

**ADDIS ABABA UNIVERSITY
FACULTY OF VETERINARY MEDICINE**

**ASSESSMENT OF IMPACTS OF TSETSE AND TRYPANOSOMOSIS CONTROL
MEASURES ON CATTLE HERD COMPOSITION AND PERFORMANCE IN
SOUTHERN RIFT VALLEY**

BY

MESSELE TAYE BELACHEW

JUNE, 2008

DEBRE ZEIT, ETHIOPIA

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A thesis submitted to the School of Graduate Studies of Addis Ababa University, Faculty of Veterinary Medicine in partial fulfillment of the requirements for the Degree of Masters of Science in Tropical Animal Health and Production

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DEDICATION

This thesis paper is dedicated to our God, who gave us eternal life, and this life is in his son and always helps me in all corner of my life.

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LIST OF ABBREVIATIONS

AHT	African Human Trypanosomes
AU	African Union
AZDA	Arbaminch Zuria District Office of Agriculture
CBPP	Contagious Bovine Pleuro-Pneumonia
DVM	Doctor of Veterinary Medicine
FA	Farm Africa
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
ILCA	International Livestock Center for Africa
ILRAD	International Laboratory for Researches in Animal Diseases
ILRI	International Livestock Research Institute
KKA	Kindo-Koysha office of Agriculture
MHC	Major Histocompatibility Complex
MSc	Master of Science
OAU	Organization of African unity
OIE	Office for International Epizootics
PAAT	Program against African Trypanosomes
PCV	Packed Cell Volume
PMAC	Provisional Military Administration Council
RFLPS	Restriction Fragment Length Polymorphism
STEP	Southern Tsetse Eradication Project
STRC	Scientific Technical and Research commission
TALA	Trypanosomosis and Land Use in Africa
WHO	World Health Organization
WZFEB	Wolayta Zone Finance Economic Burrow

ABSTRACT

This study was conducted in the Wolayta and Gamogofa Zones of the Southern Nation Nationalities and People Region. Two districts, Kindo Koysha from Wolayta Zone (community tsetse controlled areas) and Arba-minch Zuria from Gamogofa Zone (tsetse challenged and STEP tsetse controlled areas) were selected purposely based on their similar type of agro ecology and the status of tsetse control to assess the impacts of tsetse and trypanosomosis control measures on cattle herd size and composition, milk yield and reproductive performances of cattle. Two Kebeles were selected randomly from each study area (tsetse challenged, STEP tsetse controlled and community tsetse controlled areas) and 50 households were selected randomly from each Kebele that made a total sample size of 300 households. A structured questionnaire was used to collect data and a follow up study was carried out on a total of purposely selected 45 prepartum cows to collect data on daily milk yield every two weeks and also check for the occurrence of postpartum heat and subsequent pregnancy. The results showed that land holding was significantly ($P < 0.001$) higher in community controlled areas (2.80 ha) followed by tsetse challenged (2.24 ha) and STEP controlled areas (1.44 ha). The total livestock holding by a household in tsetse challenged area (11.84 heads) was higher than the livestock holding in STEP tsetse controlled (9.82 heads) and community tsetse controlled (9.98 heads) areas ($p < 0.05$). Livestock diseases were the first most important constraint of livestock production identified by 83% of respondents in tsetse challenged area. In STEP and community based controlled areas shortage of grazing area was mentioned by 88% and 63% of the respondents as a major constraint, respectively. The first priority disease mentioned by 100% of the respondents in tsetse challenged area and by 95% of the respondents in both STEP and community controlled areas was trypanosomosis. The average number of cattle herd size in tsetse challenged area (9.79 heads) was higher than the comparable number of cattle herd size in the STEP tsetse controlled (7.02 heads) and in the community tsetse controlled (7.45 heads) areas ($p < 0.001$). The number of non-pregnant dry cows ($p < 0.05\%$), bulls ($p < 0.0\%$) and oxen ($p < 0.001$) were significantly higher in tsetse challenged areas than the other two study areas. The results of cattle herd dynamics study showed that both rates of addition to ($p < 0.01$) and disposal from the herd ($p < 0.001$) were significantly higher in tsetse challenged area than the other two study areas. Cows in STEP and community controlled areas were able to give 26-27, 25-29 and 17-21% more daily milk yield at

the beginning, middle and end of lactation, respectively, than those in tsetse challenged areas. In addition, cows in STEP and community controlled areas had lactation length was longer by 1.2-1.35 months, age at first calving shorter by 5.1-5.3 months and calving interval shorter by 3.2 - 4.1 months than cows in tsetse challenged area, respectively. The results of follow up study indicated that daily milk yield was consistently higher for STEP controlled areas than the other two study areas where their values were overlapping at some points in the lactation period. The total number of cattle died in one year time in tsetse challenged area was about 9.18 and 7.29 times higher than the value for STEP and community controlled areas, respectively ($p < 0.001$). It can be concluded that tsetse control measures improve the cattle herd performances and encouraged more people to be engaged into crop cultivation.

Key words: cattle, herd composition, herd dynamics, Ethiopia, milk yield, mortality, reproductive performance, tsetse challenge, tsetse controlled

1. INTRODUCTION

Livestock in developing countries contribute up to 80 percent of agricultural GDP and about 600 million rural poor people rely on livestock for their livelihoods. Livestock does not only provide poor people with food, income, traction and fertilizer but also act as catalysts that transform subsistence farming into income-generating enterprise (ILRI, 2005). However, the African continent is faced with the challenge of satisfying the increase in demand for livestock products, in particular for milk and meat. This is mainly due to the low level of livestock production, which is caused among many reasons by parasitic, viral, bacterial and fungal livestock diseases. Trypanosomosis is arguably the most important of disease in the tropics (Jahnke *et al.*, 1988).

Trypanosomosis is a serious parasitic disease, which occurs in large areas of Africa, Latin America, the Middle East and Asia. It affects most species of domestic livestock, many species of wild animals and human. The most important trypanosomes in terms of economic loss in domestic livestock are the tsetse-transmitted species such as *T. congolense*, *T. vivax* and *T. brucei* and *T. simiae* in pigs (Mulligan, 1970). Closely related *T. brucei* subspecies, *T. b. rhodesiense* and *T. b. gambiense*, cause human sleeping sickness. It was estimated that about 50 million people (Kuzoe, 1991) and 48 million cattle (Kristjanson *et al.*, 1999) are at risk of contracting trypanosomosis.

In Ethiopia, *T. congolense*, *T. vivax* and *T. brucei* are the most important tsetse transmitted species of trypanosomes in domestic livestock and *T. evansi* of camels and *T. equiperdum* of horses are non-tsetse transmitted species of trypanosomes, causing severe economic losses (Getachew, 2005).

Trypanosomosis has serious impacts on the individual animal and national development endeavors. On an individual basis, untreated animal or human trypanosomosis will lead, at best, to a chronic debilitating condition and, at worst, to death. Furthermore, animals infected with trypanosomes are reported to have reproductive disorders (Ikede *et al.*, 1988); *T. vivax* and *T. congolense* infection in Zebu x Friesian cross bred bulls have caused highly deformed spermatozoa with multiple morphological defects. These can render the bulls unfit for breeding

with in a very short time (Sekoni *et al.*, 2004). Chronic diseases either due to *T. vivax* or *T. congolense* could be an important causative agent of infertility or sterility in bulls and it can cause severe losses on production performance in cattle and water buffalo (D'Ieteren *et al.*, 1998b). Study conducted on cattle in the tsetse and trypanosomosis infested areas showed that African cattle herd living in tsetse infested areas is 20% less productive in herd meat and milk output than cattle herd in tsetse free areas of the some countries (Trail *et al.*, 1985; Shaw, 1990).

At national level, African livestock producers and governments spend at least 30 million USD per year to treat animals exposed to trypanosomosis, administering 25-30 million curative and prophylactic treatments of trypanocidal drugs (Borne, 1996). If eradication or sustainable control of trypanosomes were achieved over the entire tsetse fly affected areas in the sub-humid and humid zones of Africa, a total of 33 million heads of cattle might be saved and would lead to an additional annual production of 495,000 metric tones of meat (assuming productivity of 15kg/head/year) and 1.26 million metric tones of milk (using estimates of 38.3kg/head/year) (Jahnke *et al.*, 1988).

In addition, about 10 million square kilometer of land in Africa is covered by tsetse flies (*Glossina spp*), the biological vectors transmitting trypanosomosis, representing 37% of the African continent and affecting 38 countries (FAO/WHO/OIE, 1982) including Ethiopia. It is considered that 7 million square kilometer of this area would otherwise be suitable for livestock and mixed agriculture.

The emergence of multiple drug resistance, reinvasion of tsetse to the controlled areas and the reluctance of funding organization to the control programs of tsetse and trypanosomosis, demands an integrated tsetse and trypanosomes control approaches which involve the active participation of the community at all levels, integrated disease management and the development of cost-effective sustainable disease control packages (Getachew, 2005). Furthermore, the use of inherent trypanotolerant traits in some breeds of animals (Holmes, 1997) can be ensuring the sustainability of the program. In line with this, there have been a number of interventions (control measures) underway to reduce the impact of trypanosomosis on livestock production in affected countries. Most of the control measures concentrate on reduction of the tsetse challenge

and hence minimize the prevalence and impact of trypanosomosis. Controlling trypanosomosis not only has the effect of reducing mortality but also improve the general health of animals and hence increase milk yield, growth rates and mature body weight. Despite the fact that there have been a number of control and prevention activities have been underway in Ethiopia against tsetse and trypanosomosis, there are few studies carried out to investigate the impacts of control measures on cattle herd size and composition, and performance.

The objectives of this study were, thus:

- To assess impacts of tsetse and trypanosomosis control measures on cattle herd size and composition in the tsetse challenged, STEP tsetse controlled and in community tsetse controlled areas;
- To assess the impacts of testes and trypanosomosis control measures on milk yield and reproductive performance of cattle in the tsetse challenged, STEP tsetse controlled and in community tsetse controlled areas.

2. LITERATURE REVIEW

2.1. *Geographical distribution and occurrence of tsetse and trypanosomosis*

Trypanosomosis is transmitted cyclically by the tsetse fly, of which there are some 36 species and subspecies, each adapted to different climatic and ecological conditions. However, only small numbers have been studied in detail, those being considered the most important, in terms of abundance or from the closeness of their contact with humans and/or domestic livestock (Ford, 1971).

2.1.1. Distribution of tsetse and trypanosomes in Africa

The distribution of African trypanosomosis in domestic animals and human coincides with the known distribution of the tsetse fly vector (Mulligan, 1970). The tsetse-transmitted trypanosomosis affects all domestic animals and are caused by flagellates' protozoa of the genus trypanosome. The major species affecting domestic animals are *T. congolense*, *T. vivax*, *T. burucie* and *T. simiae* (in pig). Tsetse fly distribution in Africa is restricted to the latitude range of 15⁰N to 29⁰S (Merck, 1986).

Mechanical transmission of trypanosome can occur both through tsetse flies and other biting flies. Out side tsetse areas of Africa, tabanus species and other biting flies can transmit *T. vivax* mechanically. The other species of trypanosome, *T. congolense* can be also transmitted mechanically and occasionally be found outside tsetse area of Africa (Merck, 1986). Species of animals mainly affected by tsetse-transmitted trypanosomosis and their geographic distributions are presented in Table 1.

Table 1 Global distribution of tsetse-transmitted animal trypanosomosis

Species	Animals affected	Geographic distributions
<i>T. congolense</i>	Cattle, sheep, goats, dogs, pigs, camels, horses, most wild animals	Tsetse region of Africa
<i>T. vivax</i>	Cattle, sheep, goats, dogs, pigs, camels, horses, most wild animals	Africa, Central and South America, West Indies*
<i>T. brucei brucei</i>	All domestic and various wild animals; most severe in dogs, horses, cats	Tsetse region of Africa
<i>T. simiae</i>	Domestic and wild pigs, camels	Tsetse region of Africa

* In non-tsetse areas transmitted by biting flies

Source: Merck (1986)

In addition to the tsetse transmitted trypanosomes, there is another species called *T. evansi*, which is the most widely distributed of the pathogenic animal trypanosomes transmitted by biting flies (haematophagus), affecting domestic livestock in Asia, Africa and Central and South America. In Africa, camels are the most important hosts of *T. evansi* and cause the disease called Sura (Luckins, 1999). Other disease of livestock caused by trypanosoma species is Dourine, which is a venereal disease of horses caused by *T. equiperdum* and transmitted during coitus. The disease is recognized on the Mediterranean coast of Africa, in the Middle East, South Africa and South America (Holmes, 2006) and recently in Ethiopia (Hagos, 2005).

2.1.2. Distribution of tsetse and trypanosomes in Ethiopia

In Ethiopia, five species of *Glossina* infest the western and southern parts of country between longitude 33° and 38° E and latitude 5° and 12° N (Langridge, 1976). The infested area extends from the southern part of the Rift Valley, around the southwestern corner of the country and along the western lowlands and escarpments to the Blue Nile. Tsetse, through the disease they transmit, largely prevent keeping of cattle and cause enormous losses wherever they come into contact with cattle, and there by hindering rural development.

The distribution of tsetse and related trypanosomosis in Ethiopia is associated with the major river systems of the country; the Abay/Didessa, Omo/Gibe, Baro/Akobo and the southern rift valley. They occupy about 135,000-220,000 km² of agriculturally suitable land (Slingenbergh, 1992), where about 14 million head of cattle, an equivalent number of small ruminants, nearly 7 million equines and 1.8 million camels are at risk of contracting trypanosomosis at any one time (Langridge, 1976; Debebe, 2003). However, tsetse fronts in many places are unstable and tsetse-animal interface is constantly moving. Consequently, new areas are being invaded and settled communities are being continually evacuated by the advancing tsetse (Getachew, 2005).

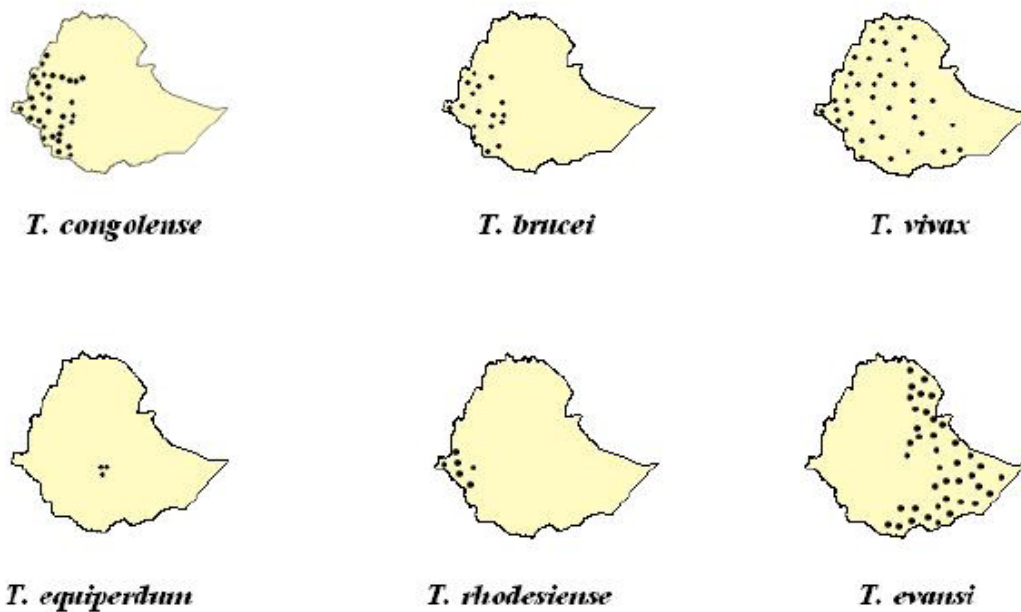
Among the five species of tsetse reported in Ethiopia, only four (*Glossina morsitans submorsitans*, *Glossina pallidipes*, *Glossina tachinoides* and *Glossina fuscipes fuscipes*) are widespread and have significant economic importance (Getachew, 2005; Debebe, 2003). Whereas *Glossina longipennis* is of minor economic importance. The geographic distributions of the different species of tsetse are presented in Table 2.

In Ethiopia, the most important trypanosomes in terms of severe economic loss in domestic livestock are the tsetse-transmitted species, which includes *T. congolense*, *T. vivax* and *T. brucei*. The other trypanosoma species of economic importance are *T. evansi* of camels and *T. equiperdum* of horses. The *T. brucei* subspecies, *T. b. rhodesiense*, causes human sleeping sickness (Getachew, 2005). Geographic distributions of pathogenic trypanosomes in Ethiopia are depicted in Figure 1.

Table 2. Tsetse infested regions of Ethiopia

Region	Major River Basin	Tsetse fly
Amhara	Abay (Blue Nile)	<i>G. m. submorsitans</i> <i>G. tachinoides</i>
Beneshangul-Gumuz	Abay (Blue Nile)	<i>G. m. submorsitans</i> <i>G. tachinoides</i>
Gambella	Baro/Akobo	<i>G. m. submorsitans</i> <i>G. tachinoides</i> <i>G. pallidipes</i> <i>G. f. fuscipes</i>
Oromiya	Abay/Didessa	<i>G. m. submorsitans</i>
	Upper Ghibe/Omo	<i>G. tachinoides</i>
	Baro/Akobo	<i>G. pallidipes</i> <i>G. f. fuscipes</i>
SNNPR	Ghibe/Omo	<i>G. pallidipes</i> <i>G. f. fuscipes</i> <i>G. longipennis</i>
	Rift Valley	<i>G. pallidipes</i>

Source: Getachew (2005)



Source: Getachew (2005)

Figure 1. Geographical distribution of pathogenic trypanosomes in Ethiopia

2.2. Control methods of animal trypanosomosis

2.2.1. Vector control

The first attempts in control of tsetse were by ground spraying of insecticides, bush clearing and eliminating the wild hosts of tsetse, which have been discouraging due to the high costs involved and environmental concerns (FAO, 1993). Recently, there has been a tendency towards smaller scale methods, which can be applied by farmers themselves (Uilenberg, 1998). The development of insecticide impregnated and odor-baited traps (Dransfield *et al.*, 1990) and targets (Vale *et al.*, 1988), and insecticide-treated cattle as pour-on (Shereni, 1990), which attract and kill tsetse, offer the prospect of cheaper alternatives with less damage to the environment (Jordan, 1988). Insecticide treated livestock can be regarded as a modification of the trap and target technique that can be used as “moving targets” (Leak *et al.*, 1995).

Application of deltamethrin pour-on to cattle was proved to be very efficient in controlling tsetse in the pastoral zone of Samorogouan, Burkina Faso (Bauer *et al.*, 1995). In another report, the use of insecticide impregnated target and application of pour-on to cattle has suppressed the tsetse population from 4.1 to 0.9 fly/trap/day. As a result, the prevalence of bovine trypanosomosis has dropped from 27 to 6% in two years time (Getachew *et al.*, 2004). A pilot program to test the principle of sterile insect technique was successfully implemented in Zanzibar (1994-1997), from where *Glossina austeni* now seems to have been completely eliminated (Vreysen *et al.*, 2000). In Ethiopia, a tsetse control campaign started in January 1991 using "pour-on" applied monthly to cattle in Ghibe Valley resulted in average reductions of 95% and 75% in the mean relative densities of tsetse and biting flies, respectively (Rowlands *et al.*, 1999).

2.2.2. Parasite control

Chemoprophylaxis against bovine trypanosomosis has been in widespread use in tropical Africa for many years. Isometamidium (Berg *et al.*, 1961) has been marketed since 1961 as a prophylactic and therapeutic drug. The most commonly used trypanocidal drugs for treatment and prophylaxis of trypanosomosis includes diminazene aceturate, homidium and

isometamidium, which are primarily used for treatment in cattle, sheep and goats. Quinapyramine, suramin and melarsomine are primarily used as therapeutic agents for infections with *T. evansi*, although quinapyramine is also used for prophylactic purposes (Getachew, 2005). The three compounds (quinapyramine, suramin and melarsomine) are generally restricted to use in camels, equines and buffaloes (Peregrine, 1994).

Prophylaxis can be useful under high challenge situations and enables cattle to remain productive, as demonstrated on a commercial ranch at Mkwaja in Tanzania. On this ranch, cattle maintained under isometamidium prophylaxis were 80% as productive as high quality Boran cattle on trypanosomosis-free ranch in Kenya (Trail *et al.*, 1985). However, resistance to one or more of the three-trypanocidal drugs used in cattle has been reported in at least 13 African countries in sub Saharan Africa including Ethiopia. In Ethiopia, the emergence of drug resistance has seriously hampered the control of animal trypanosomosis. Recent reports on multiple drug resistance in Burkina Faso (Clausen *et al.*, 1992) and Ethiopia (Yohannes *et al.*, 2000; Nega *et al.*, 2004) suggest that the concept of sanative pairs might no longer be valid. This indicates a very serious development adversely affecting the future of trypanosomosis control by a chemotherapeutic approach using the trypanocidal drugs available.

2.2.3. Trypanotolerant livestock

Trypanotolerance has been defined as the relative capacity of an animal to control the development of the parasites and to limit their harmful effects, the most prominent of which is anemia (d' Ieteren *et al.*, 1998b). Most indigenous livestock breeds in the tropics exhibit a degree of trypanotolerance when compared to the exotics. In Ethiopia, a comparison study on the response of native indigenous cattle breed of Abigar, Horro, Gurage and Sheko to the natural tsetse and trypanosomosis challenge in the Ghibe valley have shown that Sheko breed exhibited a better trpanotolerant attributes (Lemecha *et al.*, 2006).

The resistance trait is particularly pronounced in the N'Dama cattle and researches provide encouraging preliminary results on some genes associated with trypanotolerance (ILRI, 1998; Trail *et al.*, 1994). The genetic variation identified within the N'Dama breed has opened new

opportunities for improved productivity through selection for disease resistance. Experiments to determine the heritability of trypanotolerance in N'Dama cattle indicates some possibility of selection based on the capacity to control anemia, measured by percentage volume of red blood cells in blood (PCV). Same study reports that restriction fragment length polymorphism (RFLPS), mitochondria DNA analyses, major histocompatibility complex (MHC) and Y-Chromosome DNA analyses have already been applied to African cattle, facilitating, for example, the identification of pure trypanotolerant livestock as opposed to genetically-mixed ones (Bradley *et al.*, 1996).

2.2.4. Integration of various methodologies

The use of trypanocidal drugs is well established and represents the most widely adopted approach to control trypanosomes. However, there is scope for increased use (Geerts and Holmes, 1998) and hence, there are increasing cases of resistance to current drugs, both in individual cases and regionally, especially in East and West Africa. In addition, there is little hope for developing new trypanocidal drugs in the short term and tsetse is spreading aggressively to invade new agricultural areas from most tsetse-trypanosomosis infested areas in sub-Saharan Africa (Jordan *et al.*, 1988; Debebe, 2003).

On the other hand, demands for cheaper alternatives and simple tsetse control methods with less damage to the environment (Jordan, 1988) have driven much of the efforts to the developments of trapping techniques, odor-baited targets, sterile male technique and live bait animals and thus, make eradication of trypanosomosis difficult. Therefore, these indicate that no one method is perfect and it is imperative and important to have a new and integrated approach in the control of tsetse and trypanosomosis so as to reclaim the tsetse infested lands of Africa (Holmes, 1997). These integrated approaches could be addressed at three levels, which involve integration with rural development and other disease control measures and integration of various tsetse and trypanosomosis control measures. In addition, the active participation of the community at all level the development of cost-effective sustainable disease control packages can be ensuring the sustainability of the program (Getachew, 2005).

The use of vector and parasite control in an integrated package has effectively reduced the burden of tsetse and trypanosomosis in cattle in the Ghibe (Leak *et al.*, 1995) and Didessa valleys (Feyissa, 2004).

2.3. Impacts of trypanosomosis on productivity and reproductive performance

2.3.1. Impact on livestock productivity

Trypanosomosis is characterized by intermittent fever, anemia and lymphadenopathy often followed by death in untreated cases (Mulligan, 1970). In 38 countries of Africa, 30% of the total of approximately 147 million cattle and 50 million people in the continent are said to be at risk from trypanosomosis (Murray and Gray, 1984; Kuzoe, 1991).

The direct impact of trypanosomosis is anemia as a result of which the animal becomes morbid and its ability to perform function other than maintenance is reduced. In addition, trypanosomes reduce the effectiveness of the animals' immune system. It has been reported that trypanosomosis kills 3 million animals each year and reduces productivity of sick animals (Erkelense *et al.*, 2000). Another estimate has shown that trypanosomosis reduces the total number of livestock in affected area by between 10 and 50%. With an output elasticity of 0.2, we can predict that trypanosomosis would reduce agricultural gross domestic product by 2% to 10% (Trail *et al.*, 1985).

Adult cattle infected by trypanosomes undergo also weight loss, abortions and infertility. In young animals, reduced growth rate, reduced calves survival rate and delayed onset of puberty is common in herds found in areas of high trypanosomosis challenge (Osaer *et al.*, 1999). These all subsequently result in loss of meat and milk protein to the population and consequently failure to fulfill the demand for exports of meat and dairy products (ILCA, 1985). The annual loss in meat production alone in Africa is estimated at 5 billion USD in 1984 (Murray and Gray, 1984).

2.3.2. Impact on reproductive performances

In male animals, inflammation of testicles is reported in trypanosomosis caused by *T. b. brucei* that leads to degeneration of the seminiferous tubules, slowed spermatogenesis and aspermia, and in severe cases bulls become infertile (Ikede *et al.*, 1988). Decline in semen quality and quantity and spermatozoal abnormalities were observed in goats infected with *T. evansi* and in most severe cases, there were aspermia and atrophy of testicles (Sekoni, *et al.*, 1990; Ngeranwa *et al.*, 1991). In another study, it has been indicated that Zebu x Friesian crossbred bulls infected with *T. vivax* and *T. congolense* developed highly deformed spermatozoa with multiple morphological defects, which can render these bulls unfit for breeding within a very short time (Sekoni *et al.*, 2004). Chronic diseases either due to *T. vivax* or *T. congolense* could be important causatives of infertility or sterility in Zebu x Friesian crossbred bulls.

In female animals, abortion, long intervals between calving/lambing, irregular estrous cycles and infertility are common in chronic cases. Although abortions are often reported from cows infected with trypanosomes, parasites are rarely detected in the fetus. Persistent corpus luteum, a condition normally associated with endometritis, occur in *T. congolense* infected cattle and goats. Cystic ovaries and endometritis have been reported from cattle infected with *T. vivax* (ILCA, 1985).

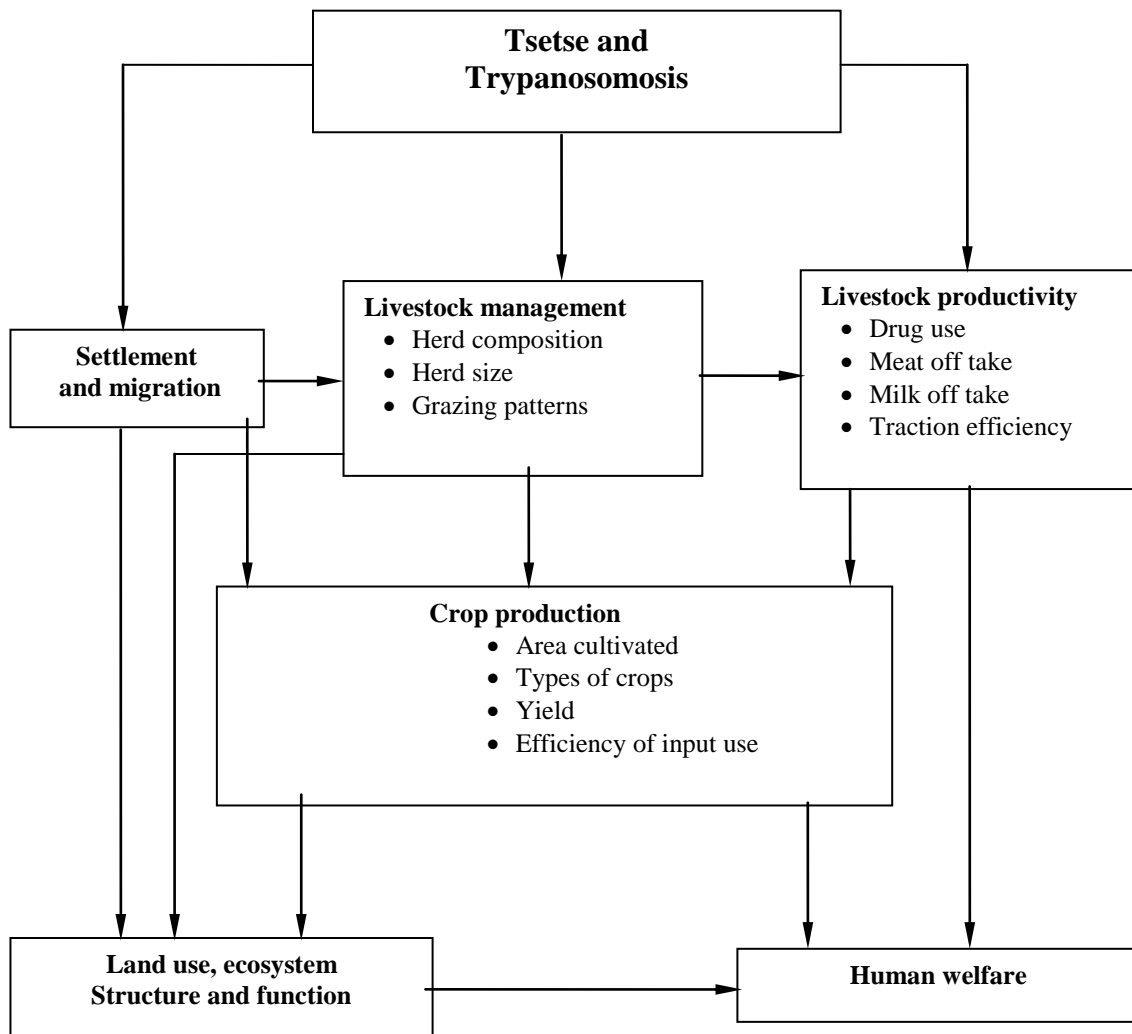
2.3.3. Indirect impacts

There are also some indirect costs associated with the use of curative and prophylactic treatments. Estimates have shown that African livestock producers and governments spend at least 30 million USD per year to treat (25-35 million doses) animals exposed to trypanosomosis (Jahnke *et al.*, 1988; Borne, 1996). In addition, the impact extends to restricted access to fertile and cultivable areas (about 10 million square kilometer of land in Africa and up to 220,000 square kilometer of fertile land in Ethiopia) (FAO/WHO/OIE, 1982; Slingenbergh, 1992), imbalances in land use and exploitation of natural resources and compromised growth and diversification of crop-livestock production systems (Mattioli *et al.*, 2004). The different impacts of tsetse and trypanosomosis are illustrated in Figure 2.

2.4. Impacts of trypanosomosis control measures

2.4.1. Impacts on livestock productivity

In the tsetse and trypanosomosis infested areas of Africa, complex studies have been carried out to estimate the impacts of controlling trypanosomosis on estrus, abortion, mortality, live weight gain, milk production per lactation, lactation length, off take and herd age structure (Trail *et al.*, 1985; Shaw, 1990). It has been estimated that eradication or sustainable control of tsetse and trypanosomosis would lead to a total increment of 33 million heads of cattle that would subsequently increase meat and milk production by 495,000 metric tones and 1.26 million metric tones per year, respectively (Jahnke *et al.*, 1988). Furthermore, a six-fold increase in agricultural output as a result of the availability of a draught ox to a family has been calculated in Africa, where 80% of traction power is non-mechanized (McDowell, 1977).



Source: Swallow (1999)

Figure 2. Conceptual frameworks of the impacts of tsetse and trypanosomosis

The work of Trial *et al.* (1985) demonstrated that Boran cattle at the Mkwaja Ranch, Tanzania, which survived due to only chemoprophylaxis, performed 80% as productive as high quality Boran cattle on trypanosomosis free ranch in Kenya. The comparison of the production performances of Boran cattle in Mkwaja Ranch and Kenya is presented in Table 3.

Table 3. Comparison of the performance of Mkwaja and Kenyan Boran cattle

Variable	Mkwaja Boran	Kenya Borana
Pre-weaning viability (%)	92.0	94.6
Annual cow viability (%)	94.2	98.0
Weaning weight at 8 months (kg)	133.5	174.0
Estimated mature cow weight (kg)	293	414
Productivity per cow per year (kg)	87.1	140.3

Source: Trial *et al.* (1985)

Another study, on a large cattle ranch heavily infested with tsetse in the part of north-east Tanzania, control of tsetse population by regularly dipped cattle in synthetic parathyroid deltamethrin, showed that within a year the disease mortality had decreased by 56% and a range of productivity measures such as calving percentages and weaning weights were raised to levels above those prevailing before the decline in herd health (Fox *et al.*, 1993).

A questionnaire survey conducted in the Agro-pastoral Zone of Yale, Southern Burkina Faso, in 1994 and again in 1997 on the impacts of a tsetse control programme using insecticide-impregnated targets and pour-on treatments of all cattle with 1% deltamethrin, proved a 25% increase in herd size and an increase in the number of oxen from 0.1 to 1.1 per household; a reduction in mortality from 63.1% to 7.1% and an increase in the milk yield from 0.2 to 2.2 liters/cow per day in the dry season (Kamuanga *et al.*, 2001).

In Ethiopia, a tsetse control program using "pour-on" to cattle decreased calf mortality (including still births) by an average of 57%; increased the ratio of live calves by 49% and the body weight of adult males by 8% (Rowlands *et al.*, 1999). In another study in Didessa Valley, mortality rate

in the herds of controlled area showed a reduction from 29-1% to 7.9% as compared to infested area. As a result, the increase in milk yield estimated to be 80% (Feyissa, 2004).

2.4.2. Impacts on reproductive performances

Trial *et al.* (1985) reported that Mkwaja Boran had a higher age at first calving (by 7.3 months) and a lower calving rate (by 12%) than Kenyan Borans. The comparison study of tsetse infested area with tsetse control area in Ghibe valleys of south west Ethiopia have shown that tsetse control increased calving rate to 35.3%. It also reduces average age at first calving, calving interval and abortion rate by 11.5% (5.5 month), 13.6% (3 month) and 39%, respectively (Feyissa, 2004).

A comparison study of reproductive performance of susceptible cattle in the high tsetse challenge and low tsetse challenge areas of Southwest Ethiopia, have shown that cattle in the high tsetse challenge areas have lower caving rate by 20% (60% and 80%), higher abortion rate by 8% (10% and 2%) and higher crude mortality rate by 14% (17% and 3%), respectively than those in low tsetse challenge area (Ahmedin and Hugh, 1995).

3. MATERIALS AND METHODS

3.1. Study area

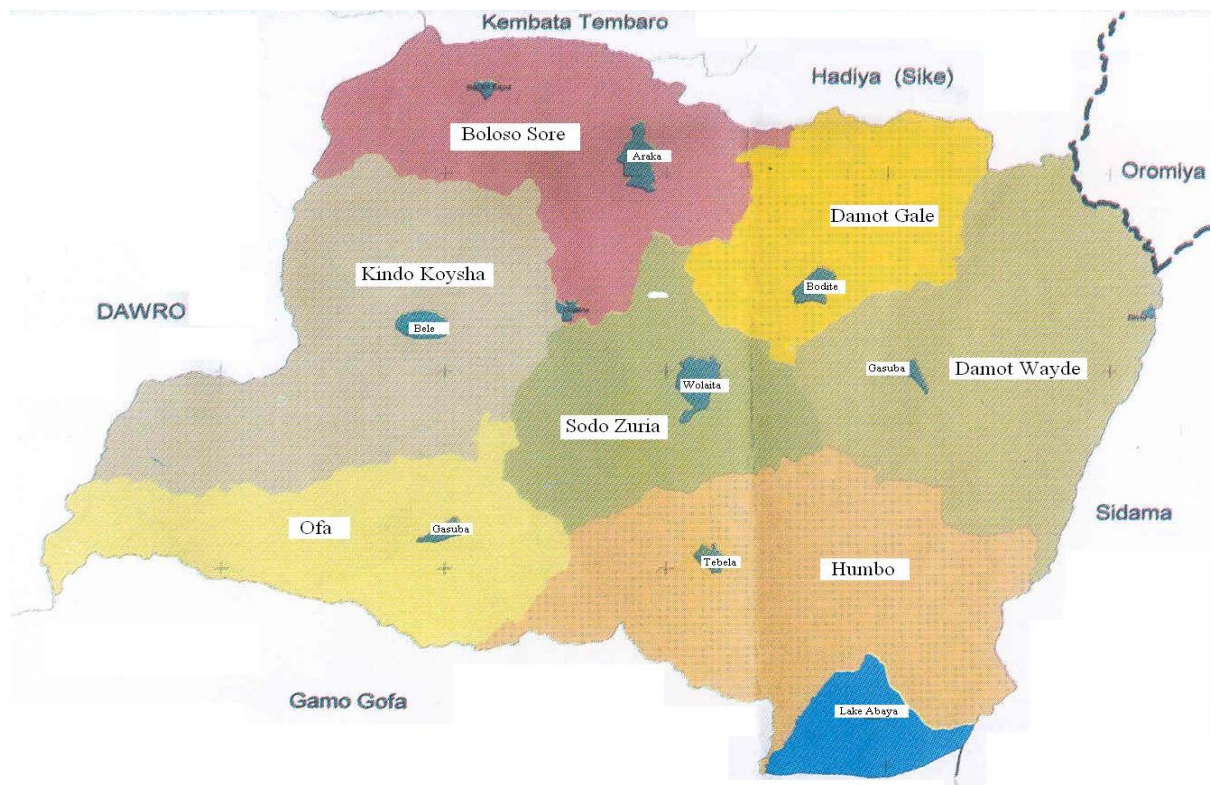
The study was conducted in the Wolayta and Gammo Goffa Administrative Zones of the Southern Nation Nationalities and Peoples Regional State. Two districts, Kindo Koysha from Wolayta Zone and Arbaminch Zuria from Gammo-Goffa Zone, were selected purposely based on their similarity in agroecological characteristics (FA, 2006; Rutebuka, 2006).

Arbaminch Zuria District is located within the southern rift valley area. It has been bordered at southeast by Chamo Lake, at northeast by the largest rift valley lake of Abaya and at the west by Ganta chain of mountains. The district has a total human population of 160,722 with an area of 168,172 hectares of land and has an altitude range of 1050-2808 meters above sea level. It has an irregular topography with plain, marshy and water covered areas in the low lands, and chain of mountains with steeply sloppy areas in the mid and highland parts. The lowland, midland and highland areas represent 33%, 53% and 14% of the total area of the district, respectively (AZDA, 2007).

The rainfall over much of the areas is typically bimodal with an average annual rainfall of 840mm that ranges from 930 to 750 mm. The major rainy season extends from June to September and the short rainy season occurs from February to April. The maximum and minimum temperatures are 31.12 and 11.4°C respectively. The vegetation cover in the areas includes wooded grasslands; various bush formations and deciduous forests dominated mainly by wooded grassland and reverine types (AZDA, 2007)

Southern Tsetse Eradication Project (STEP) has been implementing tsetse and trypanosomosis control program in the southern rift valley areas since 2002. It has tsetse controlled and tsetse infested areas in the block one area, situated north of Arbaminch town and tsetse infested area in the block two, situated south of Arbaminch town, respectively (Rutebuka, 2006).

Kindo-Koysha District is found within the Omo Valley at about 37km west of Soddo town. Omo River with Dawro Zone to the west and three districts of Wolayta Zone to the north, east and south border the District. The geographical location of the District is illustrated in Figure 3. The district has a total human population of 124,380 with an area of about 50,093 hectares of land, which has an altitude range from 700- 2650 meter above sea level. The topography of the District has irregular landscape with steep side slopes, gorges, plains, and tributaries flow down to the Omo River. The lowland, midland and highland areas represent 54%, 39% and 7% of the total area of the land, respectively (WZFEB, 2005).



Source: WZFEB (2005)

Figure 3. Map of Wolayta Zone

The district has two rainy seasons, the short rainy season occurs during February to April and the long rainy season occurring from June to September. The annual rainfall ranges from 844-

1200mm and temperature ranges from 13.12 to 30°C (WZFEB, 2005). The vegetation types in the areas include wooded grasslands and bushes in the lowland areas with forest trees comprising mainly acacia along the Omo River and its tributaries.

The District Office of Agriculture and SOS-Shale had been implementing community based tsetse and trypanosomosis control program for two years, from 2002 to 2004 in severely infested lowland areas. The control program had involved a full participation of the community at all levels during the implementation phase of the project. Before the phase out of the project, at the end of 2004, the control program has been handed over to the community. This had been done mainly to ensure the sustainability of tsetse and trypanosomosis control operations (KKA, 2007)

In both districts agriculture is the livelihood for almost 85% of the population and the predominant farming system is mixed farming system (crop-livestock production). The commonly cultivated plants in the Arbaminch District are maize, banana, mango teff, cotton, enset and root crops while in Kindo Koysha District the commonly grown plants are teff, maize, taro, banana and ginger in the lowland area; maize, coffee, sweet potatoes, enset, taro and bean in the midlands and wheat, barley and enset in the highland areas (KKA, 2007)

Livestock is mainly used as a source of draught power, milk, meat, cash income and capital asset. Arbaminch District has a total livestock population of 90,952 cattle; 19,837 goats; 17,818, sheep; 1358 donkeys; 1,090 mules and 55,889 chicken (AZDA, 2007) and Kindo Koysha District has 52,736 cattle; 2,954 sheep; 12,030 goats; 1,084 equines and 32,698 chickens (KKA, 2007), respectively.

The cattle in the areas are indigenous east African Zebu breeds. They are kept under traditional extensive husbandry system with communal herding. During the day, cattle are herded together and looked after by herdsman. During dry season, animals are allowed to graze on the communal grazing areas early in the morning (6:30am) and come back to the farmstead at about 11:30 Am. During the wet seasons, they are out for most of the time of the day (FA, 2006). Male cattle over three years of age are used as plough oxen. Animals usually work during the morning, particularly during dry seasons, and graze the rest of the day. Milking cows are milked twice a day (in the morning and in the evening) in Arbaminch area, while in Kindo Koysha District they

are milked three times a day (in the morning, at 3 pm and in the evening) (FA, 2006; Rutebuka, 2006).

In the study areas, livestock productivity has been constrained by poor management practice, poor nutrition and livestock diseases. Among a number of livestock diseases prevailing in the area, trypanosomosis is considered as the most important impediment to livestock production and also crop production in the areas (FA, 2006; Rutebuka, 2006).

3.2. Study population

The small holder subsistence farmers and their herds in the selected tsetse and trypanosomosis controlled and non-controlled areas of Kindo Koysa and Arbaminch Zuria Districts were the study population.

3.3. Study design

Cross sectional and longitudinal types of studies were undertaken from September 2007 to April 2008 to collect data by questionnaire survey and follow-up of animals for about six months. Questionnaire survey was used to collect data on household resources, farming system characteristics, cattle herd size and composition, cattle herd dynamics and performance parameters. The follow up study was used to collect data on milk yield and reproductive performances of cattle.

3.3.1. Sample size determination and sampling procedure

For questionnaire survey study, the sample size determination formula recommended by (Arsham, 2006) was used to calculate the sample size.

$$N = \frac{0.25}{S_E^2}$$

With an assumption of 5% standard error, sample sizes of 100 households were needed. Thus, 100 households were selected from each study area classified as community based tsetse control areas, government/non-government tsetse control areas and non-controlled areas.

The two districts, Kindo Koysha from Wolayta Zone and Arbaminch Zuria from Gammo Goffa Zone, were selected purposively considering agroecological similarities and the status of tsetse and trypanosomosis in the areas. Then, four kebeles were selected randomly from Arbaminch Zuria District: Elgo and Shelle Mella kebeles were selected from non tsetse controlled areas while Chano Mile and Chano Dorga were selected from areas where tsetse control has been practiced by government and non-government institutions. Fajena Mata and Mundena Kebeles were selected randomly from community based tsetse controlled areas of Kindo Koysha District. (Annex 1).

Then a simple random type of sampling was used to select 50 households from each kebele, with a total of 300 households from all the study areas

3.3.2. Data collection

Questionnaire survey

A structured questionnaire was prepared and tested for appropriateness of questions and amendments when need arise. Then a one visit interview was carried out to all heads of selected households to generate data on demographic characteristics of the households (family size, educational status, major farming activity, source of income and land holding); livestock and cattle herd compositions and dynamics (the current livestock ownership, livestock herd size, livestock herd composition, cattle herd composition, herd entries and herd disposals), performances (milk yield, lactation length, reproductive performances of cattle (age at first calving, calving interval and number of services per conception), cattle production system characteristics, major cattle health problems and mortalities (Annex 2).

Follow up study

A total of 45 prepartum cows, 15 from each study areas (7-8 cows from each Keble), were followed for a total of about 5 months (20 weeks) to collect data on daily milk yield and postpartum reproductive performance. Data was collected every two weeks from October of 2007 to March 2008. During data collection daily milk yields were recorded for each cow and animals were observed and owners interviewed about the occurrence of the first postpartum heat. Out of 45 postpartum cows followed, four cows were not milked until the end of study period, due to the death of calves and severe drought in the areas.

Meanwhile the tsetse fly trapping were conducted by setting traps once in two weeks for six months in the tsetse controlled and uncontrolled localities of the study areas. A total of 30 NUG traps were deployed in the three study areas and traps stayed at one site for 72 hours and flies caught were collected at the end of 72 hours (every three days) to estimate tsetse challenge (Challier and Lavessier, 1973).

3.3.3. Data analysis

Data collected was stored in MS-Excel spread sheet (Microsoft excel 2003). Descriptive statistics was used to summarize data. Multiple comparisons test (paired wise ANOVA) was used to compare means of different parameters for tsetse challenged, STEP and community controlled areas. Descriptive statistics and comparison of means was carried out using SPSS (Release 11.05, 2002).

4. RESULTS

4.1. Household resources and farming system characteristics

4.1.1. Household resources

The results on household resources are presented in Table 4. The highest family size was recorded for STEP tsetse controlled area (8.47) and the least was that of community controlled area (7.18). Households in community controlled area had the largest land size (2.8ha) followed by those in tsetse challenged area (2.24%). Most of the land in tsetse challenged (88.84%), STEP controlled (97.92%) and community controlled areas (81.79%) was allocated for crop cultivation. The differences between the three study areas regarding family size ($p<0.01$), total land holding ($p<0.001$), crop land holding ($p<0.001$), pasture land holding ($p<0.001$) and fallow land holding ($p<0.05$) were statistically significant.

Table 4. Mean and standard errors of household resources in the study areas

Household resources	Tsetse Challenged Area			STEP Controlled Area			Community Controlled Area			P-value
	N	Mean	SE	N	Mean	SE	N	Mean	SE	
Family size	100	7.76 ^{ab}	0.29	100	8.47 ^a	0.26	100	7.18 ^{abc}	0.23	0.003
Total land	100	2.24 ^b	0.13	100	1.44 ^c	0.03	100	2.80 ^a	0.14	0.000
Crop land (ha)	100	1.99 ^b	0.10	100	1.41 ^c	0.03	100	2.29 ^a	0.11	0.000
Pasture land	100	0.17 ^b	0.04	100	0.01 ^c	0.01	100	0.47 ^a	0.05	0.000
Fallow land	100	0.10 ^a	0.04	100	0.001 ^b	0.00	100	0.10 ^a	0.07	0.010

N= Number of Observations, SE= Standard Error, STEP= Southern Tsetse Eradication Project, means within a rows with different superscripts (a-c) are significantly different at $P<0.05$

From the total sampled households, the majority of the respondents in the three study areas were illiterates; 69% in tsetse challenged area, 56% in STEP tsetse controlled area and 55% in community based tsetse controlled areas.

4.1.2. Livestock herd size and composition

Mean and standard errors of livestock herd size and composition per household in the study areas are presented in Table 5. The total livestock holding by a household in tsetse challenged area (11.84 heads) was higher than the livestock holding in STEP tsetse controlled (9.82 heads) and community tsetse controlled (9.98 heads) areas ($p < 0.05$). However, the value between the two tsetse controlled areas was very close and not significantly different ($p > 0.05$). The same thing holds for cattle herd size, whereby, the average holding per household in tsetse challenged (9.8 heads) are significantly higher than the values in STEP tsetse controlled (7.02 heads) and community tsetse controlled (7.45 heads) ($p < 0.001$).

In all areas cattle constituted the major species of livestock compared to the other species. The number of goats in a household in the three study areas ranged from 1.65-2.14 and the difference was not significant ($p > 0.05$), while the number of sheep and donkey varied significantly ($p < 0.05$). The number of sheep per household was comparable in tsetse challenged (0.63) and STEP control areas (0.64) while that of community controlled area was the lowest (0.20). The largest number of donkeys was found in community controlled area than the other two study areas (0.19) (Table 5).

4.1.3. Major crops grown in the study areas

The type of major crops produced in tsetse challenged; in STEP controlled and community controlled areas are presented in Table 6. Maize was the most important food crop grown in all the study areas. Sweet potato and banana were also produced in all the study areas in different degrees. Teff (40%) and cotton (50%) were important crop in tsetse challenged area while fruits (85%) were important for STEP controlled area and haricot bean (34%) was for community controlled areas (Table 6).

Table 5. Mean and standard errors of livestock herd size and composition per household in the study areas

Livestock species	Tsetse Challenged Area			STEP Controlled Area			Community Controlled Area			P-value
	N	Mean	SE	N	Mean	SE	N	Mean	SE	
	Cattle	100	9.79 ^a	0.61	100	7.02 ^b	0.35	100	7.45 ^b	
Goats	100	1.65	0.28	100	2.110	0.25	100	2.140	0.23	0.131
Sheep	100	0.63 ^a	0.14	100	0.61 ^a	0.14	100	0.20 ^b	0.07	0.020
Donkey	100	0.05 ^b	0.03	100	0.08 ^b	0.04	100	0.19 ^a	0.05	0.030
Total livestock	100	11.84 ^a	1.36	100	9.82 ^b	0.78	100	9.90 ^b	0.74	0.020

N= Number of Observations, SE= Standard Error, STEP= Southern tsetse Eradication Project, means within a rows with different superscripts (a-c) are significantly different at P< 0.05

Table 6. Major crops grown by sampled households in the study areas

Major crops	Tsetse Challenged Area			STEP Controlled Area			Community Controlled Area		
	N	Frequency	%	N	Frequency	%	N	Frequency	%
Maize	100	100	100	100	99	99	100	99	99
Sweet potatoes	100	31	31	100	85	85	100	51	51
Teff	100	40	40	100	6	6	100	17	17
Fruit	100	0	0	100	16	16	100	0	0
Haricot bean	100	0	0	100	1	1	100	34	34
Banana	100	68	68	100	94	94	100	1	1
Cotton	100	50	50	100	6	6	100	0	0
Haricot bean	100	0	0	100	0	0	100	31	31

N= Number of Observations, STEP= Southern Tsetse Eradication Project

4.2. Constraints of livestock production

Livestock diseases were the first most important constraint of livestock production identified by 83% of respondents in tsetse challenged area. In STEP and community controlled areas shortage of grazing area was mentioned by 88% and 63% of the respondents as a major constraint, respectively. The major cattle diseases recognized as important in the study areas by selected farm households are presented in Table 7. The first priority disease mentioned by 100% of the respondents in tsetse challenged area and by 95% of the respondents in both STEP and community controlled areas was trypanosomosis. CBPP (56-68%) and fasciolosis (36-55%) were also mentioned by a significant proportion of farmers in the tsetse challenged and STEP controlled areas. On the other hand, blackleg (36-46%) was mentioned as an important disease in tsetse challenged and community controlled areas. Pasteurellosis was considered as important only in community controlled area (55%).

Table 7. Major cattle diseases in the study areas as mentioned by the respondents

Diseases	Tsetse Challenged Area			STEP Controlled Area			Community Controlled Area		
	N	Frequency	%	N	Frequency	%	N	Frequency	%
Trypanosomosis	100	100	100	100	95	95	100	95	95
CBPP	100	68	68	100	56	56	100	00	00
Black leg	100	46	46	100	9	9	100	36	36
Liver fluke	100	36	36	100	55	55	100	00	00
Endoparasites	100	4	4	100	00	00	100	4	4
Pasteurellosis	100	00	00	100	6	6	100	51	51

N= Number of Observations, STEP= Southern Tsetse Eradication Program

The season when there was very serious feed shortage in all the study areas was from February to April (91-95%). There was also feed shortage from November to January in all the study areas (39-77%).

4.3. Cattle herd size and composition

The average cattle herd size and composition in the three study areas is presented in Table 8. The average number of cattle herd size in tsetse challenged area (9.79 heads) was higher than the comparable number of cattle herd size in the STEP tsetse controlled (7.02 heads) and in the community tsetse controlled (7.45heads) areas ($p<0.001$). From the cattle herd composition there was significant difference in the number of non pregnant dry cows ($p<0.05$), bulls ($p<0.05$) and oxen ($p<0.001$). The number of non-pregnant dry cows was highest in tsetse challenged area (0.79) followed by the values in community (0.49) and STEP control (0.33) areas. Tsetse challenged areas had the highest number of bulls (1.62) and oxen (2.53). The number of bulls in STEP and community controlled areas were 1.11 and 1.58, respectively, while that of oxen were 1.56 and 0.87, respectively.

There was no significant difference in the number of pregnant dry cows, pregnant lactating cows, non-pregnant lactating cows, heifers, male calves and female calves between the three study areas ($p>0.05$).

Table 8. Cattle herd size and composition per household in the study areas

Cattle herd Composition	Tsetse Challenged Area			STEP Controlled Area			Community Controlled Area			P-Value
	N	Mean	SE	N	Mean	SE	N	Mean	SE	
PD cows	100	0.98	0.12	100	0.72	0.08	100	0.73	0.08	0.270
PL cows	100	0.51	0.09	100	0.40	0.07	100	0.50	0.07	0.540
NPD cows	100	0.79 ^a	0.15	100	0.33 ^b	0.07	100	0.49 ^b	0.07	0.010
NPL cows	100	0.79	0.10	100	0.67	0.08	100	0.70	0.09	0.650
Bulls	100	1.62 ^a	0.14	100	1.11 ^b	0.10	100	1.58 ^a	0.14	0.010
Heifers	100	1.22	0.14	100	1.03	0.09	100	1.28	0.12	0.290
Oxen	100	2.53 ^a	0.15	100	1.56 ^b	0.09	100	0.87 ^c	0.10	0.000
Male calves	100	0.71	0.08	100	0.79	0.08	100	0.77	0.07	0.770
Female calves	100	0.72	0.09	100	0.63	0.08	100	0.69	0.07	0.710
Total cattle	100	9.79 ^a	2.12	100	7.02 ^b	0.74	100	7.45 ^b	0.81	0.000

N= Number of Observations, SE= Standard Error, STEP= Southern Tsetse Eradication Project,

Means within a row with different superscripts (a-c) are significantly different at $P< 0.05$

The cattle herd dynamics in the study areas is depicted in Table 9. There was significant difference in the study areas regarding the addition of oxen, cow, heifers and calves. The addition rate of oxen and calves was highest in tsetse challenged areas while that of cows and heifers was highest in community-controlled areas. Regarding the overall herd size, the highest addition was done in tsetse challenged areas followed by community and STEP control areas.

The disposal rates of cattle in general, oxen, cows, heifers, bulls and calves are significantly different among the three study areas. In all cases, the highest disposal rate was seen in the tsetse challenged area. The second highest disposal rates of oxen and heifers were found in community controlled areas while the values for the other groups of cattle are comparable in the two areas.

Table 9. Cattle herd dynamics (additions and disposals) in the three study areas

Cattle added	Tsetse Challenged area			STEP tsetse Controlled area			Community tsetse controlled area			P Value
	N	Mean	SE	N	Mean	SE	N	Mean	SE	
Oxen	100	0.62 ^a	0.10	100	0.25 ^b	0.05	100	0.54 ^a	0.07	0.002
Cows	100	0.05 ^b	0.03	100	0.10 ^b	0.03	100	0.18 ^a	0.04	0.029
Bulls	100	0.04	0.02	100	0.09	0.04	100	0.13	0.04	0.194
Heifers	100	0.01 ^b	0.01	100	0.07 ^b	0.03	100	0.18 ^a	0.04	0.000
Calves	100	1.78 ^a	0.18	100	1.11 ^b	0.10	100	0.91 ^b	0.09	0.000
Total	100	2.50 ^a	0.33	100	1.62 ^b	0.25	100	1.94 ^b	0.28	0.001
Cattle disposed										
Oxen	100	1.12 ^a	0.11	100	0.42 ^c	0.07	100	0.80 ^b	0.10	0.000
Cows	100	1.15 ^a	0.13	100	0.27 ^b	0.06	100	0.25 ^b	0.06	0.000
Bulls	100	0.44 ^a	0.12	100	0.17 ^b	0.04	100	0.18 ^b	0.05	0.048
Heifers	100	1.13 ^a	0.11	100	0.42 ^b	0.07	100	0.80 ^b	0.10	0.000
Calves	100	1.15 ^a	0.13	100	0.27 ^b	0.06	100	0.25 ^b	0.06	0.000
Total	100	4.99 ^a	0.12	100	1.55 ^c	0.04	100	2.28 ^b	0.05	0.000

N= Number of Observations, SE= Standard Error, STEP= Southern Tsetse Eradication Project,

Means within rows with different superscripts (a-c) are significantly different at P< 0.05

Animal purchases and births were the major reasons for cattle coming in to the herd in tsetse challenged area (39% and 67%, respectively), STEP controlled area (20% and 65%, respectively) and community controlled area (43% and 58%, respectively). Regarding disposal, mortality and sales were the major reasons; the effect of mortality being higher in tsetse challenged areas (59%) than STEP (3%) and community controlled areas (7%). The effect of sells was equally important as mortality in tsetse challenged areas (59%). In the STEP (19%) and community controlled areas (10%), the importance of sells was less important.

4.4. Milk yield and reproductive performance of cattle

The mean and standard errors of milk yield at different stages of lactation, lactation length, age at first calving, calving interval and number of services per conception are presented in Table 10. The average daily milk yield was in general low and significantly different at the three stages of lactation between in the three areas ($P < 0.001$). The highest average daily milk yield at the beginning (2.22 liters), middle (1.40 liters) and end of lactation (0.64 liters) was recorded in community-controlled areas followed by the values in STEP controlled area. The value for tsetse challenged area was significantly lower than the values for both controlled areas. Cows in STEP and community controlled areas were able to give 26-27, 25-29 and 17-21% more daily milk yield than those in tsetse challenged area during the beginning, middle and end stages of lactation, respectively. The same holds true for lactation length in that cows in the STEP and community controlled areas had lactation length longer by 1.20 and 1.35 months, respectively than those in tsetse challenge area, respectively ($p < 0.001$).

The average age at first calving and calving interval of cows in the two tsetse controlled areas were significantly lower than those in tsetse challenged area ($p < 0.001$). Cows in STEP and in community-controlled areas gave their first calf 5.3 and 5.1 months earlier, respectively, than those in tsetse challenged area. Cows in the STEP and in the community tsetse controlled areas had a calving interval shorter by 4.2 and 3.2 months, respectively than those in tsetse challenged areas ($p < 0.001$). However, the difference in the number of services per conception between the three areas was not significant ($P > 0.05$).

Table 10. Mean and standard errors of milk yield and reproductive performances of cattle in the study areas

Variables	Tsetse challenged area			STEP Controlled area			Community controlled area			p Value
	N	Mean	SE	N	Mean	SE	N	Mean	SE	
LL (months)	100	5.20 ^b	0.12	100	6.40 ^a	0.17	100	6.55 ^a	0.22	0.000
MYBL (Liters)	100	1.64 ^b	0.47	100	2.20 ^a	0.05	100	2.22 ^a	0.07	0.000
MYML (Liters)	100	1.00 ^b	0.05	100	1.34 ^a	0.04	100	1.40 ^a	0.06	0.000
MYEL (Liters)	100	0.50 ^b	0.03	100	0.60 ^a	0.05	100	0.62 ^a	0.03	0.017
AFC (months)	100	53.4 ^a	0.93	100	48.1 ^b	0.91	100	48.3 ^b	0.31	0.000
CI (months)	100	20.9 ^a	0.29	100	16.7 ^b	0.30	100	17.7 ^b	0.57	0.000
NSPC	100	1.60	0.07	100	1.37	0.47	100	1.46	0.08	0.171

N= Number of Observations, LL= Lactation Length, MYBL= Milk Yield at the Beginning of Lactation, MYML= Milk Yield at the Middle of Lactation, MYEL= Milk Yield at the End of Lactation, AFC= Age at the First Calving, CI= Calving Interval, NSPC= Number of Services Per Conception, SE= Standard Error, STEP= Southern Tsetse Eradication Project, means within the rows with different superscripts (a-c) are significantly different at P< 0.05

The result of the follow-up study to determine the lactation curve of cows in the three study areas during the study period (October 2007 to April 2008) is illustrated in Figure 4. The daily milk yield of cows in tsetse challenged areas was consistently lower during the whole period of study than the STEP controlled areas. The lactation curves of cows in tsetse challenged and community-controlled areas are nearly overlapping indicating insignificant difference.

On the other hand, from the follow up study it was observed that in all areas the apparent density of tsetse fly catch per trap per day from the first week to the last week of sampling was dropping steadily during the six months of study period. Tsetse fly catch was dropped from 70.1fly – 15.8 fly per trap per day in tsetse challenged area, 0.22 fly- 0 fly per trap per day in STEP tsetse controlled and 1 fly- 0.5 fly per trap per day in community tsetse controlled areas. Clearly this result demonstrates that the tsetse control measures efficiently suppress tsetse challenge in the tsetse-controlled areas.

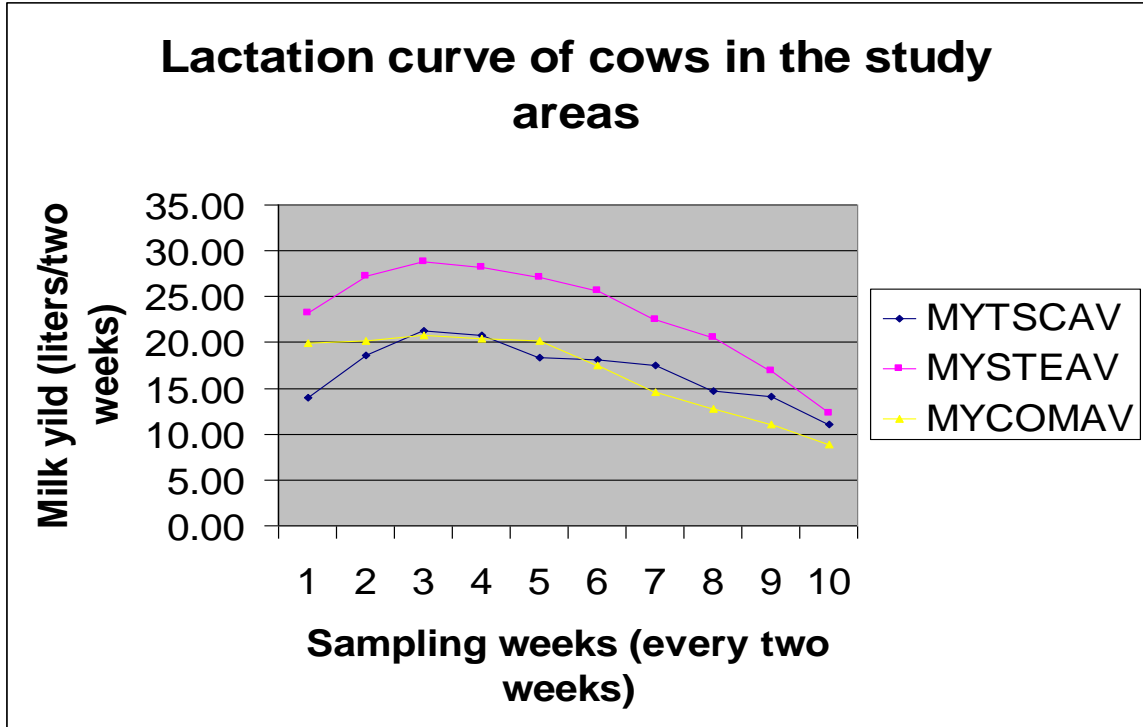


Figure 4. Lactation curves of cows in tsetse infested (MYTSCAV) STEP controlled (MYSTEAV) and in community controlled (MYCOMAV) areas.

4. 5. Mortality of cattle in the study areas

The average numbers of cattle died in 1999 E.C. in the study areas are presented in Table 11. The number of cattle and groups of cattle died in one-year time was significantly higher in tsetse challenged area than the controlled areas ($p < 0.001$). The total number of cattle died in one year time in tsetse challenged area was about 9.18 and 7.29 times higher than the value for STEP and community controlled areas, respectively. In terms of the different groups of cattle, the mortality was higher in tsetse challenged area by 18.6 folds for oxen, 4.64 folds for cows, 14 folds for heifers, 30 folds for bulls and 15 folds for calves in STEP controlled areas and by 18.6 folds for oxen, 7.3 folds for cows, 5.25 folds for heifers, 2.14 folds for bulls and 22.5 folds for calves in community tsetse controlled areas.

Table 11. Cattle mortality during 1999 E.C. in the three study areas

Parameter	Tsetse challenged area			STEP tsetse Controlled area			Community Tsetse controlled area			P Value
	N	Mean	SE	N	Mean	SE	N	Mean	SE	
Oxen	100	0.91 ^a	0.097	100	0.05 ^b	0.026	100	0.05 ^b	0.026	0.000
Cows	100	0.98 ^a	0.106	100	0.22 ^b	0.026	100	0.14 ^b	0.038	0.000
Heifers	100	0.40 ^a	0.076	100	0.03 ^b	0.022	100	0.08 ^b	0.031	0.000
Bulls	100	0.31 ^a	0.062	100	0.01 ^b	0.010	100	0.140 ^b	0.040	0.000
Calves	100	0.43 ^a	0.091	100	0.03 ^b	0.022	100	0.02 ^b	0.014	0.000
Total cattle	100	3.12 ^a	0.44	100	0.34 ^b	0.106	100	0.43 ^b	0.149	0.000

N= Number of Observations, SE= Standard Error, STEP= Southern Tsetse Eradication Project, means within a row with different superscripts (a-c) are significantly different at $P < 0.05$

5. DISCUSSION

Land suitability studies in southern and southwestern Ethiopia revealed that the tsetse-infested lowlands have the best potential for expanded agriculture, provided that tsetse constraint is removed (FAO, 1987). Slingenbergh, (1992) estimated that about 220,000 square kilometer of fertile land in Ethiopia is uncultivable only due to trypanosomosis. It is assumed that tsetse and trypanosomosis control measures encourage people to cultivate land in tsetse-infested areas. Reid *et al.* (1997) and Reid *et al.* (1999) in Ghibe Valley, Ethiopia, reported that cultivation was expanding faster in areas where tsetse control has been successful. The smaller land size and livestock and herd size per household observed in the STEP controlled areas in this study could be due to the involvement of many people in crop cultivation encouraged by the control programs.

Land in community controlled area was higher compared to STEP controlled area; this could be because of the fact that more land was allocated to farmers during government settlement program in the lowland free areas. In addition, land size in the tsetse challenged areas was higher than the case in STEP controlled area. This finding is inconsistent with the report of Slingebergh (1992) who estimated that the average land holding per household in tsetse challenged and free areas were 3.48 and 1.85ha, respectively. This indicates that land is relatively more abundant in tsetse challenged areas since people do not feel confident to settle and use cattle for crop cultivation in tsetse challenged areas.

The livestock herd size and cattle herd size in the current finding were higher in tsetse challenged area than in STEP and community controlled areas. This was not mainly because of trypanosomosis problem in the STEP and in the community tsetse controlled area rather due to the fact that there is migration of peoples into the tsetse controlled areas and expansion of land cultivation, causing shortage of livestock grazing areas. Thus, expansion of cattle herd in the tsetse controlled areas is being compromised. On the other hand, in the tsetse infested area, the higher cattle herd size was not because cattle were not challenged by tsetse rather due to the fact that there is a high turnover of cattle herd size because of mortalities and replacements. Our finding is not in agreement with the reports of Swallow (1999), Kamuanga *et al.* (2001) in

Burkina Faso and Ayeldo (2004) in the Ghibe Valley of Ethiopia. Swallow (1999) reported that farmers in areas of high trypanosomosis risk kept 25-60% as many cattle as the farmers in nearby low risk areas. Kamuanga *et al.* (2001) indicated that control of tsetse and trypanosomosis increases cattle herd size by 25% and the number of oxen from 0.1 to 1.1 per household. Recently Ayeldo (2004) showed that control of tsetse and trypanosomosis resulted in an 18.2% rise in cattle herd size and an increase in the number of draught oxen from 0.6 to 1.3 in each household.

In the current study it was observed that oxen and calves represented the highest category of cattle added to the herd in tsetse challenged areas. This was mainly because oxen are the most important cattle needed by farmers for traction purposes and their number of work efficiency is reduced very much by the tsetse challenge. Swallow (2000) indicated that oxen in high-risk areas were 38% less efficient than oxen in a low risk area in their traction performance. Regarding to high number of calves added to the herd observed in this study was mainly because of higher number of cows in the cattle herd in tsetse challenged area. This observation was in line with the report of (Rutebuka, 2006) in tsetse control and eradication in southern rift valley area.

The high number of oxen and calves in community controlled area in this study could be due to purchasing of oxen for fattening purposes in the area and the dairy cows acquired by safety net package fund for poor households (KKA, 2007). The analysis of the result also indicated that high disposal of cattle in tsetse challenged area was mainly because of high mortality and morbidity of cattle caused by trypanosomosis and frequent sale of animals, which is a local strategy to minimize loss of animals due to trypanosomosis. This finding is in line with report of Rutebuka (2006) in southern refit valley cows, bulls, and oxen were the major cattle leaving the herd largely through death and sales.

In this study trypanosomosis was considered as the most important disease in all the study areas. This result is in line with the report of Shimelis *et al.* (2005) in the North West Ethiopia, Oluwafemi (2007) in Odo State of Nigeria and Magona *et al.* (2004) in Uganda.

The number of non pregnant dry cows and oxen was significantly lower in the STEP and community controlled areas than in the tsetse challenged area in this study. However, the difference in the number of pregnant dry cows, non-pregnant lactating cows, pregnant lactating cows, heifers and male and female calves was not significant between tsetse infested and the two tsetse controlled areas. This could be due to shortage of grazing land resulting from increased cultivation of land in the tsetse controlled areas. Thus, farmers were forced to keep only small number of animals and plough oxen on their small holdings.

On the contrary, the number of non-pregnant dry cows is significantly higher in tsetse challenged area followed by community and STEP controlled areas, this could be an indication that the tsetse challenge and trypanosomosis exerted negative impact on the fertility of cows, thus the reproductive performance is seriously compromised. Sekoni *et al.* (2004) report support this finding in that chronic disease either due to *T. vivax* or *T. congolense* could be an important causes of infertility or sterility in crosses of Zebu and Friesians. ILCA (1995) also showed that persistent corpus luteum, cystic ovaries and endometrities occur in *T. congolense* infected cattle. Regarding the higher number of oxen and bulls in tsetse challenged area, it could be an indication that farmers tend to replace every time oxen died and failed to work due to infection of trypanosomosis. This finding was in line with the report of Swallow (2000) indicated that oxen in high-risk areas were 38% less efficient than oxen in a low-risk area in their traction performance.

In this study, significant positive impacts of tsetse and typanosomosis control measures in the control areas was observed on lactation length, daily milk yield at three stages of lactation, age at first calving and calving interval on tsetse challenged area. Cows in the STEP and in the community tsetse controlled areas had higher daily milk yield than cows in the tsetse infested area at the beginning, middle and end of lactation. This was also confirmed by the follow-up study. In Ethiopia, a recent work by Feyissa (2004) in Didessa Valley revealed that daily milk yield increased by 80% due to tsetse control measures and Kamuanga *et al.* (2001) in southern Burkina Faso showed an increase in the milk yield from 0.2 to 2.2 liters/cow per day in the dry season due to tsetse control measures.

The report of Trial *et al.* (1985) at Mkwaja Ranch, Tanzania, showed that Boran cattle, which survived only due to chemoprophylaxis had a higher age at first calving (by 7.3 months) and a lower calving rate (by 12%) than the high quality Kenyan Borans in tsetse free area and the recent report of Feyissa (2004) in Didessa Valley, Ethiopia, showed that cattle in tsetse controlled area had reduced average age at first calving and calving interval by 11.5% (5.5 month) and 13.6% (3 month), respectively compared to cattle in tsetse infested area. Also the present finding on the calving intervals (16.7) and (17.7) months in controlled areas were consistent with other studies done in Zambia and Malawi as reported by Doran and Van den (2000). The average calving rate along tsetse-infested edge of Malawi was 37% and in the tsetse-controlled area average calving rate was 53.7% (45% increases). in our case even though the calving rate was not calculated .

In this study, there was in general a very significant difference in number of mortality in cattle in general and the different groups in particular. The number of animals died in the 1999 E.C. in tsetse challenged area was by far higher than the case in STEP and in community based tsetse-controlled areas. The report of Kamuanga *et al.* (2001) in southern Burkina Faso demonstrated a reduction of cattle mortality from 63.1% to 7.1% following tsetse control measures. Ahmedin and Hugh (1995) also stated that in south west Ethiopia, cattle in the high tsetse challenge area had higher mortality rate by 14% than low tsetse challenge area. Moreover, the report of Feyissa (2004) in Didessa valley also supports our finding in that mortality of cattle was lower by 86 to 89% in tsetse control areas as compared to non tsetse controlled area. Kamuanga *et al.* (2001) also reported that over 60% of calves died in Burkina Faso. Swallow (2000) estimated an annual cattle mortality rate due to trypanosomosis ranging from 0-20%.

6. CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of this study and previous reports the following can be concluded. The cattle herd size was higher in tsetse challenged areas with only a significant difference in the number of oxen, non-pregnant dry cows and bulls, which are still high in number in tsetse challenged areas. The cattle herd dynamics showed that the cattle turn over was very high in tsetse challenged areas. The cattle herd in the tsetse challenged areas was maintained mainly by the high replacement rate in the area. Cows in tsetse challenged area were very much less in performance in terms of milk yield, age at first calving and calving interval than cows in STEP and community controlled areas. The level of cattle mortality in tsetse challenged area is very high which could be due to trypanosomosis.

Based on these conclusions, the following recommendations are forwarded:

- The use of integrated control measures against tsetse challenge and trypanosomosis is highly recommended to improve the level of cattle herd health and productivity, which has significant impact on cattle production and household income;
- In the long term, it is essential to consider the use of indigenous trypanotolerant breeds of cattle in tsetse infested areas;
- Further study should be carried out to investigate in detail the socio-economic impacts of tsetse challenge and trypanosomosis in the area.

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8. ANNEXES

Annex 1. Picture of the study areas



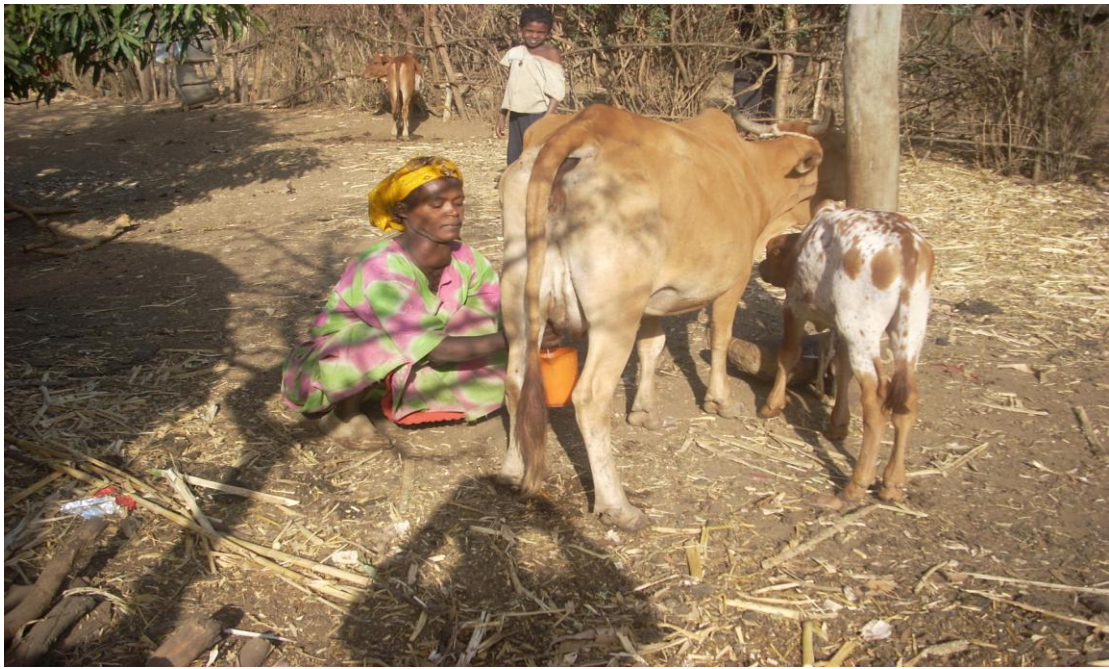
Kindo Koysha community tsetse controlled area farmers applying pour-on on cattle



Arbaminch Tsetse challenged area near Lake Chammo



Arbaminch STEP Tsetse controlled area near Lake Abaya



Milking of cow in tsetse controlled Chano Dorga kebele Arbamich



Milk yield recording in tsetse controlled Chano Dorga Kebele



Cattle in Arbaminch tsetse controlled area



Trap deploying in community controlled kindo koyha district



Tsetse fly trapped in the tsetse challenged area



Cattle in tsetse controlled area of Arbaminch Zuria district



Tsetse monitoring team preparing for trap deploying

Annex 2. Questionnaires on the Impacts of Tsetse and Trypanosomosis Control Measures

A. Survey site (location) and Household characteristics

1. Region _____, Zone _____, Woreda _____, Kebele _____, Altitude _____
2. Name of the farmer, _____ Age, _____ (in complete year)
3. Sex: 1). Male _____, 2). Female, _____
4. Length of stay in this PA, _____, (state in years)
5. Household characteristics (complete the table below by using key below table)

Name	Age (years)	Sex M or F*	Education Level**	R/ship to HH Head***	Period of stay in HH****

*sex (1=Male, 2=Female), **Education levels (1=none, 2=P primary, 3=Secondary/High school, 4=Tertiary, ***R/ship to HH (1=wife, 2=son, 3=Daughter, 4=worker, ****Period of stay in HH (state period in year) ,

B. Land holding and cropping patterns

1. Major farming activities:
 - a) Livestock farming
 - b) Crop farming
 - c) Mixed farming.
2. If livestock farming, what type?
 - a) Nomadic (move in search of livestock feed throughout the year)
 - b) Semi-nomadic (move in search of livestock feed for part of the year)
 - c) Sedentary, (settle in one place throughout the year)
 - d) Other (specify)

3. How much is the size of your Land holding (ha) _____.
 Cultivated land: _____ For Pasture _____, Fallow _____,
 Forest _____ Others _____
4. Indicate the most important food crops in the order of importance
5. Indicate the most important cash crops in the order of importance

C. Current livestock and cattle herd size, composition and dynamics

1. When did you start to raise livestock? Which species of livestock comprised your foundation stock?
2. What are the main benefits you get from your livestock in general? (List them in order of importance);
3. Indicate the type and number of livestock you have been keeping

Type of livestock	Animals you had 5 years ago	Animals You have now	Reasons for change in number	No you intend to keep in the coming years
Cattle				
Sheep				
Goat				
Donkey				
Horse				
Mule				

4. What was your source of establishing the cattle herd? _____
5. How long have you used the current cattle herd? _____
6. How long are you intending to use the herd in future? _____
7. What is your primary objective of keeping cattle in your farm? _____

8. Indicate the current structure and composition of the cattle herd

Cattle/Category	Statuses	Numbers now
Cows (dry and in milk)	Pregnant dry	
	Pregnant lactating	
	Non-pregnant dry	
	Non-pregnant lactating	
Bulls (None-castrated adult males)		
Heifers		
Oxen (castrated adult male)		
Female calves		
Males calves		
Total herd size		

9. What changes in your cattle herd happened during the last years?

Entries into the herd

Type of Animals*	Number	Reasons of entry

Disposals from the herd

Type of Animals*	Number	Reasons of disposal

D. Productivity and reproductive performance

1. What is the average daily milk yield of your cows at the beginning, middle and end of Lactation and for how long do you milk your cows?

Currently

Daily milk yield			Lactation length (months)
Beginning	Middle	End	

2. At what age did your cows show heat signs for the first time? _____ (Years)
3. At what age did your cows have their first calf? _____ (Years)
4. When did your cows give their last calving and previous calving?

Cow number	Last calving date	Previous calving date

5. How often do you expect your cows to calve (how many months between one birth and the next)? , _____ (Years/months)
6. At what age did your male cattle became active in breeding (bull)? _____
7. How many times did you take your cow for service before it got pregnant?

Cow number	Types of mating (AI, Bull or both)	Numbers of services per conception

E. Draught oxen

1. Do you keep draught oxen five years before? 1) Yes _____ 2) No _____, if yes How many? _____

If your answer is no for the above question, what was the reason? _____

2. Do you keep draught oxen currently? 1) Yes _____ 2) no _____
 If yes to the above question, how many draught oxen dose this household own? _____

If yes to the above question for haw long do you plough per day (in hr)? _____

F. Livestock management

1. Do you use communal grazing land? (Tick one) Yes _____, No _____
2. What are the major feed resources you are supplying your cattle? Natural pasture,
3. Hay/stalk, Crop residue (specify), Forage trees, Fodders, concentrates
4. Is livestock feed available all year round? Yes _____, No _____, If no, when is the
 Feed shortage common? Specify months _____
5. What is your main source of water for your livestock? _____
6. How far is the nearest reliable source of water for your livestock? (In km) _____
7. How do you keep animals at night? (Tick on the right answer), Open with out
 Enclosure, Corrals, Separate barn, in family house

G. Livestock production constraints

1. What are the major constraints of livestock rearing in your area in the order of their
 importance?
2. List in order of importance the disease that affects your cattle:

	Disease	Symptoms	Possible cause	Coping strategies
1				
2				
3				
4				

3. Indicate number of animals that died from different diseases during the last year?
 a. to 2007)

Type of livestock	No. of animals	Symptoms	Disease	How do you know the disease
Indigenous cattle;				
Sheep and goat				
Donkeys				

H. Tsetse and Trypanosomosis

- Have you ever heard of the tsetse fly? 1) Yes _____, 2). No _____
- Have your animals ever suffered from trypanosomosis? 1). Yes _____, 2). No _____
- If yes how did you know it was trypanosomosis? (List the symptoms) _____
- Which species of livestock are mainly affected by trypanosomosis? _____
- _____
- What are the major impacts of trypanosomosis in cattle in your area? _____
- _____
- Indicate the number of animals on your farm that were affected by trypanosomosis during the Past year (complete the table below)

Type of animals	Number available During the incident	Number affected	Number died
Cattle/ cow			
Cattle/ heifers			
Cattle/ male caves			
Cattle/ female caves			
Cattle/bulls			
Cattle/ steer			
Goats			
Sheep			
Donkeys			

9. Have you ever attempted to prevent your animals against trypanosomosis over the last one year?
1). Yes _____, 2). No _____ (tic as applicable)
10. If yes, which method did you use for prevention? _____
11. Are you aware of tsetse and trypanosomosis control programs? Yes _____, no _____
12. If yes, are you benefiting from these programs? _____
If yes, what are the benefits you get from the control programs? _____
13. Which months of the year are highly affected by tsetse challenge? _____
14. How do you manage cattle health problems? _____

9. SIGNED DECLARATION

This thesis is my original work, has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged”

Name Messele Taye Belachew

Signature _____

This thesis has been submitted for the examination with our approval as university Advisors.

Dr. Kelay Belihu (DVM, PhD, Assistant Professor) _____

Prof. Merga Bekana (DVM, SRVCS, PhD, Professor) _____