumption, as well as hygiene/sanitation and livestock throughout the year. Rainfall is lower and temperatures and evaporation slightly higher than in the highlands, but recharge occurs both through rainfall and through groundwater flow from the highlands. Spring yields are similar to those in the highlands, but seasonality is less pronounced.

Collection times are higher in SMC Livelihood Zone compared to WBP – by about an hour in each season. Higher livestock numbers per household – which use the same springs – also exert pressure on springs and contribute to pressure on queues.

As in other livelihood zones, access to all uses of water compared to minimum requirements increases with wealth. Similar to the highland WBP Livelihood Zone, poor households in midland SMC Livelihood Zone experience conflicts over time and labour allocation during key periods of the year when water collection and livelihoods protection duties coincide.

Lowland Shinile Agro-Pastoral (SAP) livelihood zone

Of all households across the transect, agro-pastoral households in Shinile Agro-Pastoral (SAP) Livelihood Zone are the most dependent on water for livelihoods, with poor, middle and better off households obtaining roughly 50%, 80%, and 95%, respectively, of baseline year cash income from sale of livestock and livestock products. Not only do water-dependent strategies make up a larger proportion of total income than in other livelihood zones, but absolute volumes of water required to sustain these livelihoods strategies are enormous, given the large herd sizes of all wealth groups.

The large and productive aquifer base underlying lowland SAP Livelihood Zone, characterised by high storage properties and low seasonality, supports a high number of shallow wells and boreholes. Unlike in the highlands and midlands, there are no springs in the lowland livelihood zone. Most households are heavily dependent on borehole and some shallow well sources, both of which are scattered throughout the zone.

Despite the importance of crops as a safety net to households in SAP, agro-pastoralists give priority to their animals. Migration patterns are highly dependent on the performance of the rains. In normal years, livestock are kept near the homestead year-round. Herds are usually split into different types of stock in order to manage water needs more efficiently. Shoats and cattle always remain around settlements with women and children in normal years, while men migrate with camels to the northern pastoral areas for graze and water.

Seasonal differences in access between wealth groups are telling of adaptive capacities during periods of stress. Whereas better off households increase their access from the cooler wet season to the hot dry season, poor households cannot sustain wet season access levels, travelling less frequently to water sources. They own fewer jerry cans, and, significantly – no donkeys to transport higher volumes of water for storage at the household as wealthier groups do. Although their access to water for human consumption remains adequate during normal years, the seasonal decline in access suggests that it is likely their access would drop below minimum requirements during a drought year.

A major reason for the lower access to water across uses for poor households is the scarcity of labour within these households. This is significant particularly in this livelihood zone because 2 to 4 men are required to successfully extract and carry water out of the 3 to 5 m deep excavated riverbed pits in the dry season. Crop production duties and collection of bush products such as gums and resins further restrict the labour and time available for men (and boys) to water livestock adequately.

During drought, collection times at boreholes typically increase to 4 to 5 hours for women collecting water for domestic uses, and 6 to 8 hours for livestock watering. Water use for hygiene and sanitation/ bathing and laundry is the first use of water to be rationed and even largely foregone as a coping strategy by most households, with poorer households reportedly abandoning such uses earlier due to labour constraints. Migration is undertaken predominately by men, who take non-milking animals to perennial rivers and boreholes in other woredas, and/or to highland areas where animals can be hand fed in particularly bad years.

Recommendations

In WBP and SMC, springs are the most widely used sources. However, only 1 in 7 springs are protected or developed in WBP Livelihood Zone, and 1 in 5 in SMC Livelihood Zone. Spring protection would be an appropriate and important intervention in both Livelihood Zones, as most springs become highly contaminated, due partly to their role in serving multiple uses of water – domestic, livestock watering, and also irrigation. Access points for each use are generally not separated in these zones.

Construction of ponds may also be appropriate to increase the water retention in the zone and reduce the seasonal decline in the yield of springs. Ponds may also direct livestock and irrigation users away from springs, which can be confined to domestic use to reduce risk of contamination.

SMC has further potential for development of water sources due to its higher groundwater availability and lower seasonality of aquifers. Development of protected hand dug wells is therefore possible. It is also desirable, particularly from a public health standpoint.

Finally, conflicts over sources used for irrigation are currently resolved at woreda level, arbitration is often ad-hoc and occurs after conflicts have come to head. Water user committees and/or use allocation rules for protected *and* unprotected spring sources should be set up in WBP and SMC Livelihood Zones to mitigate conflict and provide a clear and enforceable use allocation and rights regime. The establishment of water user committees for protected sources only is not sufficient, given that a large number of unprotected springs are also used for irrigation.

In SAP Livelihood Zone, the use of submersible pumps to extract water from the ground is imperative in the dry seasons. Because groundwater extraction rates for domestic and small-scale productive use is small and generally does not threaten groundwater sustainability in most areas of Ethiopia, boreholes and shallow wells can be developed where the hydrogeology permits and where borehole siting and planning is in line with community commitment and priorities.

Woreda officials in SAP report many cases of borehole failure due to the drying of boreholes during dry seasons due to improper drilling of the sources during the wet seasons when groundwater table levels are higher than they are during the dry seasons. Incorporation of customary pastoral and agro-pastoral institutions into borehole planning and siting is also imperative in order to minimize conflict and maximize productivity and efficiency, as well as community buy-in and commitment to manage such sources. Pump breakdown is a frequent occurrence in SAP, particularly in the dry season when sustained pumping from high population demand exerts strain on pump mechanisms. Strain is exacerbated if water levels in boreholes are falling and pump lifts increasing.

The retention of water in excavated pits during dry seasons and drought suggests that construction of sub-surface dams to facilitate storage and extraction of water would be an effective preventative and resilience building measure in this zone. This would be particularly useful given the high volumes of water required for livelihoods due to reliance on large livestock herds for income and food sources and as a form of insurance against drought.

1 Introduction

The study is one component of RiPPLE's[1] Growth Long-term Action Research Project (Growth LARS), which focuses on how investments in the Water and Sanitation Sector (WSS) contribute to poverty reduction, sustainable livelihoods and pro-poor growth. A central purpose of the LARS is to inform ongoing processes of program implementation within the water supply and sanitation sub-sector.

One component of the Growth LARS focuses on investigating how best to build resilience of communities and households vulnerable to climate change hazards by strengthening policy, planning, and implementation on climate change adaptation measures. The Water Economy for Livelihoods Systems (WELS) – previously known as the Household Water Economy Assessment (HWEA) – action research falls within this component of the Growth LARS and aims to provide both baseline data on household access to water and how this impacts on livelihoods systems, as well as a dynamic set of analytical tools that allows for scenario-based assessment of risk and prescriptive assessment of the impact of hazards.

1 Research-Inspired Policy and Practice Learning in Ethiopia and the Nile

2 Rationale

2.1 Disaster Risk Mitigation and Livelihoods Security

Water Economy for Livelihoods (WELS) is a new approach to water and livelihoods that was developed to bring analytical rigour to understanding the inter-linkages between water security and food security. Designed to build on approaches and methodologies that have already achieved buy-in and skills/capacity development, particularly within Ethiopia, it also aims to link to and inform the livelihoods monitoring and early warning systems in place in Ethiopia.

Ethiopia's Disaster Risk Management and Food Security Sector (DRMFSS) and its Livelihoods Integration Unit (LIU) currently use the Household Economy Approach (HEA) as the analytical framework by which to assess food and livelihoods-based needs of populations affected by a range of shocks such as those related to weather, markets, policies, or health. Many other countries, and agencies within them – particularly in sub-Saharan Africa, but also in Asia, Eastern Europe, and Latin America – have also incorporated HEA into their early warning frameworks or have turned to it to better understand the livelihoods and needs of their populations.

The premise behind both HEA and WELS is that an understanding of how people will be affected by shocks or hazards in a bad year is only possible if an understanding is achieved of how people piece together their livelihoods – and in the case of HWEA, secure access to sufficient water to meet livelihoods needs – in normal years. An analysis of household economy aims to systematically determine how people live, what puts different households at risk of food or non-food shortages, and what type of responses are most appropriate (see FEG, SCUK, RHVP 2008 for more detail).

More than simply relevant to emergency response, however, HEA is to be at the core of Ethiopia's emerging disaster risk management system that is capable of both *corrective* (current disasters) and *prospective* (future potential disasters) risk management[2] (Boudreau 2009). In Ethiopia, where emergencies are endogenous, and have posed a perpetual threat to much of its population for centuries, the capability to bridge the emergency-development divide is particularly urgent.

The strength of HEA's ability to serve this task lies in its ability to transform a descriptive analysis into a predictive one, where scenario-based risk assessment is at the centre of providing dynamic, targeted recommendations for building resilience and reducing vulnerability – as well as responding to current shocks faced by populations (Boudreau 2009).

2.1.1 The Missing Link: Water

Much as the emergency-development divide is impossible to bridge without a systems-based (as opposed to a sector-based) approach to understanding how hazards and vulnerabilities interact to create disaster risks, the livelihoods picture is incomplete without a holistic understanding of the interdependencies of food security and water security.

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[2] The UNDP Bureau for Crisis Prevention and Recovery differentiates between two types of risk management: Prospective disaster risk management should be integrated into sustainable development planning. Development programmes and projects need to be reviewed for their potential to reduce or aggravate vulnerability and hazard. Compensatory (or corrective) disaster risk management (such as disaster preparedness and response) stands alongside development planning and is focused on the amelioration of existing vulnerability and reduction of natural hazards that have accumulated through past development pathways. Compensatory policy is necessary to reduce contemporary risk, but prospective policy is required for medium- to long-term disaster risk reduction.

Access to safe water in drought – one of the most common hazards in Ethiopia – is consistently a major problem, and water-related disease resulting from restricted water availability and access often causes more fatalities than does starvation in times of famine. Integration of water security into traditionally food-centred assessments contributes to the formulation of more effective and creative multi-sectoral responses (e.g. Calow et al., 2002; Ludi, 2009). Because water interventions often have long-term impacts and consequences, if planned for properly, it would also strengthen prospective risk management.

This is where Water Economy for Livelihoods aims to fill in the gaps. Until recently, livelihoods analysis has under-appreciated how crucially water contributes to production, and to the ability of households to secure the resources they need to survive. In reality, access to food, income and water are linked in important ways, particularly during drought. WELS aims to link household economy with access to water at household level – and strengthen our understanding of livelihoods and our responses to threats to livelihoods.

3 Objectives

The WELS/HWEA action-research component aims to do the following:

a) Assess baseline household access to water for various water uses (domestic and productive) across wealth groups in a transect of livelihood zones from highland to lowland with a focus on assessing how differential access to water affects livelihoods security and potential for resilience in different livelihood zones.

b) Drawing on primary and secondary hydrogeological data collected at the regional and local level, assess how the groundwater resource base affects the opportunities for household water security in each livelihood zone and how the resource base might affect opportunities for water-based adaptation measures in the future.

c) Assess likely impacts of climate change-related geophysical shocks and hazards (e.g. increased incidence and intensity of drought, increased rainfall variability, etc.) on household access to water and on livelihood security to better identify the most vulnerable groups and geographic areas.

d) Assess likely impacts of climate change adaptation schemes on different households in each target livelihood zone.

4 Methodology

Much as the emergency-development divide is impossible to bridge without a systems-based (as opposed to a sector-based) approach to understanding how hazards and vulnerabilities interact to create disaster risks, the livelihoods picture is incomplete without a holistic understanding of the interdependencies of food security and water security.

Access to safe water in drought – one of the most common hazards in Ethiopia – is consistently a major problem, and water-related disease resulting from restricted water availability and access often causes more fatalities than does starvation in times of famine. Integration of water security into traditionally food-centred assessments contributes to the formulation of more effective and creative multi-sectoral responses (e.g. Calow et al., 2002; Ludi, 2009). A central aim of WELS is to link household economy with access to water at household level – and strengthen understandings of livelihoods and responses to threats to livelihoods.

Work carried out by the British Geological Survey (BGS) since 1996 in Ethiopia and in Africa generally on groundwater availability, particularly during drought years, has been important in advancing understandings of water security. In 1998, BGS produced a series of groundwater drought vulnerability maps for countries in southern and west Africa highlighting differences in groundwater reliability between areas were developed over the course of several phases of work in part to improve drought preparedness and response. Subsequent work in Ethiopia in 2000-2002 developing more detailed mapping of groundwater availability at national level focused on the impact of drought and the nature of livelihood vulnerability, pointing to the need to incorporate an understanding of water availability and water security into drought preparedness and early warning.

WELS builds on this important work and, catalysed by partnerships within the RiPPLE network, has taken on in this current study the assessment of groundwater availability through hydrogeological investigations at local level. This methodological component is based on extensive work related to the above BGS advances and which is elaborated on in MacDonald et al. 2005. Through these methodological innovations, WELS aims to achieve more sophisticated understandings of the linkages between how seasonal and drought year groundwater availability affects water access at household level, and how these impact on livelihood opportunities and constraints and vice versa.

4.1 Methodological components

The WELS approach has three components:

a) Water Baselines – which address both water availability and water access within each geographical unit of analysis, or livelihood zone[3]. Water access baselines capture quantified data on access to sources of water by different wealth groups, across seasons, and across uses (e.g. domestic and productive), for a specific *reference year*. A reference, or baseline, year presents a picture of the 'typical' household and water economy in a year which is 'normal': neither particularly good nor particularly bad for household livelihoods security. Detailed hydrogeological data and mapping enables characterisation of groundwater potential – or the ability of aquifers

[3] A livelihood zone is a geographical area that shares similar agro-ecological characteristics, livelihoods strategies practiced by the population (e.g. pastoralism, agro-pastoralism, cropping strategies agriculturally), and access to markets.

(or sub-surface rocks) to store and transport water during normal conditions and drought – in specific geographic areas, as well as identification of areas vulnerable to groundwater drought[4]. Water point coverage lends to this information on local water availability.

b) Hazards Analysis – which is based on seasonal or other assessments and which quantifies shocks or hazards[5] and translates them into quantified economic and water access consequences at household level.

c) Outcome Analysis – which projects the impact of the hazards against the baseline in relation to survival and livelihoods protection needs, or thresholds.

Quantified information on water access, and its importance in relation to specific livelihoods strategies, forms the baseline datasets that provide the foundation of an analytical tool, the Water Impact Analysis Sheet (WIAS). The WIAS provides an interactive interface that allows for input of seasonal hazards information and which provides outputs in the form of data and graphs illustrating impact on water access and livelihoods at household level. Please see Annex A for further detail on the methodology.

4.2 Description of study area

A highland to lowland transect area was selected for the study area. Each single livelihood zone shares similar agro-ecological characteristics, market access, and livelihoods activities pursued by the population[6]. The three livelihood zones within the transect are shown in Figure 4.1.

A highland to lowland transect was chosen so that watershed level resource transfers and flows, both natural and human-induced, could be assessed (including e.g. impact of extraction and/or withdrawals on downstream users; groundwater flows among zones). The transect also allows for assessment of economic and social inter-linkages and interdependencies among populations from highland to lowland (including e.g. inter-altitude trade, presence of water markets during drought, upstream/downstream conflict). See Annex B for woreda level maps of the transect livelihood zones[7]. Table 4.1 describes characteristics of the livelihood zones in the study area. Characteristics of livelihood zones, populations, and livelihoods within each zone are further detailed in section 5.

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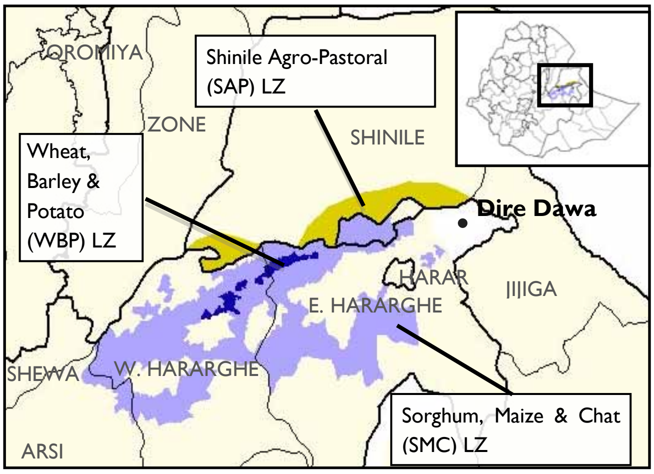
4 Groundwater drought is a term used to describe a situation in which groundwater sources fail as a direct consequence of drought (see Calow et al 1997). Groundwater is water stored below the surface in aquifers. Aquifers are subsurface rocks that store and transport water. The better the storage and transport properties of an aquifer, and combined with adequate recharge from e.g. rainfall, the greater the potential that groundwater will be available during drought or during periods of high demand.

5 A shock or hazard is an event or process that significantly affects households' access to food, income, and water. Examples include drought, cyclones, market failure, policies, war, etc.

6 While water sector data is usually collected and organised by woreda, or district, analysis of the relationship between water and livelihoods is only possible if our unit of analysis corresponds to livelihoods systems, rather than administrative boundaries. WELS and HEA data is nevertheless also able to be applied to individual woredas that fall within each livelihood zone.

7 A woreda is an administrative unit smaller than the zonal level and larger than the village, or kebele, level. It is often translated into the English term 'district'.

Figure 4.1: WELS study area: Highland to lowland transect, east and west Hararghe and Shinile administrative zones



Highland – Lowland Transect Study Area:

Highland Livelihood Zone: Wheat, Barley & Potato (WBP)

Midland Livelihood Zone: Sorghum, Maize & Chat (SMC)

Lowland Livelihood Zone: Shinile Agro-Pastoral (SAP)

4.3 Sampling, site selection, and data collection

Sampling, site selection and data collection methods are documented in detail in Annex B. They are summarised briefly below.

4.3.1 Livelihood zoning

Livelihood zoning is based on livelihood zones delineated through the DMFSS' Livelihoods Integration Unit, which houses baseline data on livelihoods and food security for all 180 livelihood zones in Ethiopia[8]. WELS livelihood zone characteristics have been further detailed using a) groundwater availability mapping carried out by BGS in 1998-2000 (see Calow et al. 2002); and b) hydrogeological reports for the study area.

4.3.2 Sampling within livelihood zones

Eight kebeles[9], or villages, were selected through purposive sampling in each livelihood zone. Kebeles are selected to be representative of the livelihood zone within which they fall in order that baseline data is reflective of the majority of the population in the livelihood zone. This is done so that prescriptive recommendations and conclusions do not over- or underestimate needs of the population as a whole, and so that conclusions apply to most of the population in those areas[10]. Key informant interviews, focus group interviews, and water source site visits have been conducted in each sampled kebele.

8 WELS zoning aims to delineate areas of broadly similar patterns of water availability, access and use. WELS and HEA livelihood zones will be similar because surface and groundwater availability/hydrogeology and rainfall characteristics of an area are important determinants of agro-ecology and influence the range of livelihoods opportunities available to people.

9 A kebele is the smallest administrative unit in Ethiopia. Kebeles are also known as 'peasant associations' (PAs).

10 In cases where needs should be assessed of the most vulnerable population within a single livelihood zone, revised 'problem specifications' or estimations of the economic or water related impact of hazards at household level are modified to reflect these cases. These are called 'pocket areas' in scenario analysis.

4.3.3 *Method of data collection*

District Interviews: Interviews with woreda officials yield information on water availability through major water sources used by the population in the district. A water source inventory is developed for each woreda, and information on water-related disease incidence across seasons and years is completed.

Community Key Informant Interviews: Field teams complete wealth breakdowns with community key informants (based on local definitions of wealth) and inventory water sources in the locality, collecting information on local water source quality, reliability, seasonality, and access constraints. Participatory community resource and water point mapping is carried out, and a season calendar of water access constructed.

Wealth Group Interviews: Wealth group interviews are conducted with four to six women and men in three to four wealth groups (very poor, poor, middle, and better off). A detailed account of how each wealth group obtains water for three primary uses is collected:

a) Human consumption (drinking and cooking)

b) Hygiene and sanitation (bathing and laundry)

c) Productive uses – e.g. livestock watering, irrigation, etc.

Water access from each source of water is quantified for each use, across seasons and in drought years is collected. Information on opportunity costs of water access is also collected, as is information on labour and time allocation across seasons. Structured interview formats facilitate the rigorous semi-structured wealth group interviews.

Hydrogeology Walks: A member of the field team also completes a 'hydrogeology walk'[11] in each kebele. Rock samples are collected at working and abandoned water point sites in each site and geographically stored using GPS[12]. Local observations on hydrogeology and water source performance seasonally and in drought years, as well as community management histories and attitudes towards each source are recorded. This information is supplemented by secondary geology and hydrology maps.

Table 4.1: Transect area livelihood zone characteristics

Livelihood zone characteristics	Wheat, Barley & Potato (WBP)	Sorghum, Maize & Chat (SMC)	Shinile Agro-Pastoral (SAP)
Geographic location	Borders E. Hararghe Zone in Oromiya Region, Harar, and Somali Regions. Addis Ababa-Djibouti road passes through the zone. Major towns within the livelihood zone are Chelenko, Hirna, Chiro, Kulibi, and Derder.	Borders Harar in the east and is found along the main Addis Ababa-Djibouti road. Major towns include Dire Dawa, Haramaya, Gelemso, Chelenko, Awiday, and Derder.	Located in the northernmost tip of Somali Region, it borders with Djibouti to the north, Somalia (Somaliland) to the northeast, Jijiga Zone to the southeast, Dire Dawa and Oromiya Regions to the south and

11 See MacDonald et al. 2005 for a detailed description of a hydrogeology walk.

12 Global positioning systems (GPS) record the geographic coordinates of specified locations, such as water sources or rock outcrops where data is collected in the case of this study.

			Afar Region to the west. The agro-pastoral LZ lies at the southern foothills of the Ad Zone and is mainly found in Dambal (60%), Meiso (20%), Erer (20%) and Shinile (10%) districts.
Woredas and administrative zones[13]	Parts of Goro Gutu[14], Tulo, Doba, Meta woredas in East and West Hararghe Zones, Oromiya Region. See Annex A for LZ woreda maps.	Parts of Meta[15], Derder, Chiro, Doba, Harbo, Goro Gutu, Kersa, Meiso, Tulo, Anchare, Kuni, Girawa, Boke, Haramaya, Kombolcha, Bedeno woredas in East and West Hararghe Zones, Oromiya Region. See Annex A for LZ woreda maps.	Southern parts of Dambal, Shinile, Erer, Meiso woredas in Shinile Zone, Somali Region. See Annex A for LZ woreda maps.
Altitude zone/ agro-ecology	Mainly highland dega	Mainly midland woina dega	Lowland kolla.
Rainfall	700-1,000mm	550-900 mm	400-700mm
Temperature	19° – 28°C	21° – 32 °C	
Rainy seasons	Bimodal: belg (March – April) and main meher (June – September).	Erratic and bimodal: belg (March – May), main meher (June – August).	Gu (late March – late May) and Karan (late July – late September).
Topography	Rugged topography, with isolated hills and intervening depressions which are the result of rift-related faulting and erosional smoothing. No major rivers.	Somewhat less rugged than WBP, undulating terrain, and depressions which can be up to 200 km2. No major rivers.	Flat terrain dotted by isolated volcanic hills. Semi-arid rugged bushland and shrubs. Major rivers: Erer, Hurso and Chow.
Population	585,178	2,113,776	84,717 (mainly Somali Gurgura, Gadabursi and Hawiye groups, who inhabit Erer, Dambal and Meiso districts respectively.)
Land area	592 km^2	14,464 km^2	3,044 km^2
Population density	989 people / km^2	148 people / km^2	28 people / km^2
Livelihoods	Mostly rain-fed mixed farming and some livestock production. Main crops: wheat, barley, some maize and sorghum. Chat and vegetables are main cash crops but cultivated in smaller quantities than	Mostly rain-fed farming combining cash crop chat with cereals and some livestock rearing. Main cash crop chat; food crops sorghum and maize and smaller amounts of wheat and barley. A minority of wealthier	Agropastoralism. Livestock rearing is prioritized: sheep/goats, cattle and camels (latter are the least important species). Cultivation of small amounts of long cycle sorghum and some maize. In normal years

13 In descending order of proportion of population within the zone.

14 WBP population in Goro Gutu makes up 51% of the livelihood zone's population.

15 SMC population in Meta makes up 15% of the livelihood zone's population.

	SMC. Livestock (sheep, goats, cattle and donkeys) are generally stall fed with crop residue and grass due to limited grazing land. Agricultural labour is important for the poor.	household practice irrigated chat production. Agricultural labour and self employment are important sources of income for the poor.	shoats and cattle stay around settlements, except in Dambal, where migration occurs to Chinahsan (Jijiga Zone).
Market access	Moderate. Chat trade route is from Chiro to Awash, Nazareth, Addis Ababa, Afar and Djibouti throughout the year. Livestock are sold locally and in Addis, Dire Dawa, and Jijiga.	Good access to all weather roads, with some localities accessible to larger markets of Harar and Dire Dawa. Both chat and livestock are sold in Dire Dawa and Awaday markets within the zone and Metahara, Harar, Addis Ababa and Jijiga outside the zone. Chat exported to Hargeisa and Djibouti daily.	Moderate. Market for livestock: Dire Dawa, Mieso, Dambal, as well as Djibouti.

Hydrogeological information is analysed and output into a series of maps and information that can then be used to identify areas that are a) vulnerable to groundwater drought – where water supply through groundwater is likely to be much reduced or unavailable during dry seasons and exacerbated during drought; b) areas where groundwater is likely to be available during dry seasons and drought, and therefore where groundwater interventions may be effective; and c) areas where groundwater quality is already, or is likely to be in future groundwater schemes, a problem (e.g. high salinity or fluoride content[16]). It also informs understandings of limitations and opportunities for water use for productive and domestic activities in the livelihood zone.

4.4 Data Analysis and Scenario Analysis

Baseline access to water across uses and seasons is compared to minimum standards of water access. This information makes up the baseline data against which projections of impacts of hazards or changes in availability conditions can be assessed.

Thresholds have been developed to represent triggers for outside intervention, below which households will begin to deplete asset bases (whether financial, human/labour related, or otherwise) in order to secure enough water or will be at risk of incurring unacceptable health consequences (in the form of e.g. high degrees of dehydration or disease from consumption of unsafe / non-potable water).

[16] BGS has produced a map of areas in Ethiopia where fluoride content in groundwater stores is higher than deemed safe by the WHO. Excessive consumption of water high in fluoride content can lead to dental fluorosis, and in more advanced stages, skeletal fluorosis, whose symptoms include calcification of ligaments, crippling deformities of the spine, muscle wasting, and neurological defects. See also: www.rippleethiopia.org/documents/stream/20080624-fluoride-mapping-poster.

WELS thresholds for water-based survival and livelihoods protection are summarised briefly in Box 4.1 below. Minimum water requirements and HEA survival and livelihoods protection thresholds are detailed in Annex C and D respectively.

Box 4.1: WELS Thresholds

Water for Survival: Human Consumption Threshold represents the minimum volume and quality of water required for survival, specified by SPHERE as a minimum of 5 litres per person per day.

The Hygiene and Sanitation Threshold represents the minimum volume of water required to maintain hygiene and sanitation activities, specified by SPHERE standards as 10 litres per person per day. This is not included in the Water for Survival Threshold above for the purposes of the assessments discussed in this paper.

The Water for Livelihoods Protection Threshold represents the minimum volume of water required to sustain household livelihoods activities so that food and income needs for livelihoods protection (see above) are met. Livestock protection needs are included as a livelihoods activity, as are other productive uses of water such as irrigation. Specific water consumption standards for livestock under various conditions are found in Annex C of this paper.

Actual or projected access compared to each of the thresholds is measured as a percent of 100% minimum needs.

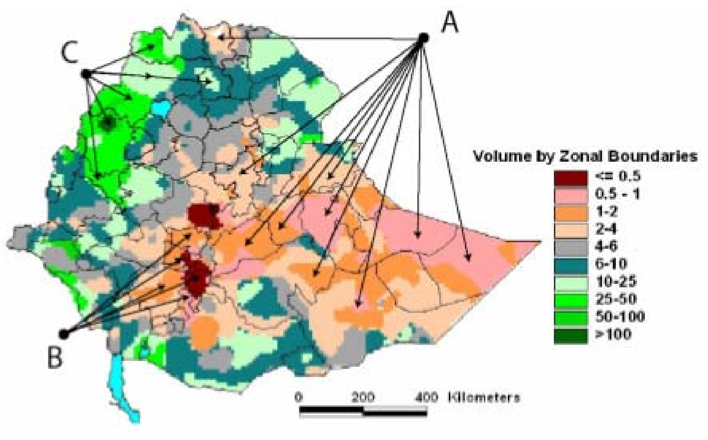
5 The Baseline: Water and Livelihoods in the Reference Year

The following section details water availability across the livelihood zones along the transect. Because hydrogeology and water resources in any one zone are so crucially linked to those in other zones, and part of wider hydrogeological trends and water resource systems (e.g. drainage basins), water availability across all livelihood zones is discussed here in a single section. The sections thereafter discuss wealth group access to water at household level, the 'nexus' between water availability and access, and the linkages between water and livelihoods for each individual livelihood zone. Results are presented by livelihood zone in order to draw out these analytical linkages between availability, access, and livelihoods. Comparisons and observations on inter-linkages among livelihood zones are nevertheless central in each of the individual livelihood zone analyses.

5.1 Water Availability Across the Transect

The transect area targeted by the study is a considered a high-risk, traditionally food-insecure area in Ethiopia: a combination of climate, health and population factors create increasing vulnerability of the populations to a range of drought-related risks. Figure 5.1 shows the estimated geographic distribution of net surface runoff that might be used for crop production (Senay and Verdin, 2004; in Funk et al., 2005). The map factors in average precipitation, actual evaporation, and population density to estimate the potential available runoff per family at a regional scale.

Figure 5.1: Volume of potentially available annual surface water per family in 1,000m³ Units*



Areas denoted with an **'A'** represent at-risk semi-arid zones facing increasing surface water shortages.

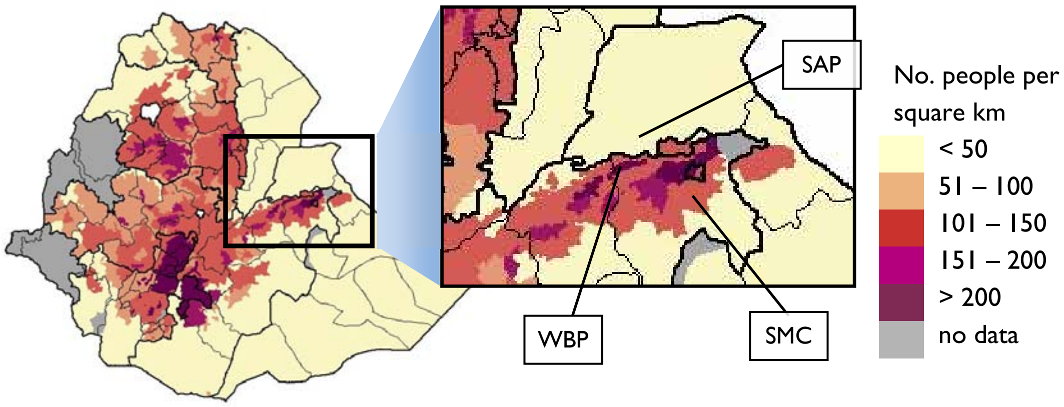
Areas denoted with a **'B'** represent wet areas with very high population densities.

Areas denoted with a **'C'** represent water surplus zones with more than 6,000 m^3 of potential runoff

*Assumes 7 persons per family. Source: Funk et al., 2005

Areas shaded light orange on the map typically have enough water and biomass to support an average family in a normal year. Blue and green areas typically have excess potential runoff. Dark orange, pink, and red areas on the map represent at-risk areas that are likely to face chronic water shortages. The latter are denoted by an 'A' on the map and include the eastern highlands and surroundings, whose high population densities contribute to high pressure on water sources and vulnerability related to water stress (see Figure 5.2). In addition, the semi-arid east (A) has experienced reduced rainfall since 1997 and poor rains in 2002, 2004, and 2009. In agro-pastoral and pastoral areas, rainfall levels may drop below levels sufficient to support livestock according to some projections (Funk et al., 2005).

Figure 5.2: Population density in Ethiopia and the transect study area



Surface water availability is one factor in water availability; groundwater is perhaps even more important, particularly in the study areas. Across Africa and elsewhere, groundwater is often the most important source of water during dry seasons, as well as drought. Long after surface water sources such as rivers and streams dry up, groundwater can still be accessed through wells, springs, and boreholes. This 'buffering' capacity – or the capacity of aquifers to store and transport water once recharge to the aquifer (e.g. through rainfall) is reduced – can vary significantly across different areas, and in some places, under certain conditions, groundwater sources can fail (Calow et al. 2002).

In general, groundwater availability has been shown to vary substantially with altitude in Ethiopia due to the location of fractures and rock types that are commonly found at different altitudes (see Calow et al. 2002). Variations in groundwater availability and groundwater potential[17] are determined largely by hydrogeological conditions and long-term average rainfall that recharges aquifers over time.

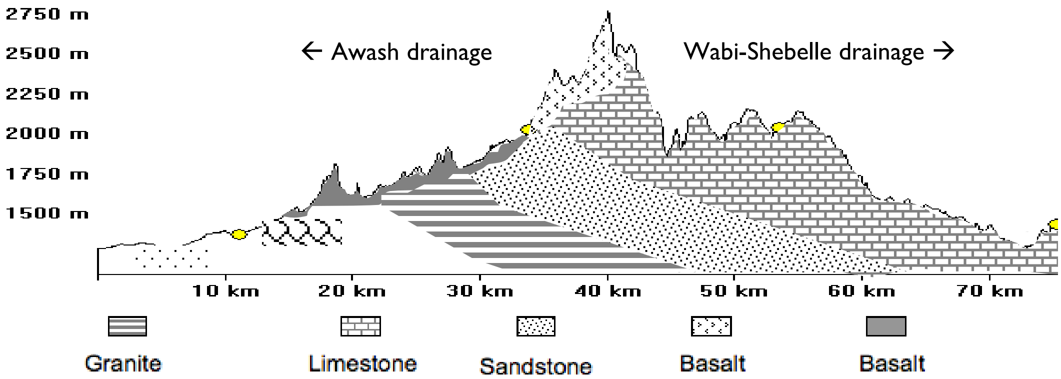
Assessing groundwater availability in each of the livelihood zones along the highland to lowland transect is thus important if we are to understand differences in water availability seasonally, as well as during times of drought and water stress. Combined with information on population and livelihood strategies that exert pressure on surface and groundwater sources, we can achieve a more sophisticated understanding of the linkages between how seasonal water availability affects water access at household level during different periods of the year, and how these impact on livelihoods opportunities and constraints and vice versa.

Figure 5.3 describes variations in water availability, source types, and seasonality of sources due to hydrogeological and climatic variations across the transect livelihood zones. Figure 5.4 provides additional information on topography and geology across zones.

[17] Groundwater potential is the measure of sustainable source of recharge, suitable storage, transmission and geometry of aquifer, sustainability of groundwater quality for intended purpose and the buffering capacity of the aquifer to changes such as recharge variation, pollution, land use changes, increased groundwater abstraction.

Figure 5.3: Hydrogeological, climatic and water resource conditions in livelihood zones along a highland to lowland transect in E. / W. Hararghe and Shinile zones

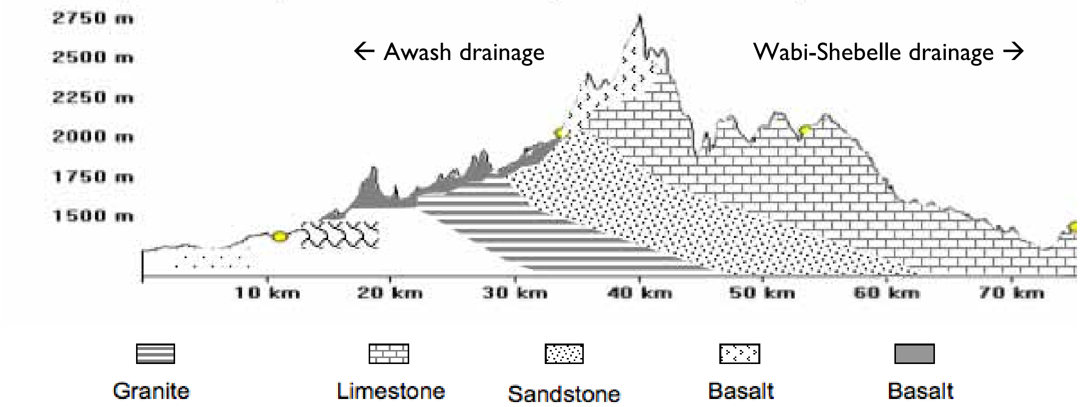
	Shinile Agro-Pastoral (SAP)	Sorghum Maize & Chat (SMC)	Wheat, Barley & Potato (WBP)	Sorghum, Maize & Chat (SMC)
Water sources	Some boreholes, riverbed excavations, seasonal pools & ponds & rare base flows.	Cold springs dominant source of water for irrigation and domestic water supply. Springs represent discharge of groundwater to depressions formed by faulting. Ponds also common.	Cold springs and roof water harvesting are the common sources of water supply.	Cold springs are common sources of water supply; sinkholes and karsts also exist.
Climate	Dry, hot and arid with evaporation far exceeding rainfall. LTM* annual rainfall 600mm.	Mild temperatures, relatively higher rainfall than SAP. LTM annual rainfall 750mm.	Relatively cold mean annual temperature, high diurnal variation in temperature, lowest evaporation. Semi-humid climate. LTM annual rainfall 900mm.	Mild temperature, relatively higher rainfall than SAP. LTM annual rainfall 750mm.
Hydro-geology	Recharge to aquifers mainly from flash floods. Streams are seasonal. Aquifers are volcanic rocks, and groundwater is often saline. Deep groundwater tables.	Recharge to volcanic aquifers takes place from rainfall. Main discharge takes place to cold springs in depressions. Seasonal variation in spring discharge is indicative of local recharge with limited regional flows emerging into this zone. Rift-related faults are main source of ground-water occurrence and movement. Ground-water contains low total dissolved solids (TDC).	Recharge to aquifers takes place from rainfall. Isolated peaks are the site of groundwater scarcity or outflow. Discharge takes place in depressions or to springs. Shallow groundwater tables. Biological pollution likely.	Aquifers are mainly sedimentary rocks. Springs emerge at the food of the highlands. In some areas, limestone is karstified and is the main source of groundwater. Shallow groundwater tables. Biological pollution likely.



Source: Kebede and Zeleke 2009.

Figure 5.4: Topographic and geological conditions in livelihood zones along a highland to lowland transect in E. / W. Hararghe and Shinile zones

	Shinile Agro-Pastoral (SAP)	Sorghum Maize & Chat (SMC)	Wheat, Barley & Potato (WBP)	Sorghum, Maize & Chat (SMC)
Topo-graphy	Flat terrain dotted by volcanic hills.	Rugged terrain with hills and intervening depressions, the result of faulting and erosional smoothing.	High ground dotted by volcanic hills and depressions intersecting with high grounds.	Rugged topography; elevation slowly decreases southeast-ward.
Geology	Horizontally lying volcanic rocks and alluvio-lacustrine sediments.	Volcanic rocks of various age. Occasionally the underlying sediments and basement rocks are exhumed by erosion and are visible on the surface.	Volcanic hills occupy higher grounds and sedimentary rocks dot the lowlands	Mainly limestones and shales in deep river incisions. Older sandstones or granites may be exposed.



Source: Kebede and Zeleke 2009.

5.1.1 Surface water availability

The only perennial surface water sources found in the transect are the Burka and Erer perennial rivers, found in lowland SAP Livelihood Zone[18]. These rivers are sustained by groundwater in the dry seasons. The only other surface water sources present in the transect are man-made ponds, which are found predominately in SAP Livelihood Zone[19] as a means of harvesting scarce water and prolonging alternative sources such as riverbed excavations for as long as possible after rains end.

5.1.2 Groundwater availability

All remaining sources of water in the transect depend on and are sourced from groundwater. In highland WBP and midland SMC Livelihood Zones, groundwater is found principally in fractures of basaltic aquifers. On the southern slopes of midland SMC Livelihood Zone facing the Rift Valley in the Wabi-Shebelle drainage basin, groundwater is also available through fractures in exposed and eroded limestone, sandstone, and granite. Groundwater is recharged by rainfall in higher grounds in the highland and midland zones, and transported south-eastwards and along east-west faults by

[18] These rivers are formed by intersecting north-south and east-west running faults that allows drainage from both fault zones to occur to form the headwaters of these rivers. In the absence of such intersection of faults would result in these rivers taking the form of intermittent streams (Kebede and Zeleke 2009).

[19] Although some PAs in WBP and SMC do construct ponds, they are not used by a majority of the population.

interconnected fractures that transport water to lower grounds[20], sometimes emerging in depressions at the surface in the form of springs in WBP and SMC Livelihood Zones. Major springs emerge mostly at the intersection of regional faults.

It is only in lowland SAP Livelihood Zone, where the aquifer is characterised by alluvio-lacustrine sediments, that groundwater is held within the pores of the aquifer itself rather than in fractures formed by faults, providing a larger aquifer base in which water can be stored. The aquifer is therefore characterised by higher storage and transmissivity and acts as a more resilient buffer during dry seasons than in the midland or highland zones.

Image 5.1: Springs


Groundwater emerges at the surface in the form of a spring in a depression bounded by highlands in SMC Livelihood Zone.

Groundwater recharge

Groundwater recharge in highland WBP and midland SMC Livelihood Zones occurs through rainfall. By contrast, due to low rainfall levels and high evaporation (the latter which exceeds the former), the primary source of recharge to aquifers in SAP Livelihood Zone is groundwater flows through rock fractures from the highlands and midlands (See Annex E for a groundwater flow model for the transect). Occasional flash floods and losing streams that emerge from the highlands also serve as a groundwater recharge source[21].

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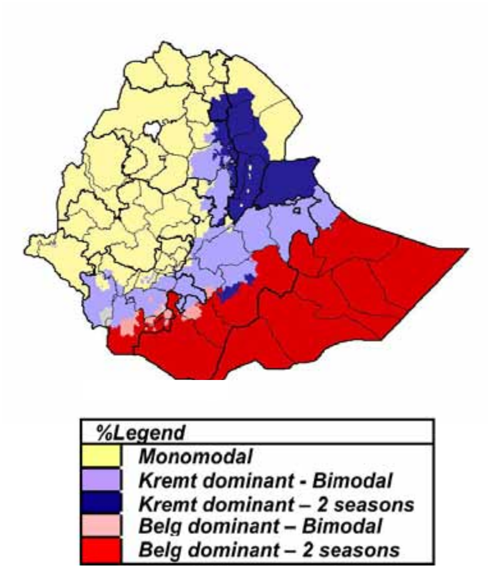
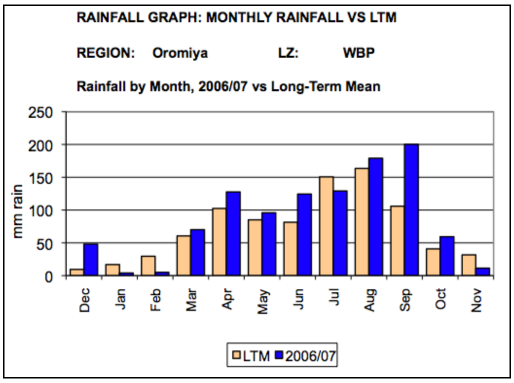
20 See Annex D for a conceptual groundwater flow model for the transect area.

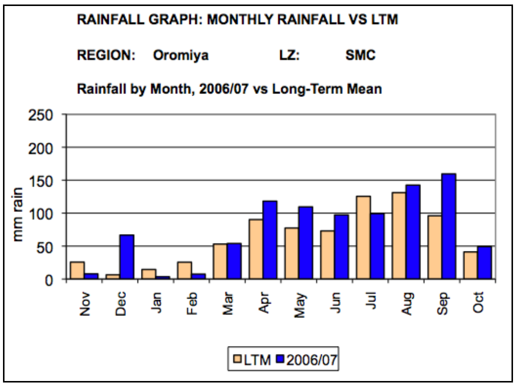
21 While recharge exceeds 100 mm per year in highland WBP and midland SMC Livelihood Zones, it reaches less than 50 mm per year in lowland SAP. These rates are roughly equivalent to 10 to 20% of rainfall in the region. Recharge rates are comparable to rates elsewhere in Ethiopia, although a wide range of rates exists in the country. Direct recharge in the central and north western highlands ranges from 90 to 150 mm annually; in some of the south western highlands recharge may reach as high as 400 mm (Kebede and Zeleke, 2009; Ayenew, 2008).

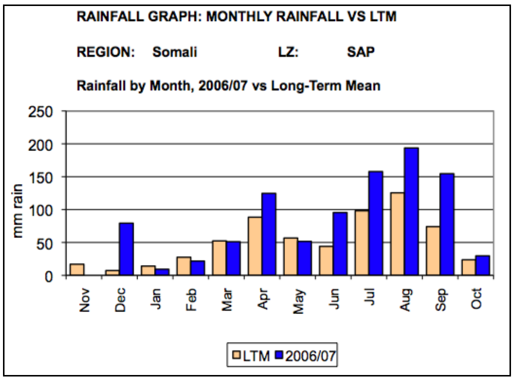
Figure 5.5: Seasonal pattern of rainfall and reference year rainfall levels vs. long term average mean in transect livelihood zones



Source: Atlas of Ethiopia, Livelihoods Integration Unit.







WBP and SMC Livelihood Zones are Keremt dominant and have a bimodal pattern of rainfall, meaning that the zones see one rainy season with two peaks (one during the belg/bedesa and one during the keremt/ gena). SAP Livelihood Zone is Keremt dominant but has two distinct rainy seasons separated by a dry season (i.e. Dira' and Karan rainy seasons separated by the Jilaal and Hagaa dry seasons).

Recharge is highly sensitive to temporal distribution of rainfall (as well as soil properties and land cover). Whereas bimodal WBP and SMC see moderate to high recharge levels for relatively sustained periods during the year, there is little to no recharge through rainfall in SAP. Surface water sources also dry up quickly due to dry season rainfall scarcity and high evaporation rates.

Although important to all zones to sustain groundwater levels, sustained and frequent recharge is more important to water availability in highland WBP and midland SMC Livelihood Zones due to the high sensitivity of aquifers in those zones to changes in rainfall levels or climatic conditions which affect recharge. This is known as 'seasonality' or seasonal variability.

Seasonality

Seasonality of water sources refers to the degree of variation in discharge of water sources (e.g. in yield of springs or streams, depth to water table, storage of aquifer or ponds, and water quality characteristics) as a result of natural or human-induced changes that affect recharge levels, including rainfall, temperature, snowmelt, and land use, etc.[22]

Diagrams in Figure 5.5 show seasonal patterns of rainfall across Ethiopia, and rainfall monthly reference year and long term average mean rainfall levels in the transect livelihood zones. Whereas bimodal rainfall seasons in WBP and SMC produce moderate to high recharge levels for relatively sustained periods during the year, in SAP, recharge through rainfall is more limited and separated by dry seasons with high temperatures and evaporation rates, which severely limits recharge through surface water sources.

Seasonal variability in water sources is important to the ability of households to access adequate water because it impacts which sources of water are available, the time and labour required for collection (due to changes in yield and availability of other sources which affects demand from a given source), and water quality. In highland WBP and midland SMC Livelihood Zones, springs – which are used by the vast majority of the population as the main water source for domestic and productive water needs – as well as scattered streams, show marked seasonal variations, or seasonality. High seasonality is related to the poor storage and transport properties of the granitic and sedimentary aquifers[23], as shown in Figure 5.6. The rugged topography and sharp slopes also create swift flow of groundwater away from high grounds to low grounds, particularly in highland WBP Livelihood Zone.

In lowland SAP Livelihood Zone, field observations confirm the high seasonality of ponds due to the high evapotranspiration rate in the lowlands. Ponds typically dry up within a few weeks after rains stop in the dry seasons. However, riverbed excavations and drilled boreholes show very low seasonality compared to other sources in the zone and in the higher altitudes. This is due to the higher aquifer storage and transmissivity of the volcanic and alluvial deposits underlying the area. Shinile Agro-Pastoral (SAP) Livelihood Zone also receives groundwater discharge from highland WBP and midland SMC. This contributes to groundwater availability in SAP Livelihood Zone even in the dry seasons due to delayed groundwater flows from the highlands (Kebede and Zeleke, 2009).

Figure 5.6 shows a map of the speed of response to changes in environmental parameters (e.g. climate, rainfall, etc) as measured by aquifer storage properties in the transect area.

As the diagram shows, highland aquifers in WBP Livelihood Zone have the highest seasonal variability, with many areas recording a response rating of 6 (in olive green) or 7 (in red). Isolated high peaks and flat-topped small plateaus in highland WBP Livelihood Zone are the most groundwater scarce areas and sources in these areas have the highest seasonality because of outward flow from the high grounds and low specific porosity (storage capacity of the aquifer). This is confirmed by observation of springs in these types of areas in the field, as well as community informant information. High seasonality of sources generally is also confirmed by data and field observations that indicate no 'transitional' water access period in between dry and wet seasons (as occurs in other livelihood zones – see section 6), and a doubling in collection time from roughly 1.5 hours during the wet season to about 3 hours in the dry seasons.

[22] The timescale over which seasonality is measured is one hydrologic year. A hydrologic year starts from the first month of moisture surplus (eg. 1 July of year x) and concludes with the last date of driest months (eg. June 30 of year x+1). The exact commencement and end of a hydrologic year may change from year to year and from place to place.

[23] i.e. low specific yield (porosity) of granitic and sedimentary aquifers and the small lateral extent of aquifers due to faulting and fragmentation which limit the size of aquifers and their storage capacity.

Figure 5.6: Degree of water table variation (response) of aquifers to environmental changes as measured by aquifer storage properties in the transect area

Speed of aquifer response: 7 6 5 4 3 2 1

Water table response ranges from a rank of 1 to 7, where 1 represents the slowest response rate and 7 represents the fastest response rate. The larger the number, the higher the vulnerability of the aquifer to changes in climate variation/seasonality.

Source: Kebede and Zeleke, 2009. Modified from EGS, 1996; EGS, 1993; and EGS, 1972.

Midland areas have moderate seasonal variability, with most areas recording a rating of 5 (yellow) or 4 (light blue). Within in the zone, depressions in the slope of midland SMC Livelihood Zone have higher groundwater potential because of convergence of flow towards these zones. In some localities, depressions in SMC Livelihood Zone that have alluvial sediments may provide high sustainable groundwater source due to the higher storage and transmission properties of alluvial sediments than the basaltic aquifers found outside these depressions (these depressions are represented by the north-south yellow shaded areas between red shaded areas).

Seasonality and response of water tables to environmental changes in lowland SAP Livelihood Zone are low – ranging from 1 (navy) to 3 (orange) or 4 in most areas. The predominant basalt and alluvio-lacustrine sediments that underlie SAP Livelihood zone are characterised by the highest porosity and specific yield, or storage properties, in the transect areas. As noted in Figure 5.3, however, other than in areas surrounding seasonal riverbeds, groundwater is not found close to the surface in most areas: water tables generally have depths of at least 30 to 70m). Groundwater also does not emerge at the surface in the form of springs as it does in the midlands and highlands. Thus boreholes with submersible pumps capable of reaching such depths are generally the favoured option to tap groundwater in the lowland livelihood zone in the dry seasons.

Water quality

Water quality varies along the transect, generally decreasing as altitude decreases. Groundwater quality as measured by total dissolved solids (TDS) and the perception of users is generally good. However, the presence of recurrent water-borne diseases in the three livelihood zones indicates biological pollution at the source and during transport and storage in homes. This is most often associated with insufficient sanitation practices, including sanitation of water containers, and source protection (e.g. unprotected springs and excavated riverbed pits that do not separate human and livestock uses, as observed in the field).

Higher salt content was reported by communities in lowland SAP Livelihood Zone, and was identified as a reason for abandonment of several boreholes in the zone. The presence of salt in the lowland zone reflects the general water geochemistry evolution trend around the Ethiopian Rift and adjacent highlands, in which salt content has been found to rise as altitude falls from the highland to the lowlands (Kebede et al., 2007).

5.2 Water access and livelihoods by livelihood zone

A comparison of livelihoods and population across the transect reveals differences important differences in wealth, livelihoods strategies, and population density that all impact on demand for water and resources. Total income levels (food and cash income) in all livelihood zones are below regional averages[24]. Households in highland WBP Livelihood Zone have the highest average overall total income levels out of the three transect livelihood zones. Typical of wealthier livelihood zones, the largest disparities in wealth from poor to better off households also occur in this zone: whereas the better off in WBP Livelihood Zone have total income levels nearly 210% of the very poor/poor, better off households in SMC and SAP Livelihood Zones have average total income levels only 170% and 150% those of their poorer counterparts. Soil fertility and productivity, as well as the ability to purchase agricultural inputs, are higher in WBP than in SMC, contributing to higher levels of food and income from crop sales[25]. See Figure 8 for a comparison of total income levels and adjusted cash income levels in across livelihood zones in the transect.

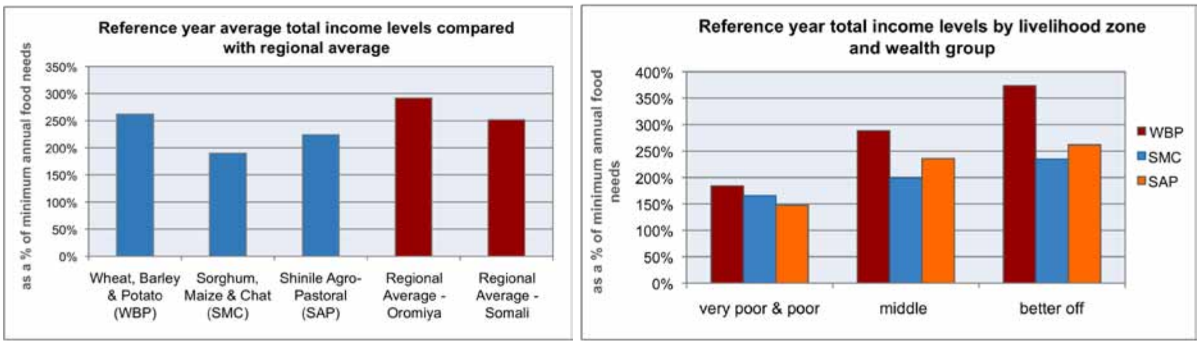
As noted in Figure 5.2, despite the relative wealth of WBP Livelihood Zone, population density is nevertheless high, at nearly 1,000 people per km^2 compared to nearly 150 people per km^2 in SMC and only 28 people per km^2 in SAP.

24 Total income represents cash income and kilo-calories (kcals) from food converted into a common unit – in this case, kcals, presented as a percent of minimum kcal requirements (100%). Thus, for instance, figures above 100% kcal needs usually represent cash income that would be used for livelihoods protection needs such as purchase of inputs, schooling expenses, health costs, transportation, etc. Total income is a more useful figure in assessing livelihoods status than cash income alone because it makes comparable livelihood zones that are food and/or cash dominant (e.g. food crop dominant vs. cash crop dominant vs. pastoral livelihood zones). It also eliminates the problem of inflation's effect on cash figures over time.

25 The middle and better off in WBP spend over double that spent on inputs by the same wealth groups in SMC.

The following section discusses the inter-relationships between water availability, access to water at household level, and livelihoods in each livelihood zone along the transect.

Figure 5.7: Comparison of cash and total income levels in the transect



Average Cash Income By Livelihood Zone (ETB)[26]		
Wheat, Barley & Potato (WBP)	**Sorghum, Maize & Chat (SMC)**	**Shinile Agro-Pastoral (SAP)**
4,490	3,795	4,740

5.2.1 Highland Wheat, Barley & Potato (WBP) Livelihood zone

Water dependent livelihoods

Water-based livelihoods in highland WBP Livelihood Zone are limited mainly to livestock rearing, a strategy taken on most significantly by middle and better off households who are able to secure a large enough herds and higher value animals like cattle and oxen to generate significant amounts of cash and food income (Figure 5.8). Very poor and poor households, whose land holdings are extremely small and whose cash income is not high enough to purchase adequate fertilizer and inputs on which successful crop production depends, instead rely heavily on agricultural labour to generate cash to meet food needs not met through their own crop production. Agricultural labour income makes up 50 percent and 25 percent of very poor and poor household baseline cash income, respectively (Figure 5.9). Wealthier households are able to secure better prices for their producer goods as well, due to their ability to delay sale of goods until after peak slaughter or harvest times when influx of goods drives prices down. Better livestock and crop management also contributes to higher prices received for commodities sold.

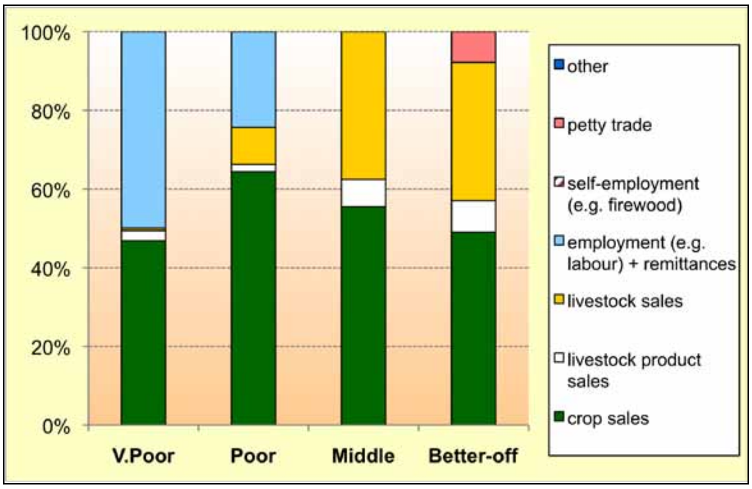
[26] The reference year for WBP and SMC, in Oromiya Region, was 2006-07, while the reference year for SAP was 2005-06. Cash incomes have been adjusted to 2005-06 levels so that income presented in ETB is comparable across livelihood zones.

Figure 5.8: Wealth breakdown and asset levels in WBP livelihood zone

	Wealth Groups Characteristics				
	HH size	Land area cultivated	Crops cultivated	Livestock/Asset Holding	Water Transport & Storage Assets
Very Poor	5-6	0.25-0.75 ha	Barley, Wheat, Field Peas, Sorghum, Maize, Irish Potatoes, Chat	3-5 hens, 0-10 eucalyptus trees	0 donekys, 1 x 20L, 2 x 3L jerry cans
Poor	5-7	0.5-0.75	Barley, Wheat, Field Peas, Sorghum, Maize, Irish Potatoes, Chat	0-1 cattle, 1-2 goats, 1-3 sheep, 0-1 donkey, 3-5 hens, 5-15 eucalyptus trees	1 donkey, 2 x 20L, 2 x 3L jerry cans
Middle	6-8	0.75-1.25	Barley, Wheat, Field Peas, Sorghum, Maize, Irish Potatoes, Chat	1-1 ox, 1-3 cattle, 2-4 goats, 2-4 sheep, 1-1 donkey, 4-6 hens, 20-40 eucalyptus trees, 0-1	1 donkey, 1 x 5L, 2 x 20L, 3 x 3L jerry cans
Better-off	7-8	1.1-1.25	Barley, Wheat, Field Peas, Sorghum, Maize, Irish Potatoes, Chat, Honey	1-3 oxen, 3-4 cattle, 3-4 goats, 2-4 sheep, 1-2 donkeys, 5-7 hens, 1-3 beehives and 40-60 eucalyptus trees	1-2 donkeys, 2 x 5L, 1 x 10L, 2 x 20L, 4 x 3L jerry cans
0% 20% 40% 60% % of population	4 timads=1 hectare				

A small minority of better off and middle households irrigate chat and vegetables. However, cash crops are less significant in this zone than in midland SMC Livelihood Zone, with food crops wheat and barley – which are better suited to the cooler temperatures of the highlands – serving as the dominant crops.

Figure 5.9: Sources of cash in WBP livelihood zone[27]



Annual income (ETB)	2,380 - 2,975	2,855 - 3,450	8,990 - 4,580	5,060 - 5,655

Seasonality and the water access-availability nexus

In highland areas, where rock fractures intersect with the surface, springs are the most common water supply source for humans and livestock alike. On average, around two springs are available within each sub-village[28] in each kebele during the rainy seasons; the presence of three or more

27 Cash income is adjusted for inflation to 2005-06 levels.

28 Sub-villages typically have around 40 to 100 households; kebeles typically contain 5 to 10 sub-villages.

springs within a sub-village is not uncommon in sampled kebeles in the zone[29]. During this time, rain-fed seasonal pools and streams are also common, but are accessed primarily for livestock, and are not preferred over springs due to the lower quality of water of the runoff-fed sources, and the relative easy of access to springs within close proximity.

Box 5.1: Water access periods – wheat, barley & potato (WBP) livelihood zone

Wet access periods: Bedesa (March – April) & Gena (second half of June – September). Characterised by high groundwater recharge through frequent rainfall (50-200mm rain per month) and high levels of surface water in the form of seasonal pools and ponds. Springs are the main source of access. Collection times are at their lowest.

Dry access periods: Chamsa (May – first half of June) & Bona (November – February). Characterised by surface water scarcity, rapidly falling groundwater table levels and groundwater source yields, and rising collection times. Perennial springs are the main source of access.

Table 5.1: Estimated seasonal spring yields – litres per second (L/s)[30] in WBP

	Dry season	Wet season
Unprotected seasonal springs	0	0.01 – 0.08
Unprotected perennial springs	0.04 – 0.07	0.08 – 0.15
Protected perennial springs	0.11 – 0.5	0.2 – 1.0

Table 5.2: Spring access specifications in WBP

Average no. beneficiary households per spring	124
Ratio of undeveloped to developed springs in sampled kebeles	7 to 1

Due to the small storage capacity of aquifers in the highlands, however, springs are sensitive to changes in rainfall, and in highland WBP Livelihood Zone, yields decline very quickly after rains end. Some springs in both highland WBP and midland SMC Livelihood Zone dry up completely or produce yields too minimal for effective access or tolerable quality, intensifying demand and waiting times at springs with water still available. This is illustrated in the seasonal calendar of water access for WBP Livelihood Zone in Figure 5.9.

Despite the seasonality in spring sources, however, due to the high rainfall and presence of intersecting E-W and N-S fractures at the surface throughout the highlands and midlands, higher yielding perennial springs are relatively abundant: at least one, and in many cases two higher yielding (i.e. at least 0.25 L/s) protected (developed) springs are still available to households within a single

[29] Figures refer to non-adaptation kebeles only.

[30] Yields are estimated from field measurements taken for major sources of water in each kebele sampled by field teams at the end of the dry *bona* season, in late January and early February of 2009. Wet season yield estimates are calculated based on community informant observation of seasonal changes in yield and thus are less reliable than dry season estimates.

kebele. Thus, availability of good quality spring water is not especially constrained during normal years, particularly for securing adequate water for human consumption. Conflicts do arise, however, over securing and allocating water for productive uses, and irrigation in particular, due to the lack of clear and enforceable water use and allocation rules and institutions for managing undeveloped spring sources[31].

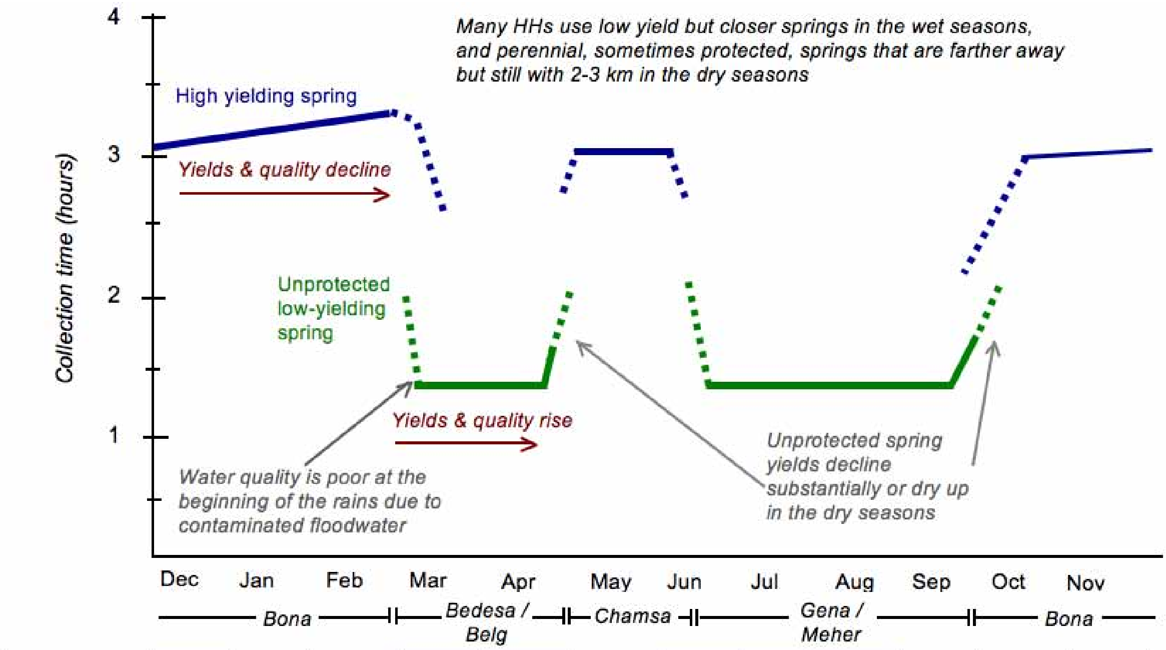
Image 5.2: Access at protected high-yielding springs in WBP and SMC livelihood zones

Image 5.3: Access at unprotected low-yielding springs in WBP livelihood zone

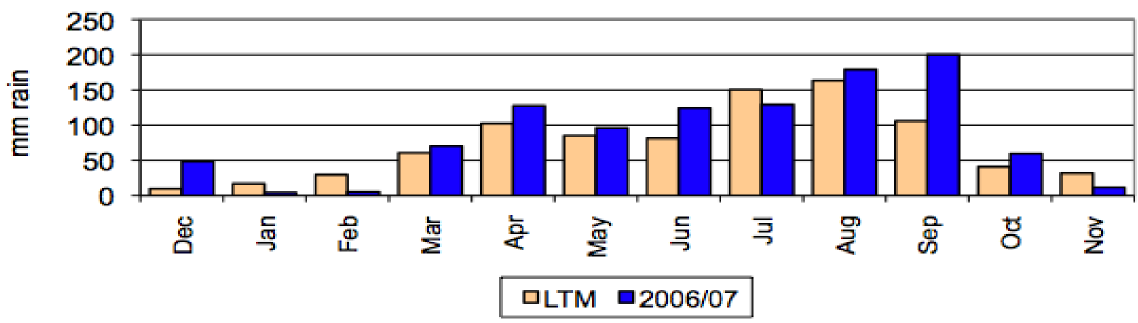
31 Although water user committees are set up for all developed sources by the government and non-governmental agencies that facilitate such source development, they are not required and are rarely set up for undeveloped sources.

Whereas in the wet seasons most households usually access unprotected, usually lower yielding springs within their sub-village, in the dry season and during drought, many households turn to other higher yielding springs 1 to 2 km farther away in other sub-villages within the kebele[32].

Figure 5.10: Seasonal calendar of water access and livelihoods in WBP livelihood zone



	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Wheat / barley	Harv-			Plant-	ing		Harv-	est	plant			
Sorgh./ maize	est		Prep/	Plant-	ing							
Potatoes												
Chat / coffee							Harv-	Est		Harv-	est	
Ag. labour												
Milk prod.												
Childcare												
Hunger period												
Diarrhoea												
Malaria												



Typically, high-yielding springs provide water for households from an average of around 1 to 3 other sub-villages in the dry seasons – serving up to 400 households. Beneficiary household numbers fall to an estimated 100 to 200 households at higher-yielding springs in the wet season.

32 Most of these are undeveloped springs, which serve 80 to 85% of the population in the dry seasons.

In the dry season, decreased yields and increased demand from the population at a smaller number of sources leads to a climb in average collection times at those sources. Collection times (round trip plus queuing) at unprotected springs average around 1 to 1.5 hours during the wet seasons (the *bedesa,* or *belg* from March through April and the *gena,* or *meher* from the second half of June through September).

Collection times increase to roughly 3 to 4 hours at high yielding protected and unprotected springs during the dry seasons (the *chamsa* from May through the first half of June, and the *bona* from October through February – see Figure 5.9). During drought collection times can reach 5 to 6 hours.

Water quality deteriorates in the dry seasons at unprotected perennial sources, as standing water collects at the eye of springs instead of flowing outward, and serves as a repository for animal waste, bacteria, and amoeba (worms). Whereas water accessed from unprotected springs must be filtered through cloth in order to remove leeches, worms and larger particulates from the spring water, water accessed at protected springs usually does not need to be filtered, as protected spring typically contain water filtration mechanisms (sand-based filters or chemicals) that eliminate most contaminants and solids. In most protected springs in WBP Livelihood Zone, spring water is channelled through an elevated pipe that allows for collection separate from water runoff underneath the spring box.

Image 5.4: The seasonality and science of water quality

In the beginning of the *Bedesa/Belg* rains, unprotected spring water quality is extremely bad due to contaminated floodwaters and surface water run-off.

Disease rates – primarily diarrhoea – reach their peak incubation point around the 2nd month after rains begin. At the end of the wet seasons, spring water quality is best because regenerated grass creates a natural filtration system that limits the amount of water contamination that can occur.

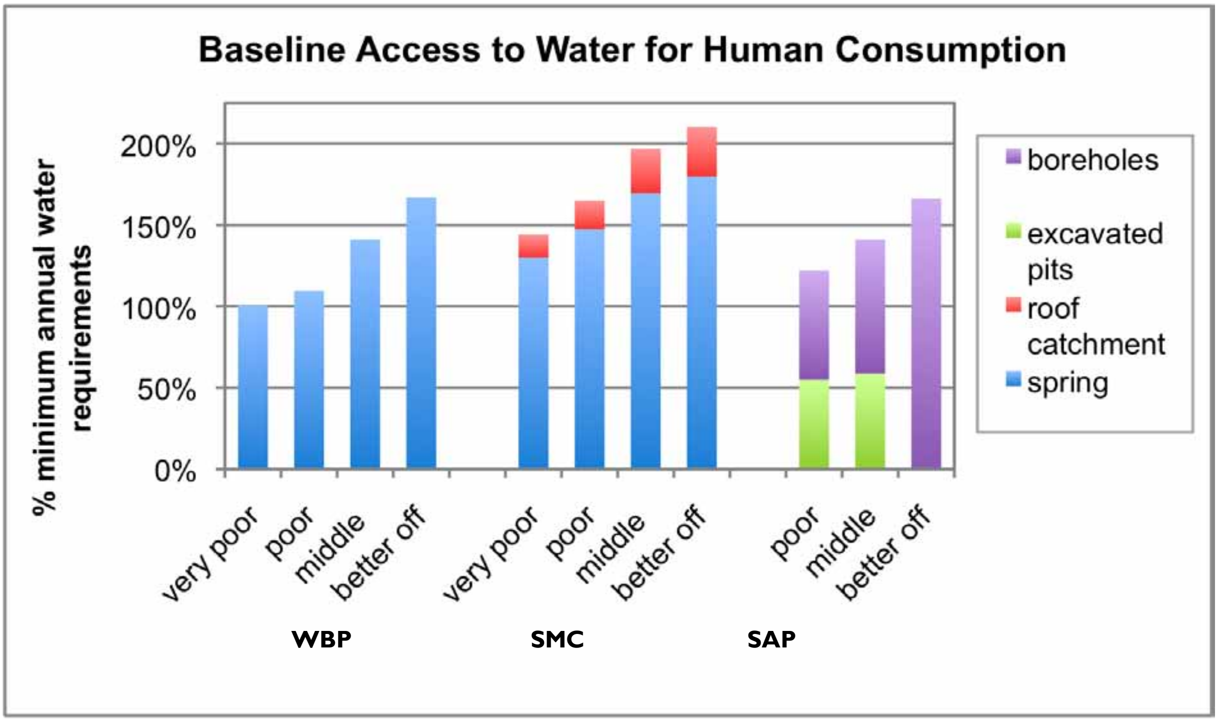
Once the dry seasons begin, water quality deteriorates quickly, as standing water increases due to lower yields. Spring pools become saturated with the contamination of livestock waste. This creates optimal environments for parasites, worms, leeches and bacteria. At left: an unprotected spring in WBP Livelihood Zone in the long dry *bona* season.

Differences in access by wealth group

Amartya Sen's seminal work on famine and entitlement, developed in the 1980s, launched a revolution of the way we think about poverty and vulnerability. Sen challenged the then commonly held position that famines occur primarily due to absolute shortages of food (availability) – instead suggesting that lack of *access* was key to understanding who went hungry, and why (Sen, 1981).

Just as food security assessment methods shifted to operationalize this new understanding of access and entitlement and their impact on food security for populations, so too must understandings of water security.

Figure 5.11: Baseline access to water for human consumption across transect livelihood zones



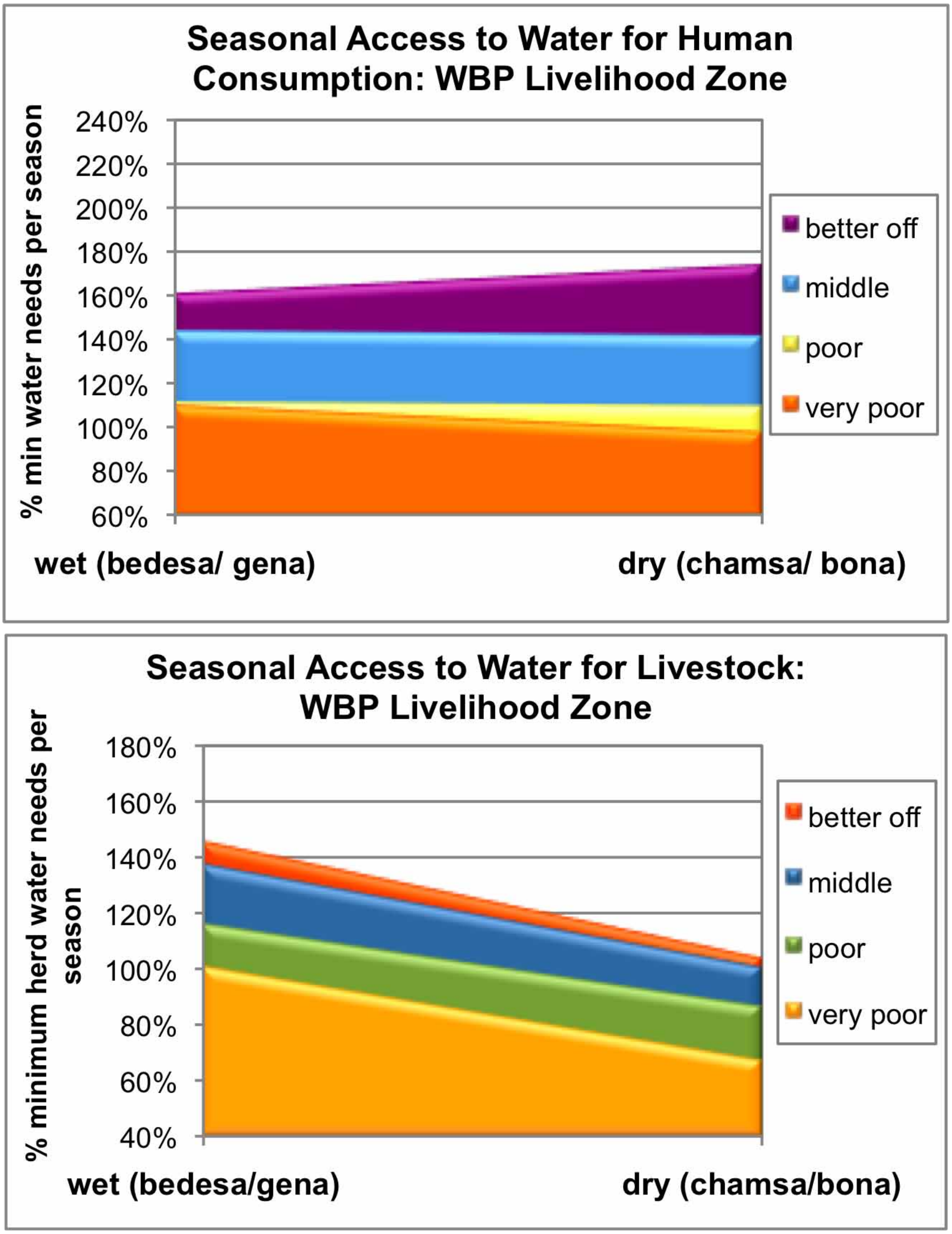
Much of the hardship and costs from lack of access to safe drinking water and sanitation is borne by the poor. Just as for access to food and cash income, access to water for all uses – human consumption (drinking and cooking), hygiene and sanitation, and productive activities (in this case, livestock production) – is found to increase with wealth. Figure 5.11, which presents annual wealth group access to water for human consumption illustrates this trend[33].

Looking at annual access levels, households in all livelihood zones meet minimum water access requirements for human consumption in the baseline year. Households in highland WBP Livelihood Zone have lower annual access than those in midland SMC Livelihood Zone overall, possibly due to the higher seasonality of sources, which leads to slightly reduced yields in the dry seasons. Similarly, slightly higher spring yields and lower seasonality of sources, a much less dense population (and fewer people to contend with at spring sources), and ownership of more jerry cans and storage containers (see Figure 5.8 and Figure 5.12) are all major reasons behind the slightly higher access to water for human consumption in SMC Livelihood Zone. Other contributing factors to the higher access and use may include higher temperatures in the midlands, which increase perceptions of greater need of drinking water.

33 In this graphic, minimum access (y-axis) refers to minimum human consumption requirements, or 5 litres per person per day (Lpcd). Access data represents water access by a majority of the population in each livelihood zone for the baseline year. Smaller pockets of population exist who access different sources of water (e.g. shallow wells or rivers, for instance), but as they represent a small minority, their access levels are not quantified here.

Annual access figures can be misleading, however. Marked differences in seasonal access exist that have particularly important implications for the poor. Awareness of these trends is important to understanding periods of vulnerability within the year for the poor in particular.

Figure 5.12: Seasonal access to water by wealth group in WBP livelihood zone



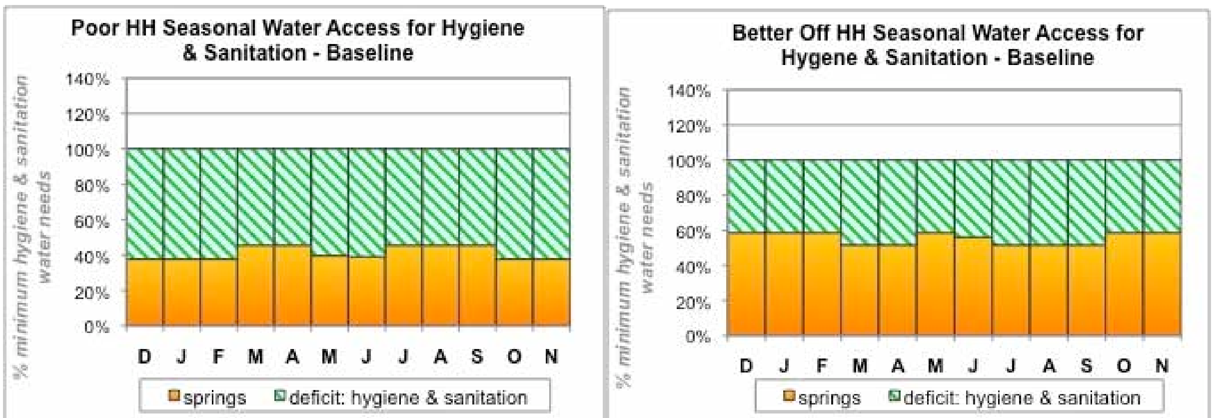
Seasonal wealth group access to water for human consumption and for livestock is presented in Figure 5.12. Although all wealth groups secure enough water for human consumption across seasons, poorer households see their access drop or stagnate in the dry seasons, while wealthier households manage to increase the amount of water brought back to the household.

Of more concern are drops in access to water for productive use that sustain livelihoods for poorer households in the dry seasons. These households fail to secure enough water for their livestock to protect herd health in the dry seasons of normal years. This results in and is reflected by the poor condition and lower prices fetched for shoats of poorer households, which are 20% lower than prices fetched by wealthier households in normal years. By contrast, wealthier households face no deficits for livestock watering, even in the dry seasons.

Reasons behind these wealth-based trends lie in the social, economic, and human asset bases, or 'entitlements' that different households are able to access. Poorer households have fewer household members to release for water collection[34], own no donkeys for transport and fewer jerry cans that are smaller in volume (see Figure 5.8). They also confront conflicts over labour and time allocation that are more significant than for wealthier households due to their smaller household sizes and income diversifying strategies which require labour to be allocated elsewhere.

All households fall short of SPHERE hygiene and sanitation minimum water requirements, which specify 6 Lpcd for bathing/hand washing and 4 Lpcd for laundry (see Figure 5.13). Except for a limited number of kebeles where NGOs have been active, education and awareness around hygiene and sanitation behaviours has not catalysed demand for soap for hand washing, latrine construction, or jerry can cleaning and sanitation that would lead to more frequent use of water for these purposes. Thus deficits do not necessarily reflect an inability to collect adequate water for these purposes, but a lack of demand for them.

Figure 5.13: Seasonal access to water for hygiene & sanitation by poor and better off households in WBP livelihood zone



34 Household sizes for most very poor households are approximately 5 to 6 people; poor from 5 to 7; middle from 6 to 8; and better off from 7 to 8.

The seasonality of vulnerability: Conflicts over labour and time allocation

For poorer wealth groups in particular, conflicts over scarce time and labour resources at household level serve as an impediment to access to water of adequate quality and quantity. Along with constraints related to education (sensitisation) and income (purchase of soap) that serve as barriers to uptake of good hygiene and sanitation practices, these constraints amplify their risk of contracting water-related disease.

In WBP Livelihood Zone, very poor and poor households, whose household sizes are two to three household members fewer than those of the middle or better off, must weigh labour release for water collection against childcare, own crop production duties, and engagement in agricultural labour. Income from the latter makes up approximately 50% of annual cash income in normal years for the very poor, and 25% for the poor. Indeed, the peak months during which poorer households engage in agricultural labour for wheat and barley production fall partly during November, December, and February – which coincides with the *bona* long dry season, when lines and collections times are at their height (ranging from 3 to 5 hours in a normal year). This is illustrated in the seasonal calendar in Figure 5.10.

Box 5.2: Constraints to effective water supply development at Woreda level

There are few developed sources in WBP and SMC. Main challenges include:

Budget constraints at woreda level, which carry across maintenance and operation allocation for existing developed sources, and new development capital

High staff turnover and general lack of qualified water experts, which impinges on the woreda's ability to respond to the needs of the community

Poor supply chains, topography and lack of all-weather roads restricts ability of maintenance crews to fix broken sources in a timely manner. Major repairs usually take at least 3 months.

Such labour constraints restrict the means available for poorer households to secure good quality water. Poorer households report never travelling to protected sources, despite the higher water quality of these sources, which are only roughly 15 to 30 minutes (or about 2km) farther than the unprotected springs accessed in the dry seasons[35]. These conflicts over time and labour allocation are also likely to impede the ability of poorer households to collect water as frequently as is necessary to access sufficient quantities of water to meet survival and livelihoods protection needs when drought years occur. Indeed, while many middle and better off household members travel twice a day to collect sufficient water for human consumption, very poor and poor households rarely do so.

[35] It is only some middle and better off households who report travelling greater distances and enduring longer collection times in order to secure better quality drinking and cooking water.

Further periods of vulnerability related to water access occur at the beginning of each rainy season (March – April and June – July). As indicated in Figure 5.10, water quality is extremely poor during these periods in unprotected springs – which the majority of households access – because high volumes of rainwater runoff and floodwater wash upstream contaminates into the springs. Incidence of diarrhoea peaks during these months due to contamination of water sources through these means.

The timing of diarrhoea during these months is unfavourable, as it coincides with the hunger season from June through August, as well as the peak season for agricultural labour from February through April. This bodes badly for poorer households again. The diarrhoea-hunger season overlap is problematic because cash reserves are lowest before the harvest, and households' own crop reserves have run out – and so medical treatment is likely to be foregone in favour of staple food purchase. The diarrhoea-labour season overlap is problematic as diarrhoea limits the productivity of these households, and therefore their income generating ability through agricultural labour.

Box 5.3: Conflicts over appropriate water uses: The importance of community buy-in and use rules

In Iffa Daba PA, Goro Gutu woreda, a health centre constructed by an international non-governmental organisation (NGO) diverted water from a high-yielding unprotected spring source to the centre so that the facility could have an on-site water tap as required by regulations. However, the households in the sub-villages which used the spring were unhappy with the construction as it reduced downstream water previously channelled from the spring to irrigation and livestock ponds. Consultation with such users was not adequate and buy-in from the community not strong enough in the scheme's planning phase.

Not long after the health centre's water was secured, some users sealed off the pipes leading to the centre and blocked the spring eye entirely.

The NGO subsequently worked with the sub-villages to develop the source, including constructing several improved cement irrigation channels. The NGO and the community also worked together to set up a system of rules rationing use of water both for the health centre and productive uses such as irrigation and livestock watering.

Conflicts over water uses and users is only likely to increase as groundwater sources in particular become more reliable than rainfall and surface water. Ensuring proper community involvement in planning and implementation will be of all the more importance if conflicts are to be mitigated in the future.

Access and availability in drought years

Although climate variability affects highland WBP zone and erratic rainfall places uncertainty on the timing of crop planting and harvests from time to time, rainfall levels are substantial enough that water stress rarely characterises the livelihood zone. During dry years, yields in some lower yielding, typically perennial spring sources falls to levels unsuitable for water collection, and water quality at all unprotected springs continues to deteriorate from dry season levels.

Collection is more concentrated at higher yielding springs in such years, and population from kebeles without protected or high yielding unprotected springs travels to neighbouring kebeles to access those more reliable sources. Collection times rise on average by 1 hour and up to 2 hours due to high demand from the population and livestock, compounded by lower yields. A common strategy pursued by households is night-time collection at these sources, when demand is lower and water levels and yields rebound from lower levels during the day that result from localised groundwater depletion. Night-time collection is undertaken by men in such cases, partly due to safety concerns.

Collection and use of water for bathing and laundry is reported to be restricted informally at spring sources. Such rationing is likely related to the reportedly higher incidence of water-related diseases such as typhoid and intestinal worms during such years.

Box 5.4: Irrigation: Sources of conflict

A small minority of households in WBP Livelihood Zone engage in irrigated chat and vegetable production in pocket areas on a very small scale. Reportedly a recent phenomenon within the last decade in this zone, irrigated production is mainly sourced from higher yielding springs which feed irrigation ponds and channels. Ponds are typically refilled during the night when irrigation channels from the spring are opened.

Conflicts have already ensued in many communities around springs used for irrigation. On the one hand, widespread perceptions exist in communities that spring supply will not be able to meet the demand for much increase in irrigated production, particularly for chat, which has a high water requirement than vegetables while at the same time providing for domestic needs.

On the other hand, the lack of water use and allocation rules or water user committees for unprotected springs, which feed irrigation channels and ponds creates an environment ripe for disagreement. Conflicts are common between users and non-users, as well as between upstream and downstream users – the latter whose water allocation declines when upstream users withdraw more than their share. Occasionally conflicts erupt into violence against property and people . Anecdotal reports from woreda officials reveal that there have been a number of irrigation conflict-related deaths over the past several years in the zone.

5.2.2 Sorghum, Maize & Chat (SMC) Livelihood zone

Water dependent livelihoods

Households in midland Sorghum, Maize & Chat (SMC) Livelihood Zone have the lowest total income levels out of the three transect livelihood zones, as shown in Figure 5.6 in section 5.3.1.

Livestock rearing, which is water-dependent, is more central to livelihoods in the midland zone than in the highland zone. Comparative herd sizes reflect this difference (see Figure 5.14 and Figure 5.7). In SMC, unlike in WBP, it is not only the wealthier but the poor as well who depend on livestock sales for a significant proportion of their cash income. Poor households generate over a quarter of reference year cash income from livestock sales, compared to less than 10% for poor households in the highlands. Middle and better off households in SMC Livelihood Zone generate 45 to 50% of cash income from livestock sales, as illustrated in Figure 5.15.

36 Most common vegetables cultivated in WBP through irrigation include cabbage, onion, and tomatoes.

37 The latest incidence of which was in 2007/08 when violence between upstream and downstream users ended in a stabbing of an upstream user by a downstream user in Tulo woreda.

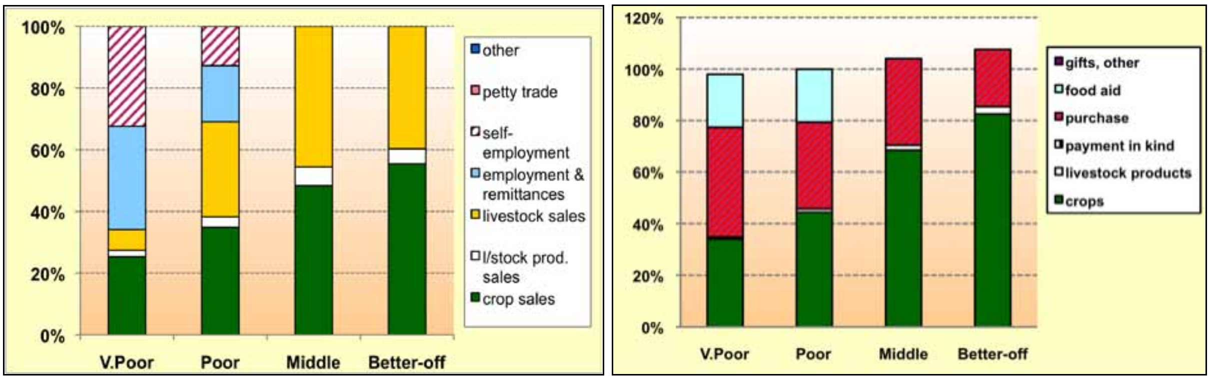
Figure 5.14: Wealth breakdown and asset levels in SMC livelihood zone

	Wealth Groups Characteristics				
	HH size	Land area cultivated	Crops cultivated	Livestock/Asset Holding	Water Storage & Transport Assets
Very Poor	4-6	0-0.5ha	Haricot bean, Sorghum, Maize, Irish potatoes, Chat	0-2 goats, 0-2 hens	0 donkeys, 2 x 5L, 1 x 10L, 1 x 20L, 2 x 3L jerry cans
Poor	5-7	0.3-0.5ha	Haricot bean, Sorghum, Maize, Irish potatoes, Chat	0-2 cattle, 2-4 goats, 0-1 donkeys, 2-4 hens	0-1 donkeys, 1 x 5L, 1 x 10, 2 x 20L, 2 x 3L jerry cans
Middle	6-7	0.2-1ha	Haricot bean, Sorghum, Maize, Irish potatoes, Chat	0-2 oxen, 2-4 cattle, 3-5 goats, 0-2 donkeys, 2-4 hens	1 donkey, 1 x 10L, 2 x 20L, 3 x 3L jerry cans
Better-off	6-8	0.6-1ha	Haricot bean, Sorghum, Maize, Irish potatoes, Chat	1-3 oxen, 3-4 Cattle, 4-6 goats, 0-2 donkeys, 3-5 hens	1-2 donkeys, 1 x 10L, 3 x 20L, 4 x 3L jerry cans
% of population 0% 10% 20% 30% 40%	1 hectare = 4 timads				

Figure 5.15: Sources of cash and food in SMC livelihood zone

Sources of Cash

Sources of Food



Annual income (ETB)

2025 – 2620; 2560 – 3155; 5120 – 5710; 7320 - 7915

Field observations also suggest a higher incidence of irrigated production in SMC Livelihood Zone. Irrigation is often directed at chat production, the major cash crop in the zone, which tends to fare better in the midlands due to higher temperatures. Although a minority of households irrigate in the zone, the practice is nonetheless important, particularly for wealthier households who cultivate export-quality chat headed for Djibouti and Somalia.

Seasonality and the access-availability nexus

In midland areas, as in highland areas, seasonal and perennial springs are the most common form of water supply and are used by a majority of households for human consumption, as well as hygiene/sanitation and livestock throughout the year. Rainfall is lower and temperatures and evaporation slightly higher than in the highlands, but recharge occurs both through rainfall and through groundwater flow from the highlands. Groundwater resides in the midlands for longer periods of time due to slightly less rugged topography and slopes, as well as the presence of depressions under which exist alluvial aquifers whose storage capacity (porosity) is good. Thus spring yields are similar to those in the highlands, but seasonality is also less pronounced.

Box 5.5: Water access periods – Sorghum, Maize & Chat (SMC) LZ

Wet access periods: *Bedesa* (March – April) & *Gena* (June – September). Characterised by regular rainfall (50 to 150mm per month) and high levels of surface water and groundwater recharge. Households access springs, seasonal pools, and scattered shallow wells with hand pumps.

Transitional dry access periods: Occur immediately following the rains: *Chamsa* (May – June) and *Bira* (October – November). Characterised by declining but low surface water availability, falling groundwater tables and source yields. Springs are the main source of access; demand and queues increase at these source types.

Dry access period: Refers to the long dry *Bona* season (December – February). Characterised by little to no surface water, high evaporation, and falling groundwater tables. Water collection times are at their highest at springs, the main source of access.

Spring 'density' (i.e. sources per unit of land area) is lower in the midland zone, however, due to the less rugged nature of the topography, and fractures intersect with the surface less often[38]. Although population density is much lower in the midland zone than the highland zone (148 km^2 compared to 989 km^2), springs in SMC nevertheless serve an average of 142 households in the dry season, while in highland WBP Livelihood Zone they serve an average of 124 households.

Table 5.3: Spring access specifications in SMC

Average no. beneficiary households per spring	142
Ratio of undeveloped to developed springs in sampled kebeles	5 to 1

Collection times are thus higher in SMC Livelihood Zone – by about an hour in each season, and reaching from 4 to 5 hours in the *bona* long dry season – due to the higher beneficiary population that depends on the spring and contributes to queues. Queuing times also increase due to the higher water volumes accessed and used by households in the midland zone (perhaps fuelled partly by sensitivity to higher temperatures), as indicated in the seasonal calendar of water access and livelihoods in Figure 5.16.

Table 5.4: Estimated seasonal spring yields in SMC – Litres per second (L/s)

	Dry season	Wet season
Unprotected seasonal springs	0	0.02 – 0.8
Unprotected perennial springs	0.02 – 1.0	0.08 – 2.0
Protected perennial springs	0.02 – 1.0	0.08 – 2.0

[38] In the sampled kebeles, an estimated average of 2 springs exists in each sub-village in WBP Livelihood zone, while an estimated average of 1 spring exists for each two sub-villages in SMC Livelihood Zone.

Higher livestock numbers per household – which use the same springs for livestock as for human consumption – also exert pressure on springs and contribute to pressure on queues, particularly in the long dry *bona* season when human and livestock populations concentrate at perennial springs. Roof water harvesting is not available to alleviate spring source demand during this time either. See Figure 5.17 for a detailed diagram of seasonal collection times by water source.

Box 5.6: Livestock, leeches and springs in WBP and SMC

Where protected springs exist, water is given to livestock in containers directly from the spring pipe to avoid intake of leeches that collect in pooled water.

Leeches are reported to be capable of growing up to 10cm in length inside cattle, which are prone to consuming them because they drink with their mouths open, unlike goats and donkeys.

Once they travel to the animals' brain, slaughter is necessary. Death of animals frequently occurs as a result of exposure to leeches. This affects livestock herd numbers and therefore livelihoods.

As in the highlands, water quality from spring eyes themselves is very good. However, unprotected springs, in which water commonly accumulates in a pool before collection for household use, are easily contaminated by livestock and surface water runoff. Where pools accumulate, it is common for water to be routed away from the spring to a makeshift cattle trough, although the effectiveness of these partitions varies widely.

Box 5.7: Bathing and laundry

Most households typically bathe on average around once a week throughout the year. Some middle and better off bathe twice a week. All Muslim adults use 1-2 Lpcd per day for *solat* – washing of the body before the customary 5 daily prayers.

The very poor only bathe around one to two times a month in the long dry *bona* season due to constraints in collecting enough water. All other households maintain bathing frequency of the wet *gena/bedesa* and transitional dry *chamsa/bira*.

Few households use soap, with wealthier households more likely to report soap useage.

However, woreda health officer trainings within the past two years have increased awareness about hygiene and sanitation and demand for soap has increased.

Households must use cloth to filter out leeches and worms for drinking water taken from unprotected springs. Leeches are particularly rampant during the *bona* long dry season when spring yields decline and standing water provides a conducive breeding environment for them.

As in WBP Livelihood Zone, protected springs are typically capped on-site with a wait-well and tap, although taps appear to be rarely working. Some provide chemical treatment in the storage chamber. Water typically flows out of the wait well through a rock funnel or pipe that allows for safe water to be safely accessed.

In addition to springs, hand-dug shallow wells are scattered throughout the zone, as their 5 to 15m depths are capable of reaching the shallow groundwater table, particularly around depressions in valleys. However, these source types are accessed by no more than 10 to 20% of the population, as they are relatively scarce. Although the quality of shallow well water is likely to be higher than unprotected springs because the former are protected, respondents repeatedly indicate their preference for shorter distances/collection time over quality of water at sources that require longer collection times, as in the highlands. Thus most households turn to typically closer springs.

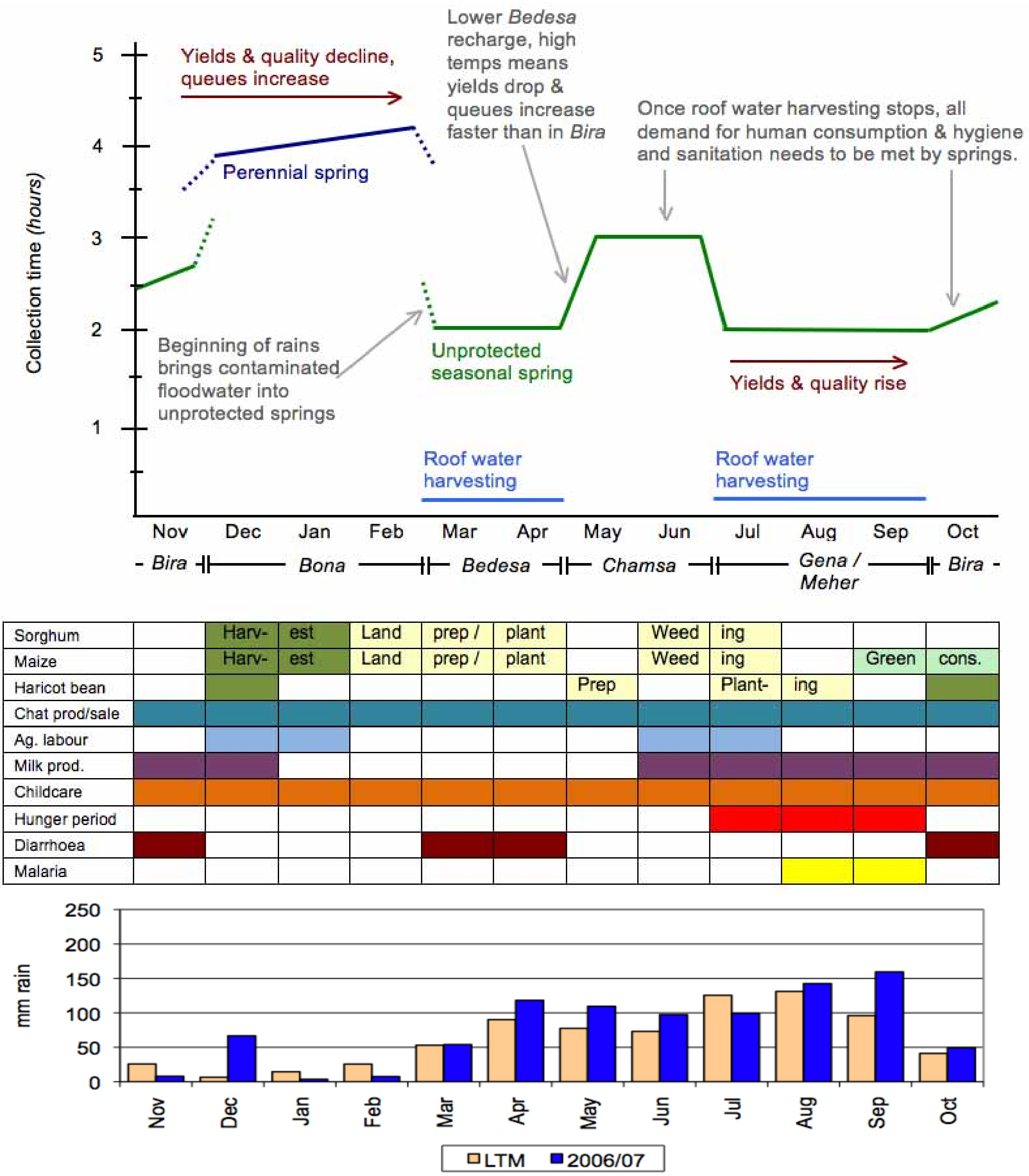
A small number of seasonal rivers or floodwater channels (sometimes called *wadis*) also exist in SMC Livelihood Zone, sourced from runoff from the highlands. In addition, wetland areas in depressions contain pools of water that remain for several days following rainfall that are accessed by people and livestock within close walking distance of these depressions. Many seasonal, spring-fed ponds have also been constructed throughout the zone; number of ponds in the sampled areas ranged from 5 to 100 ponds per kebele.

Both of these sources are primarily used in the wet season and only for livestock watering (typically during the day), and some irrigation (often at night), as high turbidity and contaminates from upstream make water quality quite poor and unsuitable for human consumption.

Many ponds were initially lined with plastic when first constructed to slow water absorption into the ground. However, lack of proper maintenance – and of any formal user committee to issue maintenance mandates and raise funds – has meant that the lining of many ponds has deteriorated without replacement.

Most households in the livelihood zone harvest rainwater collected from their house roofs in the wet seasons. The very poor are not able to do so as few have metal roofs from which to harvest water. Rainwater is generally not considered palatable for drinking due to a widespread perception of a metallic taste. It is instead used for washing of utensils and cleanup associated with food preparation, as well as all laundry needs.

Figure 5.16: Seasonal calendar of water access and livelihoods – SMC livelihood zone

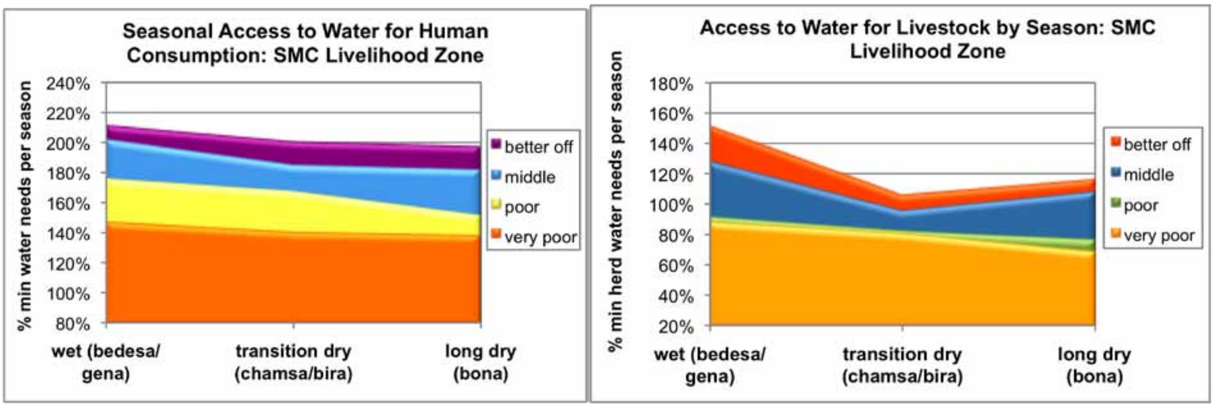


*Long-term mean (LTM)

Differences in access by wealth group

As in other livelihood zones, access to all uses of water compared to minimum requirements increases with wealth. Figure 5.17 presents graphs wealth group access to water for human consumption and for livestock by season.

Figure 5.17: Seasonal access to water by wealth group in SMC livelihood zone



Access declines for all uses – domestic and productive – across wealth groups in the transitional dry *Chamsa* and *Bira* seasons, as well as the long dry *Bona* season. Whereas middle and better off are able to just about maintain access levels from the transitional dry season into the long dry season, poorer households' access drops further in the *Bona*.

Access by the very poor is constrained by low volume jerry cans and roof catchment basins; they cannot afford to purchase larger or more numerous basins. Thus their ability to keep water in reserve and maximize rain harvesting in the wet seasons is limited.

A similar trend is present for livestock watering. Wealthier households actually increase water access for livestock despite higher requirements. Poorer households' access to water for their shoats continues to decline from the *Bira* to the *Bona*. Better management practices and the realities of having more capital at stake in the form of livestock are likely at the root of higher access levels by the wealthier.

All households fail to meet SPHERE minimum water standards for hygiene and sanitation, as in the highlands for similar reason listed for the highland zone.

The seasonality of vulnerability: Conflicts over labour and time allocation

As in highland WBP Livelihood Zone, poor households in midland SMC Livelihood Zone conflicts over time and labour allocation during key periods of the year when water collection and livelihoods protection duties coincide.

Poor and very poor households generate 20 and 30%, respectively, of cash income from local agricultural labour during December – January and June – July. The December – January harvest / local labour period again presents challenge for smaller sized poorer households, as water collection times are at their peak during these months of the long dry *bona* season, when women and children spend an average of 4 hours per day is spent collecting water from perennial springs. Although it is not customary that women engage directly in agricultural labour, they engage in it indirectly by bringing food and water to their husbands in the fields. Field respondents report that when these responsibilities clash during the long dry *bona* season, and one activity may be sacrificed for the other, domestic violence and verbal abuse are common.

Box 5.8: Opportunity costs of water stress

Opportunity costs of high collection times and poor water quality are many:

School – Children from very poor and poor households are sometimes withdrawn from school or must arrive late in the *bona* and in drought to help with water collection.

Health costs – households who opt for it report spending between ETB 50 and 600 on water-related disease medical costs.

Missed meals – Women report sometimes not being able to prepare lunch for children due to water collection duties and carrying meals and water to husbands in the fields, particularly in December and January.

Income foregone – Women report foregoing selling goods at the market and closing down petty trade shops in order to collect in the long dry *bona* season. Some estimate a loss of 15 – 20% of market/petty trade income.

Productivity decline – Men report being too weak to work if they catch malaria, which happens at least once a year. Often, medical treatment is not sought, prolonging labour days lost.

Firewood collection and sale, which is also the domain of women, also presents labour-based conflicts during the dry seasons when wood is dry enough to sell. Fully 35% of very poor households' cash income (and 10% of poor households') is generated by this livelihoods strategy ('self-employment' in Figure 5.15).

Long dry *bona* season water collection time requirements restrict the ability of households to draw on this income source (although small positive externalities may in theory be possible from this conflict: it may at least slow processes of deforestation which in themselves contribute to declining water resource bases[39]).

[39] Indeed, communities undertaking reforestation activities report an increase in groundwater availability (accessed through springs). Likewise, where deforestation has occurred, communities indicate a decline in groundwater availability.

Box 5.9: Irrigation and the wealth – water – wealth causal loop

Traditional irrigation systems – usually in the form of spring-fed irrigation ponds and channels – are used by a minority of the population in SMC who live close enough to the schemes to benefit from them. Households with this access may produce two, and up to four, chat harvests per year – a major increase from the single harvest that a rain-fed farm can produce.

In Terkamfata kebele, Doba woreda, a group of 40 households adjacent to such a traditional irrigation canal system were able to increase their chat harvests from one to four per year. Many bring in gross chat income of at least ETB 2000 over a year's time. Some households have also begun cultivating coffee as a cash crop in the most water-rich areas of the kebele. Households report reinvesting the income in livelihoods through improvement and maintenance of irrigation canals, diversification of vegetable types grown for market sales and home consumption, and payment of school fees for all children to attend school. A handful of households had also diversified their incomes by purchasing houses in town to rent out.

Similarly, RiPPLE's Income Diversification (ID) LARS research found that beneficiary households in three kebeles across the transect livelihood zones with improved irrigation schemes increased their gross annual icome by an average of ETB 170040.

However, as confirmed by both studies, better off farmers both gain larger profits from irrigation and have disproportionate access to irrigated land. ID respondents explained that this had to do with larger land holdings, better capacity to pay fees for water use (as well as invest in agricultural inputs and labour) and better access to land located near irrigation channels. The water-into-money, money-into water41 causal loop is likely to apply here, where households with access to irrigation have become wealthy and can reinvest in water systems because of their initial access to irrigation-accessible land.

5.2.3 Shinile Agro-Pastoral (SAP) livelihood zone

Water dependent livelihoods

Of all households across the transect, agro-pastoral households in Shinile Agro-Pastoral (SAP) Livelihood Zone are the most dependent on water for livelihoods, with poor, middle and better off households obtaining roughly 50%, 80%, and 95%, respectively, of baseline year cash income from sale of livestock and livestock products, as illustrated in Figure 5.20. Not only do water-dependent strategies make up a larger proportion of total income than in other livelihood zones, but absolute volumes of water required to sustain these livelihoods strategies are enormous, given the large herd sizes of all wealth groups. Average herd sizes of the better off range from 40 to 70 shoats, 10 to 15

[40] This figure represents gross income across wealth groups. Citation (Authors, 2009).

[41] See www.rippleethiopia.org: Money into Water, Water into Money.

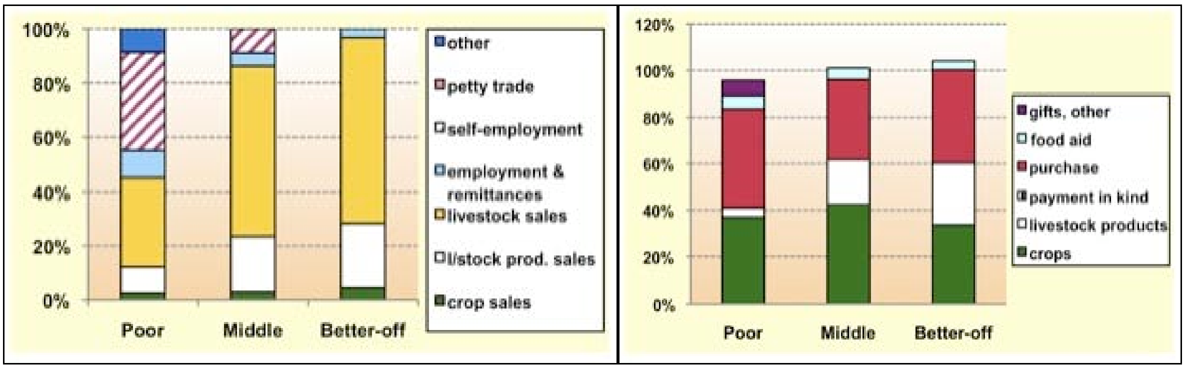
cattle, and 5 to 15 camels. See Figure 5.18 for further wealth group asset breakdowns. Agro-pasotralists make up approximately 15 to 25% of the total population in Shinile Administrative Zone.

Figure 5.18: Wealth breakdown and asset levels in SAP livelihood zone

	Wealth Groups Characteristics				
	HH size	Land area cultivated	Crops cultivated	Livestock/Asset Holding	Water Transport & Storage Assets
Poor	6-7	0.6 - 0.8 ha	Sorghum and maize	5-10 shoats, 2-3 cattle, 0 camels, 0 donkeys	2 x 5L, 2 x 20L, 1 x 3L jerry cans
Middle	6-8	1-1.4 ha	Sorghum and maize	20-30 shoats, 6-8 cattle, 6-8 camels, 0 donkeys	1 x 5L, 1 x 10L, 4 x 20L jerry cans
Better-off	8-10	1.2 - 1.6 ha	Sorghum and maize	40-70 shoats, 10-20 cattle, 5-15 camels, 0 donkeys	2 x 5L, 1 x 10L, 5 x 20L jerry cans
0% 20% 40% 60% % of population					

Figure 5.19: Sources of cash and food in SAP livelihood zone

Sources of Cash Sources of Food



Annual income (ETB)
2940 – 2130; 5510 – 4690; 8450 – 6610

In addition, the contribution of milk to all households' diet is substantial in this zone: poor households obtain nearly 5% of minimum kilocalorie (kcals) requirements from milk; middle households nearly 20%, and better off households obtain nearly 30% of minimum kcal requirements from milk. Perhaps more important than the significant food contribution milk makes to the agro-pastoral diet is the nutritional importance of such quantities to these households.

Despite livestock's large role, poor households in the zone are forced to diversify livelihoods strategies more than other wealth groups. Bush product and firewood sales are important, and some income comes from labour undertaken to assist caravans transporting contraband goods and from remittances from relatives working in Djibouti. Together, these self-employment strategies generate over 35% of baseline year cash income. Poor households do not sell any of their crops.

Inter-Linkages between livelihood zones

Shinile agro-pastoralists have economic interactions with neighbouring Jijiga Zone, Dire Dawa council, regions of Oromiya and Afar, and Djibouti and Somaliland. One of the more important set of relationships is with sedentary farmers in midland SMC and highland WBP zones in Oromiya, with whom Shinile Agro-Pastoral Livelihood Zone shares almost all of its southernmost border. Farmers in SMC and WBP sell their grain surplus to Meiso and Dire Dawa, which in turn provides cheap grains to agro-pastoralists in SAP Livelihood Zone. Dire Dawa also serves as a centre for labour migration of young men in SAP who send remittances back to their families. Oromiya highlanders also hire agro-pastoralists in SAP to transport grain from farms in the lowlands by camel to markets and other selling and distribution points, which serves as an income source particularly for the middle and better off who own camels. Shinile agro-pastoralists also migrate to Afar and Oromiya region for pasture in bad years.

Seasonality and the access-availability nexus

The large and productive aquifer base underlying lowland SAP Livelihood Zone, characterised by high storage properties and low seasonality, supports a high number of shallow wells and boreholes that tap the groundwater stored within the aquifer year-round. Unlike in the highlands and midlands, there are no springs in the lowland livelihood zone. Most households are heavily dependent on borehole and some shallow well sources, both of which are scattered throughout the zone in woreda and other large towns (e.g. Meiso, Dambal, Afdem, Ayshia, and Erer) as well as in more isolated bushland. The borehole in Dambal has considerable population pressure on it due to the high agro-pastoral population that resides in that district and its accessibility.

The southern reaches of Shinile Zone, where SAP Livelihood Zone is located, are relatively accessible by all-weather roads, facilitating water supply interventions by government and NGOs alike over the last couple of decades. Relatively small depth to water table in this zone (typically around 30 to 70m in non-riverine areas) also facilitates relatively lower costs of borehole development[42]. Although shallow wells are also scattered throughout the zone, a higher proportion of shallow wells than boreholes fail due to shallower well depths and dropping groundwater levels in the height of the dry season. However, these sources are characterised by high breakdown rates: around 1/3 of such sources were in disrepair or had been abandoned at the time of fieldwork.

[42] Depth to water table in other areas of Ethiopia often exceed 50m and can reach up to 200m.

Box 5.10: Water access periods – Shinile agro-pastoral (SAP) LZ

Wet access periods: *Dira'* (mid-March – mid-April) & *Karan* (mid-July – September). Fifty to 100mm rain per month typically fall in normal years. Flood water and surface water flows recharge groundwater. Seasonal pools, ponds, rivers, and excavated pits are all available during these months, alleviating demand on borehole/hand pump sources.

Transitional dry access period: *Hagaa* (mid-May – mid-July). Characterised by hot temperatures and high evaporation, falling groundwater tables, and lack of surface water availability. Households resort to excavated pits, boreholes, hand pumps, and perennial rivers.

Dry access period: Long dry *Jilaal* season (October – mid-March). Characterised by a lack of surface water and declining perennial river flows, increasing depth to water table at excavated pits, deteriorating water quality, and long queues at boreholes and pits.

Losing seasonal streams – or streams that lose water through absorption into the ground as they flow downstream[43] – emerge from the highlands in the *Dira'* and *Karan* wet seasons and swell with floodwaters during heavy rains. The primary source of groundwater recharge to sub-surface aquifers in SAP, they also provide channels where households can tap groundwater close to the surface in the form of excavated or dug pits, or *eelas*. All households supplement borehole and shallow well water with water accessed by excavating pits alongside these riverbed channels, particularly in the dry seasons when demand and lines at boreholes increase.

Of all wealth groups, the poor rely on these sources to the greatest extent in an effort to minimize expenditure on water, even during the wet seasons when other wealth groups mostly rely on the boreholes. Although water is obviously available in the form of seasonal streams and floodwater, households prefer to excavate pits alongside the channels, as the water flow is polluted by mud and upstream contaminants and is of extremely poor quality.

Water in riverbed pits is available even during the dry seasons because of the relatively shallow water table along river channels and the high storage properties of the alluvio- lacustrine and limestone aquifers. The seasonality of these sources is low enough that water is available in at pit-accessible depths even during drought periods, although depth to water increases in both the dry season and during drought. See Figure 5.20 for a seasonal calendar of water access and livelihoods.

Other seasonal wet season sources include man-made ponds that households construct to harvest rainwater in the rainy seasons from March – April and July – September to serve livestock. Livestock are also watered at seasonal pools that collect on days when rain falls (estimated by respondents at around 10 days per month). People occasionally use these sources to collect water for bathing and laundry.

The presences of intersecting E-W and N-S faults also create the high flowing headwaters of the perennial Erer and Burka Rivers that run through the livelihood zone. Populations within a radius of roughly 5 to 7 km of these rivers access them year-round for domestic and productive use.

43 The bottom of the stream channels is of a higher depth than the groundwater table in losing streams. Losing streams are common in regions of karst topography, as in SAP. Gaining streams, by contrast, increase in water volume farther down stream as they gain water from the local aquifer.

However, these households constitute a minority (although significant) of the population in the zone. Water quality is considerably poorer in these rivers than in the boreholes that the majority of the population accesses in the zone.

Rainfall and livelihoods decisions

Rainfall is more erratic in this lowland livelihood zone than it is in the midlands and highlands, and percolation and evaporation (*gamoochi*) high, and livelihoods strategies pursued are adapted closely to the performance of the rains in each given year. With the exception of agro-pastoralists in Hindays and Karanley, who plant short cycle sorghum in March during the *Dira'* wet season, all other households sow sorghum and maize in the wet *Karan* season in late July to harvest in early November.

Both the *Dira'* and the *Karan* are important for communities. The *Karan* rains determine what is harvested from the long maturing cereal varieties planted in the *Dira'* and also provide a second opportunity for planting short cycle maize (*dega nugul*). The *Karan* rains have shown more reliability than the *Dira'* rains in recent years and are therefore considered more important.

Despite the importance of crops as a safety net to households in SAP, however, agro-pastoralists give priority to their animals. Migration patterns are highly dependent on the performance of the rains. In normal years, livestock are kept near the homestead year-round, apart from households in Dambal woreda, where normal movements include migration to Chinahsan in Jijiga Zone. Herds are usually split into different types of stock in order to manage water needs more efficiently. Shoats and cattle always remain around settlements with women and children in normal years, while men migrate with camels to the northern pastoral areas for graze and water (SCUK, 2007).

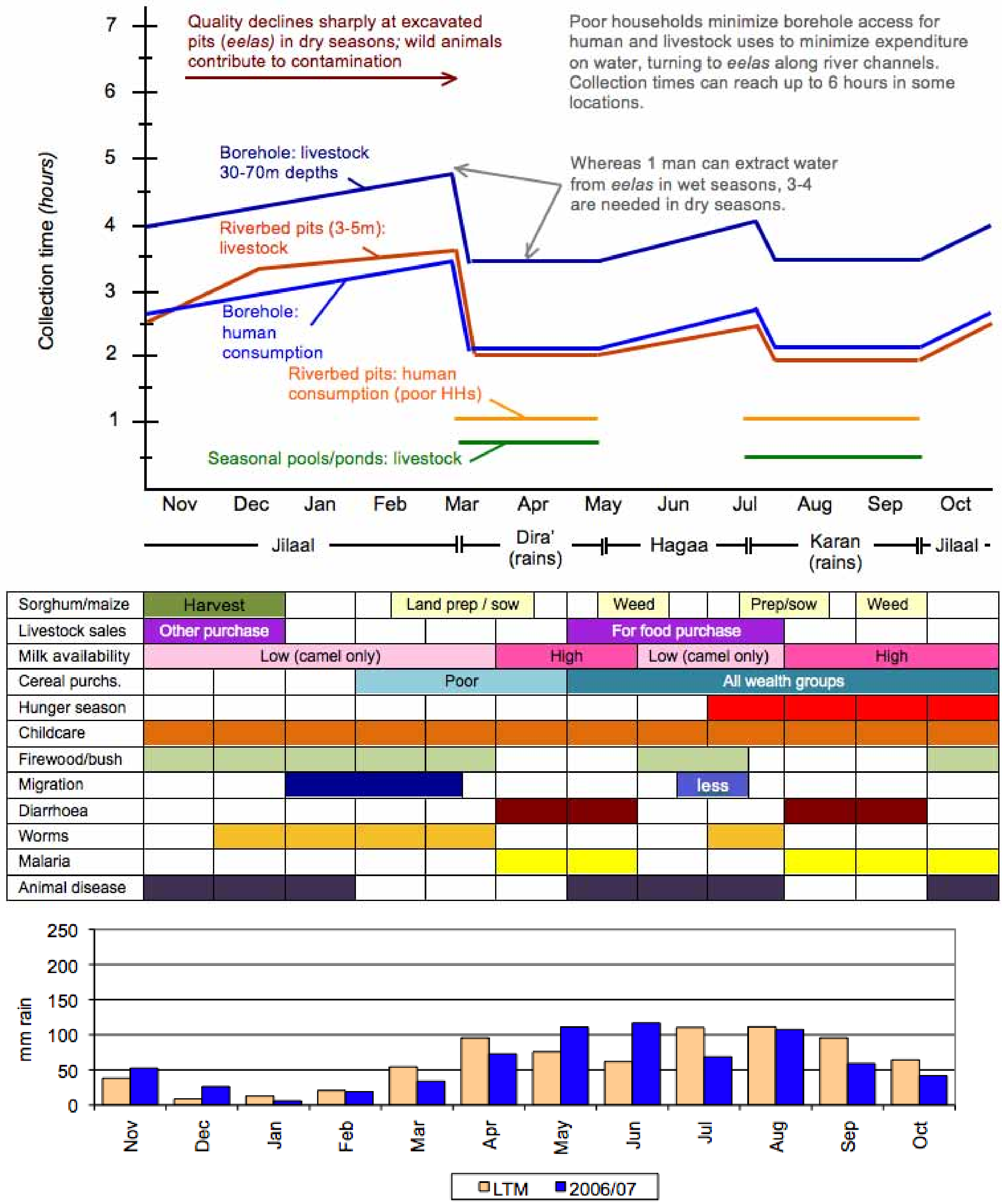
Box 5.11: Conflicts over access to land and water

Conflict frequently occurs between neighbouring ethnic Oromo and Somali groups over access to land and water resources. Often hostilities elevate to acts of retribution and violence. Restrictions on access to land in Dambal woreda, and the Karanley area in particular, have amplified such tensions. Respondents cite such conflicts and the insecurity they bring about as a frequent barrier to cultivation over the last 10 years.

Conflicts are also rife in areas where seasonal and perennial streams and rivers are present and irrigation has been set up, such as in Billa and Asbuli kebeles, Erer woreda[44].

[44] These sites were also sample sites in the Income Diversification and Climate Change Sub-LARS research.

Figure 5.20: Seasonal calendar of water access & livelihoods – SAP livelihood zone



*Long-term mean (LTM)

Differences in access by wealth group

Differences in access to water by wealth groups for all uses are again striking in lowland SAP Livelihood Zone. Figure 5.21 presents access to water for human consumption and livestock watering needs against minimum water requirements for each use.

Seasonal differences in access between wealth groups are telling of adaptive capacities during periods of stress. Whereas better off households increase their access from the cooler wet season to the hot dry *hagaa* season from mid-May through mid-July – when hotter temperatures increase the need for drinking water – poor households cannot sustain wet season access levels, travelling less frequently to *eelas* and the borehole for water. They own fewer jerry cans, and, significantly – no donkeys to transport higher volumes of water for storage at the household as wealthier groups do. Although their access to water for human consumption remains adequate during normal years, the seasonal decline in access suggests that it is likely their access would drop below minimum requirements during a drought year.

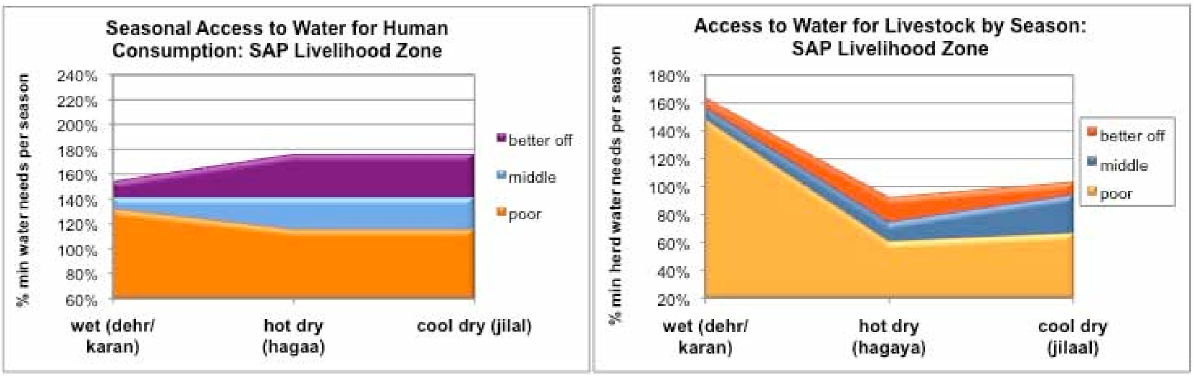
Table 5.5: Wealth group expenditure on water from borehole sources – SAP livelihood zone

	Domestic consumption (ETB)	Livestock (ETB)
Poor	120	0
Middle	280	970
Better Off	435	1,830

Not only do the poor secure less water, but they also secure water of substantial poorer quality. Although trends among poor households vary somewhat across the zone, many poor households minimize or forego collection of water at boreholes during the wet seasons when water is abundant at *eela* pit sources in order to minimize overall expenditure on water (see Table 5.5). This is also when water quality is at its worst at these sources due to flood water contamination.

Water typically costs 25 cents per 20 L jerry can at borehole sources across the zone for domestic consumption. Fifteen cents per cattle and camel head is typically charged at boreholes regardless of the litres consumed by those livestock types, while water for shoats is charged at the 25 cent per 20L rate.

Figure 5.21: Seasonal access to water by wealth group in SAP Livelihood Zone



Similar wealth group trends are present for household access to water for livestock. Although all households see a drop in access to water for their herds from the wet seasons to the dry seasons, better off and middle households are able to ensure that their herds approach meeting minimum needs in the long dry *Jilaal* season, which lasts for 5½ months.

By contrast, the poor only slightly increase already low access for herd water – securing only around 60 to 65% of water needs during the dry seasons. This has significant implications for livestock condition and prices fetched for animals sold on the market: poor households receive an average of approximately 20% less for their cattle than do middle and better off households[45].

This has serious implications for livelihoods so heavily dependent on livestock. Indeed, while the poor only secure 30% of total cash income from livestock sales, the middle and better off, with larger, more healthy herds, secure upwards of 65 to 70% of cash income from such sales. The inability to secure large profits from livestock sales is both fuelled by and a result of their poverty and poor access to water and rangeland.

The seasonality of vulnerability: Conflicts over time and labour allocation

A major reason for the lower access to water across uses for poor households is the scarcity of labour within these households. This is significant particularly in this livelihood zone because 2 to 4 men are required to successfully extract and carry water out of the 3 to 5 m deep *eela* excavated riverbed pits in the dry season. With an average of only 6 household members, some of whom are women or girls whose domain does not include such duties, poor households have fewer labour resources to assist with livestock grazing and watering duties. Crop production duties and collection of bush products such as gums and resins further restrict the labour and time available for men (and young boys) to water livestock adequately. Figure 5.20 illustrates the overlapping periods of labour, migration, water collection and livestock watering duties that converge to put high stress on labour-poor poor households in SAP Livelihood Zone.

Women often take small ruminants, lactating animals, and cattle to water, particularly in January through mid-March at the most dry period of the long dry *Jilaal* season when households – particularly in Dambal – migrate with camel herds to perennial rivers or other borehole water sources in northern pastoral areas.

Anecdotal reports indicate that disease incidence – particularly scabies and intestinal worms – is highest among poor households. This is not surprising given that this wealth group resorts to the more contaminated *eela* pit sources more frequently, and their extremely low rates of water access for hygiene and sanitation. The latter is again likely to be more an outcome of lack of demand than any other reason. Scabies are known to be particularly rampant where hygiene and sanitation behaviours are not sufficiently disseminated and practiced. Both of these conditions are at their peak in the dry seasons when water access is at its lowest and stagnant water at *eelas* provides breeding ground for worms and other amoeba. Animal disease is also highest during the dry seasons.

Access and availability during drought years

During drought, shallow well sources often dry up, and borehole sources frequently fall into disrepair in the zone as well. Sustained pumping throughout the day to accommodate higher population using borehole sources exerts considerable strain on pump mechanisms, which contributes to such breakdowns during drought.

Collection times at boreholes typically increase to 4 to 5 hours for women collecting water for domestic uses, and 6 to 8 hours for livestock watering. Water use for hygiene and sanitation/ bathing

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[45] Poor households in the reference year of 2004-05 (HEA) received an average of ETB 1,000 for their cattle, whereas middle and better off received ETB 1,200.

and laundry is the first use of water to be rationed and even largely foregone as a coping strategy by most households, with poorer households reportedly abandoning such uses earlier due to labour constraints. Migration is undertaken predominately by men, who take non-milking animals to perennial rivers and boreholes in other woredas, and/or to highland areas where animals can be hand fed in particularly bad years. A more comprehensive list of such strategies is noted below.

Box 5.12: Hazard year migration and coping strategies in SAP livelihood zone

- Men migrate with non-milking animals to water and graze:

  Mieso agro-pastoralists move to the highlands of Oromiya Region and across Afar Region.

  Erer agro-pastoralists move their animals to the highlands of Oromiya Zone and Dakhato, Fanfan Valley and Erer Valley in Jijiga Zone.

  Dambal agro-pastoalists move their animals across to Jijiga Zone (Fanfan and Erer Valleys, Dakhato, and Chinahsan) and sometimes cross the border to Somali in rare cases.

  In particularly bad years, agro-pastoralists move their animals to the mountain foothills to the south and southwest and hand feed them (*huluuleysei*) – where herders climb the mountains to gather fodder but animals remain back as they are usually too weak to do so. During such movements, milk animals – camels and cattle – remain around homes (Source: SC-UK).
- All household members minimize water collection for bathing and laundry, and decrease the frequency of collection, e.g. from every day to every other day.
- Women and children travel to other PAs and woredas to access water at working boreholes or boreholes with less population pressure. Population often congregates around Dambal borehole – and some households avoid the source due to extremely long waits (up to 6 hours queuing). Some households travel to Dire Dawa to purchase water for themselves and their livestock.
- All households increase access for human and animal use at *eela* riverbed pit sources, as queues at boreholes are prohibitive – particularly as households must make time to expand bush product and firewood collection and sale during hazard years in order to secure adequate cash for staple purchase if crops fail or livestock sales are down. Expenditure at boreholes also becomes prohibitive of access at these sources. *Eela* pit depth must be increased to at least 5 and up to 10m.
- Children are withdrawn from school to help with watering and water collection duties. Collection times rise to 5 to 8 hours.
- Camels are occasionally taken from their traditional pack animal role to assist with water collection in some cases.
- Water collection markets in Hurso are reported to exist during hazard years; 50 cents is charged per jerry can for transport of water from boreholes to homes.
- *Above: an agro-pastoralist extracts water from an eela in Dembal woreda, Shinile.*

6 Recommendations for development

6.1 Appropriateness of schemes in livelihood zones

The appropriateness of a water scheme can be measured, among other factors, by a) the scheme's ability to provide water throughout the year; b) the ease with which the community can access the schemes; and c) ease of operation, maintenance and management of the schemes.

WBP and SMC livelihood zones

Springs are the most widely used sources in the midland and highland livelihood zones. However, only 1 in 7 springs are protected or developed in WBP Livelihood Zone, and 1 in 5 in SMC Livelihood Zone. Spring protection would be an appropriate and important intervention in both WBP and SMC Livelihood Zones, as most springs become highly contaminated, due partly to their role in serving multiple uses of water – domestic, livestock watering, and also irrigation. Access points for each use are generally not separated in these zones.

Construction of artificial recharge enhancement structures such as ponds may also be appropriate to increase the water retention in the zone and reduce the seasonal decline in the yield of springs. Ponds may also direct livestock and irrigation users away from springs, which can be confined to domestic use to reduce risk of contamination.

SMC has further potential for development of water sources due to its higher groundwater availability and lower seasonality of aquifers. Water point data tells us that shallow wells and deep wells are currently few in number in SMC Livelihood Zone. However, groundwater is present at shallow depths, as discussed in section 4. Development of protected hand dug wells is therefore possible. It is also desirable, particularly from a public health standpoint.

Furthermore, looking at population figures, we see that human population is moderate in density, and livestock populations are not high; particularly given rainfall levels in the zone, development of shallow wells or boreholes is likely not to lead to over-abstraction and localized depletion of groundwater tables around wells. Emergency boreholes and even shallow wells may be effective intervention options during serious drought periods.

Finally, conflicts over sources used for irrigation are currently resolved at woreda level, arbitration is often ad-hoc and occurs after conflicts have come to head. Water user committees and/or use allocation rules for protected *and* unprotected spring sources should be set up in WBP and SMC Livelihood Zones to mitigate conflict and provide a clear and enforceable use allocation and rights regime. The establishment of water user committees for protected sources only is not sufficient, given that a large number of unprotected springs are also used for irrigation.

SAP livelihood zone

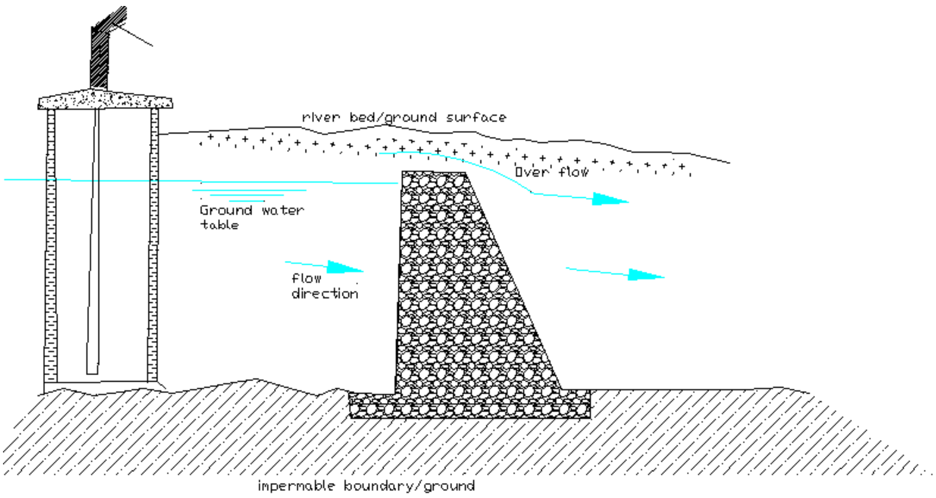
In SAP Livelihood Zone, the use of submersible pumps to extract water from the ground is imperative in the dry seasons. Because groundwater extraction rates for domestic and small-scale productive use is small and generally does not threaten groundwater sustainability in most areas of Ethiopia (see Calow and MacDonald, 2009), boreholes and shallow wells can be developed where the hydrogeology permits and where borehole siting and planning is in line with community commitment and priorities. Boreholes need to be properly sited, however, in order for these sources to be reliable.

Woreda officials in SAP report many cases of borehole failure due to the drying of boreholes during dry seasons due to improper drilling of the sources during the wet seasons when groundwater table levels are higher than they are during the dry seasons. Boreholes should be drilled during the dry season so that implementers can ensure that the water table will not fall below the pump depth each dry season. Incorporation of customary pastoral and agro-pastoral institutions into borehole planning and siting is also imperative in order to minimize conflict and maximize productivity and efficiency, as well as community buy-in and commitment to manage such sources.

Pump breakdown is also a frequent occurrence in SAP, particularly in the dry season when sustained pumping from high population demand exerts strain on pump mechanisms. Strain is exacerbated if water levels in boreholes are falling and pump lifts increasing. Moreover, if maintenance is not done regularly – e.g. when emergency drilling is prioritized over repair and rehabilitation during a drought – sources will fail even if water is still available at depth (Calow and MacDonald, 2009).

The retention of water in excavated pits during dry seasons and drought suggests that construction of sub-surface dams to facilitate storage and extraction of water would be an effective preventative and resilience building measure in this zone. Water extraction is likely to be more efficient and less labour-intensive (particularly important for labour-poor poor households who face significant water deficits in normal years). This would be particularly useful given the high volumes of water required for livelihoods due to reliance on large livestock herds for income and food sources and as a form of insurance against drought. A diagram illustrating what such an intervention would look like is presented in Figure 5.22.

Figure 6.1: Cross-section of a sub-surface dam



6.2 Lessons from abandoned sources

In Ethiopia, little documented evidence is available as to the causes of water scheme failures. Among professionals in the field, it is believed that over half of developed water wells fail to deliver water after construction. One study found that 70% of wells constructed in Dugda woreda in the central Ethiopian Rift fail due mainly to poor water quality (Kassa, 2007). Sources may also be abandoned by communities due to poor or insecure siting, or perceptions about the unappealing taste of the groundwater. Particularly in agro-pastoral and pastoral communities, sources may also be abandoned because they become sites of conflict among different clans or ethnic groups, and often are catalysts for outsiders moving into the area to settle on what was previously common land used by agro-pastoralists and pastoralists. Indeed, water source development in pastoral areas in Ethiopia has been fraught with challenges and conflict, and poor choices with regard to siting and incorporation of local leadership into decision-making processes has often been an instigator of conflict, degradation of productive grazing land and mobility systems, and deterioration of customary pastoral natural resource management institutions (Gomes, 2006).

The field survey in the three livelihood zones along the transect reports several types of water scheme failures following construction of the developed sources (See Table 5.6). This information is important in identifying interventions appropriate to both the physical characteristics of the zone as well as the social and economic motivations and interests of communities.

Table 6.1: Types and reasons for water scheme failures

Livelihood Zone	Failed Scheme/water source	Reported reason of failure
SMC	Developed spring	Conflict over water source, unclear ownership poor maintenance etc
WBP	Developed spring	Conflict over irrigation; source sabotaged
SAP	Shallow well with hand pump	Decline in water table? Or, alternatively, poor siting and construction during wet season
SAP	Borehole	Salty taste
SAP	River bed excavations	Flooding and deterioration of pits/excavations
SAP	Seasonal ponds	Siltation, flooding, seasonality in water sources
SAP[46]	Thermal spring	Long term change in climate

The most numerous and frequent breakdowns of sources occurred in shallow wells and boreholes in SAP Livelihood Zone. In several cases, communities abandoned sources because of the salty taste groundwater extracted by pumps.

In addition, a large number of abandoned boreholes had been drilled at the end of fiscal years (when cash has a mandate to be spent), which occurs in the middle of the wet season in June. Sources were found to have been abandoned because they dried up during the dry seasons. This suggests that water tables were high when drilling took place and so crews stopped drilling when they reached water – but did not account for the drop of the water table during the dry seasons.

46 A site in SAP Livelihood Zone shows signs of high groundwater discharge in the past from deeper sources as evidenced from a travertine deposit collected from hydrogeology walk. At present, thermal springs are absent around this site. This could be an indicator of long-term climate change (drying). Although extensive corroborating evidence does not exist for the study area, such travertine deposits are common in northern Ethiopia and they correspond to mid Holocene wet phases.

Annex A: WELS Methodological Components

A.1 Sampling and site selection

A1.1 Livelihood zoning

Livelihood Zoning for WELS is based on livelihood zones delineated through the DMFSS' Livelihoods Integration Unit, which houses baseline data on livelihoods and food security for all 180 livelihood zones in Ethiopia[47]. Livelihood zoning for the LIU's Oromiya Region HEA baseline data collection took place in 2007-08 through zoning workshops with regional and district experts[48]. See FEG, SCUK, and RHVP 2008 for further detail on what livelihood zoning involves. WELS livelihood zone characteristics have been further detailed using a) groundwater availability mapping carried out by BGS in 1998-2000 (see Calow et al. 2002); and b) hydrogeological reports for the study area.

A1.2 Sampling within livelihood zones

Eight kebeles[49], or villages, were selected through purposive sampling in each livelihood zone. Kebeles are selected by field teams during *woreda* level interviews with government officials. Kebeles are selected to be representative of the livelihood zone within which they fall in order that baseline data is reflective of the majority of the population in the livelihood zone, so that prescriptive recommendations and conclusions do not over- or underestimate needs of the population as a whole[50].

Out of the eight kebeles sampled for this study, one to two kebeles represented sites selected for two other Growth LARS action-research components: Income Diversification action-research and Climate Change action-research studies. These sites represented proxy sites for 'adaptation' programs and included kebeles with one of a range of adaptation activities as: small-scale irrigation; rangeland management; Integrated Water Resources Management (IWRM), and Multiple Use Systems (MUS). Thus baseline data on household and wealth group access to water was collected for these 'adaptation' sites could be compared with the control group baseline data from representative sites[51].

Key informant interviews, focus group interviews, and water source site visits were conducted in each sampled *kebele*.

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47 WELS zoning aims to delineate areas of broadly similar patterns of water availability, access and use. WELS and HEA livelihood zones will be similar because surface and groundwater availability/hydrogeology and rainfall characteristics of an area are important determinants of agro-ecology and influence the range of livelihoods opportunities available to people.

48 Livelihood Zoning was further refined during fieldwork when baseline data teams confirm characteristics and zone boundaries, as well as kebeles assigned to each livelihood zone within woredas.

49 A kebele is the smallest administrative unit in Ethiopia. They are also known as 'peasant associations' (PAs).

50 In cases where needs should be assessed of the most vulnerable population within a single livelihood zone, revised 'problem specifications' or estimations of the economic or water related impact of hazards at household level are modified to reflect these cases. These are called 'pocket areas' in scenario analysis.

51 In cases where 'adaptation sites' had activities that only benefited a minority of the population (e.g. small scale irrigation), baseline data was collected for the wealth group with the largest proportion of households who were beneficiaries of the adaptation scheme, as well as for all wealth groups as typically done in representative *kebeles.* For example, if irrigation beneficiaries in the adaptation site *kebele* represented the minority of the total population, and better off households made up the majority of irrigation beneficiaries, field teams proceeded to conduct wealth group interviews with all wealth groups as is typical (very poor, poor, middle, and better off), as well as an extra adaptation beneficiary wealth group made up of the better off.

A1.3 Method of data collection

District interviews: water availability and management

Woreda level interviews were carried out with *woreda* water, agriculture, livestock, and health officers. These key informant interviews yield information on water availability through major water sources used by the population in the district. A water source inventory (both developed and traditional sources) is developed or collected during this interview for each woreda. Information on water source seasonality (yield, queuing times, quality, reliability during drought, etc), management processes, constraints to operation and maintenance, attitudes towards payment for water, etc) is also collected and representative *kebeles* identified for sampling for community level interviews. Information available on water-related disease incidence across seasons and years is completed as well.

Community level interviews: wealth breakdowns and water source inventories and mapping

At *kebele* level, field teams interviewed community key informants to obtain a local water source inventory and collect information on local water source quality, reliability, yield/capacity across seasons, and access constraints. Participatory community resource and water point mapping is also carried out. This includes the construction of a seasonal calendar of water access (detailed in following sections). Finally, field teams conduct a wealth breakdown based on local definitions of wealth to confirm or modify wealth breakdown data collected by HEA teams (see FEG, SCUK, RHVP 2008 for further detail on wealth breakdowns). Three or four wealth groups are typically identified in the wealth group breakdown by community informants (very poor, poor, middle, and better off).

Wealth group interviews: access to water at household level

Community key informants identify other community members who fall into each wealth group category specified through the wealth breakdown to participate in wealth group interviews. Each wealth group interview typically consists of four to six wealth group informants. At least half of these must be women. Through the focus group interview, a detailed account of how each wealth group obtains water for three primary uses is collected:

a) Human consumption (drinking, cooking; must be potable)

b) Hygiene and sanitation (bathing and laundry)

c) Productive uses – e.g. livestock watering, irrigation, etc.

These interviews collect information on quantities of water obtained from each water source for each use, across seasons and in drought years. Information on opportunity costs of water access is also collected, as is information on labour and time allocation across seasons. Structured interview formats facilitate the rigorous semi-structured wealth group interviews, which include built-in cross checks.

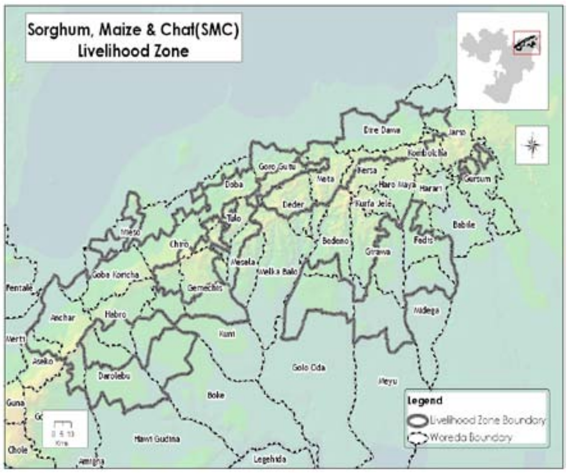
Hydrogeology Walk

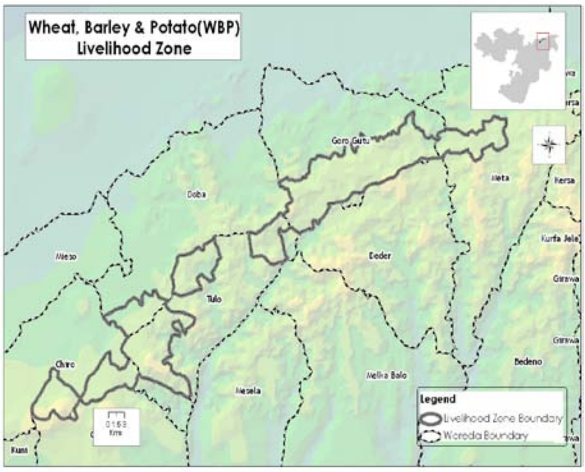
Field teams complete ‘hydrogeology walks’ in each *kebele*, constructing a map of the most important water points, natural resources, and exposed rocks in the area. Rock samples are collected at working and abandoned water point sites in each site and geographically stored using GPS. Local observations on hydrogeology and water source performance seasonally and in drought years, as well as community management and attitudes towards each source, are recorded during a 'hydrogeology walk'. A seasonal calendar of water access is constructed, noting collection times at the source in different months of the year as well as quality, yield and other relevant observations. A total of 24 seasonal calendars of water access were compiled for the current study (8 per livelihood zone). This information is supplemented by secondary geology and hydrology maps.

This information is analysed and output into a series of maps and information that can then be used to identify areas that are a) vulnerable to groundwater drought – where water supply through groundwater is likely to be much reduced or unavailable during dry seasons and exacerbated during drought; b) areas where groundwater is likely to be available during dry seasons and drought, and therefore where groundwater interventions may be effective; and c) areas where groundwater quality is already, or is likely to be in future groundwater schemes, a problem (e.g. high salinity or fluoride content). It also informs understandings of limitations and opportunities for water use for productive and domestic activities in the livelihood zone.

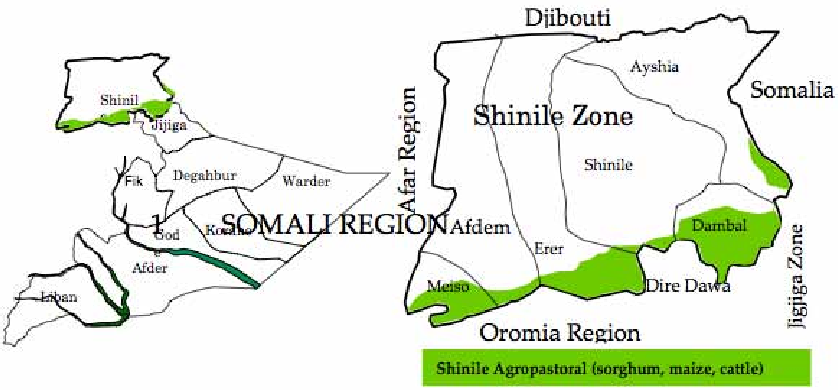
Annex B: Transect Livelihood Zone and Woreda Maps

Figure A1. Transect Livelihood Zone and Woreda Maps





Shinile Agro-Pastoral (SAP) Livelihood Zone



Annex C: Water Requirements for Humans and Livestock

Table A1. Daily water requirements for humans (Lpcd)*

Daily Human Water Requirements	**Lpcd**
Drinking & cooking	5
Hygiene & sanitation (bathing & laundry)	10
Total	15

*litres per capita per day

Table A2. Daily water requirements for livestock (Lpcd) across seasons*

Daily Water Requirements – Livestock (Lpcd)	Wet season (27° C)	Dry cold (15-21°C)	Dry hot (27°C)
	Voluntary intake	Voluntary intake	Voluntary intake
Camels	13	25	28
Lactating camels	17	30	33
Cattle	9	20	22
Lactating cows	13	26	29
Shoats	2	4	4
Horses & donkeys	5	16	18
Hens	0.10	0.10	0.10

* Voluntary intake is the daily amount of water drunk by an animal assuming that feed plants have 70-75% moisture during the wet season and 10-20% moisture during the dry season

Annex D: Survival and livelihoods protection thresholds

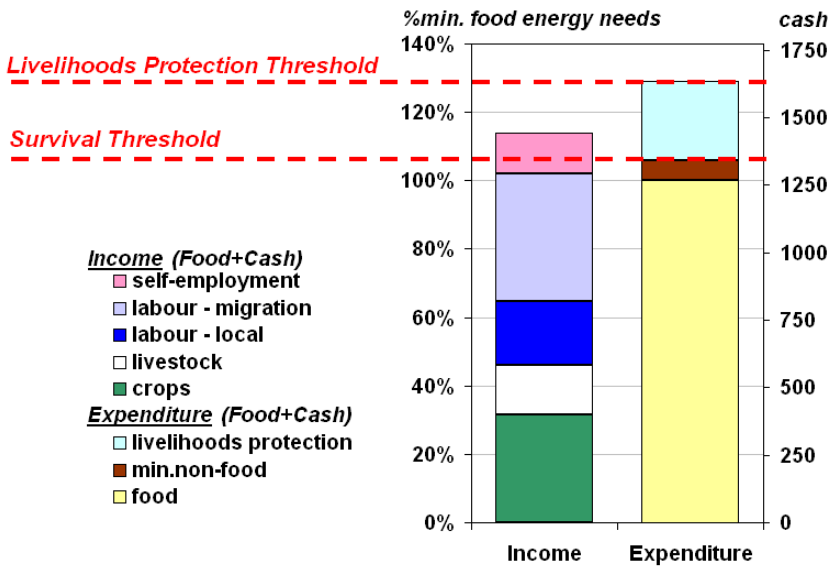
Projected total income is compared against two thresholds defined on the basis of local patterns of expenditure.

The Survival Threshold represents the total income required to cover:

a) 100% of minimum food energy needs (2,100 kcals per person), plus

b) the costs associated with food preparation and consumption (i.e. salt, soap, kerosene and/or firewood for cooking and basic lighting), plus

c) any expenditure on water for human consumption.



Note: *Items included in categories b) and c) together make up the minimum non-food expenditure basket, represented by the brown bar in the expenditure graphic.*

The Livelihoods Protection Threshold represents the total income required to sustain local livelihoods. This means total expenditure to:

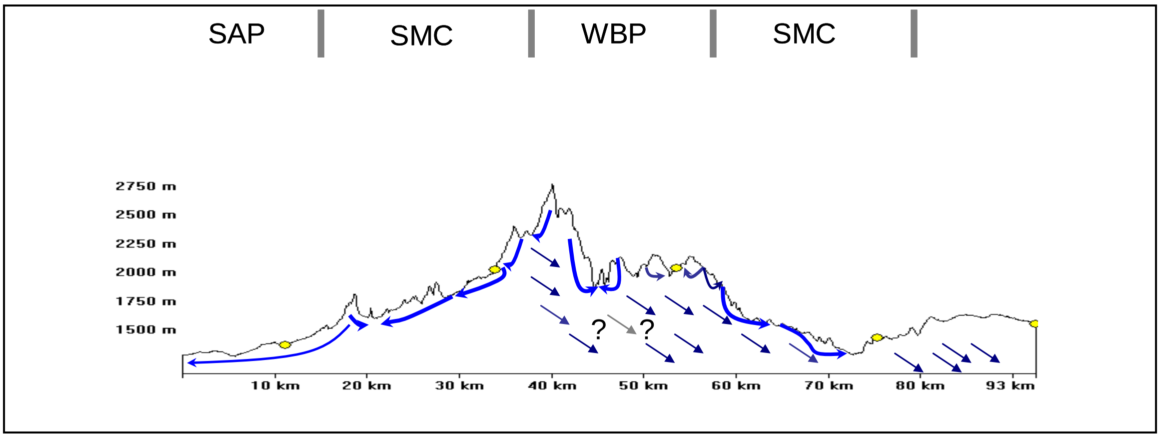
a) ensure basic survival (see above), plus

b) maintain access to basic services (e.g. routine medical and schooling expenses), plus

c) sustain livelihoods in the medium to longer term (e.g. regular purchases of seeds, fertilizer, veterinary drugs, etc.), plus

d) achieve a minimum locally acceptable standard of living (e.g. purchase of basic clothing, coffee/tea, etc.)

Annex E: Conceptual groundwater flow model for the Highland to Lowland transect



Source: Kebede and Zeleke, 2009.

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