Livestock Owners' Perception on the Impact of Ghibe-III Hydroelectric Dam on Bovine Trypanosomosis, Southern Ethiopia

Author: Wudneh, Solomon Mekuria

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Solomon Mekuria Wudneh

Hawassa University Faculty of Veterinary Medicine, Ethiopia.

ABSTRACT

BACKGROUND: Trypanosomosis is an endemic livestock disease in Ethiopia. The problem prevails mainly in the South, Southwest, and Northwest regions following main rivers and their tributaries.

METHODS: A cross-sectional questionnaire survey was conducted in Loma and Kindo Didaye districts near the Ghibe-III hydroelectric dam, to compare dam impact upstream and downstream, from January 2019 to June 2020. Two hundred standardized questionnaire surveys were administered. The questionnaire included biography, livestock population before and after dam construction, knowledge of major livestock diseases, clinical signs, transmission, seasonality, and wildlife population status was assessed. Data were analyzed using Mann–Whitney *U* Test.

RESULTS AND DISCUSSION: A total of 189 questionnaires were returned out of 200 questionnaires administered. Among the respondents, the majorities were males and had an average age of 39.4 + 10.6. In all herd size levels, there was no significant ($P > .05$) difference before dam construction between the 2 districts; whereas, statistically significant ($P < .05$) large and medium herd sizes increased by 16%(95% CI: 0.5, 31.5) after dam construction in Loma district; whereas, the same herd size reduced by 20%(95% CI:0,43.7) after dam construction with statistically significant($P < .05$) difference. Bovine trypanosomosis ranked first among major diseases. Knowledge of clinical signs, transmission, and seasonality of trypanosomosis was consistent with the literature. 87.8% of respondents in Loma associated reduction of trypanosomosis and tsetse population, but 77% of Kindo Didaye respondents perceived no change in prevalence after dam construction. More reduction in wildlife population was observed upstream than downstream, health services improved, and disease outbreaks and cattle deaths were reduced. Studies in African countries indicate the reduction in tsetse apparent density and absences of wildlife contributed to the reduction of trypanosomosis.

CONCLUSION: An increased herd size, reduced trypanosomosis prevalence, and wildlife population observed upstream, indicate artificial Lake has an impact on tsetse apparent density. Therefore, follow-up of the disease prevalence and investigation of drug resistance is recommended to prove the situation in the study area.

KEYWORDS: Community perceptions, Ghibe-III dam, trypanosomosis, upstream and downstream, Southern Ethiopia

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CORRESPONDING AUTHOR: Solomon Mekuria Wudneh, Hawassa University Faculty of Veterinary Medicine, Hawassa, P.O.Box 05, Ethiopia. Email: solmk2010@gmail.com

Introduction

African animal trypanosomosis is one of the economically important livestock diseases in sub-Saharan African countries.[1] The disease is mainly caused by *T.brucei*, *T.congolense*, *and T.vivax*, and is transmitted cyclically by the tsetse fly (Glossina spp).[2] Nearly 37 sub-Saharan African countries and their productive land is excluded from livestock and crop production due to trypanosomosis and its vector tsetse fly. Cattle production in Africa plays a significant contribution to crop production through draught power, beyond their meat, milk, manure, and economic value.[3] Despite their inevitable economic role, livestock diseases in general and animal trypanosomosis, in particular, continue stumbling promote blocks promoting the livestock production sub-sector.[1] Animal trypanosomosis affects negatively due to mortality, retarded growth rate, reduced reproductive performance, low milk production, and poor draught power.[4] Trypanosomosis is estimated to reduce cattle density by 37% to 70%, off-take by 50%, reduce calving rate and increase calf mortality by 20%.[3] Diagnosis of trypanosomoses in affected sub-Saharan Africa particularly in Ethiopia, merely depends on farmers' information confirmed by parasite identification. Other diagnostic tests like serological and molecular diagnostics techniques are not applicable in routine disease investigation, which is usually used for research purposes. Furthermore, the cost and complex technology of PCR analyses are still limiting factors for generalized routine use of the test in remote enzootic/endemic areas. Although DNA detection methods exhibit higher sensitivity and specificity than parasitological methods, they are affected by the same limitations mentioned above.[5] Serological methods for trypanosomoses appear useful, because of their high sensitivity and specificity regarding the pathogenic trypanosomes. However, cross reactions are very strong between pathogenic trypanosomes.[6]

As a result of the variant surface antigen (VSG) nature of the parasite and the emergence of drug resistance, control measures including vaccine production remains a challenge for all stakeholders. Trypanosomosis situation end with ineffective control methods, despite the significant negative impact of trypanosomosis in sub-Saharan Africa. Though there are parasites and vector control techniques using chemotherapy, insecticide, trap, and target intervention, and hence disease problems remained for years.[1,4]

In Ethiopia, tsetse and trypanosomosis are widely distributed in North-Western, Western and South-Western regions following main rivers and their tributaries. Didessa, Blue Nile, Baro-Akobo, Ghibe–Omo, and their tributaries are among many other infested areas; hence livestock and crop production are severely affected in these river gorges.[7] Ghibe-III hydroelectric dam is located within the Ghibe-Omo gorge where tsetse and trypanosomosis are prevalent. The dam construction period took 10 years from 2006 to 2016 G.C. During the dam construction period and at the time of water reserve tsetse habitat was disturbed significantly. The water reservoir covered 200 km^2 that was hindered livestock production. The study has not been conducted following dam construction.

Therefore, it was important to understand the influence of human activities in the area, assessment of community perceptions toward the impact of the Ghibe-III hydroelectric dam on trypanosomosis was one of the targets to be studied. Furthermore, poor health coverage in most trypanosomosis-affected areas, the responsibility of health management mainly falls to livestock owners,[8] shortage of knowledge leads to under-dosing and fostering drug resistance.[9,10]In line with this it was important to understand community perceptions of the Ghibe-III hydroelectric dam's impact on bovine trypanosomosis. Hence, the objective of this questionnaire survey was to understand community perceptions on the impact of the Ghibe-III hydroelectric dam on animal trypanosomosis and to assess community knowledge on major livestock diseases in the area, causes, clinical signs, transmission, and seasonality of trypanosomosis.

Material and Methods

Study area

Two districts were used for this study. Kindo Didaye and Loma districts are located in Wolayta and Dawro zones, respectively; as shown in Figure 1. The study area encompasses 2 physical features due to the presence of the Ghibe-III hydroelectric dam; where Loma is located on the upstream (reservoir) side which is covered by a water reservoir. Loma has 36 peasant associations (PAs) and 4 towns. Out of these, 9 PA's are bordering Omo River near Ghibe-III water reserve side. Loma district has 4 tributaries that supply the Omo River. Namely: Kareta, Mala, Manta and Gindera rivers. Despite trypanosome and other diseases in the district, it was endowed with a livestock population according to the district veterinary officials. Accordingly, Cattle 183 832, Ovine 74 943, Caprine 92 768, Equine 18 205, and Poultry 207, 927 animal population was recorded according to Loma district Livestock resource office annual report of 2017. Kindo Didaye is located downstream (below the dam), where the ecosystem remained more or less naturally intact except due to seasonal bushfires. According to veterinary officials' livestock population in the district record indicate Cattle 113 122, Ovine 11 298, Caprine 24 452, Equine 6186, and Poultry 96 504 from district livestock resource office report. The district has 20 Peasant associations(PAs) and 3 towns. 13 PAs were affected by trypanosomosis disease in the district. Of these, 7 PA's are known to border the Omo River.

Climate

The amount of rainfall decreases throughout the Omo-Ghibe catchments with a decrease in elevation, which varies from a minimum of 1200 mm to a maximum of about 1900 mm. The average annual rainfall calculated over the whole Ghibe III basin where the dam is located is 1426 mm. 75% to 80% of the annual rainfall occurs during 5 months from May to September. The mean annual temperature is 20.4°C .[11]

Fauna and flora in the study area

Wildlife in this study area is not populous as that of game reserve areas in the Mago and Omo national wildlife reserve area. However, different wild animals have been recorded at various levels of density. Among these warthogs, guzzles (greater kudu), buffalo, lion, deer, fox, apes, monkey, hyena, etc were reported. Vegetation was a good habitat for diverse wildlife species except those threatened by wildfires during the dry season. On top of bushfires, intensive human activities at the time of dam construction affected the habitat, especially in the upstream area. At the time of deforestation, before water reservation started, wildlife was pushed from its original place downstream where there were lesser human activities.

On the other hand, various species of flora were recorded in Omo-Ghibe Valley.[11] Among these riparian vegetation covers 8.8%, and deciduous woodland covers about 82.2% and it is characterized by approximately 2% tree cover and 98% grass. Mixed woodland and savanna trees recorded in the area, such as *Brachystegia, Terminalia spp. Commiphora, Combretum, Acacia spp, and Teclea*.[1] River/ water body covers 4.3% of the reservoir area. Farming practices and settlement are concentrated in areas outside the valley at 1100 m.a.s.l and above. Dense vegetation and tickets are concentrated between the reservoir and farming activities with the range of 880 to 1000 m.a.s.l. Trees found near the reservoir are more diversified, due to moisture and a suitable environment. The altitudinal ranges, temperature, humidity, and the composition of the vegetation in the reservoir area provide ideal conditions for tsetse fly infestation. Upstream of the dam have been covered by water reservoir about 200 km^2 area as the result wildlife habitat and tsetse breeding site submerged. It was assumed tsetse population and trypanosomosis challenge may be reduced due to environmental shock until the survivors regain or adapt new environment.

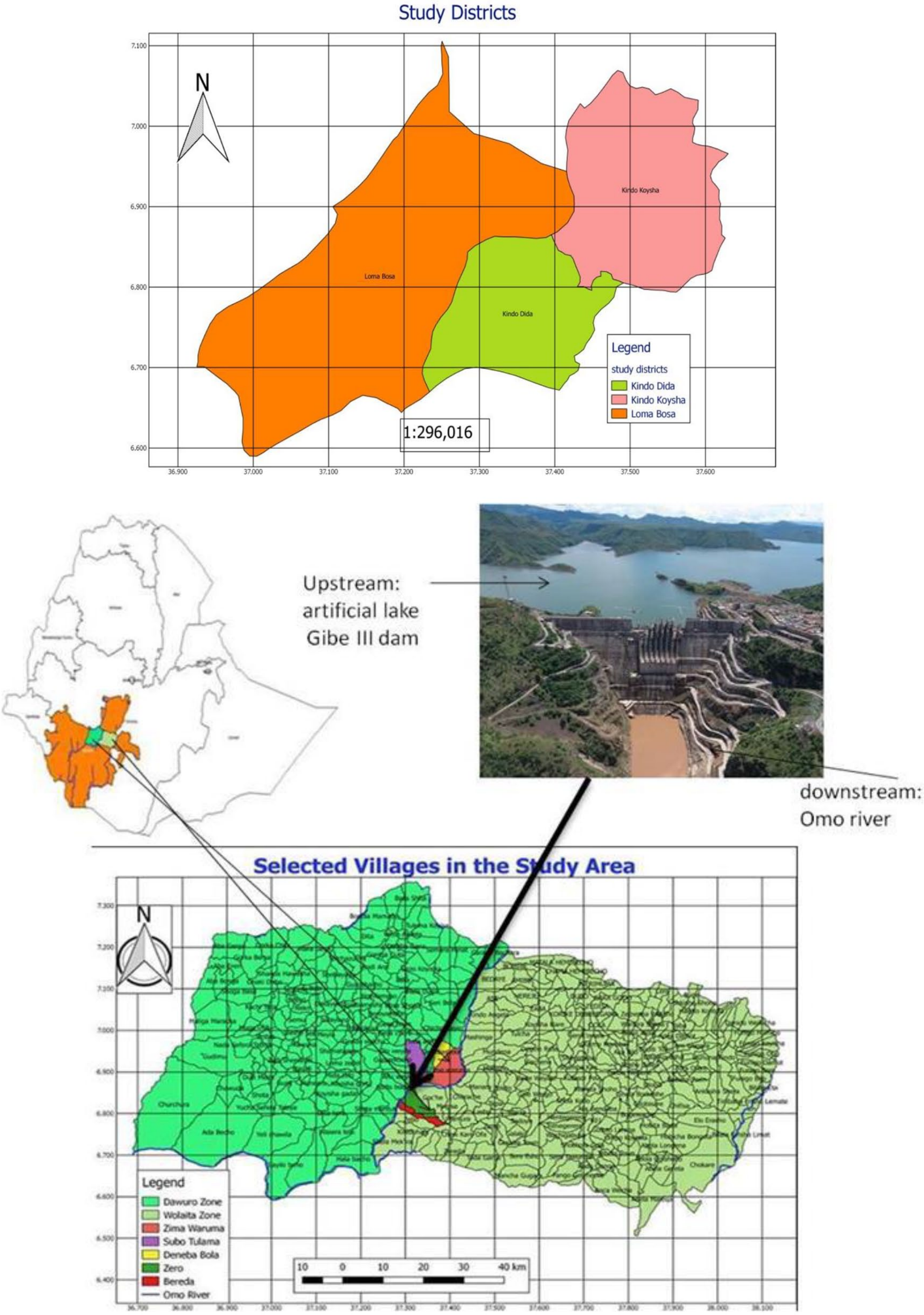

Figure 1. Map of Ethiopia showing study sites in Lomma (left side) and Kindo Didaye (right side) district (Dam image: https://www.salini-impregilo.com).

Study population and design

Peasant associations that are affected by tsetse and trypanosomosis were identified and used for further sampling. Three tsetse-infested peasant associations were selected from each district and a total of 6 peasant associations were used to administer the questionnaire.

Smallholder farmers located in each selected PA of Loma and Kindo Didaye districts were considered. All farmers found in the selected PA's are included in the list before randomization takes place. An individual farmer was selected randomly from the list using a lottery system. A cross-sectional study design was used for this particular questionnaire survey. The information includes herd/flock size owned by the interviewee before and after dam construction, major diseases, perception of trypanosomosis and the tsetse fly, transmission and seasonality of trypanosomosis, and other related questions included.

Sample size determination

The study area was stratified into 2, Ghibe-III dam being a reference point, where the Loma district is located the upstream and Kindo Didaye district downstream. The sample size for the questionnaire survey was determined using the formula given,[12] with the assumption of a 5% standard error, and the study considers a 95% confidence interval. For an item scored 0/1 for no/yes, the standard deviation of the item scores is given by SD = (p(1-p)/n)1/2 where p is the proportion obtaining a score of 1, and n is the sample size. The standard error of estimate SE (the standard deviation of the range of possible p-values based on your sample estimate) is given by SE = SD/√n. Thus, SE is at a maximum when $P = .5$. Thus the worst-case scenario occurs when 50% agree, and 50% disagree. The sample size, n, can then be expressed as the largest integer less than or equal to $0.25/SE^2$. Therefore, SE of 5% is given as follows:

$$n = \frac{0.25}{s_E{}^2} = \frac{0.25}{(0.05)2} = \frac{0.25}{0.0025} = 100$$

Accordingly, 100 animal owners were interviewed in each district. Most statisticians agree that the minimum sample size to get any kind of meaningful result is 100. Therefore we used a total of 200 questionnaires administered in 2 districts since the household populations in each district were above 500 households, and the sample size was doubled to represent sufficiently.

Questionnaire administration

Livestock owners' perceptions were assessed using a semi-structured open and closed questionnaire survey from January 2019 to June 2020. At the beginning of interview before actual data collection, a pre-test was made and checked whether there was unnecessary questions and edited accordingly. Then in every interview verbally the consent of the interviewee was asked at the begging of questionnaire administration, if there is an unwilling farmer, bypassed to the next farmer. The face-to-face interview method was used to generate information from individuals in selected peasant associations of the Loma and Kindo Didaye districts. Each questionnaire contained 21 questions. The first 5 questions were about the interviewee's biography (age, gender, primary occupation).

Animal spp and herd/flock size of livestock owned before and after dam construction, major diseases that were ranked based on the frequency of respondents to understand how much farmers aware of trypanosomosis is their major livestock production constraint and hence their perceptions of dam construction impacted trypanosomosis prevalence. The next 8 questions were focused to explore farmers' knowledge about bovine trypanosomosis, clinical signs, mean of transmission, seasonality, and susceptibility among livestock owned. The last group of questions included the effect of the dam on trypanosomosis, the status of wildlife population after dam construction as compared to before dam existence based on interviewee perceptions of the abundance of wildlife and comparison of animal health services, the occurrence of animal disease outbreaks and number of animal death before and after dam construction were interviewed using a semi-structured questionnaire.

Secondary data

Information on trypanosomosis prevalence and tsetse fly apparent density in both study districts were extracted from the annual report of Soddo Regional Veterinary Laboratory (SRVL) and Southern Tsetse Eradication Project (STEP).

Data analysis

Information obtained from the questionnaire survey was entered into a Microsoft Excel spreadsheet and summarized using descriptive statistics. Farmers reported major cattle diseases using local terms; translated to the equivalent English terms were used in the analyses based on the clinical signs they mentioned for each disease. For instance, to mention trypanosomosis disease, farmers described as gulfo or shulula, or gundia and the name "*Eduxinia or Chibebia*" for tsetse fly which was stated as the cause of trypanosomosis.

Farmers' disease diagnosing capacity was either accepted when consistent with the clinical signs described by the reference book or rejected if the responses were inconsistent with the clinical signs. After farmers have mentioned diseases, they have to describe the clinical signs to fit with the standardized clinical signs, for example, descriptions such as 'emaciation, staring coat hair, and weakness were the most common signs for trypanosomosis described by farmers. Each clinical sign was then compared within the given 2 reference veterinary texts .[1,13] A farmer's diagnosis was accepted when at least half of the clinical signs described were consistent with those given in reference texts, otherwise, it was rejected. In this respect, all clinical signs were given equal weight. Herd size response compared before and after dam construction within and between 2 districts using Epicalc 2000 statistical calculator that works for pre-tabulated data, to appreciate herd size proportion difference before and after between the 2 districts. Non-parametric U test was employed to compare independent responses between 2 districts, whether the response for the given scenario is different or not. Mann-Whitney U test statistic used, which is denoted by the U value, where the smaller of U_1 or U_2 is used as a test statistic to compare with the critical value from the table at a 95% confidence interval ($\alpha = .05$). Where: U_1 and U_2 defined as $U_1 = n_1n_2 + n_1(n_1+1)/2 - R_1$, $U_2 = n_1n_2 + n_2(n_2+1)/2 - R_2$: Where R_1 = sum of the ranks for district 1 and R_2 = sum of the ranks for district 2. n = total number of observation, n_1 = the number of observation in district one and n_2 = number of observation in district 2. The test is considered to be significant when the calculated U- value is less than the critical value in Table.[14]

Ethical consideration

The permission to carry out this study was granted by the research ethics review committee of the College of Veterinary Medicine and Agriculture of Addis Ababa University (Reference number: VM/ERC/05/20/11/2018). The study used those ethical approaches, which have been documented as a guideline.[15] The objectives of this study were well explained to all participating farmers and informed consent, for willful participation in the questionnaire interview and discussion, was obtained from participants before the beginning of the study.

Results

Farmers' characteristics

Out of 200 questionnaires administered 99 and 90 questionnaires were responded to from Kindo Didaye and Loma districts, respectively. The main reasons for missed ones were after they started the interview they fail to complete the response due to suspicion or unable to understand due to lack of knowledge or maybe recently arrived.

The age group of the interviewee ranges from 25 to 70 years. In Kindo Didaye 99 interviewees had an average age of 39.4 ± 10.6 and ranging from 25 to 70 years of age, among them 14 were female and 85 were male; whereas in Loma 90 interviewees had an average age of 43.1 ± 9.93 and ranging from 26 to 70 years of age, out of these 6 females and 84 male farmers participated. All of them were livestock owners or took responsibility for their relatives.

Perceptions on livestock herd size before and after dam construction

Farmers' responses showed differences in herd size before and after dam construction. Accordingly, in Kindo Didaye(located downstream from the dam) majority of the herd and flock sizes per household were limited to small (<5) and medium (6-20) herd sizes, but only 6 interviewees had large cattle herd sizes (>20) before dam construction. There was no large herd size among 99 respondents after dam construction in the Kindo Didaye district. Thirty-three (33.3%) respondents had medium cattle herd size and the remaining percent was in small herd size; there was no large herd size during data collection. Goat, sheep, and poultry flock sizes were also dominated by small flock sizes. Such proportion of flock and herd size shift from large flock size to small herd size in Kindo Didaye district, which is located downstream, might be an indicator of the severity of disease problems especially animal trypanosomosis prevalence advancing in the area and Ghibe-III dam doesn't show any impact in downstream

Whereas, following dam construction, cattle herd size appears to be improved in Loma District (upstream). Where owners with medium and large herd sizes in the Loma district were 77(85%) out of 90 respondents after dam construction compared to 62(69%) before dam construction, which was increased by 16% (95% CI: 0.54, 31.46) the difference was statistically significant ($P < .05$). Conversely, in the Kindo Didaye district, out of 99 respondents, 33(33.3%) of them had a medium herd size after dam construction compared to 54(60%) before dam construction, and medium herd size was reduced by 20% (95% CI: 0, 43.7) after dam construction, the difference was significant ($P < .05$). It was observed that livestock ownership before dam construction in both study districts had no significant difference ($P > .05$) as shown in Table 1. But herd size increased in Loma whereas reduced in Kindo Didaye district significantly; the water reservoir might have contributed to the reduction of trypanosomosis and increased herd size upstream than downstream.

Data generated from the questionnaire survey indicate that livestock production systems in both districts were based on a free-grazing system. Only kids, calves, and weak animals stay around the homestead while all adults were allowed to move toward free grazing land near to Omo-Ghibe River. In these 2 districts, tributaries and the main river are used as water sources for their animals. All livestock species kept in both districts were local breeds and breeding practices using the natural mating technique. Animals were kept to build economic status, and serve as a source of food through milk and meat. There was little draught power activity due to inaccessible and rugged land topography. The most common cereal crops produced were sorghum and maize, but production was very limited due to ragged and narrow arable land. Especially in Kindo Didaye landholding was very narrow, because of land shortage they use to plant more root crops. Due to human and animal vector-borne diseases, the lowland area near the Ghibe river was not fully utilized. In the Loma district, communities keep their animals on the grazing site for long period near the created Lake upstream of the Ghibe-III dam. At night animals are kept in the open-air collecting pen. Animals were allowed to come back homestead either for mass vaccination or treatment and/or if a cow is in trimester pregnancy or a milking cow. Whereas in the Kindo Didaye district farmers downstream do keep their animals in the homestead but daily move down to the riverside for grazing and bring them back home every night.

The proportion of respondents having sheep and goat flock size greater than or equal to 6 has significantly increased after

Table 1. Frequency and proportion of respondents in each herd size category in Kindo Didaye and Loma districts after and before dam construction.

SPP	HERD/FLOCK SIZE/ HH	FREQUENCY OF RESPONDENTS (PERCENTAGE)			
		AFTER DAM CON.		BEFORE DAM CON.	
		KINDO DIDAYE	LOMA	KINDO DIDAYE	LOMA
Cattle	0	1 (1.01%)^{a}	2 (2%)^{a}	4 (4.04)^{a}	8 (8.9)^{a}
	1 ⩽ 5	65 (65.7%)^{a***}	11 (12.2%)^{b}	42 (42.42)^{c}	25 (27.8)^{c}
	6 ⩽ 20	33 (33.3%)^{a}	54 (60%)^{b**}	47 (47.5)^{c}	53 (58.9)^{c}
	>20	0^{a}	23 (25%)^{b**}	6 (6.1)^{c}	9 (10)^{c}
Goat	0	49 (49.9%)^{a*}	8 (8.9%)^{b}	61 (61.61)^{c**}	13 (14.4)^{d}
	1 ⩽ 5	48 (48.1%)^{a*}	18 (20%)^{b}	32 (32.32)^{c}	50 (55.6)^{d*}
	6 ⩽ 20	2 (2%)^{a}	56 (62.2%)^{b*}	7 (7.07)^{c}	26 (28.9)^{c}
	>20	0^{a}	8 (8.9%)^{a}	0^{b}	1 (1.1)^{b}
Sheep	0	85 (85.5%)^{a**}	36 (40%)^{b}	93 (93.5%)^{c**}	58 (64.4%)^{d}
	1 ⩽ 5	14 (14.5%)^{a}	41 (45.6%)^{b*}	6 (6.5%)^{c}	29 (32.2%)^{c}
	6 ⩽ 20	0	13 (14.4%)^{a}	0	3 (3.4%)^{a}
	>20	0	0	0	0
Poultry	0	51 (51.5)^{a**}	4 (4.4)^{b}	71 (71.7)^{c**}	18 (20)^{d}
	1 ⩽ 5	39 (39.4)^{a}	13 (14.4)^{a}	20 (20.2)^{c}	51 (56.7)^{d**}
	6 ⩽ 20	9 (9.1)^{a}	68 (75.6)^{b}	7 (7.1)^{c}	19 (21.1)^{d}
	>20	0	5 (5.6)^{a}	1 (1.0)^{a}	2 (2.2)^{a}
Equine	0	96 (96.5)^{a}	67 (74.4)^{a}	96 (96.5)^{b}	78 (86.7)^{b}
	1 ⩽ 5	3 (3.5)^{a}	23 (25.6)^{a}	3 (3.5)^{b}	12 (13.3)^{b}
	6 ⩽ 20	0	0	0	0
	>20	0	0	0	0

0 = with no animal, 1 < 5 = small; 6 < 20 = medium; >20 = large herd /flock size per respondents; value with the same superscripts indicates statistically non significant and row with different superscript shows significant difference in 2 districts when it compared "after or before dam" construction; *P*-values (*$P < .05$. **$P < .01$. ***$P < .001$).

dam construction in Loma District ($P < .05$). On the other hand, respondents in Kindo Didaye have shown a decline in goat ownership while there was no change in sheep flock size following the construction of the Ghibe - III dam.

Knowledge of major livestock diseases. During the semi-structured open and closed questionnaire survey, farmers listed major livestock diseases chronologically based on the severity of the disease on their livestock productivity. In both districts, all questionnaire respondents listed the main diseases which they perceived as more severe diseases according to their experience. The first 6 diseases that were frequently mentioned by respondents were listed in Table 2, while those less frequently mentioned were collectively categorized as "others." Bovine trypanosomosis ranked first with 97.8% and 93.4% followed by blackleg with the proportion of 85.5% and 79.8%, in the Loma and Kindo Didaye districts, respectively. Lumpy skin disease (LSD) was reported with high frequency in Loma compared to the Kindo Didaye district. Respondents associated the presence of stagnant water due to created Lake coupled with wind direction contributed to the multiplication and spread of the LSD vector, which resulted in increased prevalence of LSD in the Loma district.

Knowledge of clinical signs of animal trypanosomosis

Among the diseases listed in the questionnaire survey, trypanosomosis received the highest frequency and number one priority disease. Hence, knowledge of the community about clinical

Table 2. List of major livestock diseases, frequency, proportion and rank of the respondents in Loma and Kindo Didaye districts.

DISEASES	LOMA		1	KINDO DIDAYE		2
	FREQUENCY	PROPORTION	RANK	FREQUENCY	PROPORTION	RANK
Trypanosomosis	88	97.8	1	93	93.4	1
Blackleg	77	85.6	2	79	79.8	2
Anthrax	64	71.1	4	66	66.7	3
LSD	73	81.1	3	5	5.1	6
FMD	42	46.7	6	12	12.1	5
Pasteurolosis	47	52.2	5	0	0	7
Others*	5	5.6	7	42	42.4	4

Table 3. Knowledge of the respondents on most frequently mentioned clinical signs of animal trypanosomosis in Loma and Kindo Didaye districts.

CLINICAL SIGNS	LOMA(N=90)			KINDO DIDAYE(N=99)			
	FREQ	R_1	PROPORTION	CLINICAL SIGNS	FREQ	R_2	PROPORTION (%)
Emaciation	88	12	97.8	Emaciation	91	14	91.9
Swollen lymph node	64	7	71.1	Swollen lymph node	31	5	31.3
Fever and dry muzzle	72	9	80	Fever and dry muzzle	9	2	9.1
Rough coat hair	83	11	92.2	Rough coat hair	90	13	90
diarrhea	69	8	76.7	Diarrhea	8	1	8.1
Cough/salivation	77	10	85.6	Coughing/salivation	40	6	40.4
Others[a]	10	3	11.1	Others[b]	24	4	24.2
	sum	=60			sum	=45	

[a]alopecia, lacrimation, weakness, stop regurgitation, lethargy,
[b]anorexia, shivering, lacrimation, constipation, tail lesion, bloat, death(each of these signs mentioned by at least one farmer)
R_1 = group one rank: R_2 = group two rank.

signs of trypanosomosis was further assessed, and frequently mentioned clinical signs were summarized in Table 3. Out of 7 clinical signs listed for bovine trypanosomosis, "emaciation" and "rough hair coat" were the most frequently mentioned signs. All 7 clinical signs listed were consistent with conventional clinical signs written in veterinary textbooks.[13,16] Response differences between 2 districts were compared statistically using Mann–Whitney U test. The smaller U test value was compared with the tabulated critical value using the formula mentioned in the methodology. Therefore, the calculated value of U_1 and U_2 of the 2 districts were 17 and 32. The critical values based on 7 degrees of freedom in 2 districts were 8. The smaller U value, in this case, was U = 17. Since, 17 > 8, there is no significant difference between the 2 districts on bovine trypanosomosis clinical signs knowledge shown in Table 3.

Community perceptions on the transmission of bovine trypanosomosis. Majority of the respondents in the Loma district associated transmission of trypanosomosis with tsetse and biting flies (58.9%) followed by animal contact (25.6%) during feeding and watering; whereas 7.8% of farmers reported transmission is only through tsetse fly. 41.4% of farmers in Kindo Didaye perceived transmission is mainly associated with the watering site and tsetse fly bites shown in Table 4. In both cases, the route of transmission associated with tsetse and biting flies scored high frequency than others. Knowledge of the respondents on animal trypanosomosis transmission was compared between the 2 districts using the U test. Test statistics results of U_1 and U_2 were 49.5 and 31.5, in Loma and Kindo Didaye, respectively. The smaller U was compared with the tabulated critical value of 17 at 9 degrees of freedom. Therefore, 31.5 greater than 17, hence there was no significant (P > .05) difference between the 2 districts on the perception of transmission of bovine trypanosomosis.

Community perceptions on seasonality of bovine trypanosomosis. Individual responses in both districts revealed the seasonality of trypanosomosis. All respondents agreed trypanosomosis

Table 4. Farmer's perception on transmission of trypanosomosis in Loma and Kindo Didaye districts.

ROUTE OF TRANSMISSION	LOMA = 90			KINDO DIDAYE = 99		
TRANSMISSION OF DISEASE	N	R_1	%	N	R_2	%
Animal contact at feeding & watering, biting and tsetse fly	23	15	25.6	29	16	29.3
Biting and tsetse fly only	53	18	58.9	10	14	10.1
Animal contact, feed & water	2	7.5	2.2	5	11	5.5
Tsetse fly only	7	12	7.8	8	13	8.1
Feed and water	0	2.5	0	1	5.5	1.1
Water and tsetse fly	0	2.5	0	41	17	41.4
Water only	0	2.5	0	4	10	4
Others	3	9	3.3	0	2.5	0
I don't know	2	7.5	2.2	1	5.5	1
	sum = 76.5			sum = 94.5		

is a seasonal disease, but respondents disagreed on which season the disease is more prevalent. In the Kindo Didaye district, 40% of respondents perceived trypanosomosis as more prevalent in the dry season, whereas 42% responded the problem prevails in both dry and rainy seasons. On the other hand, in the Loma district, 62.2% of respondents believed trypanosomosis is more prevalent in the rainy season followed by 25.6% of respondents who thought the problem is common in the dry season. Few Loma district respondents (7.7%) perceived the problem exists in both dry and rainy seasons, and the remaining 3.3% of respondents couldn't decide in which season the disease exists. Their main reason for seasonality also differs among respondents within 2 districts. A substantial number of the respondents perceived that drought and feed shortage contributes more to the occurrence of trypanosomosis in the dry season; whereas the other group of interviewee conceived trypanosomosis occurrence increases in the rainy season due to increased tsetse population.

The perception of 98% of respondents on the susceptibility to trypanosomosis in the Kindo Didaye district indicates cattle are the most susceptible followed by goats. Whereas almost all respondents in the Loma district have mentioned cattle, equine, and goats followed by sheep are more susceptible in chronological order.

Community perceptions and practices on animal health management. In the Loma district, 87.8% of respondents perceived trypanosomosis problems reduced significantly because of improved health care through trypanocidal drug treatment and spray via extension health workers in their village since dam construction. They also believe the tsetse fly population reduced since dam construction because of the vast area of tsetse suitable environment covered by water reserve. Whereas, in Kindo Didaye majority of respondents perceived the problem associated with the trypanosomosis, it is remained a bottleneck in livestock production. Respondent emphasized there is still intensive tsetse challenge, and trypanosomosis is prevalent in Kindo Didaye district, unlike Loma district.

Community Perceptions on trypanosomosis and tsetse fly population after dam construction. Respondents of the 2 districts mentioned the change in prevalence of trypanosomosis after the dam construction. 70.7% of respondents in the Kindo Didaye district believed that there is no reduction in the prevalence of trypanosomosis and tsetse fly population, whereas 29.3% of respondents believed there is a reduction.

Whereas, in the Loma district 87.8% of the respondents believed that there is a reduction in the prevalence of trypanosomosis and tsetse population; of these 77.8% of them agreed that dam has contributed to the reduction of trypanosomosis prevalence and tsetse population. Whereas 12.2% disagree about the reduction of the problem and they believe also dam construction does not affect prevalence reduction as shown in Table 5.

Wildlife status before and after dam construction. Questionnaire interviewee in both Kindo Didaye and Loma districts shared their experience with wildlife distribution in the area. Some 15 years back the Omo-Ghibe River gorge particularly where the Ghibe-III dam was built was naturally endowed with abundant fauna and flora. There were different species of wildlife, including lion, buffalo, woodland antelope, common warthog, bushbuck, hyenas, monkey, apes, and others. However, after 10 years due to human intervention and deforestation in the area for Ghibe-III hydroelectric dam construction, wildlife populations and diversity were significantly reduced, especially upstream. According to 87% of respondents in Loma districts, lion, lesser kudu, warthog, buffalo, and bushbuck moved from

Table 5. Frequency of respondents about reduction of trypanosomosis prevalence and tsetse population after dam construction in the study site.

STUDY SITE	N	IS THERE REDUCTION IN TRYPS* AND TSETSE?		DOES THE DAM HAS EFFECT	
		YES	NO	YES	NO
Kindo Didaye	99	29 (29.3%)	70 (70.7%)	35 (35.4)	64 (64.6%)
Awasho	29	18	11	14	15
Hamaya	35	4	31	11	24
Petere	35	7	28	10	25
Loma	90	79 (87.8%)	11 (12.2%)	70 (77.8%)	20 (22.2%)
Zimawaruma	34	28	6	25	9
Denbella Bolla	21	19	2	18	3
Subotulema	35	32	3	27	8

Tryps* = trypanosomosis.

Figure 2. Forest, dung and hoof print of hippo and warthog observed downstream to Ghibe-III dam.

upstream to downstream to the less ecologically disturbed due to less human intervention. On contrary, monkeys, and apes significantly increased and moved into human settlement areas. In Kindo Didaye, which is located downstream from the dam, respondents confirmed there is a significant change in wildlife population, especially following seasonal trends due to natural phenomena and dam construction. During the rainy season when green grass occupies the area, some of the wildlife resumes their original place. Warthog, Hoof print of buffalo and hippo, and dung of greater kudu, as well as several monkeys, were observed during the study period as shown in Figure 2.

Other changes following the Ghibe III dam construction. Participants in Loma (upstream) district agreed that veterinary service was improved, and animal disease outbreaks and cattle deaths were reduced after dam construction compared to those who perceived that it was good right from the beginning shown in Table 6, on the contrary, participants from Kindo Didaye

Table 6. Event comparison before and after Ghibe III dam construction in both Loma (upstream) and Kindo Didaye(downstream) using a median score.

EVENTS	UPSTREAM		DOWNSTREAM	
	BEFORE*	AFTER*	BEFORE*	AFTER*
Satisfaction on animal health services	8 (6-12)	22 (18-24)	10 (7-13)	20 (17-23)
Occurrence of animal diseases outbreaks	18 (16-24)	12 (6-14)	14 (8-16)	16 (14-22)
Number of cattle deaths	21 (17-23)	9 (7-13)	17 (14-19)	13 (11-16)

*Values are in median score and ranges are in parentheses.

Table 7. Retrospective data extracted from 2002 to 2016 in Kindo Didaye and Loma districts.[18]

DISTRICT	2002	2004	2005	AVERAGE	2006–2016
Lomma					
Tryps.prevalence	18.71	20	15	17.9[a]	Dam construction period Bush clearing activities on water reservoir site in upstream from dam
Apparent density	13	9	8	10.0[b]	
tsetse species	*G.f,*				
Identified	*G.pallidipes G.m.subm*				
Kindo Didaye					
Tryps prevalence	18.5	20	19	19.2[a]	Downstream intact with natural vegetation minor human activities during construction
Apparent density	15	14	12	13.7[b]	
Species identified	*G. pallidipes G. fuscipes*				

Source. Sodo Regional Veterinary Laboratory and Southern Tsetse Eradication Project, superscript "a" and "b" are comparing tryps prevalence and apparent tsetse density, respectively; between 2 districts. The similarity shows the difference is not significant ($P > .05$).

revealed no significant change in the perception on the above events though there were animal health services.

Secondary information. Kindo Didaye and Loma districts were assessed at least more than 3 times before Ghibe-III hydroelectric dam construction started. Both districts are bordered by Omo River in place where the dam construction conducted. However, Kindo Didaye located below the dam and still borders East of Omo River, whereas Loma district borders in the west of dam Lake. Due to the severity of trypanosomosis and tsetse fly challenge in the area, 2 NGO's namely SOS-Sahle and Action Aid supported veterinary health activities to reduce the impact of trypanosomosis and other diseases. Despite all the efforts made trypanosomosis prevalence and tsetse apparent density was high in both districts before dam construction as shown in Table 7. The average trypanosomosis prevalence and apparent tsetse fly density has no significant difference between study districts before dam construction. Whereas, community perceptions after dam construction showed differences where community in Loma district perceived the reduction of tsetse and trypanosomosis but reduction of trypanosomosis was not perceived by Kindo Didaye community.

Discussion

Livestock production was a more important component of agriculture in both districts. Community perceptions indicate that the cattle population was more dominant followed by goats and poultry, whereas sheep were very small. The finding agrees with the data reported by the central statistics authority for the respective area in Wolayta and Dawro Zones.[17]

According to the questionnaire survey, cattle herd size was not significantly different before dam construction between Loma (upstream) and Kindo Didaye (downstream) districts ($P > .05$). This might be associated with similar managing experience of the farmers in the same environmental situation in both study areas before dam construction. The environment was naturally intact, there was no human intervention that can disturb tsetse ecology before dam construction, and hence animal exposures to trypanosomosis in both districts were equal. This finding was in agreement with retrospective data generated from the regional laboratory, where the prevalence of trypanosomosis and tsetse population was high but it was not significantly ($P > .05$) different between the 2 districts. On the other hand, after dam construction farmers with cattle herd sizes greater than 6 were significantly ($P < .05$) increased in Loma than in Kindo Didaye district; where Loma district located upstream of the dam that is covered by a water reservoir that has occupied about 200 km^2; this situation might prevent the breeding site of tsetse and hence reduced transmission and prevalence of animal trypanosomosis. Conversely, in the Kindo Didaye district which is located downstream of the dam, the ecology is relatively intact after dam construction because of less human intervention during dam construction in the area. This environmental difference after dam construction might have contributed to the herd size difference between the 2 districts. The finding was in agreement with a seasonal survey conducted on trypanosomosis prevalence and tsetse apparent density where there was a significantly ($P < .05$) high tsetse apparent density and prevalence of trypanosomosis in Kindo Didaye observed than Loma district; this could be one of the reasons for reduction of herd size in downstream.[18] The finding was in agreement with other studies in west Africa.[19] even though there could be variation from place to place, trypanosomosis has a significant negative impact on livestock population growth. In addition,[3] in his socio-economic impact assessment study indicated trypanosomosis and tsetse challenge affect livestock population growth, reduction on market off taking of livestock and others.

Community participants have listed more than 6 major livestock diseases in the study area. Among the diseases listed, bovine trypanosomosis had the highest frequency and ranked the number one disease of priority in both Loma (upstream) and Kindo Didaye (downstream) districts. This was followed by blackleg, anthrax, LSD, and FMD, accordingly. The community response was in agreement with a recent study conducted in Dawro zone[20,21] have also indicated that trypanosomosis is a major problem in the study area. In Kaffa and Bench Maji zone, which is adjacent to the current study area, 94.1% of questionnaire survey respondents considered bovine trypanosomosis as an economically important cattle disease accounting for 64.6% of the total annual deaths in the year 2011/2012.[22] Similar information was reported in tsetse infested areas elsewhere in sub-Saharan Africa. The study conducted in Kenya,[23] Tanzania,[24] and Nigeria[25] have shown the same report, indicating trypanosomosis is a major constraint in livestock production. The response of farmers to the problem of trypanosomosis and tsetse fly correlated with the actual situation in the study area in Nigeria.[26] Animal trypanosomosis is also prioritized as the most important disease among others in West Africa.[27]

Questionnaire survey respondents were able to fairly describe the clinical manifestation of trypanosomosis in cattle in both study locations. The majority of the respondents agreed mainly on emaciation and rough coat hair. The finding also agreed with focus group discussion conducted in the same area, the knowledge of a swollen lymph node, cough/salivation, fever, loss of appetite, and diarrhea also were considered as clinical manifestations.[28] Studies in the Orma community in Kenya reflected similar clinical signs for chronic trypanosomosis infection but hemorrhage and sudden death reported to the acute form of the disease.[29] Comparable knowledge was mentioned in the agro-pastoralist community in Lamwat and Kwale, Kenya.[23,27] The majority of the responses of the communities were also in agreement with existing literature.[4,13,16] Many studies have substantiated that local communities have accumulated knowledge about their animals and their wellbeing.[30]The strong concordance observed between diseases and clinical symptoms listed above strengthens the rich indigenous knowledge of the community.

Most participants perceived animal trypanosomosis as transmitted by tsetse and biting flies due to direct animal contact during the grazing and watering period. The response in both districts had no significant difference and it was in agreement with scientific descriptions.[1,13,16]This finding was also supported by many community perceptions including those in South Western Ethiopia, the Serengeti community in Tanzania, and the community in Southern Sudan.[22,30,31] It was also reported that trypanosomosis causes a reduction in productivity of livestock; including reduced milk yield, body weight loss, poor hide quality, abortion, and costly treatment. Similar observations were recorded in various studies.[4] Other studies have shown that more than half of the study participants associated draught power reduction and high drug cost reported as the result of animal trypanosomosis in the Metekel and Guji zones of Ethiopia.[32,33]Weight loss and milk reduction were also stated by the Nigerian community.[26] Almost all respondents agreed the occurrence of trypanosomosis and its cause of transmission depends on season mainly in the long rainy season which is in agreement with other research work.[22,28] Seasonal observation in the same study site showed a significantly high prevalence of trypanosomosis and high tsetse and biting fly apparent density observed in the rainy season.[18] Knowledge on signs and transmission of trypanosomosis by farmers observed in the high tsetse challenge area,[27] agreed with current finding; 44% of farmers agreed tsetse fly accompanied with the river, grazing site and wet season are the main cause of trypanosomosis.[34]

Altogether, the local community in both study sites has adequate experience with bovine trypanosomosis and the disease is considered a major threat to their livestock and their livelihood.[30]To combat the trypanosomosis problem trypanocidal drugs and pour-on insecticide spray was the major control method in the area. Most farmers obtain trypanocidal drugs from public service and treat their animals; when there is a drug shortage they look for private vender and open markets, similar activities indicated in other study areas too.[23]The dose and the frequency of treatment per month also depend upon communities' level of understanding, the effectiveness of the drug type, and the intensity of the disease; 53% of respondents practice inappropriately.[34] Whereas, in West Africa treatment applications, are conducted following appropriate clinical signs.[27] However, farmers lack knowledge on appropriate dosage, and poor hygienic injection.[23,27] This knowledge gap might have contributed to under dosage and repeated treatment, which could lead to drug resistance. 41.6% of farmers experienced treatment failure this was more associated with the use of diminazene aceturate in West Africa.[27] Such a high proportion of repeated treatment coupled with farmers' poor preparation and application could contribute to drug resistance development.[22] Similar repeated treatment activities are common in the study area; might be the same reason for treatment failure due to repeated injection of diminazene aceturate.

In general, the impact of the dam on animal trypanosomosis and tsetse fly is explained differently by the 2 districts. The majority of the respondents from the Loma district reported that dam construction and water reserve has reduced disease problem, whereas in the Kindo Didaye district majority of respondents reported there is no change in disease problem due to dam construction. Focus group discussion and seasonal observation in the same study site demonstrated a similar situation in line with respondents, where there was a low prevalence and tsetse fly apparent density in Loma than in Kindo Didaye district.[18,28] Other experiences on mosquito abundance and malaria disease in Ghibe-I hydroelectric dam showed that stagnant water in the dam contributed 88% to the increase of mosquitoes thereby increasing malaria cases.[35]Stagnant water might be a favorable environment for mosquito multiplication. Water reserve upstream of Ghibe-III hydroelectric dam could also have the same contribution to mosquito multiplication but tsetse breeding site might have been affected due to water flooded site; since female tsetse fly burrow moisture sandy area to deposit their puparium inside in a place where there is no water reserve or swampy area. It was difficult to compare with a similar study because this observation was the first. However, International Rivers Networks[36] indicated that water filling affect plants, animals, and agricultural activities in the land covered with water reservoir. This could be the reason for the reduction of tsetse fly apparent density in the water reserve site. Climate changes could also occur as the result of water evaporation in the periphery of the reserve, which could contribute a negative impact on tsetse apparent density as the result of humidity change. Respondents reported that honey harvest and wild animals reduced substantially upstream due to water reserve that has flooded vegetation and habitat.

Conclusion

According to this study herd size before dam construction was not significantly different between study districts; but cattle herd sizes greater or equal to 6 have significantly increased after dam construction in the Loma district, whereas in Kindo Didaye farmers with such cattle herd sizes have declined significantly. Seventy percent of respondents in Kindo Didaye(downstream) reported no reduction of trypanosomosis; whereas, 79% of respondents in the Loma district perceived the reduction of trypanosomosis and its vector after dam construction. The strong concordance observed between diseases and clinical symptoms listed by the community ensures the presence of rich indigenous knowledge within the community. The majority of the respondents from the Loma/upstream district reported that the impact of the disease and its vectors has significantly reduced after Ghibe- III dam construction, wildlife population reduction, reduced animal death, and improved veterinary service observed; while participants from Kindo Didaye district reported no change in disease problem as the result of dam construction. Therefore, follow-up and study on drug resistance are recommended.

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Authors' Contributions

SM: Developed the project, wrote the protocol, collected the data during field work, analyzed the data and interpreted the result, and drafted the manuscript and final proof reading of the manuscript before it was submitted to the journal.

Availability of data and materials

Data available with corresponding author and will be provided upon request.

Ethics approval and consents of the participants

All methods were **carried out in accordance with relevant guidelines and regulations.**

Consent for publication

Not applicable

Supplemental material

Supplemental material for this article is available with authors will be provided upon request.

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