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REGULAR ARTICLES

Constraints and challenges of meeting the water requirements of livestock in Ethiopia: cases of Lume and Siraro districts

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Abstract Compared to the total water use in livestock production systems, water for livestock drinking is small in amount but is an important requirement for health and productivity of animals. This study was carried out to assess constraints and challenges of meeting drinking water requirements of livestock in rural mixed smallholder crop–livestock farming districts in the Ethiopian Rift Valley area. Data was collected by individual interviews with randomly selected respondents and farmer group discussions. Farmers ranked feed and water scarcity as the two most important constraints for livestock husbandry, although the ranking order differed between districts and villages. Poor quality water was a concern for the communities in proximity to urban settlements or industrial establishments. Water provision for livestock was challenging during the dry season, since alternative water sources dried up or were polluted. Though rainwater harvesting by dugout constructions was practiced to cope with water scarcity, farmers indicated that mismanagement of the harvested water was posing health risks on both livestock and people. A sustainable water provision for livestock in the area, thus, depends on use of different water sources (intermittent or perennial) that should be properly managed. Industrial establishments should adopt an environment-friendly production to minimize pollution of water resources used for livestock consumption. Technical support to farmers is required in proper design and use of existing rainwater harvesting systems. Further investigations are recommended on effect of poor quality water (perceived by farmers) on performance of livestock.

Keywords Water scarcity · Poor water quality · Livestock production constraints · Farmers' perception · Ethiopia

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Introduction

Livestock have versatile roles in the Ethiopian farming systems. On top of provision of food (i.e., meat and milk), livestock play important functions as repositories of household savings, as insurance to mitigate risk, and as a source of draft power. Livestock are kept in various agroclimatic zones and agricultural production systems of the country, including mixed crop–livestock, pastoral/agropastoral, and urban/periurban systems (Benin et al. 2003; Gizaw et al. 2010). The mixed crop–livestock system in the highlands and the pastoral system in the lowlands represent the dominant form of agricultural production. The crop–livestock mixed farming system constitutes about 44 % of the total land area (Dejene 2003). It is estimated that out of 44.7 million cattle, 23.3 million sheep, and 23.3 million goats in

Ethiopia, 79, 59, and 47 % of the respective livestock species are raised in mixed crop–livestock farming systems (Cecchi et al. 2010). The synergetic interaction between crop and livestock in the system is an opportunity for sustainable food production (Legesse et al. 2008).

However, crop–livestock systems are confronted with various constraints and challenges regarding utilization of water and land resources because of very intense competition for these resources (McDermott et al. 2010). Especially, water is a very limited resource affecting sustainability of livestock and crop agriculture, people's livelihoods, and the environment (Malley et al. 2009; Descheemaeker et al. 2010; Tarawali et al. 2011). At local, regional, or global level, there is rapidly increasing competition over freshwater for domestic, industrial, environmental, and agricultural activities (Rosegrant and Cai 2002; Zimmerman et al. 2008). This necessitates application of remedial interventions in water management through targeted research and development activities.

Adequate water supply is one of the important services for the well-being of rural communities for both people and their livestock. Large amounts of water are indirectly consumed for food and feed crop production in comparison to the amount directly consumed by livestock or people (Peden et al. 2003). Though relatively small amounts are consumed directly, animals require water of adequate quantity and quality (Wilson 2007). Water requirements of livestock are affected by different factors such as species, breed, body weight, physiological status, feed type, and air temperature, among others (Schlink et al. 2010). Under tropical conditions, about 20 l of drinking water is required per tropical livestock unit (TLU) per day (Wilson 2007).

Though Ethiopia is endowed with huge water resources (World Bank 2006), a very high variation in spatial and temporal availability of water resource is one of the main problems in the country (Awulachew et al. 2007). Moreover, quality of water is also becoming one of the main problems of communities in the vicinity of urban areas associated with indiscriminate disposal of industrial and domestic wastes (Legesse and Kloos 2010). Particularly, the quality and availability of water resources in the Rift Valley area of the country is adversely affected by anthropogenic activities (Ayenew 2007). From the perspective of providing adequate drinking water to livestock, the high variation in the availability of water and the poor quality of water can have adverse effects on the health and productivity of the animals. In spite of the aforementioned facts, studies focusing on the quantity and quality of water, which are intended for livestock production, are very limited in Ethiopia. Studies assessing livestock production in Ethiopia hardly included issues of the availability and quality of livestock drinking water and at the most only gave a very limited insight without further details (e.g., Tsegaye et al. 2008). Tsegaye et al. (2008) reported scarcity of water during the dry period as one of the main constraints to livestock production. In this respect, the present study aimed to assess constraints and challenges of meeting the water requirements of livestock in the Rift Valley area of Ethiopia, mainly based on questionnaire surveys and focus group discussions with farmers. The study specifically focused on: (1) the extent to which the scarcity and low quality of water are concerns of the farmers compared to other livestock production constraints (e.g., feed and diseases), (2) the factors impairing the quality of water, and (3) the strategies adopted by farmers to cope with water problems. The study, thereby, contributes to better identify priorities for utilization and management of water sources intended for livestock.

Materials and methods

Description of the study area

The study was carried out in Lume and Siraro districts of Oromia Regional State, both located in the Ethiopian Rift Valley. The districts are characterized by mixed crop–livestock farming systems. Mojo and Lokke, the respective administrative centers of Lume and Siraro districts, are situated 70 and 308 km south of Addis Ababa, respectively (Fig. 1). The two districts were purposively selected to cover different water quantity and quality challenges of Ethiopia, in general, and the Rift Valley, in particular. Lume has a subhumid climate receiving an average annual rainfall of bout 1,065 mm. On the other hand, Siraro is characterized by a subhumid to semiarid climate, with a relatively low annual precipitation (on average, 926 mm). Vertisols (44.8 %), randzinas, and phaeozems (36.8 %) are the dominant soil types in Lume district, while sandy–loam is the dominant soil type in Siraro.

While in Lume water availability is comparatively good but prone to pollution from industrial, agricultural, and domestic effluents because of the proximity of the district to urban areas (Berehanu 2007), perennial water sources are scarce in Siraro and frequent food insecurity arises from droughts (Senbeta 2009). Mojo River traverses through Lume district from north to south and the southern border of the district is also bordered by Koka Lake. Bilate River represents the only perennial surface water in Siraro, marking the extreme southwestern border of the district. In both districts, rainwater was harvested in the form of traditional ponds (dugouts) during the rainy season.

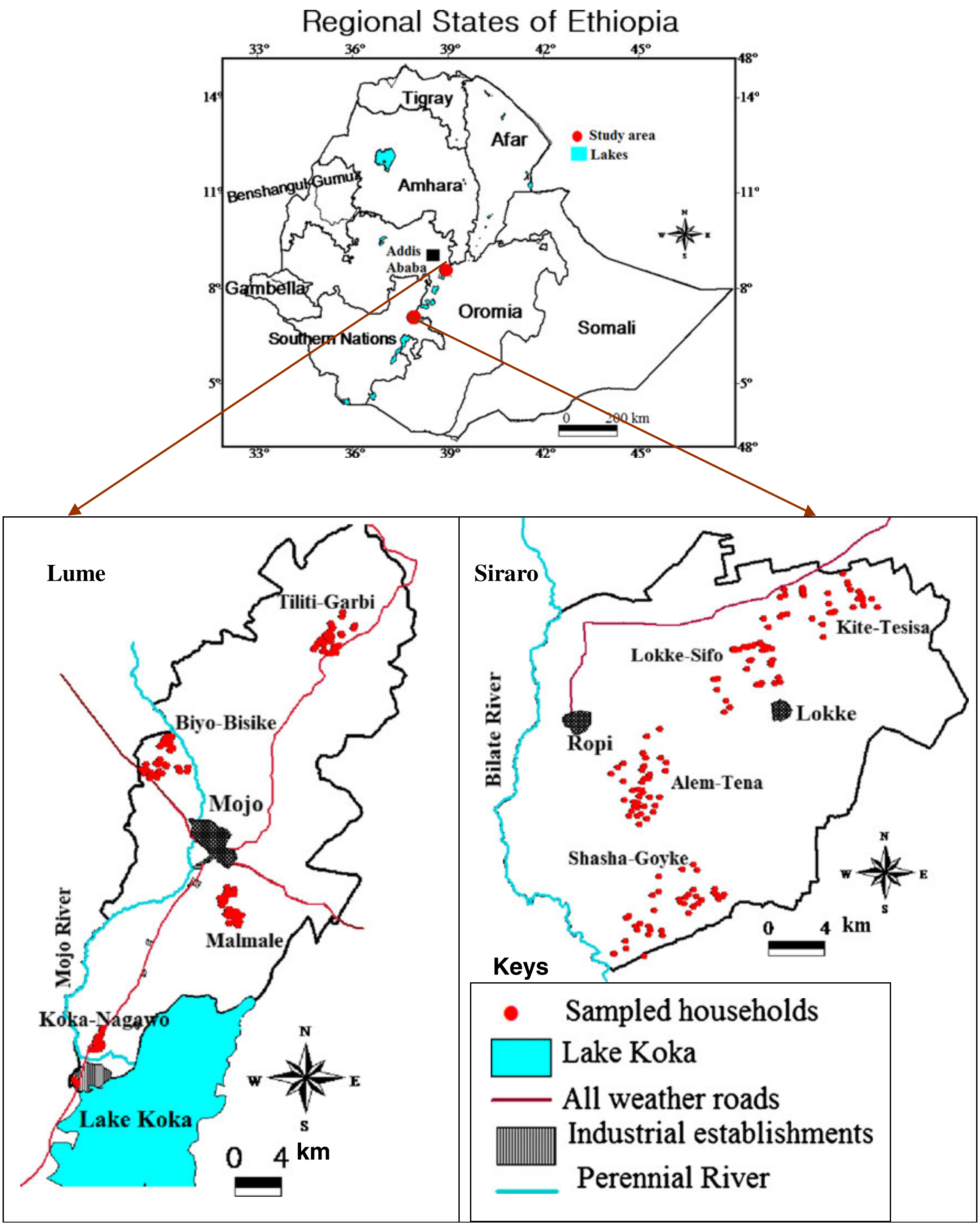

Fig. 1 Location of the study districts and surface water-bodies

According to unpublished secondary data obtained from the districts' Agricultural Offices in 2010, the livestock population in Lume accounted for 80,188 cattle, 21,922 sheep, 21,489 goats, and 20,510 donkeys. Correspondingly, in Siraro, the livestock population was estimated at 159,521 cattle, 29,803 goats, 23,933 sheep, and 19,755 donkeys. The same source of data in Lume showed that about 2.6 % of cattle are crossbreds (Zebu × Holstein or Jersey), mainly kept as dairy animals. Information on the proportion of crossbred cattle in Siraro was not available but assumed to be less than in Lume. Those farmers keeping crossbred dairy cattle, specifically in Lume, sell surplus milk to primary milk marketing cooperatives, private milk collectors, hotels, or neighbors.

Sampling scheme

After selection of the districts, a two-stage random selection (selection of villages followed by selection of households) was employed to identify the households for the questionnaire survey. Based on the lists of villages obtained from each district and village administrative offices, four villages (Biyo-Bisike, Koka-Nagawo, Malmale, and Tiliti-Garbi) were selected from a total of 35 villages in Lume, and four villages (Alem-Tena, Kite-Tesisa, Lokke-Sifo, and Shasha-Goyke) from a total of 28 villages in Siraro district. In each of the selected villages, 40 households were randomly chosen using computer-generated random numbers (with 10 additional households selected for reserve, in case of inaccessibility of the households or insufficient participation). In total, less than 5 % of the households were replaced during the actual questionnaire survey.

Data collection

The data collection lasted from July to October 2010, employing individual farmer interviews and focus group discussions with farmers. The latter served to complement information collected by the individual interviews. In the questionnaire survey, a total of 320 households (160 in each district) were interviewed using a structured questionnaire format developed in English and translated to Oromo, a language widely spoken in the study area. The format was pretested for clarity and logical flow by interviewing selected households (three respondents in each district), which were later discarded from the random selection for the actual interviews. Before the interviews, verbal consent was obtained from each of the respondent by explaining the objectives of the survey. At the same time, the anonymous use of the collected information was assured. The questionnaires included socioeconomic characteristics of the households, rankings of the constraints for livestock production, and seasonality of water scarcity. In order to assess the constraints for livestock production, the respondents were requested to list constraints they were experiencing in relation to livestock husbandry. Thereafter, the constraints were grouped into categories, i.e., disease, feed scarcity, low offspring output, inadequate veterinary service, water shortage, and poor water quality. The constraints were ranked according to their priority, starting with one for the highest priority problem and continuing ranking up to the number of constraints mentioned by a respondent. There was the possibility to make “tied rankings” (giving two or more constraints the same rank) or to leave the constraints unranked. Unranked constraints were later given the last number and considered as “tied ranks” (Allison and Christakis 1994).

Two group discussions (one each for male and female participants, respectively) were held in each village (in total, 16 group discussions). Random selection of participants for the group discussions was not possible due to difficulty in calling the participants to a central place from the scattered households. Instead, a transect walk was made through the villages, stopping at household clusters and inviting people from nearby households to join the discussions. It was aimed to limit the number of participants to eight to 10 people. In Siraro, there were several occasions when up to 15 participants attended the discussions, however, without affecting the flow of discussions. Criteria for participating in the group discussion were that the participants were residents of a specific village and above 18 years old. The participants were informed about the discussion topics and verbal consent was obtained before starting the discussions. Among other livestock constraints, the discussion mainly focused on three key issues: (1) water problems (quantity and quality) for livestock uses, (2) local coping practices to tackle the water problems, and (3) potential challenges regarding the practices. In addition to questionnaire survey and focus group discussions, secondary data on the price, status, and management of improved water sources intended primarily for domestic uses and also used for livestock were obtained from the Water Resources Development Offices of the respective districts.

Data analysis

Descriptive statistics (frequencies and means) were used to summarize households' socioeconomic characteristics and livestock ownership. We applied chi-square test for proportions of categorical variables and Student's t test for continuous variables to compare the two districts. The Shapiro–Wilk test confirmed normality for age of household head and family size, while other variables such as landholding size and number of different livestock species were skewed. Homogeneity of the variance was tested using Levene's test for different variables. The variances of the continuous variables were found to be equal between the two districts, except for sheep and goats flock size, family size, age of household head, and landholding. The sample size in each comparison group was fairly large ($\geq$34), and under such condition, the independent t test is considered to be robust, even in the presence of skewed distributions (Stonehouse and Forrester 1998). Therefore, the t test was preferred to compare the means of the continuous variables.

The mean ranks of the different constraints were calculated for the overall sample as well as for the district and village levels. To further elucidate the extent of water shortage and poor quality in the study area, the percentage of respondents who ranked the two constraints as first or second priority problem was calculated. Data collected through group discussions were analyzed qualitatively by organizing the issues

Table 1 Households' socioeconomic characteristics in Lume and Siraro districts, Ethiopia

Characteristics	Lume (n=160)		Siraro (n=160)		Significance of variables
Continuous variables	Mean	SD	Mean	SD	
Age of household head (years)	46.9	14.2	38.6	13.5	*
Family size (number)	6.3	2.4	8.3	4.1	*
Landholding (ha)	2.5	2.1	1.8	1.3	*
Categorical variables	Percent		Percent		
Male-headed households	90.0		94.4		ns
Education of household head					
Illiterate (no writing and reading abilities)	35.0		68.1		*
At least writing and/or reading abilities	65.0		31.9		*

SD standard deviation of the mean, *ns* not significant

*α=0.05 (statistical significance using chi-square for proportions or *t* test for means)

raised into logical categories. All statistical analyses were done in Stata 9 (StataCorp, College Station, TX, USA).

Results

Households' socioeconomic characteristics and livestock keeping

As can be seen in Table 1, most interviewed household heads were male, with a considerably higher average age in Lume than in Siraro. The survey showed a higher illiteracy rate and larger average family size in Siraro than compared to Lume (68 % vs. 35 % and 8.3 vs. 6.3, respectively). The average landholdings in Siraro were smaller than in Lume (1.8 vs. 2.5 ha).

The farmers kept multiple species of livestock and all of the surveyed households owned at least one cattle. Next to cattle, donkeys were the second most common livestock species kept by the majority of surveyed households in both districts. The cattle herd in Lume was dominated by oxen, whereas a larger number of cows and bulls were kept by households in Siraro (Table 2). In Siraro district, farmers kept more goats and less sheep than in Lume, while overall small ruminant flock sizes were higher in Lume (Table 2).

Seasonality of water provision

Results of the questionnaire survey show that different water sources in the districts were utilized to meet the water requirements of livestock. The water sources for livestock were either groundwater (hand-dug wells and boreholes) or surface water (rivers, dugouts, and surface runoff from roadsides).

High seasonal variation becomes evident from the percentage of respondents utilizing different water sources for livestock (Fig. 2). The Bilate River was the dominant source of water for livestock in the dry season in both districts. During the wet season, farmers in Siraro were shifting towards dugouts as the main source of water for their livestock. There was a large variation between dry and wet seasons in the perceived water scarcity by the farmers with the

Table 2 Livestock ownership, herd size, and composition by district

Types of livestock	Lume			Siraro			Significance of variables
	n	Mean	SD	*n*	Mean	SD	
Cattle	160	5.3	5.2	160	6.5	6.9	*
Oxen	156	2.2	1.4	133	1.8	2.2	*
Uncastrated male	60	1.3	1.0	97	1.6	1.4	*
Nonlactating cows	121	1.6	1.5	154	2.1	2.3	*
Lactating cows	70	1.5	1.1	117	1.4	1.3	ns
Heifers	71	0.7	1.0	115	1.6	1.4	*
Calves	65	1.7	1.7	110	1.5	1.3	ns
Donkeys	131	1.0	0.6	125	0.9	0.6	ns
Goats	49	0.6	0.6	70	0.4	0.4	*
Sheep	53	0.6	0.5	34	0.3	0.3	*
Total TLU	160	6.5	5.7	160	7.5	7.6	ns
No. of respondents	160	–	–	160	–	–	–

Conversion factors: 1 head of cattle=0.7, 1 head of horse=0.8, 1 head of mule=0.7, 1 head of donkey=0.5, 1 head of sheep/goat=0.1 (Jahnke 1982)

n number of households keeping the specified type of livestock, *SD* standard deviation, *TLU* tropical livestock unit (equivalent to a hypothetical animal of 250 kg), *ns* not significant

*α=0.05 (statistical significance; *t* test)

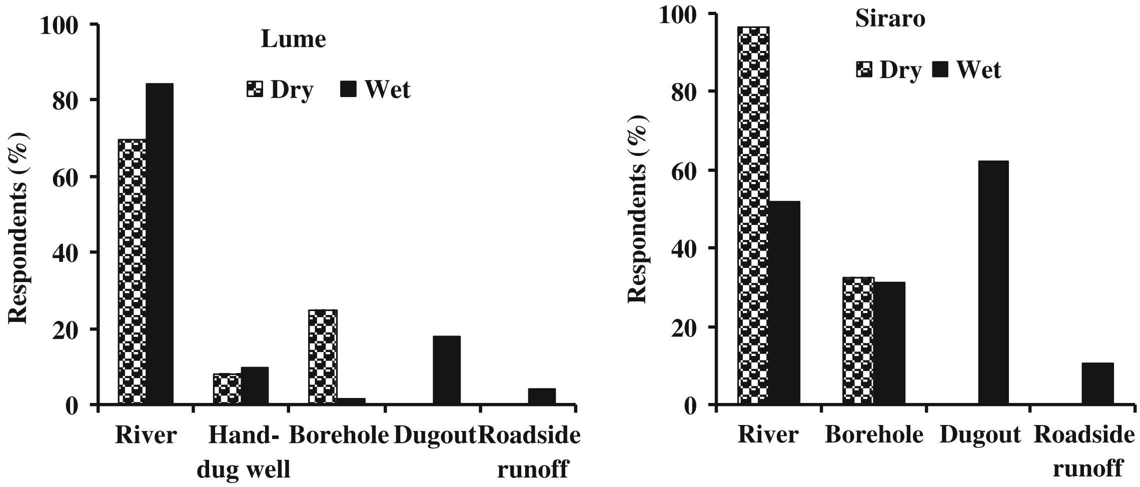

Fig. 2 Sources of water for livestock consumption in dry and wet seasons: results of questionnaire survey (percentages do not add up to 100 % because multiple answers were allowed)

majority of the people experiencing water scarcity for livestock during the dry months of a year. The results show that more than 40 % of the respondents in Siraro experienced water scarcity for their livestock the whole year round (Fig. 3).

Water problems in comparison with other constraints for livestock production

Table 3 shows the mean ranks of the constraints of livestock production assessed in this study. The order of the ranking was different between districts and villages. The top ranked constraint in Lume was shortage of feed, followed by shortage of water and diseases, while in Siraro water shortage was perceived as more important in limiting livestock productivity than feed shortage. Out of the total respondents in each district, 34 and 65 % of the respondents stated water shortage as a first or second priority constraint in Lume and Siraro, respectively. The corresponding percentages for poor quality water were 34 % in Lume and 11 % in Siraro (Fig. 4). The results disaggregated to the level of villages show that the farmers in the downstream of Mojo River (Koka-Nagawo and Malmale) ranked poor water quality as the second most important problem for livestock husbandry. In Siraro, shortage of water was the first priority problem of Kite-Tesisa and Lokke-Sifo villages and was given an intermediate rank compared to other constraints in the other two villages (Table 3). In the villages of Lume district, the percentage of respondents who ranked water shortage and poor quality water as first or second top priority constraint ranged from 38 to 43 % with the percentage for poor quality water ranging from 0 to 63 % with the high percentage in the downstream villages. In the villages of Siraro district, water shortage was ranked as first and second priority problem by a large number of the respondents ranging from 28 to 100 %. Only 3 to 25 % of the Siraro respondents ranked poor water quality as first or second priority constraint (Fig. 4).

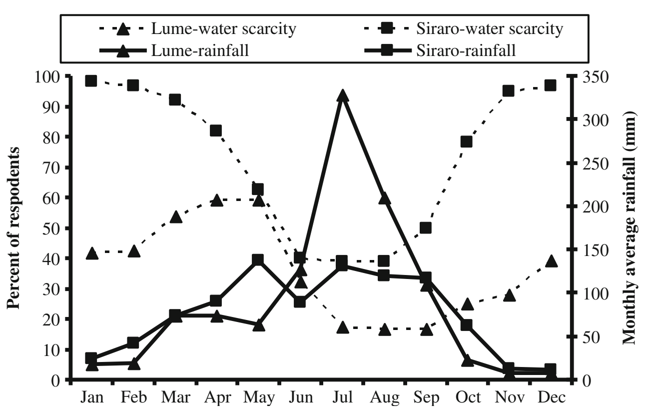

Fig. 3 Monthly pattern of water scarcity, as experienced by farmers, in relation to monthly rainfall distribution (note: rainfall data obtained from the National Meteorological Service Agency of Ethiopia for the duration of 2004–2008, for Mojo (in Lume) and Alaba (near Siraro) stations)

Group discussions

In the group discussions, different constraints related to water provision for livestock were identified and described in detail in order to complement the results of the individual questionnaire survey. The constraints were more specifically described on village level and varied accordingly. In Biyo-Bisike and Koka-Nagawo, two villages in Lume, water availability in terms of quantity was not perceived as a problem, contrary to the other two villages in the district. Instead, seasonal flooding of the farm and grazing land was mentioned as problematic, specifically, in Koka-Nagawo. Poor quality water was reported as another pressing problem in Koka-Nagawo, being associated to tanneries and abattoirs

Table 3 Mean rank of the constraints for livestock production by districts and villages

Constraints	Overall	Lume	Siraro	Villages in Lume				Villages in Siraro			
				KN	M	BB	TG	AT	SG	KT	LS
Shortage of feed	1.8	1.3	2.3	1.4	1.1	1.7	1.2	2.5	2.4	2.0	2.3
Shortage of water	2.5	2.9	2.1	3.4	2.6	2.8	3.0	3.3	2.5	1.1	1.5
Diseases	2.9	3.0	2.7	2.9	3.6	2.6	3.0	1.4	1.8	3.6	4.1
Poor quality water	3.5	3.4	3.5	2.7	2.4	3.1	5.5	3.8	4.0	3.6	2.7
Inadequate vet. service	4.1	3.6	4.6	3.4	3.6	3.0	4.3	4.2	4.9	4.2	5.0
Low offspring output	4.2	3.4	5.0	3.3	3.6	3.1	3.5	5.0	5.3	4.4	5.4

The lower the mean rank of a constraint, the higher the importance of the problem

BB Biyo-Bisike, *KN* Koka-Nagawo, *M* Malmale, *TG* Tiliti-Garbi, *AT* Alem-Tena, *KT* Kite-Tesisa, *LS* Lokke-Sifo, *SG* Shasha-Goyke

located along Mojo River, into which effluents from the factories were directly discharged without any treatment.

In Siraro, water scarcity was the highest priority problem mentioned and a major concern for the people, limiting livestock productivity. It was indicated that in most villages of the district, animals were trekked over long distances to get access to water, particularly in the dry season when temporary water sources like dugouts and roadside runoffs dried up.

Different local strategies were applied to cope with the existing problems of water provision for livestock. These were either making use of alternative water sources or altering livestock management to suit to current conditions (e.g., decreasing herd size and keeping only selected groups of livestock). Water resources harnessed by initiatives of the local community included dugouts (rainwater harvesting) in Siraro and hand-dug wells in Lume. Dugouts were constructed in such a way that the runoff from slope fields or along roads is diverted and collected in excavated land. Dugouts were used when perennial water sources were inaccessible for the rural residents. Shallow wells primarily dug for domestic consumption in Lume were also used for livestock drinking, especially for selected groups of animals (oxen, lactating cows, and young animals). The associated problems reported by the farmers in the use of hand-dug wells for livestock were collapse of the wells, poor financial capability of the farmers to cover the cost of construction, and high labor requirement to lift the water. The farmers had indicated various problems and challenges with regard to dugout construction and management of the harvested rainwater. The commonly mentioned problems were failure of the dugouts to receive enough surface runoff and quick loss of water through evaporation and seepage. Shortage of land for dugout constructions and dwindling interest of the farmers in the proper management of the harvested rainwater were also the main challenges reported by the farmers in Siraro. According to the group discussants (specifically in Siraro), the recently drilled boreholes were perceived to be unreliable and expensive, generally reducing interest in the proper management of dugouts by the farmers. As a result of the mismanagement, the quality of the water was found to be deteriorating to such an extent that even animals abandoned drinking the water. The farmers reported animal morbidity and mortality to be a result of drinking the poor quality stagnant water, especially at the end of the wet season.

A change in livestock management was adopted by the farmers as a strategy to cope with the prevailing constraints, particularly, water scarcity in the area. The strategies included keeping only important animals (e.g., oxen for draft power in Lume), giving access to water for selected groups of animals (e.g., oxen and lactating cows), and reducing the frequency of livestock watering in the dry seasons.

Improved water sources and water price

Protected springs, boreholes (diesel or electrically operated), and shallow wells (hand pump or wind pump) were the improved water sources in Lume. In Siraro, all of the improved schemes were boreholes. Improved water schemes

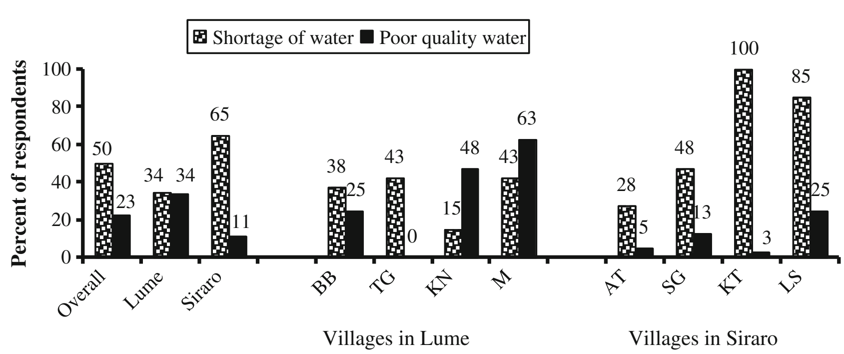

Fig. 4 Percentages of respondents ranking shortage of water and poor quality water as top (first or second) priority constraints for livestock production

were constructed by the government or nongovernmental organizations with relatively small one-time contributions (in cash, in kind, or in labor) from the local communities. In both districts, a community-based water management approach was used to manage the improved water schemes. Operational and maintenance costs of the water schemes are covered by its users (i.e., the communities) with subsidies from the government (when major maintenance is needed). According to data obtained from the water resources development offices of the respective districts, the price set for rural improved water supply was village- and scheme-specific. As an example, water price for a specific borehole in Lume was 7 and 16.7 Birr/m^3 in Siraro (exchange rate: US$1=13.5 Birr in July 2010). It was evident that variation in the price existed among villages depending on the types of energy used to abstract the water. In addition to the regular pricing, an informal market for water was also common in Siraro. In times of scarcity, water fetched from any source (including from rivers and dugouts) was usually sold at a high price (up to 3 Birr/20-l jerrycan). At the time of the questionnaire survey (July 2010), livestock watering troughs connected to improved water schemes were available in four villages of Lume (out of 35 villages) and in three villages of Siraro (out of 28 villages). The price for livestock drinking was commonly set based on the assumption that one cattle or donkey drinks 20 l of water (one jerrycan). For small ruminants, no price was set and they were watered irregularly.

Discussion

The differences in the livestock holding size and herd structure observed in the study area are a direct reflection of the objectives of keeping the specific livestock species. Cattle specifically dominate in the area, with all of the interviewed households keeping at least one. In the mixed crop–livestock systems of Ethiopia, cattle play a major role as a source of draft power, among other functions (Gryseels 1988). The large number of oxen kept by farmers in the more crop production-oriented district of Lume is linked with the power required for land tillage of the vertisols (predominant soil type in the district), compared to the sandy–loam soils of Siraro. The high clay content and the unfavorable consistency of vertisols makes seedbed preparation a difficult task and up to six passes are required before crops like teff and wheat can be sown (Woldeab 1988), necessitating more draft oxen. Moreover, it became evident in the group discussions that the scarcity of resources (e.g., feed and water) was forcing the farmers to keep only small herds of livestock.

The overall rank ordering of the various constraints for livestock production in this study is consistent with a previous one (Tsegaye et al. 2008) that reported continuous shrinkage of land, feed shortage, and water scarcity as the main constraints for livestock production in Central Ethiopia (including Lume district). Similarly, Gruber et al. (2009) reported forage, diseases, and water as the main difficulties faced by farmers in mixed crop–livestock farming systems of Benin. The differences in the ranks among villages of the same district could be associated with site-specific problems. As such, the communities in the proximity to urban settlements or industrial establishments (i.e., in the downstream of Mojo River) stated poor water quality as the second most important constraint for livestock husbandry after feed scarcity. Those villages were facing problems of water and environmental pollution associated with upstream urban and industrial activities. Mojo is one of the industrial towns in Ethiopia, where many poorly regulated industries are located (Berehanu 2007). Tanneries and abattoirs are the predominant industries, which directly discharge effluents to water bodies without control (Leta et al. 2003). For example, it was reported that only two out of five tanneries located along Mojo River (in July 2010) had functional wastewater treatment facilities (Amenu et al. accepted). Related studies showed that some quality parameters (e.g., pH and total dissolved solids) of Mojo River water are above the recommended levels for livestock consumption (Leta et al. 2003; Amenu et al. accepted).

Water shortage was ranked as an important problem in those villages, which are located far from perennial surface water sources (up to 20 km straight-line distance for some villagers). In order to cope with the problem of water scarcity, dugout constructions were common in the area. The dugouts were available in many of the villages in Siraro during the wet season, with the exception of villages with sandy (porous) soils. In the case of porous soils, the people continuously depended on distant river water or bought water from boreholes. The tendency of mismanaging the dugouts by the farmers, which was evident in this study, can pose a health risk to humans and livestock. The reason for the low interest in the proper management of the dugouts might be associated with people shifting towards borehole water sources. However, boreholes are inherently expensive and unreliable. It was observed that rainwater harvesting in the form of dugouts in the study area was not getting enough technical support from governmental or nongovernmental organizations. If properly managed, the harvested rainwater can satisfy substantial water requirements for livestock in the area. Therefore, technical support is needed for farmers in the proper design and use of already existing rainwater harvesting systems.

Provided that surface water sources in the study area are either industrially polluted (e.g., Mojo River) or mismanaged (e.g., dugouts), an increasing dependency on groundwater sources (e.g., boreholes) could be uneconomical, leading to high competition with water intended for domestic consumption.

The seasonal variation in the availability of water for livestock was significant and closely linked to rainfall patterns (Fig. 2). Water scarcity was a pronounced problem of the communities especially in the dry season. The high seasonal fluctuation in the quantity of water for livestock consumption can adversely affect the performance of livestock. Small changes in body water content can cause profound changes in the animal's body functions and lead to reduced productivity within a relatively shorter time compared to feed deprivation (Nicholson 1985). In addition, water scarcity might also affect the safety of milk and milk products, as farmers are obliged to use low quality water for cleansing of the milk utensils in case of water shortages especially during the dry season. This can be a potential source of contamination of the milk and milk products (Kivaria et al. 2006; Grimaud et al. 2009), increasing the public health risk in the study area.

Climate change could additionally aggravate the challenge in meeting the water requirements of livestock, as it might affect the hydrological regime in the area and subsequently, the availability of water resources (Malley et al. 2009). Previous studies (Hailemariam 1999; Wagesho et al. 2012) showed that climate change in terms of uncertain rainfall and increased temperature is affecting the availability of water resources in the Rift Valley of Ethiopia (including the study area). In response to increased temperatures, the water demand by livestock increases for body thermoregulation (Thornton and Herrero 2010).

It can be concluded that water quantity and quality were perceived as the major constraints for livestock production by farmers. The seasonal fluctuation in the availability of water was the most specific problem of the livestock keepers. Water pollution attributed to industrial activities in downstream villages of Lume district has the potential to cause reduced productivity and impaired health of livestock. Therefore, there is a need for enforcement of existing environmental rules and regulations. Moreover, awareness creation is required involving the owners of the industries on proper waste disposal mechanisms and environmental accountability. Technical support is required in the proper design and management of dugouts, which were established to cope with water scarcity, specifically in Siraro district. Further investigations on the direct effects of water sources on the health and performance of livestock are recommended.

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