EFFECT OF GRAZING LAND EXCLOSURE AND FEEDING STRATEGY ON LIVESTOCK WATER PRODUCTIVITY IN LENCHA DIMA WATERSHED, GUBA LAFTO WOREDA, AMHARA REGION

M.Sc. THESIS

SEMIRA MEKONNEN

HAWASSA UNIVERSITY, HAWASSA

APRIL 2009

EFFECT OF GRAZING LAND EXCLOSURE AND FEEDING STRATEGY ON LIVESTOCK WATER PRODUCTIVITY IN LENCHA DIMA WATERSHED, GUBA LAFTO WOREDA, AMHARA REGION

M.Sc. THESIS

SEMIRA MEKONNEN

A THESIS SUBMITTED TO THE DEPARTMENT OF ANIMAL AND RANGE SCIENCES, HAWASSA COLLEGE OF AGRICULTURE, SCHOOL OF GRADUATE STUDIES

HAWASSA UNIVERSITY

HAWASSA, ETHIOPIA

IN PARTIAL FULFILMENT OF THE

REQUIREMENTS FOR THE

DEGREE OF

MASTER OF SCIENCE IN ANIMAL AND RANGE SCIENCES

(SPECIALIZATION: ANIMAL NUTRITION)

APRIL 2009

HAWASSA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
FINAL THESIS APPROVAL FORM

As member of the Board of the Examiners of the final M.Sc. open defense, we certify that we have read and evaluated that the thesis prepared by Semira Mekonnen under the tile "**Effect of Grazing Land Exclosure and Feeding Strategy on Livestock Water Productivity in Lencha Dima Watershed, Guba Lafto Woreda, Amhara Region**" and recommend that it be accepted as fulfilling the thesis requirement for the degree of **Master of Science in Animal Science** with specialization in **Animal Nutrition**.

______________________	______________________	______________________
Name of the chair person	Signature	Date
Dr. Adugna Tolera	______________________	______________________
Name of the major Advisor	Signature	Date
Dr. Tilahun Amede	______________________	______________________
Name of Co-Adviser	Signature	Date
Dr. Katrin Descheemaeker	______________________	______________________
Name of Co-Adviser	Signature	Date
______________________	______________________	______________________
Name of Internal Examiner	Signature	Date
______________________	______________________	______________________
Name of Internal Examiner	Signature	Date

Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the CGS through the DGE of the candidates department.

Thesis approved by

______________________	______________________	______________________
Dean of the SGS	Signature	Date
______________________	______________________	______________________
VPAAR	Signature	Date

Certification of the final Thesis

I hereby certify all the corrections and recommendations suggested by the Board of Examiners are incorporated into the final thesis entitled "Effect of Grazing Land Exclosure and Feeding Strategy on Livestock Water Productivity in Lencha Dima Watershed, Guba Lafto Woreda, Amhara Region" by Semira Mekonnen.

Dr. Adugna Tolera	______________________	______________________
Name of the Designate	Signature	Date

ACKNOWLEDGEMENTS

This work would have not been completed without the contribution of many institutions and individuals, among which I am indebted to the International Water Management Institute (IWMI), through its Comprehensive Assessment Project funded of this work and deserves acknowledgement, in addition Dessie Urban Agricultural Office for offering my salary. I am greatly indebted to my major advisor Dr Adugna Tolera, co-advisors, Dr. Tilahun Amede and Dr. Katrien Deshemeher for their advice and sharing their invaluable time and ideas and for critically reading the earlier versions of this manuscript.

I would like to record my gratitude to Dr. Katrien Descheemaeker for her supervision, advice, and guidance from the very early stage of this research as well as giving me extraordinary experiences through out the work. Above all and the most needed, she provided me unflinching encouragement and support in various ways. She visited me twice in the field and encouraged me to carry out the hard work of primary data collection successfully. I will never forget her kind and friendly treatment. Many thanks go in particular to Ato Mekete Bekele I am much indebted to Mekete for his valuable advice in data collection, supervision in analysis.

A special acknowledgment goes to one individual, who saw me through all the joys and frustrations of this research, while helping me stay focused on the present. Thank you, Abdulhafiz Aragaw, for always believing in me and reminding me that the journey to a goal is one step at a time.

Where would I be without my family? My parents deserve special mention for their inseparable support and prayers. My Father, Mekonnen Mekuria, in the first place is the person who put the fundament my learning character, showing me the joy of intellectual pursuit ever since I was a child. My Mother, Zinetu Seid, is the one who sincerely raised me with her caring and gently love. Sara and Kedir thanks for being supportive and caring siblings. What else? An extraordinary recognition extends to my beloved, Abdella Kemal for his persistent advising and supporting in all times.

Finally I would like to thank Jemila Aragaw, Abdelaziz Aragaw, Selamawit Debel, and everyone who was important to the successful realization of this thesis, as well as expressing my apology that I could not mention personally one by one.

DECLARATION

I declare that this thesis is my original work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree at Hawassa University and is deposited at the university library to be made available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Brief quotations from this thesis are allowable with out special permission provided that accurate acknowledgement of the source is made. Request for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the dean of the school of graduate studies when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author.

DEDICATION

To my beloved mother, Zinetu Seid

Rest in peace!

LISTS OF ABBREVIATIONS AND ACRONYMS

AMAREW	Amhara Agriculture, Extension, Watershed Management
ANOVA	Analysis of Variance
BO_j	Total livestock beneficial output (ETB) obtained per year by the j^{th} household
CRPWP	Crop Residue Physical Water Productivity
CRWP	Crop Residue Water Productivity
CSA	Central Statistics Authority
CWP	Crop water productivity at field level
DM	Dry Matter
ETB	Ethiopian Birr
ETc	Crop Evapotranspiration
ETcil	Crop water requirement in mm per unit of time of the i^{th} crop type at l^{th} location.
ETo	Reference Evapotranspiration
FAO	Food and Agriculture Organization of United Nations
GLU	Utilization factor of grazing land by livestock
ha	Hectare
HH	Household
HU	Hawassa University
ILCA	International Lactation Consultant Association
ILRI	International Livestock Research Institute
Kc	Grazing land coefficient
LGP	Length of Growing Period in days.

LL	Lactation Length in days.
LWP	Livestock water productivity at the field level
mm d^{-1}	Millimeter per day
m.a.s.l	Meters above sea level
MP	Price of one liter of milk at the Weldiya market.
Max	Maximum
Min	Minimum
MoWR	Ministry of water resource
N	Number
C	Degree centigrade
R_i	Conversion factor for grain yield to crop residue yield of the i^{th} crop type
RF (mm)	Rain fall in millimeter
RH (%)	Relative humidity in percent
SD	Standard Déviations
SE	Standard Error
SPSS	Statistical Package for Social Sciences
t	Tone
TLU	Tropical Livestock Unit
USAID	United States Agency for International Development
WBISPP	Woody Biomass Inventory and Strategic Planning Project

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF TABLES IN THE APPENDIX

Effect of Grazing Land Exclosure and Feeding Strategies on Livestock Water Productivity in Lencha Dima Watershed, Guba Lafto Woreda, Amhara Region

By

Semira Mekonnen Mekuria(B.Sc), HU, ACA, Awassa, Ethiopia
Major Advisor: Adugna Tolera (PhD), HU, ACA, Awassa, Ethiopia
Co-Advisor: Tilahun Amede (PhD), ILRI, Addis Ababa, Ethiopia
Katrien Descheemaeker (PhD), ILRI, Addis Ababa, Ethiopia

ABSTRACT

The study aims to estimate the livestock water productivity (LWP) and to examine the effect of grazing area closure and feeding strategies on LWP at farm household level under wealth and intervention categories at Lencha Dima watershed.
Results are based on survey of 120 sample households and focus group discussion. Beneficial outputs of livestock and depleted water for producing them were estimated then livestock water productivity as the ratio of the beneficial out puts and depleted water was estimated.
LWP shows difference between participant with in the interventions and non participant with the intervention farm households. The value of LWP in ETB was 1.7±0.3 in non participant farm household and 0.79±0.03 in participant farm household and it ranges from 1.7 at better off non participant farm household to 0.7 in very poor participant farm households. The highest livestock feed financial water productivity was estimated at very poor non participant farm households (5.5± 2.3 ETB m^{-3} *per year). Crop residue accounted much in depleted water for livestock feed production and it is also the major contributor for livestock feed resource base, which were found at negative feed balance to the existing livestock holding at household and watershed level. To mitigate this shortage framers use different feeding strategies according to livestock importance and age. Much of the beneficial output valued at the present LWP accounted by traction and transport services and ranked as the primary purpose of cattle.*
Exclosure can improve the condition of degraded land and can also be used as source of income generation and source of wood for different purposes. But it has negative effect on livestock number, which are at low production level and it is difficult to conclude the effect of area closure on LWP and livestock productivity in short period of time. Strategy of improving livestock productivity through improved feed availability and quality together with livestock management and health care as well as water saving and conservation is crucial for lifting up benefits from livestock and LWP for the farm households.

Key words: Lencha Dima watershed, participants, non participants, feeding strategies, depleted water, beneficial outputs, livestock water productivity, area closure.

1. INTRODUCTION

Ethiopia has great potential for increased livestock production, both for local use and for export. However, expansion is constrained by inadequate nutrition, disease, lack of adequate support services such as extension services, and inadequate information on how to improve animal breeding, feeding, marketing, and processing.

Water for crop and feed production as well as human and animal consumption is a limiting factor. It is a scarce resource in most parts of Ethiopia, especially during the eight months dry period, which extends from October to May. Both people and their livestock commonly travel long distances daily to obtain the water they need thus impairing agricultural productivity (Astatke et al., n.d.). Due to the dependence of the rural economy on rain-fed agriculture, the income and consumption of the rural population are highly volatile depending on the weather (Alemayehu et al., 2006). Undernourishment and malnutrition in children in developing countries is closely linked to environmental degradation, repeated droughts and poverty (D'souza, 2001). Rainfall is the major source of agricultural water in Ethiopia. The major problem associated with the rainfall-dependent agriculture in the country is its high degree of variability and unreliability. As a result, production capacity varies from region to region each year. The mixed crop-livestock farming system is largely based on plough and draught power, which has created complementarities between crop and livestock production for centuries (Awulachew et al., 2005).

Livestock production is an important component of agriculture, but it is largely ignored in water management for food security. There is a great need to understand livestock water interactions for improving productivity of crop-livestock systems.

Knowledge of the impact of livestock keeping on water resources has not been adequately synthesized and applied to integrated water management (Peden et al, 2007). Water use to increase production of animal-based food products for people must be balanced with water demand for crop production and other uses. Demands for animal products originate in the same markets that drive demands for other intensified, high valued horticultural crops, and those products likely compete for the same water needed to produce them. Managing this demand for agricultural water for livestock products dictates a need to integrate livestock development with agricultural water development (Peden et al., 2005).

The livestock production in general has grown faster than crop production in most developing countries, and this trend is likely to continue with growth rates at about 4.5 % per annum over the next twenty years. The growing need for livestock products and services makes the water scarcity more severe (FAO, 2006).

Small streams, rivers, lakes, ponds, springs, and wells are common sources of drinking water for ruminants (McDowell, 1985). Ruminants also take water in via their feed of varying type and moisture content. Generally, these livestock-water interactions differ in different agricultural production systems, like irrigation systems, mixed crop livestock systems, pastoral systems and agro-pastoral systems. In mixed crop livestock systems, animals consume crop residues and drink water either directly from natural sources or at drinking troughs. Limited land constrains both food and feed production by farmers in mixed systems. In pastoral and agro-pastoral systems, animals largely depend on grazing (ILRI, 2005). The widespread perception that livestock production is a wasteful use of the world's water recourses is not relevant to many developing country contexts. Livestock can be efficient and effective users of water while they depend on crop residues and by products and well managed rangelands unsuitable for crop production. Application of livestock water productivity concepts may lead to some of the greatest improvements in efficiency of future agricultural water use in developing countries (Peden et al., 2007). Livestock water productivity (LWP) is about accounting for water consumption of livestock as a ratio of output functions, including milk, meat, dung, draught power and threshing (ILRI, 2005), over the amount depleted to produce them. It is part of overall food water productivity and is the scale dependent efficiency of direct and indirect use of water for provision of livestock products and services. There are two aspects of livestock water productivity: the livestock impact on water resources and the livestock water use for production (ILRI, 2005). Water productivity can be estimated by the method of Peden et al. (2002):

$$LWP = \frac{\sum Livestock\ \mathrm{Pr}oducts\ \&\ Services}{\sum Water\ Depleted\ \&\ Degraded}$$

Improvements in livestock water productivity require adoption of four basic strategies. These are feed sourcing strategies that reduce water transpired for production of feed, enhancing animal productivity, water conserving practices and providing quality drinking water. When combined these strategies can increase effective transpiration, infiltration and animal production and reduce evaporation, contamination and discharge of water **(**Peden *et al.*, 2007).

Different interventions were introduced in the study area by AMAREW project in four different disciplines, which include natural resource development, livestock production, crop production and social development. In natural resource development area closure, gully rehabilitation and water conservation practices were held. In animal production sector grazing land improvement and goat revolving fund were practiced. This goat revolving fund was carried out in very poor farm households; the first receiver gives the offspring of the goat to the second selected farmer. At this stage it is important to assess the effects and influences of these interventions on resource use and productivity. Hence, the current study was carried out with the following objectives.

Objectives

The main objective of this study was to investigate the effect of interventions related to water resources and integrated watershed management on livestock productivity and on the productivity of mixed crop livestock systems. Specific objectives were to:

- Characterize crop-livestock farming systems in terms of livestock feeding strategies, animal husbandry, land and water management
- Analyze the balance between feed requirements and feed availability.
- Estimate livestock water productivity in terms of products (milk, meat, manure, hides and skins) and services (draught power, transport)

2. REVIEW OF LITRATURE

2.1. Livestock and Crop Production

In mixed farming systems the inputs and outputs of the crop and animal enterprises are integrated inextricably and help very poor farming households primarily to maximize the returns from their limited land and capital and on the other hand to minimize production risks, diversify sources of income, provide food security, increase land productivity, and improve sustainability (Paris, 2002).

Livestock keeping is one of the most important agricultural livelihood generating activity practiced in Africa and particularly so in water scarce arid and semiarid regions. Globally, livestock make up, on average, 45% of the agricultural contribution to GDP and more than half in some African countries (e.g., Sudan and Somalia). Not included in this economic indicator are the difficult to value livestock services, such as the contribution of livestock to traction and transport, which are essential for producing food crops and moving them to markets and consumers. Livestock provide draught power and fertilizer for the crops in the form of manure, and dry animal manure is also used as household fuel. Additionally, crop by-products and residues provide feed for the animals. Milk, meat and eggs contribute significantly to improved family nutrition and health. The sale of animals and their products help to improve and stabilize household income for the purchase of farm inputs, and to offset expenditures on school fees and health care (Paris, 2002).

The major contribution of cattle to agricultural production in Ethiopia is through the draft power provided by oxen. The oxen are used almost exclusively for seasonal land preparation in cropping systems and remain unproductive during the remainder of the year (Astatke et al., n.d.).

Mixed crop livestock systems are being used by many smallholder farmers mainly in Sub Saharan Africa and South Asia to intensify production as they perceive multiple benefits. The integration of food-feed crops in mixed systems can contribute significantly to human and animal nutrition without the need for additional cropland and optimize the allocation of depleted water within the cropping system. Strategies to increase the dual purpose efficiency of these crops are to increase nutritive value of the crop residues and to integrate food-feed legumes with cereal crops (Parthasarathy Rao and Hall, 2003; Singh et al., 2003).

Livestock is a form of currency. For many farmers, animals represent savings and sale of livestock manure is quick cash in hard times. Income from livestock products can allow very poor families to improve their nutrition, send their children to school and improve family livelihood. Livestock plough agricultural fields and provide means of transportation and reduce the human load. Considering the importance of livestock in the national economy, the ministry of water resources (MoWR, 2002) has already integrated the livestock water need into its water supply projects for urban areas (MoWR, 2002).

In Ethiopia, the sale of livestock and their products is often the major or only source of income. However, productivity per animal is very low, due to mainly very poor nutrition and high mortality rates. Grasses contribute a large portion of the feed but the quantities are limited and the nutritive value is low. Where pasture is the sole source of animal feed, its crude protein content should be above the critical level of about 70% DM and if herbage with protein content below the critical level is fed, low voluntary intake and protein deficiencies contribute to reduced production and retarded growth of animals (MoWR, 2002). Livestock keeping contributes up to half of the agricultural GDP in countries like Sudan and Ethiopia. In addition, livestock provide subsistence farming communities with manure, traction, transport, cultural value and insurance against drought. Managing water resources without due consideration of the contribution of livestock to agricultural production ignores a major component of food security.

2.2. Livestock Feed Sources

Animal production depends on access to sufficient supplies of feed, including high quality feed-grains, crop residues and other by-products, pasture, tree fodder, and forage crops. The production of feeds is one of the world's largest uses of agricultural water. The entry point for improving global livestock water productivity must be strategic sourcing of animal feed, an issue that has largely been ignored during the past 50 years of research on livestock and water management. Judicious selection of feed sources is potentially one of the most effective ways of improving global agricultural water productivity.

The use of crop residues, coupled with the use of fodder crops and purchased feed, can facilitate the transition from open grazing to a system of stall-feeding. In fact, it can be argued that crop residues have the potential to more than offset reduction in traditional feeds, which results from reduced grazing land in areas where irrigation schemes are established (Dejene, 2005). As the nutritional quality of crop residues is very low, their quality should be improved by appropriate supplementation and/or different treatments, such as urea treatment, which can be afforded and practiced by the farmers.

2.3. Water for Livestock Production

Water is not normally thought of as a nutrient even though it clearly meets all criteria for definition as one. The importance of an adequate supply of potable water for livestock is well recognized and currently is receiving more emphasis in the quest to clean up polluted environments by improving the quality and dependability of water supplies (Pond et al., 2005).

The fat-free body water content is relatively constant for many different animal species including cattle, sheep, swine, mice, rats, chickens, and fish. The range is from 70 to 75% of fat-free weight, with an average of 73 % (Pond *et al*., 2005). Water requirement for animals is affected by numerous dietary and environmental factors. Other factors include, such as ability to conserve water or differences in activity and physiological state (i.e. growth, gestation, and lactation). In very general terms, animal will consume 2 to 5 kg of water for every kg of dry feed consumed when they are not heat-stressed (Pond et al., 2005).

Agricultural water used for feed production is much greater than drinking water consumed by animals (Peden et al., 2003). Livestock drink about 25 liters of water per day per TLU (Zinash et al., 2003), but actual water required for daily feed production for livestock is about 100 times the actual daily requirements for drinking water (Peden et al., 2003). This is important because the prime constraint to livestock production is feed shortage, the production of which is often water limited.

Animals raised on irrigated forages require much more “managed” water than those raised on rain fed grazing land. Even in rain fed mixed farming, production of water demanding feed such as the rhizomatic and deep rooted forages and trees and shrubs may compete with farmers' ability to grow food crops. The challenge is to develop strategies of how, when and where to produce animal feed in order to minimize demand on irrigated water and to reduce competition with rain fed crop production (Alemayehu Mengistu, 2002). Increasing use of crop residues for animal feed and shifting feed sourcing to land unsuitable for rain fed crop production may be part of the solution. The trade-off between using irrigated water for forage production and food crops must be considered. Furthermore, strategic investments in watering points for livestock can help spread grazing pressure to areas where feed production does compete with human food production. Balanced and selected investment in water supply for livestock drinking may complement investment in water development for production of human food and animal feed.

Livestock get their water from three sources: drinking water, water contained in feeds and metabolic water (Zinash et.al. 2003). Water contained in feeds consumed (performed water) is highly variable from feed to feed according to the moisture content, which can range from as low as 5% in dry feeds to as high as 90% or more in succulent feeds (Zinash et al., 2003). Water derived from dry feeds may be insignificant compared with the total water intake, while that obtained from succulent feeds can supply all the water needs. When water content of the feed ingested is low, drinking water is the major source of water intake, and its provision for livestock becomes the main concern.

Assuming that one m^3 of transpired water would be used to generate 4 kg of dry feed; water for feed production amounts to 450 m^3/TLU/year, and water for drinking purpose is 9.1 m^3/TLU/year (Sonder et al., 2005). Transpiration is not the only form of depleted water associated with feed production. Water evaporates from plant and soil surfaces six times more than transpiration, particularly in heavily grazed areas with little vegetative cover.

2.4. Livestock Water Productivity

Although water accounting models have helped to understand crop water productivity, no systematic consideration has been given to understanding livestock's use of and livestock impact on water resources. In recent years, livestock and livestock products have been exposed to much criticism due to a widely perceived use of large amounts of water for production and due to their negative impacts on water resources and the environment, e.g. according to (Steinfeld, et al*)* water pollution because of livestock as he explained most of the water used by livestock returns to the environment part of it may be re-useable in the same basin, while another may be polluted or evapotranspired and there by, depleted. Water Polluted by livestock production, feed production to and product processing detracts from the water supply and adds to depletion. Evidence suggests that such criticism is often founded or of restricted validity (Sonder et al*.*, n.d.).

Livestock water productivity is defined as the ratio of livestock products and services to the amount of water depleted, diverted or degraded to produce them. Often water related to livestock production is assumed to include only water either directly consumed by the animals or used for cleaning and other service functions during the processing of animal products.

Development and governmental strategies often consider only watering needs, environmental degradation and pollution of water sources by livestock (World Bank, 2004; Ministry of Agriculture, 2002). The water needed by the animals for drinking is often a major factor limiting production and has to be available in sufficient quantity and quality, although the amount of water needed to produce the daily feed resources can be over 100 times higher (Peden et al*.*, 2002).

Livestock water productivity could be improved through the production of feed sources that efficiently utilize transpired water and the use of livestock species and breeds that have higher conversion rates for the available feed. In all the cases, it will be important to consider the sustainability of the agro ecosystems. Improving the grazing and watering management of livestock will benefit the productive capacity of the land through better soil and water conservation and diminish pollution with positive environmental impacts (Sonder et al., n.d.).

The household feed requirements depend on the amount of crop residue produced and number and type of livestock owned by household substantially. Farm systems that depend more on feed coming from hay and pasture have lower livestock water productivity (Wagnew et al., n.d.).

The potential for increasing livestock water productivity in mixed crop-livestock traditional systems could be further improved, e.g. through higher efficiency of water use under irrigation, integration of forages and food-feed crops, more efficient use of animal power and management, veterinary services etc., thus making livestock production more attractive and more sustainable in terms of water (Wagnew et al., n.d.). As many livestock production systems rely on crop residues as main feed resource, enhancing water productivity on the plant side can also enhance productivity of the livestock (Sonder et al., n.d.).

2.5. Livestock Water Productivity Framework

According to (Peden et. al., 2006), the livestock water productivity framework (Figure 1) demonstrated how feed sourcing, water conservation, crop improvement and animal productivity enhancing strategies can contribute to increased efficiency and effectiveness of water use. When integrated with crop production, increased use of crop residues and reduced overgrazing lead to more productive use of transpired water used for crops and reduced loss from evaporation and run-off. The three major components for increasing livestock water productivity (LWP) are feeding strategies, water conserving strategies and beneficial outputs from livestock. The amount of water used for drinking is strategic in improving livestock beneficial outputs but is very small, 70-100 times less than the water used to produce feed for livestock. The LWP framework is scale independent as it could be used at farm, community or watershed/landscape (Peden et al., 2006***).***

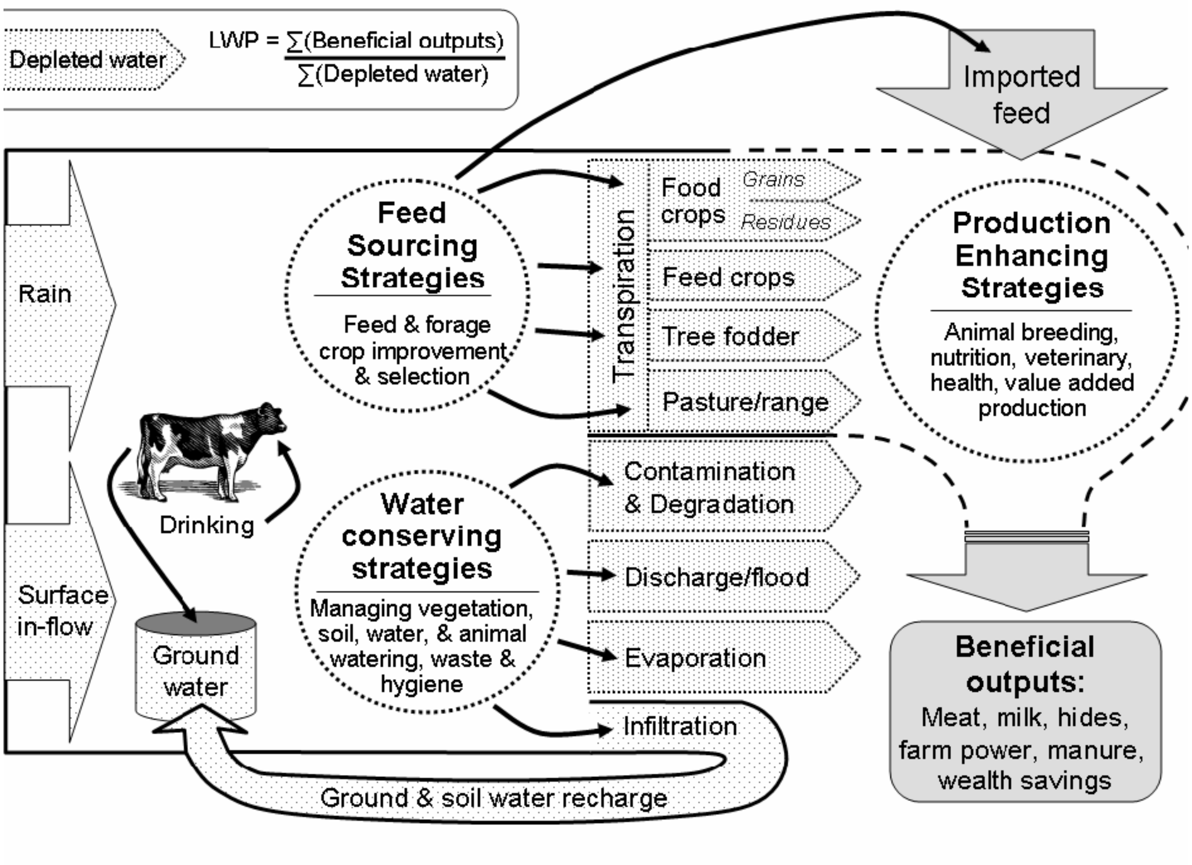

Figure 1: Simplified framework for assessing livestock water productivity (Peden et al., 2006).

Water being transpired by the vegetation is water dedicated to production of crops, pastures and other vegetation. Once transpired, water is no longer available to users within the domain.

Livestock water productivity could be improved through the production of feed sources that would utilize transpired water efficiently and the use of livestock species and breeds that would have higher conversion rates for the available feed. In all the cases, it will be important to consider the sustainability of the agroecosystems. Improving the grazing and watering management of livestock will benefit the productive capacity of the land through better soil and water conservation and diminish pollution with positive environmental impacts (Sonder et al., 2004). The potential for increasing the livestock water productivity in the mixed crop– livestock traditional systems could be further improved, e.g. higher efficiency of water use under irrigation, integration of forages and food–feed crops, more efficient use of animal power and management, veterinary services etc., thus making livestock production more attractive and more sustainable in terms of water (Wagnew et al., 2005).

Livestock water productivity framework has been a useful tool for comparing different schemes. At household level, it was found to be a good way of identifying the contribution of the different components of livestock production to the livestock water productivity (Wagnew et al., n.d.).

2.6. Livestock Production and Watershed Development

Watershed development focuses on the regeneration of the catchment of a stream or river. Treatments comprise of developing forests, pasturelands, implementing soil conservation measures and building water harvesting structures (gully plugs, check dams) along water courses. It also includes developing appropriate land use and economic strategies that meet both conservation and production needs. Such an initiative requires approximately 4-6 years for a micro watershed (approximately 10 km^2) (D'Souza, 2001).

As watershed development advances, the otherwise barren and degraded lands start producing grasses and fodder for livestock. Watershed development requires either a ban on free grazing, or controlled grazing as a soil conservation measure, which results in the added benefit of fodder production. With improving land productivity and the ban on free grazing, marginalized wastelands become a good source of fodder (D'Souza, 2001).

In the past, the type of approach in watershed management mainly aimed at building physical structures by mobilizing farmers or sometimes forcing them with little success. Integrated watershed management did not include the role of livestock production systems and grazing systems. Some of the areas were closed without prior planning for livestock grazing options. It is a paradox that even the large irrigation developments have excluded the livestock production systems and solely concentrated on crop production (Girma and Peden, 2002). But AMAREW project followed different strategies when the interventions were practiced. The strategy was watershed based natural resource conservation and agricultural development approach, with farmers' participatory and multidisciplinary problem/constraint identification, planning, design, implementation, monitoring and evaluation will continue to be followed. This approach includes: Natural resource conservation and agricultural development considered for the entire watershed at once; genuine community participation ensured during planning, implementation, and monitoring and evaluation of proposed activities; capacity building of the farmers through training and demonstration; developing and deploying effective institutional linkages for implementing integrated watershed development (AMAREW, 2007).

Loss of vegetation promotes evaporative depletion of scarce water. The key to successful crop and livestock production in the dry land areas is therefore first the development of efficient and effective soil water management techniques (Sonder et al., n.d.).

Under-nutrition is closely associated with land degradation. Watershed development has a potential for environmental rehabilitation and enhanced land productivity. Enhanced land productivity, can help withstand the effects of drought even in rain-shadow regions or despite lower than normal rainfall. It is generally assumed that with an increase in crop and milk production there should be an increase in food intake that could improve the nutritional status of people in environmentally degraded regions (D'Souza, 2001).

3. MATERIALS AND METHODS

3.1. Site Description

The study was conducted in Lencha Dima watershed which is located 16 km east of Weldiya town in North Wello Zone, Guba Lafto Woreda in Amhara regional state. (Figure 2). The watershed is further divided in to three sub-catchments, which are Oromo, Kolokobo and Lencha Dima.

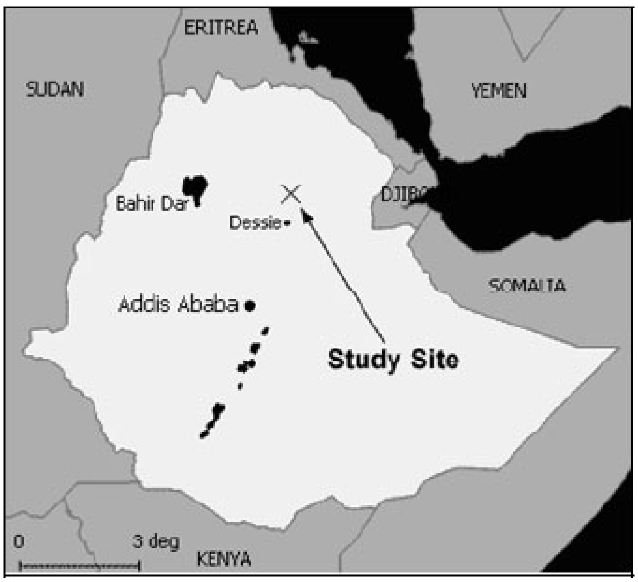

Figure **2**: Location of the Lencha Dima watershed in Ethiopia

Lencha Dima watershed is a densely populated (218 persons per km^2) rural area located at N 11^o 49.2’-11^o 52.1’ and E 39^o 41.3’- 39^o 44.6’ and is in the dry sub humid warm temperate highlands (1465-1900m above sea level). The mean annual precipitation in the watershed (for the years 1975-81 and 2003-04) was 849 mm. (Ethiopia National Meteorological Services Agency 1975-1981). Rainfall distribution is bimodal with a small rainy season called Belg (mean 208 mm*)* during March to May and main rainy season called Kremt (mean 483 mm) during July to September. A mean of 158 mm of rainfall comes during all other months (McHugh, 2006).

Major soil types in the Lencha Dima watershed vary with topography. The distribution of soils is as follows: Regosols and Leptosols on the steep hills and mountains (33% of total watershed area), Regosols on the upper footslopes (6%), vertic Luvisols at the lower footslopes (18%), Vertisols at the valley bottom cultivated areas (35%), and Fluvisols in the plain areas that receive alluvial sediments (8%) (Gizaw et. al., 1999). The geology of the Lencha Dima watershed area, which is located in the marginal graben of the northeast Ethiopian plateau escarpment in the Afar depression, is comprised of varieties of trap series rocks from weathered basalt, graben fill quaternary sediments, and valley-floor later granite intrusions of probably tertiary age (Gizaw et al., 1999).

3.2. DESCRIPTION OF THE SUB-CATCHMENTS

Kolokobo

Kolokobo sub catchment is 180 ha and is located at the southeastern corner of the watershed (Figure 3). It is comprised of three villages and different interventions were practiced. The interventions were well protected in this sub catchment. Cropland covered 42.9%, shrub/bush land covered 42.9% and settlement covered about 7.1% of the total land area. Above 30% of the rangeland (hillslope) was closed from livestock grazing, bench terracing and numerous planting was practiced. In addition gully rehabilitation was practiced by treatment with gabion, check dam and planting. (Mc Hugh, 2006)

Compared to the other two catchments, Kolokobo sub catchment is better protected.

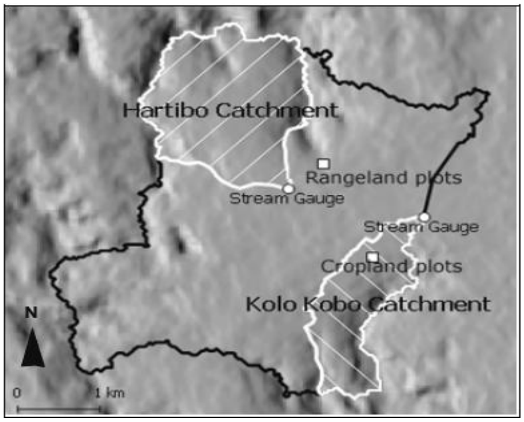

Figure 3: Kolokobo and Hartibo sub catchments (source McHugh, 2006*)*

Oromo (Hertibo)

Oromo or Hartibo sub catchment is 351ha and is located at the northwest corner of the watershed (Figure 3). It is comprised of nine villages and few interventions were practiced. Cropland covered 71.4%, shrub/bush land covered 21.6% and settlement covered about 6.2% of the total land area. Less than 5% of the rangeland (hillslope) bench terracing and few planting was practiced. No gully rehabilitation was done (Oloro, 2006). As a result the width of gully is very wide compared to Kolokobo.

Lencha Dima

Lencha Dima sub catchment is comprised of two villages and like Kolokobo hill exclosure (Begido) was practiced and well protected, with area of 33 ha. Like Oromo sub catchment in Lencha Dima sub catchment the width of the gully as we compared from Kolokobo. The farmers in the sub catchment use nine grazing lands.

3.3. Methodology

3.3.1. Selection of the Study Area

The study area was purposely selected as it is an area where a number of integrated watershed development interventions have been introduced by the past AMAREW project. Besides that, the area is representative for the Ethiopian highlands where land degradation and deforestation are common problems. The interventions were in four disciplines: livestock development, natural resource development, crop production and social development. In livestock development the main interventions were a goat revolving fund and grazing land management by restricting grazing in degraded hillslopes. .In natural resource development the main interventions were soil and water conservation, gully rehabilitation and improving enclosures with enbetter offment planting. In crop production the main interventions were introduction of insitu moisture conservation practices, introduction and promotion of improved and early maturing of crops and promotion of tied ridges on farm for moisture conservation. Intervention components in social sector were water development, pond construction and community organization and participation (AMAREW project, 2007

).

3.3.2. Selection of Respondents

By selecting farm households in the watershed with and without interventions, it is possible to investigate the influence of applying interventions on livestock water productivity. Households in the watershed were listed and divided into two groups based on their participation in exclosure, gully rehabilitation and water harvesting. Then, the households were stratified in to three classes based on wealth status, using the following division of wealth in the study area: very very poor households, owing one ox and grass thatched house; poor households, owing two oxen, one cow and grass thatched house; better off households, owing more than two oxen, one cow and a house with an iron sheet roof.

The sample households were selected randomly from the three sub-catchments (Kolokobo, Lencha Dima and Oromo). The total sample size was 120 farm households: 60 participants and 60 non-participants (20 very very poor, 20 better off and 20 poor farmers both from the participants and non-participant).

3.3.3. Data Collection Method

In this study different data gathering methods were involved. The study involves mainly survey, discussions with key informants, direct observation and direct measurements. A structured questionnaire and check list were used and information was gathered from randomly selected respondents and key informants from each category of interventions. Direct measurements, assumptions and secondary data were used for calculating some of the variables of livestock water productivity.

In what follows a more detailed explanation will be given of the different methods and materials employed.

3.3.3.1. Survey

A structured questionnaire was prepared and pre-tested with five farmers after which some corrections were made. Seven enumerators who are residing in the area were employed to assist in the household survey. Enumerators were trained and their work closely followed up during data collection. The field work was conducted during September to November 2008.

The questionnaire covered demographic characteristics, household socio-economic factors, livestock holding and species composition, draft power services, sales and consumption of livestock and livestock products, feed sources, feeding group, feeding calendar and feed amount for the different feeding groups, water management practices, cropping patterns and crops grown, agricultural input and yields at plot level and livestock production constraints. The questionnaire used is given in Appendix 1.

3.3.3.2. Discussion with Key Informants

Check list were prepared for discussion with key informants. Key informants were included of the Woreda livestock expert, the development agent and the vice-chairman of the farmers association and farmers familiar with the interventions. Discussions with these groups included topics like land management, dynamics of the grazing area, value of livestock services, constraints and opportunities in livestock health, preference of meat and investment options to increase productivity. The check list used is given in, Appendix 2.

3.4. Determination of Water Productivity

In this study the households' plots under the rain fed farming system, cultivated in 2007, were considered. Water supply through direct precipitation and the fraction of applied water that is consumed by evapotranspiration were considered. To calculate water productivity, only the water lost thorough evapotranspiration is used in the denominator of the equations. Other components such as runoff and deep percolation, or losses along the water delivery infrastructure are not accounted for.

To relate crop evapotranspiration (ETc) to reference evapotranspiration (ETo) and for calculating evapotranspired water, crop coefficient (Kc, dimensionless) values from the literature were applied.

Therefore the crop water productivity relationships can be expressed as (FAO, 1998):

$$CWP = \frac{Cj * Pj}{Kc, j * ETo * Bj}$$ ....Equation 1

Where:

CWP = Crop water productivity at field level

Cj = Yield of crop type j

Pj = Market value of crop j

Kcj = Crop coefficient of crop type j

ETo = Reference evapotranspiration and;

Bj = Land area under crop j.

Correspondingly LWP can be computed by using the following equations (Peden et al., 2006):

$$LWP = \frac{\sum_{j=1}^{n} Oj * Pj}{\sum_{j=1}^{n} Kcj * ETo(Gj) + \sum_{j=1}^{n} [Kcj * ETo(Bj)] * Rj}$$ ………………………Equation 2

Where:

LWP = Livestock Water Productivity at the field level

Oj = Livestock beneficial output of type j

Pj = Price of output j

Gj = area of grazing land type j

Bj = the land area under crop j

Rj = proportion of crop residue yield to the total biomass produced from crop type j from where livestock feed is collected

Kc and ETo are as defined above.

3.4.1. Determination of Depleted Water

In computing water depletion for livestock production only the water used to produce livestock feeds (crop residue and grazing) were considered. Livestock drinking was not considered as it is insignificant compared to water depletion for the production of feeds. It amounts to only 2-5% of the total water requirements (Peden et al., 2005).

The depleted water was computed in terms of the amount of water depleted in evapotranspiration (ET) from the cropland and grazing land. The ET was computed for each month from weather data by using CropWat software (FAO, 2003), which uses the penman-monteith method as the standard method for the computation of the reference evapotranspiration (ETo) and Kc value (FAO, 1992). The methods for calculating reference evapotranspiration from meteorological data require various climatological and physical parameters. Some of the data are measured directly in weather stations. Other parameters are related to commonly measured data and can be derived with the help of a direct or empirical relationship. All data required for the calculation of the crop evapotranspiration by means of the FAO Penman-Monteith method are:

- Climatic data (min and max temperature, rainfall) and climatic factors (wind speed, air humidity, sunshine, humidity).
- Crop data like length of growing period, Kc value, rooting depth, crop height, and crop yield response factor and critical depletion.
- Soil characteristics like total available moisture, maximum rooting depth, and initial soil moisture depletion.

The kobo climatic weather data was used to get the monthly ETo data, Appendix 3Table 18).

The grain yields from cereal crops were calculated based on crop yield data from the literature (CSA, 2004) and farmers' land area cultivated during the reference year. The crop residues yields were then calculated based on the harvest index for each crop type (FAO, 1987; De Leeuw et al., 1997; Tessema et al., 2002), Appendix 3. Table 15. The amount of water depleted for the production of each type of crop residue was based on the crop water requirement calculated using CROPWAT software.

To determine the hay and grass consumption the calculated average (see paragraph 3.7) of the exclosure biomass production and the amount grazed by animals was used. The amount of grazing land which was allocated for each household was calculated based on the total grazing area in the catchment and the ratio of the households' tropical livestock unit (TLU) holding over the total TLU of the catchment. For free grazing land a utilization rate of 75% estimated by WBISPP (2002), was assumed. And for exclosures it is assumed that 75% of the hay production is utilized by the animals. The amount of water depleted for the production of hay from exclosure and grass from gazing land was based on the grass water requirement calculated using CROPWAT software and the size of land the household owned. The following assumptions were used for calculating grass water requirement: a growing period of six months and four months and a crop height of 0.1 m and 0.8 m for free grazing and exclosure, respectively.

The total depleted water for livestock at household level was estimated based on the evapotranspiration and area covered for each crop grown during the previous cropping year and the allocated area of grazing land and exclosure.

A. Crop Water Requirement

For calculating crop water requirement the crop coefficient approach (FAO-56, Allen et al., 1998) was used:

$ETcij = Kc * ETo$ ………………………………………….…….. Equation 3

Where

ETcil = Crop water requirement in mm per unit of time of the i^{th} crop type at l^{th} location.

Kc= Crop coefficient [dimensionless]

ETo= Reference crop evapotranspiration [mm d^{-1}].

ETc of each crop type was calculated.

Water depletion for the production crop residues was determined based on crop harvest index of each crop type (using reported crop residue yield). This amount was then adjusted based on the recovery and utilization rates of particular crop residues by the livestock type kept by the farm household. The water depleted on the grazing land was adjusted based on the amount of grass feed assumed to be available for livestock grazing. Utilization and recoverable factor of 50% and 75% were applied for crop residue of sorghum Stover and grazing land respectively (WBISPP, 2000).

Water requirement of crop residue

Crop yield was estimated by;

$CYi = CAi * Yi$ ……………………………………………………… Equation 4

Where:

CYi = Crop production in kg of the i^{th} crop type

CAi = Cultivated area (m^2) covered under the i^{th} crop type

Yi = Average yield in kg per hectare of the i^{th} crop type

In estimating crop water requirement of crop residue, first crop residue yield was calculated by using this equation;

$$CRYi = CYi * Ri$$ ……………………………………………… Equation 5

Where:

CRYi = Crop residues production in kg of the i^{th} crop type

CYi = Crop production in kg of the i^{th} crop type

Ri = Conversion factor for grain yield to crop residue yield of the i^{th} crop type

For the water requirement of crop residues, the value of Ri was used:

Total biomass = Grain + Crop residue

Total biomass = Grain + Ri*Grain

Total water requirement = Grain water + RI*Grain water

Total crop water requirement = (1+ Ri) Grain water

Therefore, the crop residue water requirement was calculated as follows

$$WRCRil = \frac{Ri * ETcil}{1 + Ri}$$ ……………………………………….……Equation 6

Where

WRCRil = water requirement of i^{th} crop residue in l^{th} location (mm)

Ri= conversion factor for grain yield to crop residue yield of the i^{th} crop type

ETcil= crop water requirement in mm per unit of time of the i^{th} crop type at l^{th} location.

Then the water requirement for the total crop residue production for each household was estimated in m^3.

$$WRCRj = \sum_{l} WRCRil \times ACil \quad \text{..} \text{ Equation 7}$$

Where:

WRCRj = the water requirement of total crop residue type in j^{th} household during the reference year (m^3)

WRCRil = water requirement of i^{th} crop residue in l^{th} location (m)

ACil = total area i^{th} crop type cultivated by the j^{th} household in the reference year (m^2)

B. Grazing land and Exclosure Feed Water Requirement

The water requirement for grazing land and exclosures is calculated as follows:

a) For grazing land

$$GLWRij = Kc * ETo * GLAj * GLU * LGP \quad \text{...........................} \text{ Equation 8}$$

Where:

GLWRij= grazing land water requirement in mm per square meter of in j^{th} household (= Depleted water of grazing land that is utilized by livestock)

GLAj = Grazing land area in square meter of the j^{th} household

GLU = Utilization factor of grazing land by livestock (proportion of the grass biomass production that is available for livestock feeding, 75%).

Kc = crop coefficient for grazing land (Kc value of Extensive grazing)

ETo = Reference evapotranspiration in mm per unit time

LGP = Length of growing period in days.

b) For exclosure water requirement

$$EXWRj = ETo * Kc * EXLj * LGP * GLU$$ ……………………………… Equation 9

Where:

EXWRj= Exclosure Water requirement of jth household

EXLj= exclosure land area of jth household

LGP= Length of growing periods in days

ETo= Reference evapotranspiration in mm per unit time

GLU = Utilization factor of grazing land by livestock (proportion of the grass biomass production that is available for livestock feeding, 75%).

Kc= crop coefficient for exclosure land (Extensive grazing land Kc value)

c) Livestock feed water requirement

$$WRfeed = \sum WRCRil \times ACij + \sum WRGRil \times ACij + \sum WREXil \times ACij$$ ….. Equation 10

Where:

WRfeed= total water requirement for feed production

WRCRil= water requirement for ith type crop residue in lth location

WRGRil = Water requirement for grazing land

WREXil= Water requirement for exclosure

ACij= Total area ith crop type/ grazing/ exclosure cultivated by the jth household in the reference year (m^2).

3.5. Determination of Livestock Beneficial Outputs

For determining livestock beneficial output the type and amount of livestock outputs, which include livestock service for the preparation of cultivated land (ploughing), threshing, transportation and the other livestock products like milk, manure, meat, hides and skins (from slaughtered animas) were determined and their value estimated in Birr. For calculating the beneficial outputs in monetary terms their market price in the study area, Appendix 3 Table 16, was used. Specific conversions to tropical livestock unit (250 kg live weight) were used for the different types of animals, Appendix 3, Table 12.

Livestock out puts

3.5.1. Total Milk Yield and Value

The total milk production of each household was computed by using this formula

$$TMY_j = NLC * DMY * LL$$

……………………………………… Equation 11

Where:

TMYj = Total Milk production (in liter) of the j^{th} household;

NLC = number of lactating cows,

DMY = the average daily milk production (liter) and

LL = lactation length in days in the area (data from key informants)

Milk production value is:

$$MYV_j = TMY_j * MP$$ ……………………………..……………. Equation 12

Where:

MYVj = Total Milk production value of the j[th] household per year,

TMYj as defined above

MP = price of one liter of milk at the Weldiya market.

3.5.2. Livestock off Take

A. Meat Value

Meat production from ruminants at the household level was estimated from the number of slaughtered ruminants per year (cattle, sheep and goat) for household consumption. The number of each animal type was converted into TLU. Using the average dressing percentage for each livestock type (Ermias et. al., 2000; Addisu et. al., 2002; Nega et. al., 2002; Negussie et. al., 2004; Jemal, 2004; Moses, 2006; Mesfin, 2007), Appendix 3 Table 13, the meat production per year was estimated. Total meat value was estimated based on the current market price of meat per kg.

The following calculations were employed:

$$LWij = STij * TLUi * 250$$ …………………..…………………….. Equation 13

Where:

LWij = the slaughtered live weight of i[th] animal type in j household per year,

STij = the number of slaughtered animals of the i^{th} livestock type by j^{th} household per year and,

TLUi = TLU conversion factor of the i^{th} type of livestock. 1 TLU is equivalent to 250 kg

$$MYij = DPi * LWi$$ ……………………………………. Equation 14

Where:

MYij = Meat yield of the i^{th} type of livestock in the j^{th} household per year

DPi = Dressing percentage of i^{th} livestock

LWi = Live weight of the i^{th} livestock.

$$MVYj = \sum_{i=1}^{n} (MYij * MPi)$$ …………………….…………………….. Equation 15

Where:

MVYj = total meat value in birr obtained from ruminants in the j^{th} household per year

MYij = meat production in kg per year from i^{th} livestock in the j^{th} household

MPi = Market price of meat from i^{th} livestock (market price of Weldya)

B. Value of Sold Animals and Animals Given as Gifts

For estimating the total value of animals which are sold and given to others per household in a year the number of animals sold and given and the current price in the study area were used.

$$VSGAj = \sum NSGij * MPi$$ ……………………………… Equation 16

Where:

VSGAj = Value animals sold/given in j^{th} household per year

NSGij = Number of i^{th} animal sold/given in j^{th} household per year

MPi = Market price of i^{th} animal

3.5.3. Value of Skins and Hides

For estimating the total hide and skin produced per household in a year the number of slaughtered animals were used and the current market price (in the study area) of hides and skins were used.

$$VSHj = \sum_{i=1}^{n} NGSj * MPGS + \sum_{i=1}^{n} NSSj * MPSS + \sum_{i=1}^{n} NHj * MPH \quad \text{...............Equation 17}$$

Where:

VSHj = Value of hide and skin per year in j^{th} household

NGSj = Number of goat skin produced in j^{th} household per year

MPGS = Market price of goat skin

NSSj =Number of sheep skin produced in j^{th} household per year

MPSS = Market price of sheep skin

NHj = number hide obtained in j^{th} household per year

MPH = market price of hide

3.5.4. Total Manure

Total manure obtained in each household was estimated based on the TLU holding of each household and the daily manure production per TLU for each livestock type on dry matter basis. The nutrient composition of manure from the different classes of livestock was obtained from literature (Lupwayi et. al., 2000; Workneh et. al., 2003; FAO, 2004; Haileselassie et. al., 2006). Appendix 3 Table 15 Based on that, the nutrient production from manure is calculated per year at household level. The total nitrogen and phosphorus produced in each household was converted into equivalent value of fertilizer. To estimate the value obtained from manure the current fertilizer (Urea and DAP) market price was used.

The following equations were employed:

$$MRj = \sum MDRi * TLUIij * 365\ days$$ ………..……………… Equation 18

Where:

MRj = manure produced per year in jth household

MRDi= manure produced per day from ith animal

TLUIj = tropical livestock unit of the ith livestock type owned by the jth household

$$MRNj = \sum MRDi * TLUij * 365 * Ni\,\%$$ ………………………….Equation 19

Where:

MRNj= manure Nitrogen production in jth household per year (in kg)

MRDi= Manure produced per year from ith animal

TLUij= Tropical livestock unit of the ith livestock type owned by the jth household

Ni% = Nitrogen percentage in manure from ith livestock type

$$MRPj = \sum MRDi * TLUij * 365 * Pi\%$$ …………………………………Equation 20

Where:

MRPj= Manure phosphorus production in j^{th} household per year (in kg)

MRDi = Manure produced per year from i^{th} animal

TLUij = Tropical livestock unit of the i^{th} livestock type owned by the j^{th} household

Pi% = Phosphorus percentage manure from i^{th} livestock type

$$MRNVj = MRNj * NP$$ ……………………………...………… Equation 21

Where:

MRNVj = Manure nitrogen value in j^{th} household in birr

MRNj = Manure nitrogen production in j^{th} household per year (in kg)

NP = Nitrogen Price derived from current urea fertilizer price

$$MRPVj = MRPj * PP$$ …………………………………. Equation 22

Where:

MRPVj= manure phosphorus value in j^{th} household in birr

MRPj= manure phosphorus production in j^{th} household per year (in kg)

PP= phosphorus price derived from DAP fertilizer current price.

$$TMRVj = MRNVj + MRPVj$$ …………………….………… Equation 23

Where:

TMRVj= Total manure value (Birr) obtained in j^{th} household

MRNVj= Manure Nitrogen value in j^{th} household in birr

MRPVj= Manure Phosphorus value in j^{th} household in birr

3.5.5. Traction Service

Traction service obtained in the households was estimated by the number of days per year the different livestock give service like ploughing and threshing. These were obtained from the household survey and the local hiring price for each service delivered by each type livestock.

Ploughing and threshing days required for 1 ha differs for the different crops, Appendix 3 Table 12.

$$TSVj = \sum STil * DSTil * PSTil \qquad \text{…………………………………… Equation 24}$$

Where:

TSVj = Traction service value (ETB) obtained per year by the j^{th} household

STil = Service type l delivered by the i^{th} livestock type

DSTil = Number of days per year for the l^{th} service type delivered by the i^{th} livestock type (For Traction / threshing service day, type of crop and land holding of the household was used

PSTil = Current daily hiring price (ETB) of the l^{th} livestock type for i^{th} service type.

3.5.6. Transport Value

Transport service obtained in the households was estimated by the number of days per year donkeys give service like transport for crop to home and to market, transport to the mill house and fetching water. These were obtained from the household survey and the local hiring price for each service delivered by each type livestock.

$$TVj = Tl * DSTl * PSTl$$ ……………………………...…………… Equation 25

Where:

TVj = Transport value (ETB) obtained per year by the j^{th} household

DSTl = Number of days per year for the l^{th} service type delivered by donkey

PSTl = Current daily hiring price (ETB) of donkey for l^{th} service type.

3.5.7. Total Traction and Transport Value

Total traction and transport value was the sum of total transport value and total traction of donkey and oxen respectively.

Total traction and transport value was calculated by;

$$TTVj = \sum TVj + TSVj$$ …………………………..……………….. Equation 26

Where:

TTVj = Traction/Transport value (ETB) obtained per year by the j^{th} household

TVj = Transport value (ETB) obtained per year by the j^{th} household

TSVj= Traction service value (ETB) obtained per year by the j^{th} household

3.5.8. Total Livestock Beneficial Output

Lastly the total beneficial output of the livestock is

$$BOj = \sum_{i=1}^{n} (Oij * Pi)$$ …………………………...………………. Equation 27

Where:

BOj = Total livestock beneficial output (ETB) obtained per year by the j^{th} household

Oij = Livestock beneficial output type i^{th} obtained by the j^{th} household per year

Pi = Current price of livestock beneficial output type i^{th} (ETB)

In this study total beneficial output obtained from livestock in each household in terms of monetary value is computed by;

$$BOj = MYVj + MVYj + VSGAj + VSHYj + TMRVj + TVj \quad \text{.................. Equation 28}$$

Where:

BOj = Total livestock beneficial output (ETB) obtained per year by the j^{th} household

MYVj = Total milk yield value of the i^{th} household per year

MVYj= Total meat value in birr obtained from ruminants in the j^{th} household per year

VSGAj= Total value of animals sold and gifted in the j^{th} household per year

VSHYj = Value of hide and skin per year in j^{th} household

TMRVj= Total manure value (BIRR) obtained in j^{th} household

TTVj = Traction/Transport value (ETB) obtained per year by the j^{th} household.

3.6. Determination of Dry Matter (DM) Production

To estimate the availability of feed from gazing land, exclosure and rehabilitated gully, the dry matter production of grass and five major trees were determined by the following methods.

For exclosures the samples were collected from five different exclosures (Kolokobo, Dolamba, Begido, Minchugora and Dishke). Grass was harvested from the holding of two farmers from each exclosure and three quadrants (1m*1m) per farmer. The harvested grass was oven dried to determine the DM yield. Then the average value of DM yield per quadrant was multiplied by the area owned by each household.

For free grazing lands six month data were used, representing the growing period of the grass from July to December. Grass was collected from two quadrants (1m*1m) in each of two grazing lands (Debiso and Kolokobo). The quadrants were located in a fenced off area and the grass was cut weekly to imitate livestock grazing. Samples were oven dried to determine DM yield.

The total biomass of grazed grass during the six months period in the 1m*1m quadrant was calculated by;

Total production = Weekly yield*24 weeks. Then the average of the two grazing lands was used.

For calculating the grass biomass consumed by grazing for each household, the total catchment grazing area and the total TLU of the watershed and the total TLU of the household was used.

$$TGAj = \frac{TTLUj * TGAw}{TTLUw}$$ …………………………………………… Equation 29

Where:

TGAj = total grazing area for j^{th} household

TTLUj = Total TLU of j^{th} household

TGAw = Total grazing area in the watershed

TTLUw = Total TLU in the watershed

For determination of forage biomass production from tree. Five major forage trees were selected based on the key informant information. From each tree species two trees were selected and all the branches of the tree were cut and weighed. All branches were given to animals and the leftovers were weighed. A sample was taken to determine the moisture content so that the DM of the edible part could be determined. The number of each tree species per households was determined from the survey result and multiplied by the DM of the trees.

3.7. Determination of Feed Balance

The daily maintenance feed requirement of the animals was calculated as 2.5% of the live body weight (Boudet, 1975). The contribution of each feed resource (crop residue, exclosure, free grazing land and stubble) to feed intake were determined proportionally, in relation to both feed availability and requirements.

The feed balance of the household was calculated based on the feed available and the maintenance feed requirement at household and catchment level. Based on the feed balance the annual feed gap of the households is also estimated. Stubble grazing production was estimated at 0.5 t per hectare (FAO 1987).

Feed balance at household level was calculated based on the total TLU holding in the household and total available feed in that household:

Feed balance at HH level = Total available feed per year - Total maintenance feed requirement per year.

At catchment level, first the total available feed from the different feed resources was calculated by using calculated value of each type of crop cultivated area per household then converted to catchment level (multiplying cultivated land of each crop type per HH by the total HH in the catchment) and maintenance feed requirement was calculated for total TLU in the catchments. Then, the above equation was used to calculate the feed balance for the catchment.

To compare which feed resource contributes more to the total feed available, feed resource contribution (%) was calculated by:

$$Feed\ \ Rresource\,\% = \frac{Amount\ \ of\ \ Feed\,(kg)}{Total\ \ Available\ \ Feed\,(kg)} * 100$$ ……………..….Equation 30

And to see how much percentage of feed requirements was satisfied by the available feed was calculated by;

$$\mathrm{Re}\,quierment\% = \frac{Total\ Available\,Feed(kg)}{Total\ Feed\ \mathrm{Re}\,quierment(kg)} * 100$$ ………….……. Equation 31

To support the above equation the feed gap was also calculated by using the following equation;

$$Balance\ as\%\ of\ \mathrm{Re}\,quierment = \frac{Feed\ Balance}{feed\ \mathrm{Re}\,quierment} * 100$$ ……………Equation 32

3.8. Livestock Mortality Rate

Livestock mortality rate in the watershed was estimated based on the survey results from the household questionnaires.

$$MRi(\%) = \frac{TNDshi}{TNshi} * 100$$ ………………………………………. Equation 33

Where:

MRi = Mortality rate of i^{th} animal in the study area

TNDshi= Total number of i^{th} type of animal died in the sampled household

TNShi= Total number of i^{th} type animal in the sampled household at the beginning of the year.

3.9. Physical and Financial Water Productivity

3.9.1. Physical and Financial Water Productivity of Crop Residue

For estimating crop residue water productivity the partition of depleted water to crop residue was estimated based on crop harvest index of the particular crops in all wealth status under each participation category level during the study period. . Estimated by this equation:

$$PWPCR = \frac{TCR(KgDM)}{DWCR(m3)}$$ ……………………………..…….. Equation 34

Where:

PWPCR= Physical water productivity of crop residue

TCR = Total crop residue yield of the three crops

DWCR= Total depleted water for the production of crop residue (m^3)

And

$$FWPCR = \frac{TCR(ETB)}{DWCR}$$ ……………………………………….. Equation 35

Where:

FWPCR= Financial water productivity of crop residue (ETB/m^3)

TCR= Total crop residue of the three crops in ETB, (estimated at 1.22 ETB from key informants)

DWCR= Total depleted water for the production of crop residue (m^3)

3.9.2. Physical and Financial Water Productivity of Animal Feeds

Physical and financial water productivity of animal feeds was estimated based on the available feed from crop residue (from own, shared in and rented in land), grazing land and exclosure.

$$PWF = \frac{AF(kg)}{DWFP}$$ ………………………………………………….. Equation 36

Where:

PWF= Physical water productivity of feed (kg per m^3)

AF= Total available feed (kg)

DWFP= Depleted water for feed production (m^3)

And

$$FWF = \frac{AF(ETB)}{DWFP}$$ ………………..…………………………….. Equation 37

Where:

FWF= Financial water productivity of feeds (ETB per m^3)

AF (ETB) = Available feed cost (ETB)

DWFP= Depleted water for feed production (m^3)

3.9.3. Financial and Physical Water Productivity of Grazing and Exclosure Land

For estimating pasture water productivity depleted water of grass (from grazing land and exclosure) and amount of production (DM) was estimated in all wealth status under each participation category level during the study period. . Estimated by this equation

$$PWG = \frac{TDMG}{DWG} \quad \text{………………………………………………… Equation 38}$$

Where:

PWG = Physical water productivity of pasture from grazing land/ exclosure (Kg/m^3)

TDMG = Total dry matter of pasture from grazing/ exclosure land (kg)

DWG = Depleted water for pasture production in exclosure/ grazing land (m^3)

And

$$FWG = \frac{TG(ETB)}{DWG} \quad \text{……………………………..…………….. Equation 39}$$

Where:

FWG = Financial water productivity of pasture (ETB/m^3)

TG = Total pasture production ion ETB

DWG = Depleted water for pasture production in exclosure/ grazing land (m^3)

3.10. Data Analysis and Management

The survey and relevant secondary data were organized, cleaned and analyzed using SPSS 13.0 (2003) and MS Excel 2003/07. Descriptive and one way ANOVA (Zar, 1996) were employed in data analysis. Mean and percentage comparison of parameters were done across the households (participants and non-participants as well as wealth categories).

4. RESULTS AND DISCUSSION

4.1. Social and Economic Profile of the Study Area

4.1.1. Family Composition

Of the sampled participant households 76.7% were male headed and 23.3% female headed and in the non-participant group, 75% were male headed and 25% female headed. This result showed differs from what Mekete (2008) reported in Alewuha and Golina irrigated and rainfed farming system, where the majority (about 92.5%) of the households were male headed.

According to the data obtained from the household's survey the average family size of participants and non participants were 4.5 and 4.6 respectively (Table1). The overall mean family size of the sampled households was 4.6 ± 8, ranging from 2 to 8 with an average 2.5 (range: 0 - 6) males and 2.2 (range: 1 - 5) females. The family size in this study is less than what Mekete (2008) reported for Alewuha and Golina irrigation (5.0 ± 0.1) and also less than the national average of 5.2 person per household (CSA, 2003).

Mean family size of better off households is generally bigger than that of the poor and very poor households in both participant and non participant groups. A higher proportion of males in the better off farm household in both participation categories than poor and very poor farm households were observed. (Table 1). The result of the present study is in line with what Mekete (2008) reported regarding the proportion of male and female family members for Alewuha and Golina irrigation (51.8% male and 48.2% female). However, some deviation is observed from the male (50.2%) and female (49.8%) proportion for Amhara region, reported by CSA (2007).

Table 1: Means, standard errors, range and total number of farm family size

Wealth class	Participation	Category	Mean(SE)	Range	Percentage
Better off	Non participant	Total	4.9(0.4)	2−8	100.0
		Male	3(0.3)	1−5	60.8
		Female	2.9(0.2)	1−4	39.2
	Participant	Total	5.3(0.4)	2−8	100.0
		Male	3(0.3)	1−6	57.1
		Female	2.3(0.2)	1−3	42.9
Poor	Non participant	Total	4.8(0.4)	2−7	100.0
		Male	2.7(0.3)	1−5	55.2
		Female	2.2(0.2)	1−4	44.8
	Participant	Total	5.1(0.4)	2−8	100.0
		Male	2.4(0.4)	0−6	47.1
		Female	2.7(0.2)	1−5	52.9
Very poor	Non participant	Total	3.9(0.4)	2−7	100.0
		Male	1.9(0.2)	1−4	42.3
		Female	2.3(0.2)	1−4	57.7
	Participant	Total	3.6(0.3)	2−7	100.0
		Male	1.9(0.3)	1−4	49.3
		Female	1.8(0.2)	1−5	50.7
	Overall	Total	4.6(0.2)	2−8	100
		Male	2.5(0.1)	0−6	52.5
		Female	2.2(0.1)	1−5	47.5

The majority of the respondents in all wealth categories are married. The proportion ranged from 50% to 90% in the very poor non participant group and in the better off non participant group respectively. The proportion of widowed and divorced respondents ranged from 5%-20% and 0%-20% respectively. The overall marital status of the sample households was found to be 2.5% not married, 75% married, 7.5% divorced and 15% widowed (Appendix 3, Table 1). Then result differ from the findings of Mekete (2008), where 91.3% were married, 3.1% divorced and 5.6% widowed.

The overall mean age of sample household heads in the watershed is 44 ± 1.4. Generally, the age composition of the population can be described by the fact that 39.3%, 55.1% and 5.8% of the household members are less than 15 years, in the productive age class (15-64) and older than 64 years respectively. MoFED(2007) reported comparable age wise distribution for national age structure with 43% under the age of fifteen, 54.2% in the working group (15-64 years) and 2.8% in the old age (> 64 years). Similar to this study, Yisehak (2008) reported relatively larger number of children per household in Jimma Zone. These age distributions are indicative of high population growth. In this study the highest proportion of children was observed in poor participant farm household (44%) and the least in very poor participant farm households (32.4%), Appendix 3 Table 1. Early marriage and less awareness on family planning might be the possible causes for large proportion of children in the family and hence young population age.

4.1.2. Education

In all cases, the literacy level was found to be very low. About 85% of the household heads were illiterate, 8.3% were able to read and write, while the reminder (6.75%) of the population attained formal education, Appendix 3 Table.1 A large number of the respondent's family members are illiterate (78.5%, 80.2%, 73.1% and 57.1%, 63.3%, 63.2%) in better off, poor and very poor non participants and better off, poor and very poor participants respectively. The illiteracy rate was higher in the non participant families than participant families. This might be due to non participant farm households having more livestock than participant farmers (see paragraph 4.1.4). As a result they need more labor for herding the livestock, with consequently more family members engaged in herding rather than school. Participant farm households have higher awareness and have better access to new technologies, which might be a result of better education. Details of the respondents' education level are presented in Table 2.

Table 2: Education level of households in each category (%)

Descriptors	Non participant			Participant		
	Better off	Poor	Very poor	Better off	Poor	Very poor
Family members who are illiterate	78.5	80.2	73.1	57.1	63.3	63.2
Family members who have attended 1-4th grade	19.4	16.7	19.2	37.1	30.6	29.4
Family members who have attended 5-8th grade	2.2	2.1	6.4	3.8	4.1	5.9
Family members who have attended 9-10th grade	0	1.0	1.3	1.0	2.0	1.5
Family members who have attended preparatory	0	0	0	1.0	0	0

Family members who have attended 1-4th grade accounted for the highest proportion of the non-illiterate categories. This showed that there is a good start towards primary education in rural areas, which is supported by the government policy on spreading education in the entire country.

Education plays a central role for economic and social development. The educated households tend to have higher productivity as they are able to decode new production technology (Abera et al., 2002). In addition, as the household's attitude towards education changes, this may initiate them to send children to school, which diversifies their knowledge and readiness to adopt new technologies. It is assumed that in the long run this will have positive implications for agricultural productivity and livestock productivity in particular.

The present result showed there is need for interventions on formal and informal education programs and integration of those with better management of livestock production. Besides this, the spread of improved or new technologies depends on the decision of individual farmers, which is directly related with education. In support of this result Yisehak (2008) reported that low literacy level was one of the factors blocking women from getting access to productive resources in Jimma Zone.

4.1.3. Land Holding and Land Ownership

In this particular study the land holding was calculated by considering own, rented out and shared out cultivated land.

According to FAO (1997), farm resources generally fall into two broad categories. The first category is fixed resources that provide services over a number of years or at least over a period longer than the production cycle of short-term (seasonal, annual) crop or livestock enterprises. Common examples of this are land, machinery, and an irrigation system. In this category, land is typically the most important that will usually provide its service indefinitely.

Significant differences of cultivated land holding were observed between the different household categories. The mean total cultivated land in the two participation categories was 3.34 ha, 3.05 ha, 2.82 ha, 2.67 ha, 2.3 ha and 1.7 ha in better off non participants, better off participants, poor participants, poor non participants, very poor participants and very poor non participants respectively.

4.1.4. Livestock Holdings

Livestock in the study area are kept to meet the demand for draft power, milk, meat (to a lesser extent because they use to sell live animals more than to consume meat), as a store of wealth, and as means to relieve debts.

The average number of each type of livestock species was less in participant households than in non participants, except in poor households. From key informant's discussions it became clear that this is due to shortage of grazing land (due to the hillslope exclosures in those specific villages) and changed attitude of the farmers towards increasing livestock productivity by decreasing the number of animals. The overall mean and range of each livestock type per household were 4.15 (0-18), 1.75 (0-25), 0.14 (0-9), 0.83 (0.8), 0.87 (1.7) and 0.05 (0-2) of cattle, goat, sheep, donkey, poultry and camel respectively (Table 3).

Table 3: Mean number and standard deviation of each type of livestock in the different household categories

Descriptors	Participants			Non Participants			Overall	
	Better off	Poor	Very poor	Better off	Poor	Very poor		
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Range
Cattle	6.4(2.7)	4.7(2.58)	1.5(1.43	7.6(3.56)	3.3(0.73)	1.5(1.3)	4.15(3.2)	0-18
Goat	1.8(3.2)	2.6(5.8)	0.8(2.0)	2.6(3.30)	2.0(3.33)	.0.7(1.3)	1.75(3.8)	0-25
Sheep	0.1(0.4)	0.7(2.25)	0.0	0.0(0.00)	0.1(0.22)	0(1.1)	0.14(1)	0-9
Donkey	1.1(0 .7)	0.9(0.8)	0.2(0.4)	1.3(0.8)	1.1(0 .6)	.6(0.0)	0.83(0.8)	0-4
Poultry	0.7(1.3)	1.3(1.9)	0.5(1.3)	0.7(1.3)	0.9(1.9)	1.2(0.8)	0.87(1.7)	0-9
Camel	0.1(0.2)	0.1(0.2)	0	0.2(0.5)	0(0.0)	0(0.0)	0.05(0.3)	0-2

4.1.5. Livestock Density

The main feed resources in the study area are crop residues and grazing lands. In this study the livestock density was considered in terms of cultivated land (own, shared in and rented in), grazing and exclosure land together and cultivated, grazing and exclosure land together.

Livestock density per cultivated land of the farm household was calculated to show how many TLU are stocked under the existing land area. The grazing land livestock density in the watershed was 5.8 TLU per hectare of grazing land.

Table 4: Means and standard errors of livestock density per household (TLU/ha)

Participation	Category	LDC	LDGE	LDCGE
Non participant	Better off	4.7(0.5)[a]	5.8 [a]	2.6(0.2)[c]
	Poor	3.3(0.5)[b]	5.8 [a]	1.98(0.2) [c]
	Very poor	1.3(0.5)[c]	5.8 [a]	1.0(0.2) [c]
Participant	Better off	3.5(0.6)[a]	4.6(0.3) [a]	1.9(0.2)[c]
	Poor	3.4(0.6)[b]	4.4(0.3)[a]	1.7(0.2)[c]
	Very poor	1.4(0.6)[c]	2.6(0.3)[a]	3.7(0.2)[c]

Tukey HSD, [abc]: rows within a column with no letter in common are significantly different ($P<0.05$), LDC = livestock density on cultivated land, LDGE = Livestock density on grazing land and exclosure together, LDCGE = livestock density on cultivated, grazing and exclosure land.

Overall mean of livestock density on cultivated land, grazing and exclosure land together and cultivated, grazing and exclosure land together was 2.9 ± 2.1 TLU/ha, 4.8 ± 1.3 TLU/ha and 1.7 ± 0.9 TLU/ha respectively.

There was a significant difference in livestock density under cultivated land among better off non participant (4.7±0.5 TLU/ha), poor non participant (3.3±0.5 TLU/ha) and very poor non participant (1.3±0.5 TLU/ha). In the non participants group the livestock density per hectare was much higher than in the participants group for all wealth categories (Table 4).

The livestock density on grazing and exclosure land together in non participant farm household have similar mean value This is because the grazing land holding was calculated based on the livestock TLU holding (expressed in TLU) of the household.

4.2. Land Use and Land Tenure System

Land tenure systems and agreements on sharing land and its produce yield mutual benefits for capable farmers (having sufficient human and animal power for crop cultivation) and farmers, which were unable to cultivate their land due to lack or unavailability of these resources (especially for female headed households and farmers facing unexpected death of oxen).

The two land tenure agreements made between land owner and cultivator are based upon sharing the crop yield and renting in monetary terms. The farmer who shared in or rented in land will use his human and animal power and will get the total crop residue.

In Table 5 the cropland area under the various land tenure agreements is shown. The proportion of cropland under different land tenure agreements cultivated during 2008 was compared in relation to the land owned by the household.

As can be seen in Table 5, poor farmers who were in the participant category shared out more of their land (29.7%) than poor non participant farm households (4.3%). This might be due to the fact that most of the very poor participant farmers were female headed, who generally lack human and animal power for cultivation. On the other hand, better off farmers in both participation categories shared out their land to a lesser degree than the other wealth classes. This might be due to better off farmers having more animal and human power.

Table 5: Distribution of the land tenure agreements for cropland cultivated during 2008

Household categories	Land tenure type of cropland											
	Crop land		Land own		Shared out		Rented out		Shared in		Rented in	
	Total area(ha)	% from Own* land	Total area(ha)	% from Own* land	Total area (ha)	% from Own *land	Total area(ha)	% from Own* land	Total area (ha)	% from Own land	Total area (ha)	% from own *land
Participants												
Better off	59.19	171.9	34.4	100	2.75	8.0	2	5.8	17.5	50.8	2	5.8
Poor	54.01	174.6	30.9	100	9.19	29.7	0	0	13.13	42.4	0.75	2.4
Very poor	44.29	198.2	22.4	100	3.19	14.3	0	0	18.25	81.7	0.5	2.2
Non Participants												
Better off	64.275	182.3	35.3	100	0.75	2.1	1.75	5.0	26.01	73.8	0.5	1.4
Poor	52.64	163.8	32.1	100	1.38	4.3	0	0	19.13	59.5	0	0
Very poor	31.76	167.1	19.0	100	7.75	40.8	0	0	5	26.3	0	0

* Calculated based on entitled (owned) land holding as a base.

Table 6: Distribution of the land tenure agreements per HH for cropland cultivated during 2008

Household categories	Land tenure type of cropland											
	CLR		CLRo		CLRso		CLRro		CLRsi		CLRri	
	N	Avg/ HH (ha)	N	Avg/ HH (ha)	N	Avg/HH (ha)	N	Avg/ HH (ha)	N	Avg/ HH (ha)	N	Avg/HH (ha)
Participants												
Better off	20	2.96	20	1.7	2	1.4	2	1.0	10	1.8	2	1
Poor	20	2.7	19	1.6	7	1.3			9	1.5	1	0.8
Very poor	20	2.2	16	1.4	6	0.5			10	1.8	1	0.5
Non Participants												
Better off	20	3.2	20	1.8	1	0.8	1	1.8	12	2.2	1	0.5
Poor	20	2.6	20	1.6	2	0.7			10	1.9		
Very poor	20	1.6	14	1.4	7	1.1			5	1.0		

CLR = Total cultivated cropland, CLRo = Total cultivated land own, CLRso = Total cultivated land shared out, CLRro = Total cultivated land rented out, CLRsi = Total cultivated land shared in, CLRri= Total cultivated land rented in

4.2.1. Cropping Pattern and Cover of the Crop Grown

Based on cultivated land result in each wealth and participation category the total cultivated land in the watershed was calculated.

The total cultivated land in watershed was 895.4 ha with 2.65 ha per household. Sorghum covered 420 ha (46.8 %) with 1.24 ha per household followed by tef 416.2 ha (46.4%) with 1.23 ha per household, chickpea covered 37.7 ha (4.2%) with 0.11 ha per HH and maize covered 21.5 ha (2.4%) with 0.07 ha per household and. (Figure 4, Table 6).

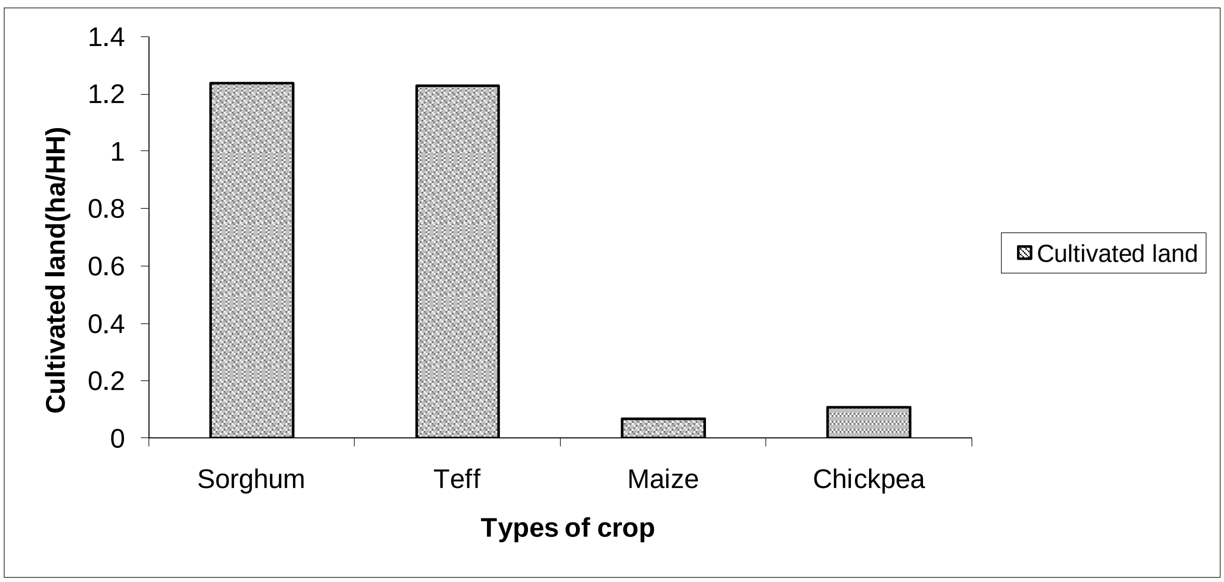

Figure 4: Cultivated land per HH (ha) for the 4 types of crops in the watershed in 2008

Farmers mainly planted Sorghum, tef, Chickpea and maize. Mean of the four major crops show significance among the category. The mean cultivated land under sorghum was 1.8 ha in the better off non participant group, followed by 1.4 ha, 1.3 ha, 0.9 ha and 0.7 ha in poor participant, poor non participants, very poor participant and very poor non participant respectively. The overall mean for total cultivated land and land under sorghum, tef, maize and chickpea was 2.7 ha, 1.3 ha, 1.2 ha, 0.1 ha and 0.12 ha respectively, Table 6.

Table 7: Mean and standard error of total own, shared out and rented out cultivated land for different types of crops and different household categories

Cultivated land	Participants			Non Participants					
	Better off	Poor	Very poor	Better off	Poor	Very poor	Overall		
	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	F	P
Total	3.15(0.2)	2.82(0.2)	2.28(0.3)	3.24(0.6)	2.7(0.4)	1.7(0.2)	2.7(0.2)	7.2	0.001
Sorghum	1.2(0.2)	1.4(0.1)	0.9(0.2)	1.8(0.7)	1.3(0.3)	0.7(0.1)	1.3(0.1)	3.2	0.05
Tef	1.60(.2)	1.2(0.1)	1.2(0.2)	1.2(.2)	1.2(.2)	0.9(.1)	1.2(0.1)	2.9	0.05
Maize	0.2(0.3)	0.1(0.2)	0.03(0.1)	0.10(.1)	0.1(0.03)	0	0.1(.02)	4.35	0.02
Chickpea	0.15 (0.3)	0.12(0.03)	0.08(0.1)	0.14(0.2)	0.09(0.1)	0.1(0.3)	0.12(0.02)	3.42	0.01

P= significance level, F= calculated F value

The differences in the area of land cultivated per household per year are not due to additional land entitlement allocation through land redistribution, but because of the different land tenure agreements in the study area. Capable farm households with more farm labour force and draught power lease or share the croplands of elders, divorced and widowed female headed households. The land tenure agreement is between the owner and the cultivator. Besides his share of the grain yield (usually 50%), a farmer who rents in or shares in land, gets the total crop residue, which is advantageous for getting more livestock feed in the form of crop residue.

4.3. Crop and Crop Residue Yield

Based on the cropping pattern and total area covered by each crop type, the total grain and crop residue production and yield was calculated for each type of crop cultivated under the different wealth status in the two participation categories (Table 8). Sorghum and tef contribute the highest crop residue. These two crops are the major source of animal feed in both participation categories and they account for the major part in water depleted for livestock feed. Sorghum grain (29.13 t) and crop residue (73.0 t) production in poor participant farmers was higher than in poor non participant farmers, with 20.6 t grain and 51.6 t crop residues, which was followed by sorghum grain (26.3 t) and crop residue (65.7 t) in better off participant farmers. This is due to the fact that the categories with higher production have more sorghum cultivated land. In the non participant very poor farmer category, tef contribution with total grain production of 14.6 t and 21.9 t crop residue is low compared to participant very poor farmers. Contribution of chickpea to animal feeds from crop residue is small: 1.7 t in better off participant farmer which is followed by better off non participant farmers (1.5 t).

Table 8: Sum of production of Crop and crop residue production (t) and yield (t/ha) in 2008 cropping year for sampled households.

Crop type	Wealth status	Participants N=60				Non- participant=60			
		Total production(t)		Average yield (t/ha)		Total yield(t)		Average yield (t)/ha	
		Grain production	Crop residue production	Grain yield	Crop residue yield	Grain yield	Crop residue yield	Grain yield	Crop residue yield
Sorghum	Better off	26.3	65.7	1.1	2.7	20.39	50.97	0.6	1.4
	Poor	29.19	73.0	1.0	2.6	20.6	51.6	0.8	1.9
	Very poor	19.6	49.0	1.5	3.7	19.2	47.89	1.4	3.6
Tef	Better off	24.9	37.4	0.8	1.2	19.8	29.73	0.8	1.2
	Poor	19.7	29.5	0.8	1.2	19.9	29.86	0.8	1.2
	Very poor	18.9	28.4	1.0	1.6	14.6	21.92	0.8	1.2
Chickpea	Better off	1.38	1.7	0.4	0.5	1.25	1.5	0.5	0.6
	Poor	0.78	0.9	0.5	0.6	0.38	0.45	0.38	0.45
	Very poor	0	0	0	0	0	0	0	0

NB: the same conversion factors to estimate crop residue yield from grain yield were used in all participation and wealth categories

The average grain yield per hectare of sorghum (1.1 t/ha) for better off participant farmers is higher than the average grain yield of sorghum (0.6 t/ha) for better off non participant farmers. But for chickpea the average grain yield of better off non participant farmers (0.5 t per ha) is higher than for participants (0.4 t per ha). For tef the value was equal for both participation categories (0.8 t per ha) with 1.2 t per ha crop residue. In line with this result for tef grain and crop residue yield, Mekete (2008) reported 0.9 t/ha tef grain and 1.3 t/ha tef crop residue for Alewuha rain fed farmers.

Total grain production (t) calculated per household was significantly different in the three wealth categories at $p<0.05$. The highest mean total grain (sorghum, tef and chickpea together) production per household is obtained by poor non participant farmers (3.1±0.3 t) followed by better off non participant farmer (2.6 ±0.3 t) and poor participants (2.1±0.3 t). Similarly, total crop residue per household is higher for poor non participants (6.2±0.6 t) followed by better off non participants (5.3±0.6 t) (Table 9).

Table 9: Means and standard errors of harvested grain, crop residues and available grazing land production (t per HH)

Feed Type	Participants			Non participants				
	Better off	Poor	Very poor	Better off	Poor	Very poor		
	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	F	Sig
TGY	1.9±0.3[a]	2.1±0.3[a]	1.8±0.2[a]	2.6±0.3[a]	3.1±0.3[a]	1.4±0.2[c]	6.9	0.02
TCRY	4±0.6[a]	4.1±0.6[a]	3.6±0.5[a]	5.3±0.6[a]	6.2±0.6[a]	2.8±0.5[c]	6.3	0.03
TCBY	5.9±0.8[a]	6.2±0.8[a]	5.4±0.7[a]	7.8±0.9[a]	9.3±0.9[a]	4.2±0.7[c]	6.5	0.02
TUGGE	0.7±0.1[a]	1.1±0.1[a]	0.9±0.1[a]	1.2±0.1[a]	1.2±0.2[a]	0.7±0.1[c]	4.3	0.02
TLF	4.7±0.8[a]	5.2±0.8[a]	4.5±0.8[a]	6.5±0.9[a]	7.4±1[a]	3.5±0.7[c]	7.2	0.01

Tukey HSD, ab: rows within a column with no letter in common are significantly different ($p<0.05$), TGY= Total grain yield, TCRY= Total crop residue yield, TCBY= Total crop biomass yield, TUGGE= Total utilizable grass from grazing & exclosure land, TLF= Total livestock feed.

There was a high significant difference among the wealth classes ($p<0.05$) for total utilizable grass from grazing and exclosure land. For better off and poor non-participants, the total utilizable grass from grazing land and exclosure was 1.2 t, followed by 1.1 t in poor participants and 0.9 t in very poor participants.

In very poor non participant farm households crop residue yield and grain yield show significant difference with poor and better off non participant farm households

Generally, non participant farmers in all wealth status have higher total livestock feed production than participant farmers except in very poor farmer households (Table 9).

The total grain and crop residue production in the total watershed was 875.2 t and 2178.2 t respectively, which was dominated by sorghum with 504 t grain and 1260 t crop residue. Average sorghum grain yield per hectare was 1.2 t and crop residue was 3 t (Table 10).

Table 10: Total cultivated land, grain and crop residue yield of the watershed

Crop type	Total area covered (ha)	Average area per HH (ha)	% of crop covered	Grain		Crop residue	
				Total production (t)	Averag e yield (t/ha)	Total production (t)	Average yield (t/ha)
Sorghum	420	1.24	46.8	504	1.2	1260	3
Tef	416.2	1.23	46.4	332.96	0.8	832.4	2
Chickpea	37.7	0.07	4.2	18.85	0.5	47.1	1.3
Maize	21.5	0.07	2.4	19.4	0.9	38.7	1.8
Total	895.4	4.94	100	875.2	3.4	2178.2	8.1

4.4. Livestock Production

Crop and livestock production in the study area have complementary benefit from one another as the products and by-products of one serve as an input for the other. Livestock are the only means of draught power for crop production and crop residue is the main feed source for animals. In the study area livestock comprises cattle, sheep, goat, camel, don key and poultry.

4.4.1. Purpose of Livestock Keeping

The purposes of livestock keeping in the study area are shown in Table 11. As goats can tolerate drought, feed and water shortage, farmers prefer goats in the first place for income source and saving. Camels is needed for insurance in the first place and secondly for prestige followed by transport. Chickens are important for immediate cash income and meat. Chickens are mostly owned by women. Cows are kept for production of oxen and milk production for home consumption (milk sale is a taboo in the area). (Table 11)

Table 11: Purpose of livestock keeping (Ranks from 1 = most important to 6 = least important)

Type of animal	Meat	Milk	Draft power	Tran sport	Income source	Manu re	Saving	Insura nce	Presti ge
Oxen	3		1		5	4	6		2
Cows	3	1			4	6	5		2
Goat	4				1	6	2	3	5
Sheep	1				2				3
Chicken	2				1		3		
Donkey				1	4		2		3
Camel	5		4	3			6	1	2

Source: key informants.

4.4.2. Livestock Herd Composition

Only indigenous livestock are found in the study area. Livestock species including cattle, goats, sheep, donkeys as well as chicken and bees are kept. The cattle in the area are nondescript zebu type and some long-horned Raya cattle. The goats are predominantly of brownish coat color, while the few sheep are fat-rumped Afar sheep.

In the watershed the total cattle population (3116.2 heads) is the highest compared to the other livestock types, followed by the goat population (2972.8 heads). This was much higher than the local district data on cattle population for the watershed (2109 heads).in addition to this the oxen population (1268.3 heads) was higher than the population of cows (1220.3 heads). Camel population is smaller than the donkey population, which showed that the farmers use more donkeys for transport than camels. This might be due to the higher purchasing price of camels as compared to donkeys.

Table 12: The total population of livestock in the sampled households

Type livestock	Participants						Non participants						In watershed
	Better off		Poor		Very poor		Better off		Poor		Very poor		Total number
	Sum	N	Sum	N	Sum	N	Sum	N	Sum	N	Sum	N	
Cattle	127	20	94	20	29	15	152	20	66	20	30	17	3116.2
Goat	39	10	53	8	15	6	61	13	39	8	15	8	2972.8
Sheep	2	1	14	4	0	0	0	1	1	1	0	0	1215.0
Donkey	21	16	18	13	3	3	3	19	21	18	11	9	758.6
Poultry	14	5	26	7	10	3	19	6	18	6	22	6	2391.2
Camel	1	1	1	1	0	0	4	3	0	0	0	0	405.0
Cow	34	17	30	19	8	6	50	19	20	16	5	4	1220.3
0xen	44	20	37	20	19	14	42	20	35	20	13	11	1268.3

N= Number of farmers who have that specific type of livestock

In the sampled households, the number of cattle is higher than the number of other livestock species. In better off non participant farmers the total number of cattle (152) is higher than in better off participant farmers (127) followed by poor participants (94) and poor non participants (66). The cattle population in the participant farmers group was smaller than in the non participant group. The cow population in the participant group was smaller than in the non participant group, except for poor farmers (Table 12).

Table 13: Average livestock holding per HH in the sampled household and watershed

Type of livestock	Participants N=60			Non participant N=60			In the watershed
	Better off	Poor	Very poor	Better off	Poor	Very poor	
Cattle	6.35	4.7	1.9	7.6	3.3	1.8	4.3
Goat	3.9	6.625	2.5	4.7	4.875	1.9	4.1
Sheep	2	3.5	0	0.0	1	0.0	1.0
Donkey	1.3	1.4	1	0.2	1.2	1.2	1.0
Poultry	2.8	3.7	3.3	3.2	3	3.7	3.3
Camel	1	1	0	1.3	0	0.0	0.6
Cow	2	1.6	1.3	2.6	1.25	1.3	1.7
0xen	2.2	1.85	1.3571	2.1	1.75	1.2	1.7

The average cattle population per household in the watershed was 4.3 whish is less than in better off non participant farm households. As can be seen in Table 13 the average cattle population in non participant households was higher than in better off participants but in poor and very poor farm HHs it was the reverse. This shows better off participant farm HHs decreased their livestock number after joining the intervention but the other wealth status increased their livestock number.

In Table 13, the importance of livestock types demonstrated in terms of ratios were based on their physical numbers rather than on monetary values. The livestock ratios showed that cattle and goats were kept in larger number than other livestock. This implies cattle on the one hand and goats on the hand are the most important livestock types. Goat can alleviate and overcome the shocks and disasters of drought and more need of draught power from cattle, which are the common problems occurring in the study area.

Table 14: Ratio of livestock species for the different household categories

	Participants			Non participants			
	Better off	Poor	Very poor	Better off	Poor	Very poor	overall
Oxen: cow	1.1	1.2	1.0	0.8	1.4	0.9	1.0
Goat: Sheep	2.0	0.9	0.0	0.0	4.9	0.0	2.4
Cattle: Sheep	3.2	0.7	0.0	0.0	3.3	0.0	2.5
Cattle: Goat	1.6	0.7	0.8	1.6	0.7	0.9	1.0
Cattle: Shoat*	1.1	0.3	0.8	1.6	0.6	0.9	0.7
Cattle: Donkey	4.9	3.4	1.9	38.0	2.8	1.5	4.3
Cattle: Camel	6.4	4.7	0.0	5.8	0.0	0.0	7.2

* Shoats include both sheep and goats (small ruminants).

As can be seen from Table 14 there are different proportions within the different wealth classes. For example for every single goat there were 1.6, 0.7, 0.8, 1.6, 0.7 and 0.9 numbers of cattle in better off participant, poor participant, very poor participant, better off non participant, poor non participant and very poor non participant groups respectively.

The overall ratio among ruminants showed a goat to sheep ratio of 2.4, whereas the cattle to sheep ratio were 2.5. This shows that the importance of sheep is much lower compared to goats and cattle. The overall ratios of cattle to pack animals were 4.3 and 7.2 for donkeys and camels, respectively (Table 14).

Table 15: Cattle herd structure in the sampled households

Herd Structure	Participants N=60						Non participants N=60							
	Better off		Poor		Very poor		Better off		Poor		Very poor		Overall	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Lactating cow	13	10.2	14	14.9	2	6.9	26	17.1	11	16.7	3	10	69	14
Dry cows	21	16.5	16	17	6	20.7	24	15.8	9	13.6	2	6.7	78	16
Oxen	44	34.6	37	39.4	19	65.5	42	27.6	35	53	13	43.3	190	38
Bull	6	4.7	4	4.3	-	-	3	2	1	1.5		0	14	3
Calf	14	11	12	12.8	-	-	23	15.1	3	4.5	2	6.7	54	11
Heifer	13	10.2	5	5.3	-	-	15	9.9	5	7.6	4	13.3	42	8
Steer	16	12.6	6	6.4	2	6.9	19	12.5	2	3	6	20	51	10
Female	57	44.9	40	42.6	8	27.6	83	54.6	27	40.9	10	33.3	225	45
Male	70	55.1	54	57.4	21	72.4	63	41.4	39	59.1	20	66.7	267	54
Total Cattle	127	100	94	100	29	100	152	100	66	100	30	100	498	100
Mature	78	61.4	282	300	27	93.1	450	296.1	198	300	18	60	337	68
Immature	49	38.6	27	28.7	2	6.9	60	39.5	11	16.7	12	40	653	131

Immature include calves, bulls and heifers and matures include dairy cows and oxen. Lactating cows include both lactating and dry cows. N= Number of livestock

The smaller number of immature animals reflects the shortage of home grown oxen in future crop cultivation, even at the existing land entitlement scenario of the farm households.

4.4.3. Livestock Death Rate

Death rate can give an indication about the management and health service of the animals. In the study area there was one veterinary clinic around the town and investment on livestock production input, especially in veterinary service, was very low. This is due to lack of awareness and scarcity of the services nearby or the inability of the farmers to afford the veterinary costs. Around Dessie, Shiferaw (2004) showed that the community in his study area neither knows, nor practices, any of the conventional methods for anthrax control, while the disease occurs annually in this area in May and June. Livestock disease is one of the main causes for low animal productivity, and high mortality and morbidity in the study area. Major livestock disease types listed by key informants are external parasites (ticks, lice), Anthrax, pasteurellosis (locally known as Gogobsa), which attack cattle, sheep and goat in dry season. Bloating, internal parasites, Coccidiosis (which attack poultry), foot rot (which attack sheep), diarrhea, faciolosis (locally known as Entete), which show swelling of the mandibular area are problems mainly in the rainy season.

Specific causes for livestock death were not extracted, but generally attributed to disease. The total death rates reported to be 18.2% for calves, 8.2% for cattle, 10% for camels, l 7.1% for goats, 6.7% for donkeys and 3% for sheep. Reports of Mekete (2008) on studies at Kobo Girana showed somehow higher result for goat (9.8%) and sheep (5.9%) but less for cattle (7.8%). On the other hand, death and other losses for goats flock reported by Workneh (2000) at 22.5% in eastern Ethiopia were between these extreme results.

Teshale Sori (2005), reported on top of direct economic loss arising from cattle death and cost of treatment, there had been a significant depression of production (mainly milk production), traction power, manure, body weight, etc. in Ethiopia. This report gave an indication for decreases in beneficial outputs due to diseases and eventually lower livestock productivity and thus appropriate intervention to mitigate such effect would be sought to improve the current livestock disease occurrence and prevention or treatment as one strategy for livestock water productivity improvement.

4.4.4. Livestock off Take Rates

Off take rate was estimated based on the number of livestock sold, slaughtered and given out per household per year. Ruminant off take rate is higher in all cases compared to non ruminants, which indicates that the sale of non ruminants is lower than ruminants. The highest and lowest off-takes rates were recorded for cattle in the non-participant better off households (16.3%) and in the very poor participant HHs (0.6%). Next to cattle, the second highest off take rate was recorded for goats. Goat off take rate is higher in better off participant farmers 15.1% followed by 14.2%, 10.3%, 9.2 %and 4.2% in better off non participant, poor participant, poor non participant and in both very poor participant and non participant, respectively. But the total goat off take was higher than the other livestock off take rate (Table 16)

Table 16: Sum of livestock off take rates of the sampled households

Participation	Wealth status		Cattle	Sheep	Goat	Equines	Camel
			Off take of livestock				
Participants	Better off	N	27	9	79	2	1
		%	5.2	1.7	15.1	0.4	0.2
	Poor	N	7	17	54	2	1
		%	1.3	3.3	10.3	0.4	0.2
	Very poor	N	3	8	22	0	0
		%	0.6	1.5	4.2	0	0
Non participants	Better off	N	85	19	74	3	1
		%	16.3	3.6	14.2	0.6	0.2
	Poor	N	7	15	48	2	0
		%	1.3	2.9	9.2	0.4	0
	Very poor	N	4	9	22	1	0
		%	0.8	1.7	4.2	0.2	0
	overall	N	133	77	299	10	3
		%	25.5	14.8	57.3	1.9	0.6

N= number of livestock

As can be seen in Table 16 the participant farmers off take rate of all types of livestock (except goat) were lower than the non participant farmers. The off take rate of equines and camels are very low, which indicates that farmers prefer them as transport means rather than for income generation. The overall off take in the study area were 25.5%, 14.8%, 57.3%, 1.9% and 0.6% of cattle, sheep, goat, equine and camel respectively. The total off take of cattle and goat was much higher than what Mekete (2008) in Golina and Alewuha irrigated and rain fed farming in Kobo Girana, which were 9.7%, and 38.2% for cattle, and goats, respectively. Sheep off take rate result was in line with result of Mekete (2008) (14.7%).

4.5. Feed Resource Availability and Feed Balance

In the study area the major feed resources were natural grazing lands, crop residues and stubble grazing from harvested fields. The types of the crop residues produced were related to the varieties of crops used as staple food in the area.

Dynamics of Grazing Land

Key informants indicated that during Hailesilase's regime (1930-1974 G.C), there was large grazing area, with excellent grass condition. The dominant grasses were "Serdo" (Cynodon dactylon), and "Netch Saar" (Bothirochloa spp). The forests were very dense (one couldn't see the Hara wetland, as it was surrounded by dense forest) and all land was open access land, except the cropland. During the subsequent Derg regime (1977-1999 G.C), the size of grazing land and quality of vegetation as well as the density of the forest land decreased gradually. This change was mainly due to the gradual increase of human population. According to key informants, there was a good recovery of the forest land in 1987 G.C, after the 1985 G.C drought. After the fall of Derg, the forest land dramatically became bare and the size and the quality of vegetation decreased highly, as a result of the expansion of Hara town and increased human population.

Figure 5 shows the annual pasture biomass yield (DM) of the five exclosures in respect to their starting year of conservation in G.C. The oldest exclosure in the area is Minchgora (closed in 2004) followed by Kolokobo and Begido (2006) and Dolamba and Dishke (2007).

As can be seen in Figure 5 there was a difference in the dry matter production among the different exclosure. Aged exclosure produced more dry matter than newer except in Begido exclosure, which produced highest grass dry matter (DM), followed by Minchgora and

Doalamba. Begido exclosure produced more pasture DM than the other four exclosure. This might be due to the fact that production of pasture DM depends on the type of woody vegetation (shrubs and trees) some of which may depress pasture production. Pasture production may be depressed by a developing canopy of shrubs and trees

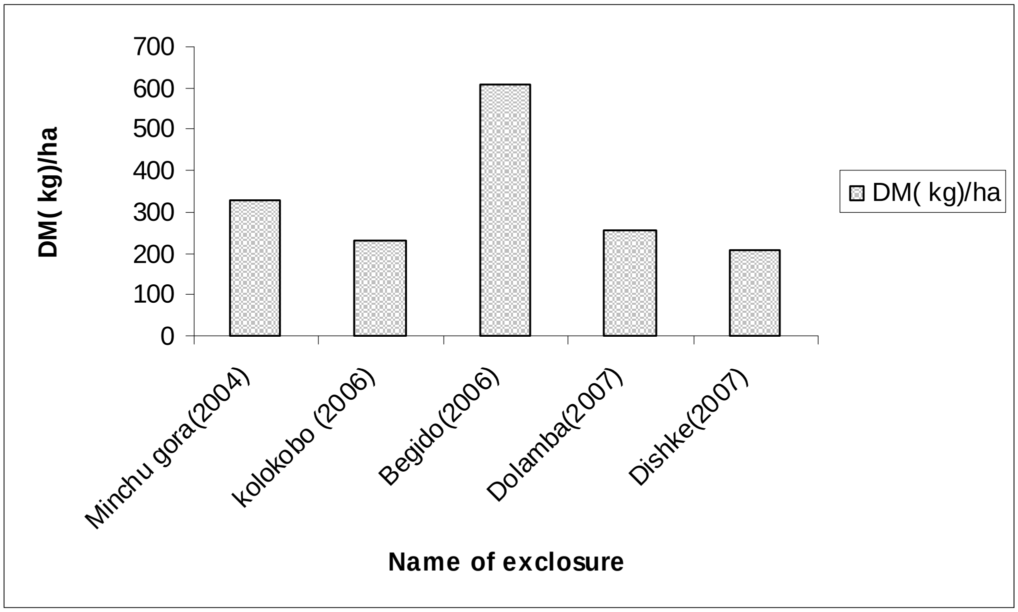

Figure 5: Dry matter biomass pasture yields (kg/ha) of the exclosures

As can be seen in Figure 5 there is a difference in the dry matter production among the different exclosures. Aged exclosures produced more dry matter than newer except in Begido, which produced the highest pasture dry matter (DM), followed by Minchgora and Dolamba. Begido exclosure produced more DM pasture biomass yield than the other four exclosures. This might be due to the fact that production of pasture depends on the type of woody vegetation (shrubs and trees). Pasture production may be depressed by developing canopy of shrubs and trees.

In the exclosure important grass types were Sembelet (***Hyparrhenia ruffa***), Netch Saar (***Aristidia*** spps), Serdo (***Cynodon nlemfuensis)*** Bila(***Harpachne schimperi***), and tree species included Sebensa (***Acacia asak)***, Dedho (***Euclea schimperi***), Arorosi ***(Grewa mollis)*** and the likes.

Herbaceous dry matter production (1.66 t/ha) in Kolokobo open grazing land was better than in Debiso open grazing land (1.48 t/ha). As can be seen in the figure 6 as the time far from rainy season (Kremt) the dry matter grass production became declined gradually.

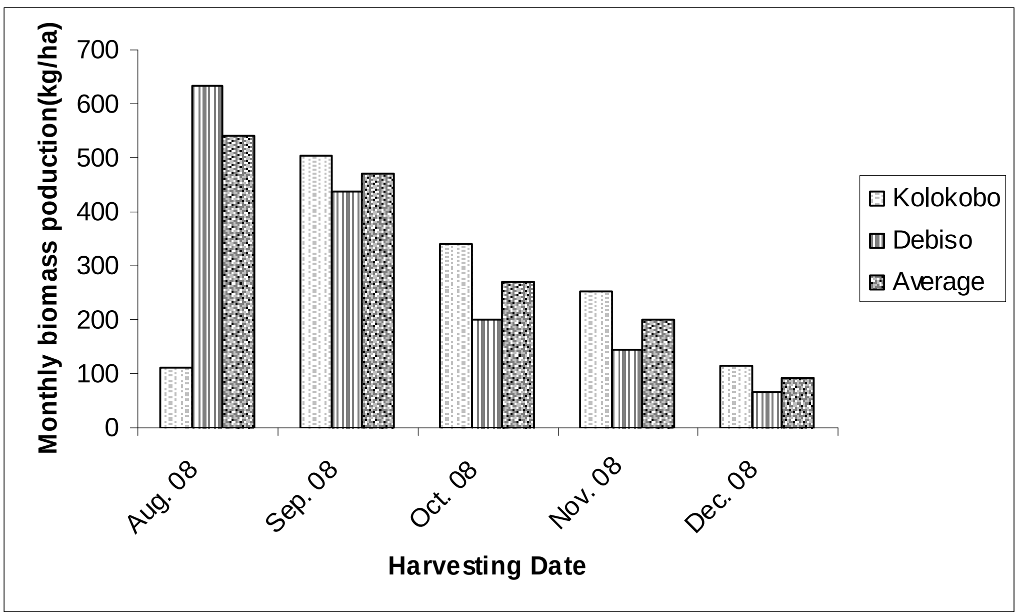

Figure 6: Monthly grass yield from open grazing land (kg/ha)

Feeding group and calendar

In the study area farmers traditionally group their livestock for feeding based on their livestock preference (Table 17).

According to key informants, tef straw was mostly fed to oxen in feed shortage time, from February to August. Chickpea residue was fed only to donkey from November to June. Most green feeds were given to lactating cows.

Feed shortage in the area is associated with very poor grass availability (even during the wet season), dry season shortage and shortage of grazing land, the former being a priority problem. Furthermore, due to the severe shortage of grazing land farmers are forced to migrate to neighboring areas in search of grazing areas. Feed/grazing land shortage becomes more critical during the dry season when large herds/flocks of better off farmers move back to the area from seasonal migration in the Afar region. More importantly, feed becomes absolutely unavailable except for some browse species during the dry period. Dry season feed shortage is more serious for cattle (oxen and lactating cows). Goats are less affected as they thrive well on evergreen browses such as *C. edulis* and *Ziziphus* spps. Although cattle can feed on broad-leaved shrubs, browse with nutritive value of 0.25-0.40 feed units/kg DM cannot support their maintenance requirements of 0.65 feed units per kg DM (Houerou, 1980).

Table 17: Feeding calendar, feeding group and average amount given per day per HH

Feed type	Feeding group	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tef straw	A		X	X	X	X	X	X	X				
Sorghum stover	C		X	X	X	X	X	X	X				
Sorghum green	C									X	X		
Maize green	C								X	X			
Weed	C								X	X			
Grass from farm land	F								X	X			
Grass from exclosure (green)	F										X	X	
Chick pea residue	E	X										X	X
Tree leaves	G					X	X						
Tinkesh	A										X		
After math	C	X										X	X
Salt	G							X	X	X	X	X	
Alewuha	C	X	X	X	X	X	X					X	X
Atella (litr)	H												

Feeding group A= oxen only, B= oxen and donkey, C= All animals, D= Oxen and lactating cows, E= Donkey only, F= oxen, lactating cow and claves, G= all animals except donkey and H= All cattle

4.5.1. Feed Balance

In this study, the feed balance was based on feed resources production on dry matter basis and the number of livestock at household level entitled to use these resources in a specified period of time.

Annually required feed intake for maintenance and the annually available feed in the study area is presented in Table 18. The estimated feed resources from grazing land and crop production show differences in the different wealth categories. The total available feed in the sampled household were 587,802 kg per annum and total feed requirement per annum was 1,188,349 kg. Generally, only 49.5% of feed requirement of the whole livestock herd of the sampled households was fulfilled, which is less than what is reported by Mekete (2008) for Alewuha and Golina schemes, where 55.4% of the feed requirement was satisfied (Table19). This study showed that there is a 50.5% feed deficit in the area, illustrating that there is a serious shortcoming to meet the required feed intake of the livestock in the study area. In addition, the nutrient content of the feed source and livestock need was not considered.

There was difference in the feed balance among the wealth classes and interventions. The highest feed production was in better off participant farm households (126,287 kg feed DM) and the least was in very poor non participant farm households (59,146 kg feed DM). The total feed requirement per annum for better off non participants (332,013 kg feed DM) was higher than for better off participant farm households (284,221 kg feed DM). This might be due to the fact that the number of livestock in better off non participant households was higher than in better off participant farm households.

On the contrary, feed deficits are higher in better off households, with -55.6% and -66.8% in better off participants and better off non participants respectively. To overcome this feed deficit farmers used different strategies like purchasing feed from farmers who have surplus feed and from Kobo area. In addition to this, they used green feeds like weed, 'Tinkesh' and tree fodder. Participant farmers in all wealth categories, except poor, have better feed balance than the non participants. This might be due to the fact that participant farm households have less livestock than non participants (Table 13), which results in a lower feed requirement than the non participants. In addition to this, participants get additional feed from the exclosures.

As can be seen in Table 18 the total available feed in the watershed was 3,752,110 kg which is derived from the sampled household and the total feed requirement was 5,050,687.5 kg and the feed balance was -1,298,578 kg.

Various studies in feed balance are reported in the literature. ILCA (1994) reported that farms in the central highlands of Ethiopia produce only 60% of the feed needed by livestock. A feed balance study by Habtemariam (2000) at Kombolcha Woreda of eastern Ethiopia showed that the available feed is only sufficient to cover about one fourth of the maintenance requirement of cattle and about one fifth of the requirement of all livestock in the area. Besides these studies, Kahsay (2004) reported feed resources in the central highlands of Ethiopia (Yerer Mountain) could only meet about 68% of the minimum annual energy required plus additional 20% for production by livestock in the study area.

Table 18 Feed balances based on available feed and feed intake requirement of livestock (kg) and the contribution of each type of feed resource in 2008

Feed type	Participants N=60			Non Participants N=60			Watershed level
	Better off N=20	Poor N=20	Very poor N=20	Better off N=20	Poor N=20	Very poor N=20	
Feed availability (kg)	126,287	111,041	79,201	110,133	101,994	59,146	3,752,110
Total pasture (kg)	29,493	24,708	11,136	29,349	16,371	6,681	648,070
Total stubble grazing (kg)	19,359	17,267	13,613	16,157	17,125	10,493	925,840
Total crop residue (kg)	77,435	69,067	54,452	64,627	68,499	41,972	2,178,200
Feed maintenance requirement (kg)	284,221	232,437	78,908	332,013	185,192	75,578	5,050,687.5
Feed Balance (kg)	-157,934	-121,395	-293	-221880	-83198	-16432	-1,298,578
Availability as % of requirement (%)	44.4	47.8	100.4	33.2	55.1	78.3	74.3
Balance as % of requirement	-55.6	-52.2	0.4	-66.8	-44.9	-21.7	-25
Contribution to total feed production							
Crop residue (%)	61	62	69	59	67	71	58.1
Stubble grazing (%)	15	16	17	15	17	18	24.7
Pasture grazing (%)	23	22	14	27	16	11	17
Contribution to feed requirement							
Crop residue (%)	27	30	69	19	37	56	43.1
Stubble grazing (%)	7	7	17	5	9	14	18.3
Pasture grazing (%)	10.4	10.6	14.1	8.8	8.8	8.8	12.8

N= Number of household

Generally, in the study area the available feed was insufficient and the feed requirement and the feed availability were in negative balance. In the whole study area, feed was in short supply by 25% of the annual feed intake requirement on a dry matter basis. Because of this, the productivity of livestock was low together with the health problem, so involvement in the management to improve feed availability and keeping of more productive livestock according to the feed availability is essential for increasing the livestock benefit and livestock water productivity.

4.5.2. Feed Resource Contribution

The contributions of existing feed resources to the feed resource base as well as *requirement* of livestock were different at participation and wealth category level.

In this study, the contribution of crop residues to the total available feed is higher than the other feed sources. The total annually feed production in the sampled household was 587,802 kg of DM of which 64%, 16% and 20% were contributed by crop residue, stubble grazing and grazing land respectively. Alternatively, the contribution of the various feed resources to the estimated DM requirement of which 49.5% was satisfied was 30% by crop residues, 11% by stubble grazing and 7.8% by grazing land (Table 18). On the contrary, CSA (2003) reported that grazing was the major source of feed supply accounting for 60%, while crop residues accounted for 26%, nationally. The contribution of the grazing land was low because of low productivity of grazing lands in the study area.

The feed resource contribution result of this study is similar to Bekele (1991), who reported that 71% of the feed supply for Ada district originated from crop residues and only 12% from communal grazing land. The expansion of cropland causing the reduction of grazing land areas and poor productivity was the reason for the low contribution of natural grazing lands to the total feed supply in the study area.. In support of this study, Kahsay (2004) showed that cultivated land increased by 125% in three decades in the central highlands of Ethiopia, mainly at the cost of grasslands. Population increase is one of the major driving forces to these changes and erosion rates increased in due course. The contribution of different feeds to the total available feed showed differences among the wealth classes. Crop residue contribution to the total feed available DM in very poor non participant farm households (71%) was the highest and in better off non participant farm household it was the lowest (59%). This indicates that better off farm households have alternative feed resources. As can be seen in Table 19 Better off farmers in both participation categories gain more feed from grazing land than the other wealth classes. This might indicate that natural resources flows are affected by wealth. As a result of large number of livestock in better off farmers contribution of fertilizer (manure) to the grazing land was higher than the two wealth category.

The high proportion of livestock feed coming from crop residue shows that there was strong integration of crop and livestock farming. If more than 10% of the feed for livestock comes from the crop sub-sector, the production system is known as mixed crop livestock farming system (Seré and Steinfeld, 1995). Thus the production system in the study area can be classified as mixed crop livestock production system. In this study crop residue is the main contributor for the total feed available and the required feed in the watershed (43.1%).

4.6. Water Source

The water sources in the watershed include three seasonal traditional ponds excavated for each village or neighboring villages (*gots*) in Kolokobo, Lencha Dima and Oromo. The Lencha Dima pond is in better condition than the other two, which might be due to the fact that a fence keeps the animals away. Besides its use for animal drinking, farmers use the water also for cleaning the house and for smoothing the threshing site. As farmers said the ponds can serve for about 9 months (July- March). At the end of March the animals go to the permanent water sources. Permanent rivers like Alewuha and Chireti, which are located outside the watershed and the kebele administration respectively, serve as dry season sources. According to (Gizaw, et al., 1999) cattle are watered every other day during the dry season; goats are watered once every 1-3 days. The farmers' decisions with respect to livestock watering are based on the animal's value and importance and species and age.

In the watershed most of the households get their domestic water (for human drinking, cooking, cleaning and bathing) from water pumps. There was one generator - powered ground water pump (near Oromo village) which delivered to three water distribution points with one in each of the three sub catchments. This water is pumped from the ground water table and people's contribution is used to cover the fuel costs of the pumping station. The other water source was dome-type water harvesting structures Built with the help of AMAREW Project. There are four dome type water harvesting structures were constructed for 19 beneficiaries. The water is used for irrigation of vegetables and fruit garden, domestic uses and animal drinking.

Figure 7: Tulubademe water pond

4.7. Effect of the Intervention

Recently, closure of hillslopes has become a protection system to improve land with degraded vegetation and/or soil through restoration of the natural vegetation. If properly managed, the closed hills can serve as sources of animal feed, fuel wood, construction material and farm implements. The AMAREW project (USAID) implemented different soil and water conservation measures to rehabilitate the degraded hillslopes and gullies, with increased feed availability as a result.

Exclosure

According to key informants, due to the hillside closure degraded vegetation and soil were rehabilitated and flood damage was decreased. The availability and quality of feed from harvested hay increased, as well as income from selling the pasture (this is mostly practiced by households without livestock). It has also an indirect effect on the crop production, as the loss of crop due to flood water decreased. But, some farmers blame the exclosure intervention as it reduced the available grazing area. Exclosure also have effect on grazing land size negatively, also exclosure have low grass production than grazing land but exclosure have other benefits like, woody biomass production tree fodder production and environmental protection.

Gully rehabilitation

About 5.6 ha of gully land was rehabilitated and distributed to 26 farm households in the Kolokobo sub- catchment. According to the key informants, the rehabilitated gully became a source of animal feed, wood for house construction and fuel and also income generation (by selling the pasture). The size of the gully formation was decreased and soil erosion decreased. Generally, the gully was changed to a productive asset.

Figure 8: Gully land
(a) Untreated gully (b) Treated gully

Water harvesting ponds

From key informants and direct observation, there were nineteen water harvesting structures in four households. The water is used for vegetable irrigation, livestock drinking. Farmers generate additional income by selling vegetables and get fresh vegetables (like green pepper) for their family.

4.8. Water Productivity and Related Indicators for Participant and Non Participant Farmers in Lencha Dima Watershed

4.8.1. Livestock Beneficial Outputs

In this study, beneficial livestock outputs estimated at the household level include milk from cow, manure from all livestock except poultry, meat from ruminants, traction service from cattle (ploughing, threshing), transport service from donkeys and sale of all livestock. Benefits from poultry as well as amount of depleted water for poultry feed were not considered.

As can be seen in Table 19, beneficial outputs at household level showed significant differences among all wealth status. The quantity of meat produced per annum per HH in very poor farm HH in both participation category was significantly different (P< 0.05) from better off farm HH in both participation category (Table 19). The highest mean annual meat production from ruminants off take per household was by better off non participants 35.7 ±7 kg and the lowest for very poor participants 7.8±2.5 kg. Better off participants, poor participants, poor non participants and very poor non participants obtained 31.6± 5.9 kg, 21.3 ± 3.8 kg, 19 ± 3.5 kg and 11± 3.8 kg of meat respectively. This might be attributed to the high livestock off take per household in better off farmers in both participation categories than very poor farmers. The highest meat yield per household per year (in better off non participants) in this result was in line with what Mekete (2008) reported for Golina irrigator farmers (30.58 ± 3.67 kg) and the lowest meat yield was highly deviated from Mekete (2008) result reported for Golina rain fed (14.05 ± 2 kg)

The mount of milk yield produced per year per HH in very poor farm HH in both participation category was significantly different (P< 0.05) from poor and better off farm HH in both participation category. This difference might be due the fact that very poor farmers have lower number of lactating cows than poor and better off farm households. But milk yield per year per HH was not significantly different (P < 0.05) in poor and better off farm HH in both participations. The reason might be comparable number of lactating cows in both wealth categories.

The amount of manure and manure nutrients (N & P) produced per annum per household were significantly different (p < 0.05) among the wealth categories under the participating and non-participating group (Table 16). This might be because of the difference in TLU holdings and livestock composition of farm household.

The number of oxen days traction services and donkey transport was delivered per year per HH in very poor farm HH in both participation category was significantly different ($P<0.05$) from poor and better off farm HH in both participation category.

The highest mean number of service days per year by oxen was for better off non participants (184.7 ± 30.3 days per year) and the lowest was for very poor non participants (97.8 ± 10.8 days per year). Based on (Table 16), oxen service days per year by oxen in both participating and non-participating groups was significantly different in all wealth classes at $p<0.05$. The reason behind this difference possibly would be very poor farm HH lack oxen for cultivating their land; at this time mostly what they did was that they borrow oxen from their neighbor. This system of borrowing locally known as ‘Mekenajo’ occur between the owner and the borrower with out any payment only what they did is if the owner need more oxen for cultivating or threshing he can borrow. The average cultivated land size was also another reason for the difference in number of days per year on which oxen traction services were delivered to the farm HH.

Number of services in days delivered by donkeys to very poor farm household per year was significantly different at $p<0.05$. As can be seen in Table 17 donkey service in day in better off and poor farmers in both participations was not significant ($P> 0.05$). The difference might be caused by lack of donkey in very poor farm HH, in addition very poor farmers might not capable of paying for fetching water as a result of incapability of paying they restricted their water demand.

Table 19: Mean and standard error of beneficial output and livestock production

Out put per year & unit measurement	Non Participant						Participant					
	No	Better off	No	Poor	No	Very poor	No	Better off	No	Poor	No	Very poor
Donkey service date(days)	18	38.2±3.5^{a}	19	35.8±2.8^{a}	8	14.6±6.4^{b}	16	36.0±5^{a}	3	32.7±5.5^{a}	3	3.95±2.3^{b}
Oxen service days	20	184.7±30.3^{a}	20	156.6±23.4^{a}	20	97.8±10.8^{b}	20	179.5±14.7^{a}	20	159.7±10.3^{a}	8	134.4±2.3^{b}
Total milk yield (liter)	16	409.5±684^{a}	20	173±35.9^{b}	3	47.3±25.8^{b}	11	204.8±57^{a}	11	220.5±51.6^{a}	2	31.5±21.7^{b}
Total meat yield (kg)	20	35.7±7.1^{a}	11	19±3.5^{b}	20	11±3.8^{c}	18	31.6±5.9^{a}	18	21.8±3.8a^{b}	8	7.8±2.5^{c}
Total manure yield (kg)	20	8248.7±711^{a}	20	4670.8±210.7^{b}	20	1885.5±339^{c}	20	7221.4±531.8^{a}	20	5843.6±553^{a}	15	2042.5±38^{b}
Total N yield (kg)	20	150±12.9^{a}	20	85±3.9^{b}	20	34.4±6.2^{c}	20	131.8±9.7^{a}	20	106.3±9.9^{a}	15	37.3±7^{b}
Total P yield (kg)	20	37±3.2^{a}	20	21.1±1^{b}	20	8.5±1.5^{c}	20	36.8±4.9^{a}	20	57.3±21^{a}	15	9.2±1.7^{b}
Service value (ETB)	20	5524.3±658.9^{a}	20	4977.97±493.9^{a}	20	2657.5±271.9^{b}	20	5471.7±336^{a}	20	4719±281^{a}	8	2938±435^{b}
Oxen value(ETB)	20	3693.3±605.5^{a}	20	3131.84±467.7b^{a}	20	1956.9±216.9^{ab}	20	3690±294	20	3194.6±205	8	2687.7±401
Donkey service(ETB)	18	1831.8±183.6^{a}	19	1846.1±117.4^{a}	8	700.5±203^{b}	16	1781±236.4^{a}	3	1524.8±240.9^{a}	3	250.5±137^{b}
Sold animals(ETB)		6050.57±561.8^{a}		480±188.1^{b}		316.9±228^{c}		1599±346^{a}		574±155.8^{b}		243.8±119.9^{c}
Total meat value(ETB)	20	1004.53±11875.6^{a}	11	508.6±101^{b}	20	303.2±90.5^{c}	18	926.7±180^{a}	18	331.6±95.7^{b}	8	194±63.5^{c}
Hide skin value(ETB	20	102.6±24.6^{ab}	11	65.7±15.9b^{c}	20	26.65±8.3^{c}	18	85±20^{a}	18	72.5±11^{ab}	8	25.8±9.2^{b}
Total annual off take	20	7055.1±5599		989±198.3		620±322		2525.7±318^{a}		1105.9±197^{b}		437.9±148.9^{b}
Total milk yield	16	2457±413^{a}	20	1039.5±215^{a}	3	283.5±154.8^{b}	11	1228.5±343^{a}	11	1323±302.6^{a}	2	189±130^{b}
N value(ETB)	20	1663±30.4^{a}	20	942.4±9.3^{b}	20	381.4±14.6^{c}	20	1461±22.8^{a}	20	1178.5±23^{a}	15	413.5±16.5^{b}
P value(ETB)	20	556.6±10.2^{a}	20	317±3.2^{b}	20	127.9±4.8^{c}	20	553.6±15.8^{a}	20	861.9±67.9^{a}	15	138.4±5.4^{b}
Manure value(ETB)	20	2219.6±406^{a}	20	1259.8±12.5^{b}	20	509.3±247^{c}	20	2014.7±33.9^{a}	20	2040.5±71^{a}	15	551.9±21^{b}
Beneficial output ETB	20	15036.4±5691^{a}	20	8266.2±583^{ab}	20	4070.3±426.6^{bc}	20	11240.6±543.4^{a}	20	9188.4±599^{b}	15	4116.8±536^{c}

Tukey HSD, P = phosphorus, N = Nitrogen, No = Number of farmer, SE = standard error, ETB = Ethiopian Birr ab = means across the rows by the same letter of superscript didn't show significant difference ($p<0.05$), No= Number of farmers who get the benefit/ yield

In this particular study, meat and hide and skin production value were estimated from the number of ruminants slaughtered per year per household and the current market value. Meat value provided per household per year was significantly different among the wealth classes under each participation level ($p<0.05$). The highest mean annual meat value was obtained by better off non participant households (1004.5 ± 1875.6 ETB) and the least by very poor participant farm households (194 ± 63.5 ETB). As can be seen in Table 19, the better off farm households obtained more meat mean annual value than the other two wealth classes. This might be because the better off farm households have more livestock than the other wealth classes. This indicates that better off households can get better nutrition than the rest. Non participant farmer households obtained a higher mean annual meat value than participant households in each wealth category except in poor households. Higher hide and skin value per year per household was obtained by better off non participant households (102.6 ± 24.8 ETB) and the least by very poor participants (25.8 ± 9.2 ETB).

Mean traction/transport service values (ETB) obtained per household per year in very poor farm HH in both participations category was significantly different ($P< 0.05$) from poor and better off farm HH in both participation categories. This difference is due to service day not the hiring price; local hiring prices for traction services were similar in the study area. As mentioned above paragraph 5 and 6, the service day difference might be due to lack of oxen in very poor farm HH and in addition difference in size of cultivated land in the category.

As can be seen in figure 9, donkey transport for fetching water contributes more to total donkey service value than the other transport types. For instance in better off non participant farm HH, donkey transport for fetching water was 58%, followed by donkey transport for crops to home and mill 31.3% and donkey transport to market 10.69%.

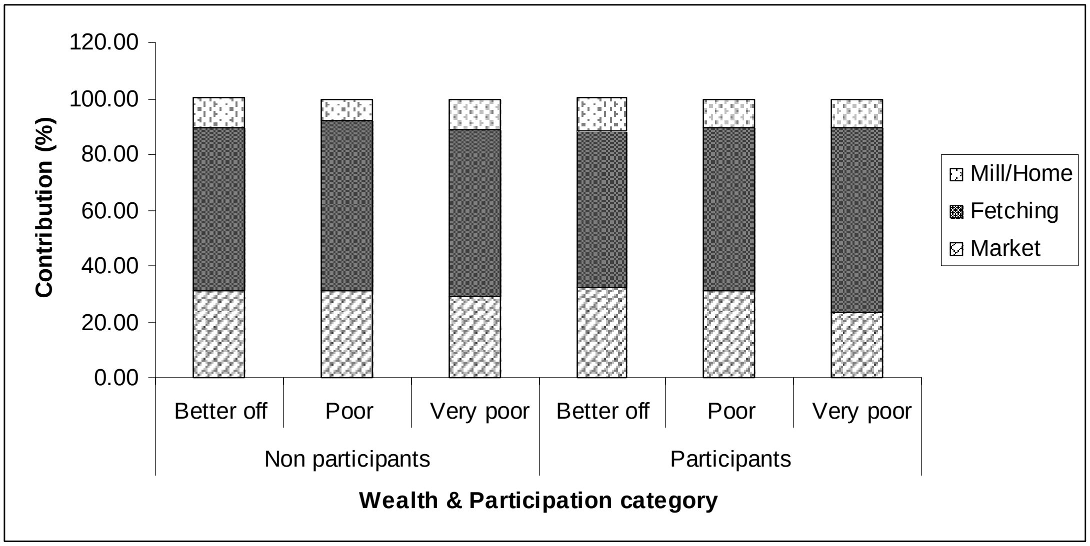

Figure 9: Contribution of various types of transport value (ETB) in total donkey transport value Market = Donkey transport value for market, Fetching = Donkey transport value for fetching water, Mill/Home= Donkey transport value for crops to home and mill).

There was significant difference of total value of sold and gifted animals among all wealth status under each intervention category. The highest mean value of sold/gifted animals was obtained by better off non participants (6050.6 ± 561.8 ETB) and the least by very poor participant households (243.8 ± 119.9ETB). As can be seen in Table 19, the mean value of total sold animals was higher in all wealth classes of the non- participation category as compared to the participants. This might be because non participant households have more livestock than participant farmers. As a result of high livestock density, farmers are forced to sell more animals to mitigate feed shortage and also they can maintain a larger herd

In this particular study, service, off take rate, milk value, manure and hide and skin were the main contributors of total beneficial out put in order of importance. Service value was the highest contributor of the total livestock beneficial out puts. The proportional contribution of the different livestock products and services to the total livestock beneficial output value estimated at HH level reflected only a slight variation among all household categories. (Figure 10)

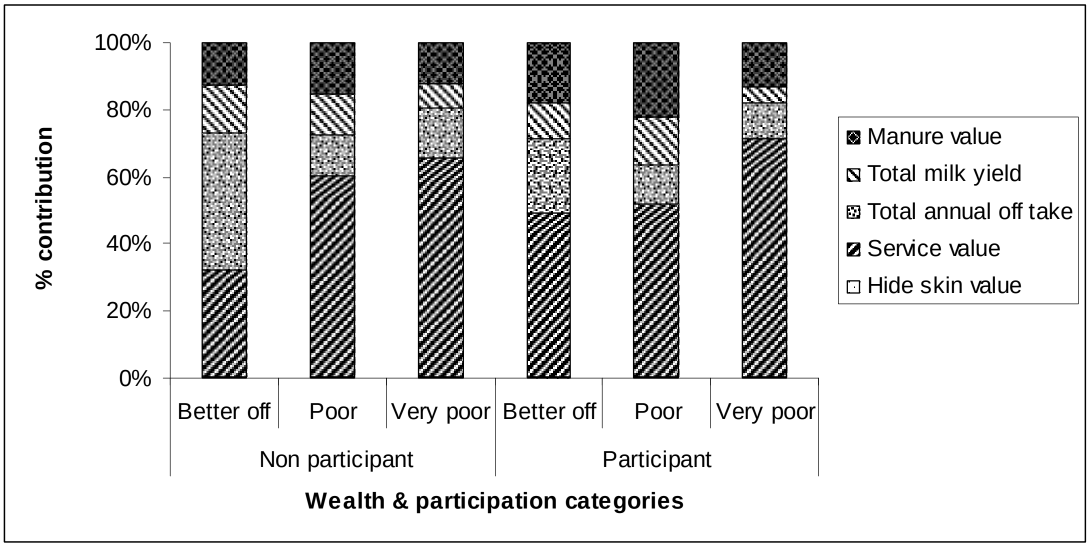

Figure 10: Contribution of various beneficial outputs to the total livestock beneficial output

Beneficial out put proportion has supported farmers ranking on purpose of keeping livestock, for instance cattle were the prime important as source of draught power for crop cultivation in all categories.

4.8.2. Depleted Water for Livestock Feed Production

Depleted water in each wealth status in both intervention levels was determined at household level. Climatic factors like humidity, wind speed, temperature and sunshine are the major determinant factors for depleted water through evapotranspiration. In addition to these climatic factors water depletion was influenced by improper water and land use and management. In this particular study, water depletion for livestock production was considered as the estimated evapotranspiration for the production of livestock feed from the different land use types (cropland, grazing land, exclosure).

Haileslassie et al., (2007) suggested that to take into account feed related water depletion based on what the ecosystem can produce rather than what the livestock are actually demanding. This is more realistic, especially in ecosystems where one would expect negative feed balances. This is because under feed deficit conditions, estimating depleted water for livestock feed production based on their demand would result in overestimation of the depleted water for feed within the domain and eventually underestimation of the livestock water productivity.

Total water depletion for livestock production was highest in better off non participant households and the least was in very poor non participant farm HH (2955.2±527 m^3 per year per HH) (Table 20). The contribution of water depleted for the production of crop residues to the total water depleted for livestock feed was high everywhere, but varied according to the household category.

Table 20: Mean and standard errors of depleted water at household level (m^3 per household)

Parameters	Non Participant			Participants		
	Better off	Poor	Very poor	Better off	Poor	Very poor
	Mean(SE)	Mean(SE)	Mean(SE)	Mean(SE)	Mean(SE)	Mean(SE)
DWCR	5185(1313.)[a]	4181.8(731)[a]	1863.5(382)[b]	4184(420.)	3743.4(379.7)	3242.7(602.0)
DWE	0.00	0.0	0.0	436(36.6)	415(0)	415(0)
DWG	4795.8(399)[a]	2675.0(128)[b]	1091.7(192)[c]	5155(269.)[a]	4319.9(319.0)[a]	2102.3(208.5)[b]
DWLF	9981(1394)[a]	6856.8(775)[a]	2955.2(527)[b]	9775(465)[a]	8478.4(452.7)[a]	5760.0(761.1)[b]

DWCR= Depleted water for Crop residue, DWG= Depleted water for grazing land and DWLF= Depleted water for livestock feed and DWE= Depleted water due to exclosure

The contribution of water depleted from grazing lands increased proportionally with the wealth status of the household (Figure 11). The reason for increasing water depleted due communal grazing as wealth status increased might be due to as the grazing land holding was calculated based on the TLU holding,

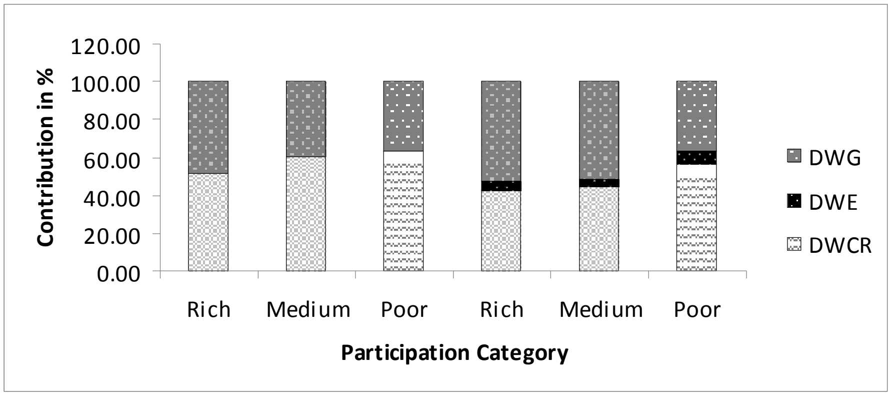

Figure 11: Contribution of different feed sources in water depletion for livestock feed

4.8.3.Physical and Financial Water Productivity

In this chapter livestock feed refers to crop residue of the different crops (own, shared in and rented in land) and grass from grazing land and exclosure together.

In very poor non participant farm households, livestock feed physical water productivity (kg feed DM per m^3 of water depleted) was the highest at 1.8 ± 1.9 kg m^3 per year. And the least was in better off non participant and participant farm households 0.5 ± 0.05 kg m^3 per year. The highest value in this result was much deviated from what Mekete (2008) reported the highest at Alewuha irrigated farming system at 0.7±0.03 kg m^{-3} yr^{-1} and also with what Hailesilase et al (2007) reported for rice based cash crops (0.5 kg m^3 per year) at Gumera watershed. The highest livestock feed physical water productivity in this study was comparable with the value reported by Astatke and Saleem (1998) on different crops and pastures in Ethiopia: for 1 kg DM production 0.25 m^3 water was evapotranspired. On the other hand, (Peden et. al.; 2007) summarized available literature, showing that evapotranspiration to produce 1 kg of dry animal feed is highly variable, ranging from 0.5 cubic meter to about 8 kg. The result of this particular study was in line with this range.

Table 21: Means and standard errors of physical water productivity (kg m^{-3})

Parameters	Non participants			Participants				
	Better off	Poor	Very poor	Better off	Poor	Very poor	F	P
FPWP	1.1(0.08)[a]	1.1(0.08)[a]	1.8(1.9)[b]	1.1(0.06)	1.2(0.05)	1.2(0.05)	4.7	0.01
CRPWP	0.8(0.18)[a]	0.9(0.09)[a]	1.5(1.2)[b]	0.9(0.09)	1(0.7)	1.1(0.9)	0.6	0.55
GPWP	0.3(0)	0.3(0)	0.3(0)	0.2(0.01)[a]	0.2(0.0)[a]	0.15(0.01)[b]	5.7	0.00

Tukey, HSD ab= means across rows followed by the same superscript were not significantly different (P<0.05) SE= standard error, FPWP= Feed Physical Water Productivity (kg/m^{-3}), CRPWP= Crop Residue Physical Water Productivity (kg/m^{-3}), GPWP= Grazing land Physical Water Productivity (kg/m^{-3})

Financial water productivity of livestock feed in very poor farm HH was significantly different at P<0.05 from better off and poor farm HH. The mean value among the wealth status was highest value for very poor participant farm HH (2.1 ±0.05 ETB m^{-3} per year) and lowest for better off non participant farm households (1.5±0.04 ETB m^{-3} per year) (Table 21).

The financial water productivity of crop residue ranges from 1.5 ± 0.3 ETB m^{-3} yr^{-1} to 0.8 ± 0.08 ETB m^{-3} yr^{-1} for very poor non participants and better off participants, respectively.. Grazing land financial water productivity in very poor participants farm HH differs significantly from poor and better off participants. The lowest financial water productivity of grazing land was 0.2 ± 0.4 ETB m^{-3} yr^{-1} for very poor participant (Table 21 & 22).

Table 22: Means and standard errors of financial feed water productivity (ETB m^{-3})

Parameters	Non participant			Participant				
	Better off	poor	Very poor	Better off	Poor	very poor	F	P
	Mean(SE)							
FWP	1.51(0.04)	1.7(0.0)	1.8(0.4)	1.7(0.05)	1.9(0.0)	2.1(0.05)	4.7	0.01
CRWP	1.3(0.17)	1.3(0.1)	1.4(0.1)	1.4(0.18)	1.3(0.2)	1.9(0.72)	0.6	0.6
GLWP	0.4(0.00)	0.4(0.0)	0.4(0.0)	0.3(0.01)	0.3(0.0)	0.2(0.02)	5.7	0

FWP = Feed Water Productivity, CRWP = Crop Residue Water Productivity, GLWP= Grazing Land Water Productivity.

4.9. Livestock Water Productivity

Livestock water productivity shows significant difference between participants and non participants. The overall mean LWP was 1.26 ±0.16 ETB m^{-3} across all household categories. For non participant households the LWP was higher (1.7±0.3 ETB m^{-3}) than for participants (0.79 ±0.03 ETB m^{-3}). This is due to the higher value of total livestock beneficial output and livestock off take in non participant households (Table 23).

In support of this observation, Haileslassie et al. (2007) reported that LWP is strongly associated with the magnitude of livestock beneficial outputs and the livestock feed related water depletion, whereby the value of LWP will be higher when higher beneficial outputs are combined with lower evapotranspiration. In addition to climatic factors, LWP depends on the quantity and quality of livestock beneficial outputs and livestock feed resources. These factors are constrained by complex interacting factors, for example in the present study shoe beneficial out put was constrained by low off take rate, low milk yield (1.5 lit per day) and short lactation period (210 days) (used in this study) and combined with negative feed balances and low feed quality. These constraints indicate the opportunity for increasing LWP through application of planned interventions like breeding system and feed scarcity. In the study area the intervention was area closure, so the effect of this intervention will be seen in long term to by supplying feed to Participant farm HH

Table 23: Means and SE for key LWP factors and LWP

Parameters	Non participants N=60	Participants N=60	Overall	F	Sig
	Mean (SE)				
Livestock density(TLU/ha)	1.8(0.13)	1.6(0.1)	1.8(0.1)	3.1	0.8
Beneficial out put(ETB)	9422.1(1999.9)	7488.2 (493.9)	8634.7 (442.9))	0.5	0.5
Milk yield (Lit)	2835(271)	2268(153.3)	2507.9(153.3)	3.5	0.1
Total off take (ETB)	3208.9(2084.5)	1507(182.1)	2358.1(1044.6)	0.7	0.4
Livestock water productivity (ETB/m^3)	1.7(0.3)	0.79(0.03)	1.26 (0.16)	9.08	0.03

As shown in Figure 12 the highest LWP was obtained in better off non participant farm HH (1.7) followed by very poor non participant farm households (1.3). But as shown in Table 19 beneficial out of very poor non participants was the least, this result clearly shows that conclusion from the values of LWP alone with out considering the prevailing production and biophysical data may lead to wrong conclusion. The current climatic parameters and consequential reference evapotranspiration which itself is a climatic parameter derived from temperature, rainfall, humidity, wind speed and sunshine hour day of a given locality played crucial role in depleted water determination in a given agro ecological condition and thus affected the water productivity in general and livestock water productivity in particular. The type of crop grown and the cropping patterns prevailed as well as type of and productivity of grazing land played their part in determining LWP.

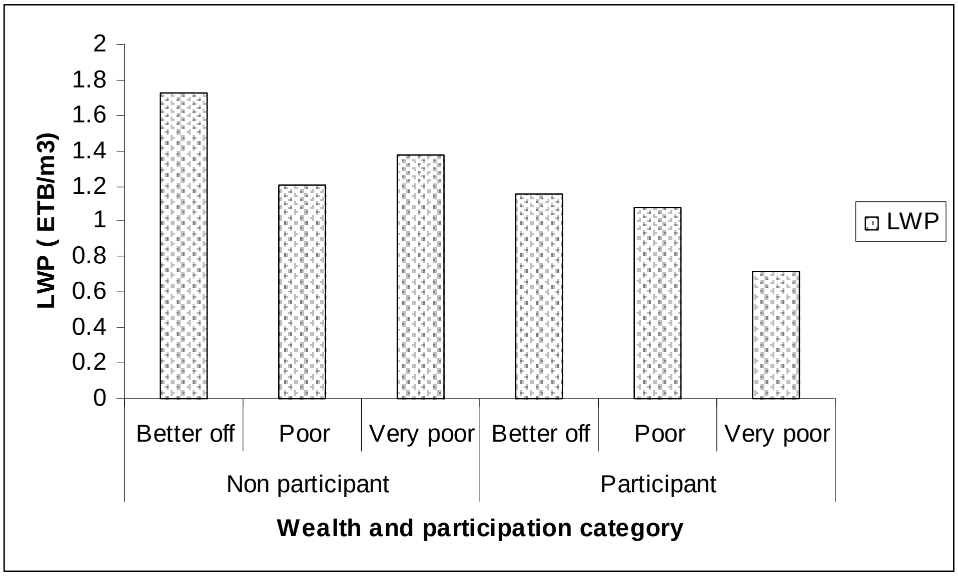

Figure 12: Livestock water productivity (ETB m^{-3}) across the interventions and wealth categories

LWP can be improved by reducing feed scarcity by food-feed integration, improved forages, improving production of local breeds with crossing or selection, combining with good livestock management and veterinary services.

In this particular study area the cattle breed was local as key informant information in the area farmers did not practiced breeding practices like artificial insemination, forage plantation and livestock health was not well practiced. If this problems solved and utilization of crop residue and crop residue quality increased (by practicing different crop residue treatment like urea treatment) livestock water productivity will increase as result of increasing beneficial out put increase and feed scarcity decrease.

4.10. Effect of exclosure in livestock population

The total number of livestock population before and after area closure in each wealth and participation category was presented in Table 24.

As can be seen in Table 24 after the exclosure, very poor non participant farm HH increased their cattle population by 88%. But very poor participant farm HH decreased their cattle population by 28%. In all categories the goat population was decreased by different value of ratio after the intervention was practiced, especially in better off farm HHs. As framers information this was because of lack of browsing area for goats as a result of most of the hillslopes were closed.

In participant farm households poor wealth class increased most of their livestock number after joining the interventions except goat population.

Table 24: Total population of livestock in sampled HH before and after the area closure

Type of animal	Non participants						Participants					
	Better off		Poor		Very poor		Better off		Poor		Very poor	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Cattle	181	152	94	66	16	30	170	127	92	94	40	29
Goat	175	61	106	39	21	15	147	39	120	53	39	15
Sheep	15	0	1	1		0	15	2	12	14	1	0
Equines	29	25	20	21	7	11	22	21	9	18	3	3
Camel	2	4		0		0	5	1		1		0

5. SUMMARY AND CONCLUSIONS

Interventions like water development, goat revolving fund and area closure were made in response to the recurrent drought, food insecurity and moisture stress in the area. The production system in the study area is generally mixed crop livestock farming, in which rain fed crop livestock production is predominant. The major crops in the study area were sorghum, teff and chick pea in decreasing order. High livestock density was observed in all wealth and participation category. The cattle population was high in all wealth categories followed by goats. This was strongly evidenced by the contribution of cattle for traction services and goats for immediate cash need.

One of the greatest livestock production constraints in Ethiopia is not creation of breeds that can give high yields of productivity. It is rather the optimum utilization of potential of existing genome which has high adaptive traits to the Ethiopian agro- ecology by improving efficient utilization of locally available resources as feeds. In this case Lencha Dima watershed is not an exception and has to go through the same step stated above. One who sees this result can confidently speak that the greatest livestock production constraints in Lencha Dima watershed is that of feed shortage especially during dry period which causes tremendous losses to livestock productivity. Most of the feed resources are contributed by crop residue, grazing land and stubble grazing. In land congested and degraded areas like Lencha Dima watershed where the proportion of grazing land and its productivity is highly diminishing (about 1570. 8 kg/ha) and rate of cultivation is taking over grazing lands and major feeds are obtained from crop residues. These feed is not only short in total production obtained and deficient in their nutrient content compared with the total tropical livestock unit of an existing area, but not also utilized to the optimum efficiency by treating with different crop treatment technologies like Urea treatment.

Water sources in the watershed is inadequate to the existing livestock population even farmers keep and practice different water conservation practices like creation of pond in each village.

Beneficial livestock outputs quantified at household level show difference across the wealth and intervention categories. In this particular study traction/ transport service, off take rate, milk value, manure and hide and skin were the main contributor of total beneficial out put in order of importance. On aggregate highest beneficial output estimated in monetary terms per year was obtained by in better off non participant farm households (17256ETB) followed by better off participant farm households (11240.6ETB).

Livestock feed from crop residue was the most water intensive followed by grazing land in most wealth and participation categories. The scarcity of feed resources and competition for scarce water is aggravated by invasion of undesirable plants for feed there by much water will be depleted for small amount of utilizable feed produced from crop residue.

Livestock water productivity showed difference among wealth class with each participation categories. Surprisingly LWP was higher in non participant's farm household than participant farm households. This is due to the beneficial out put difference between the two the former beneficial output was higher than the latter this is because of the livestock number as a result of decreasing livestock number after the intervention (exclosure) was practiced.

LWP was higher in better off non participant farm households followed by very poor non participant farm households but the beneficial out of very poor farm category was the least, this result clearly shows that conclusion from the value of LWP a loan without the considering prevailing production and biophysical data may lead to wrong conclusion.

By considering all factors, improvement in feed availability and quality in one hand and improving livestock production potential by breeding or selection together with improved livestock and feed management and veterinary services as well as could be an area of intervention to increase the livestock productivity as well as the livestock water productivity and it has a direct effect on improving food security of farm households.

Natural resource conservation strategies such as soil condition (manuring), area closure to avoid soil and over grazing have along term positive effect on livestock water productivity.

6. REFERENCES

Abera. A, Tegegne. A and A. K. Banerjee. 2002. Slaughter Component Yield Characteristics of Some Indigenous Goat Types in Ethiopia. Ethiopian Journal of Animal Production 2(1): 87-96.

Allen, R. G., L. S. Pereira, D. Raes, and M. Smith. 1998. Crop Evapotranspiration. Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage Paper, 56. FAO, Rome.

Amare, H., Peden. D, Negash.F. Gidyelew. T. 2006a. Sediment sources and sinks in the Gumera watershed,Ethiopia: implications for livestock water productivity in the Nile River Basin. Proceeding of international conference on the role of the River Nile in poverty reduction and economic development in the region. November 30-December2, 2006. Addis Ababa, Ethiopia. Pp. 156-164.

Amare, H., Peden. D, Gebreselassie. S, Ayalneh. W, Amede. T and Tadesse. G. 2007. Farm scale livestock management and land use decisions in the upper Blue Nile basin: implication for spatial variability of livestock water productivity. ILRI (International Livestock Research Institute). Addis Ababa, Ethiopia.

Aredo. G, Don. P and Taddese. G. 2005. Gender, Irrigation and Livestock: Exploring the Nexus. Policy Briefing, ILRI. Addis Ababa. Ethiopia.

Astatke, A. 1993. Research on the draught animal power systems in Ethiopia. In: Lawrence, P.R, K. Lawrence, J.T. Dijkman, and P. H. Starkey, (eds). 1993. Research for development of animal traction in West Africa. Proceedings of the Fourth Workshop of the West Africa Animal Traction Network held in Kano, Nigeria, 9-13 July 1990. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 306 pp.

Astatke, A. and M.A. Saleem. 1998. Effect of different cropping options on plant-available water of surface-drained vertisols in the Ethiopian highlands. Agricultural Water Management 36(2): 111-120.

Astatke, A., K. Sonder, Tadesse. G and Don. P. n.d. Animal power, a cheap alternative for the construction of reservoirs in Ethiopia. www.iwmi.cgiar.org/ Assessment/files/pdf/publications/WorkshopPapers/AnimalPower_Astatke.pdf (Accessed on 9 April 2008).

Awulachew, S. B., D. J. Merrey, A. B. Kamara, B. Van Koppen, F. Penning de Vries, E. Boelee, and G. Makombe. 2005. Experiences and opportunities for promoting small-scale/micro irrigation and rainwater harvesting for food security in Ethiopia. IWMI Working Paper 98. IWMI, Colombo, Sri Lanka. 86p.

Ayalew. W. 2000. Do small farmers benefit from crossbred (Somali x Anglo-Nubian) than from indigenous goats. PhD Thesis. Georg-August University of Geottingen, Geottingen, Germany, Cuvlliar Verlag, Goettingen.

Ayalew. W, J.M. King, E. Bruns, B. Rischkowsky. 2003. Economic evaluation of smallholder subsistence livestock production: lessons from an Ethiopian goat development program. Ecological Economics. 45(3): 473-485.

Ayalneh. W.2004. Socio economic and environmental impact assessment of community based small-scale irrigation in the Upper Awash Basin. *A case study of four* *community based irrigation schemes*. Msc Thesis. Addis Ababa University of Adiss Ababa, Adiss Ababa.

Bekele. M. 2008. Integrating livestock production into water resources development: assessment on livelihood resilience and livestock water productivity at Alewuha and Golina rivers. MSc Thesis, Hawassa University.

Bekele, S. 1991. Crop-livestock Interactions in the Ethiopian Highlands and Effects on Sustainability of Mixed Farming: A Case Study from Ada District. M.Sc. Thesis. Agricultural University of Norway. Oslo, Norway.

Berhene. K. 2004. Land Use and Land Cover Changes in the Central Highlands of Ethiopia: The Case of Yerer Mountain and its Surroundings. M.Sc. Thesis. Addis Ababa University. Addis Ababa, Ethiopia. p147.

Boudet, E. G. 1975. Problems encountered in estimating the rate of stocking of “natural pasture land’’ in a tropical zone. In: Evaluation and Mapping of Tropical Rangelands. Proceedings of a seminar held at Bamako, Mali, 3-8 March 1975. ILCA. Addis Ababa.

Castillo, G.E.; Namara, R.E.; Ravnborg, H.M.; Hanjra, M.A.; Smith, L.; M.H. Hussein. 2007. Reversing the flow: Agricultural water management pathways for poverty reduction. In: Molden, D. (ed.) "Comprehensive Assessment of Water Management in Agriculture. 2007. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan and Colombo: International Water Management Institute. Chapter 4.

Coppock, D.L.1993. The Borana plateau of Southern Ethiopia: synthesis of pastoral research, development and change, 1980-91. Executive summary, ILCA, Addis Ababa.

CSA (Central Statistical Authority). 2004. Statistical Report on Socio-economic Characteristics of the Population in Agricultural Households and Land Use, Part I. Addis Ababa, Ethiopia. 2003. Statistical Report on Livestock and Farm Implements. Part IV. Addis Ababa, Ethiopia.

Dekebo. J, Mererra. C, Geleti. D, Gelmessa. U, Diba. D, Hirpa. A and Jambare. T. 2003. Weight gain, Carcass characteristics and economic evaluation of Horro ram supplemented with different substitution levels of maize grain and molasses. In: Tamrat Degefa and Fekede Feyissa (Eds). 2004. The Role of Agricultural Universities/Colleges in Transforming Animal Agriculture in Education, Research and Development in Ethiopia: Challenges & Opportunities. Proceedings of the 13th Annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 25-27, 2004. ESAP, Addis Ababa. p244.

Deleeuw, P.N. 1997. Crop Residues in Tropical Africa: Trends in Supply, Demand and Use. In: Lekasi and Kiamani (eds.) Livestock Management and Manure Quality. Organic Resource Management in Kenya: Perspectives and Guidelines. Nairobi, Kenya.

D'souza, M. 2001. Participatory Watershed Development: Impacting Under Nutrition in Rural India. Watershed Organization Trust (WOTR), Ahmednagar, India.

Ermias, E., J.E.O. Rege and A.K Banerjee. 2000. Alternative approaches for evaluating small ruminant genotypes for meat production in Ethiopia. In: R.C. Merkel, G.

Abebe and A.L. Goetsch (eds.). The Opportunities and Challenges of Enhancing Goat Production in East Africa. Proceedings of a conference held at Debub University, Awassa, Ethiopia from November 10 to 12, 2000. Institute for Goat Research, Langston University, Langston. pp 196-200.

FAO. 1987. Master Land Use Plan, Ethiopia Rangeland/Livestock Consultancy Report Prepared for the Government of the People's Democratic Republic of Ethiopia. Technical Report G/ETH/82/020/FAO, Rome.

FAO. 1992. CROPWAT — A Computer Program for Irrigation Planning and Management. FAO Irrigation and Drainage Paper No. 46. FAO, Rome.

FAO. 1997. An international statistical database 1961-1998 on CD-ROM. FAO, Rome, Italy.

FAO, 1998. Crop evapotranspiration - guidelines for computing crop water requirements. FAO, Rome.

FAO.2003. Water Resources Development and Management Service http://www.fao.org/ag/agl/aglw/cropwat.stm(Acessed on 12-June-2008)

FAO (Food and Agriculture Organization of the United Nations). 2004. Scaling soil nutrient balances. Enabling meson level applications for African realities. FAO. Rome, Italy.

FAO, 2006. Addressing the impact of livestock on water availability and quality, Conference on Water for Food and Ecosystems: Make it happen.June 3-5 2008, Rome.

Gebremedhin, B. and Don. P. 2002. Policies and Institutions to Enhance the Impact of Irrigation Development in Mixed Crop–Livestock Systems. In: Integrated water and land management research and capacity building priorities for Ethiopia, eds. McCornick, P. G.; Kamara, A. B.; Tadesse, G. Proceedings of a MoWR/EARO/IWMI/ILRI international workshop held at ILRI, Addis Ababa, Ethiopia, December 2–4, 2002. Colombo, Sri Lanka: International Water Management Institute (IWMI) and Nairobi, Kenya: International Livestock Research Institute (ILRI).

Geda. A, Shimeles. A and Zerfu. D. 2006 Finance and Poverty in Ethiopia: A Household Level Analysis. Research Paper No 2006/51. UNU-WIDER, 2006

Gizaw, S., Mekonnen, K., Desta, L., 1999. Lencha Dima Integrated Watershed evelopment Project feasibility study report. Amhara National Regional State,Bahir Dar, Ethiopia.

Kassa. H. 2000. Livestock production, household food security and sustainability in smallholder mixed farms. A case study from Kombolcha Woreda of Eastern Ethiopia. M.Sc Thesis. Swedish University of Agricultural Sciences, Department of Rural Development Studies. Uppsala, Sweden. p102.

Koch. T. 2007. Production and Marketing Systems of Sheep and Goats in Alaba, Southern Ethiopia. M.Sc. Thesis. University of Hawassa, Awassa.

ILCA (International Livestock Centre for Africa). 1994. Improving livestock production in Africa: Evolution of ILCA's Programme 1974-1994. ILCA, Addis Ababa, Ethiopia. p233.

ILRI, 2005. Improving Livestock Water Productivity in the Nile Basin. A project of the CGIAR Challenge Program on water and Food.

Le Houerou H.N and Corra, M.1980. Some browse plants of Ethiopia. In: Browse in Africa: the current state of knowledge. H.N Le Houerou (ed), ILCA, Addis Ababa. pp 109-104.

Lupwayi, N. Z., M. Girma and I. Haque. 2000. Plant nutrient contents of cattle manures from small-scale farms and experimental stations in Ethiopian highlands. Agriculture, Ecosystems and Environment 78: 57-63.

Mengistu. A. 2002. Forage Production in Ethiopia: A case Study with Implication to Livestock Production, Ethiopian Society of Animal Production, Addis Ababa, Ethiopia.

McDowell L. R. 1985. Nutrition of Grazing Ruminants in Warm Climate. Academic Press Inc., London.

McHugh. O. 2006. Integrated water resources assessment and management in a drought-prone watershed in the Ethiopian highlands. PhD Thesis, Cornell University.

Ministry of Water Resources. (MoWR). 2002. Water sector development program 2002-2016, Volume II: Main Report. Ministry of Water Resources, Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

MoFED (Ministry of Finance and Economic Development Population Department). 2007. Ethiopia Population Images. Addis Ababa, Ethiopia.

Moses J. 2006. Report on Goat and Sheep Production and Marketing in the Amhara Region of Ethiopia. Amhara Micro-Enterprise Development; Agricultural Research, Extension, and Watershed Management (AMAREW) Project. p28

Tadeese. G. T and Peden. D. 2002. Effective Management of Water and Livestock Resources for Community Based Irrigation in Ethiopia. http://www.ilri.org/data/livelihood/cpwf/DevelopingPolicy.pdf (Accessed on 03-April 2009)

Taddesse.G, Don. P, Astatke. A and Ayalneh. W, 2005. Livestock Water Productivity in the Nile Basin, International Livestock Research Institute, Addis Ababa.http://gisweb.ciat.cgiar.org/wcp/download/PES_Workshop/Girma_PES_Nairobi_2006.pdf (Acessed on 28- March- 2009)

Tolla. N, Mirkena. T and Yimegnuhal. A. 2002. Comparison of the Efficiency of Compensatory Growth of Borana and Arsi Cattle in Ethiopia. Ethiopian Journal of Animal Production 2(1): 11- 24.

Negussie E., O. J. Rottmann, F. Pirchner and J. E. O. Rege. 2004. Growth and carcass composition of tropical fat-tailed Menz and Horro sheep breeds. Journal of Animal Science 78: 245-252.

Paris, T. R. 2002. Crop–animal systems in Asia: socio-economic benefits and impacts on rural livelihoods. Agricultural Systems 71: 147–168.

Parthasarathy R. P. and A.J. Hall. 2003. Importance of crop residues in crop–livestock systems in India and farmers' perceptions of fodder quality in coarse cereals. Field Crops Research. 84(1):. 189-198.

Peden. D, Taddese. G. and Mulugeta M. (2002).Improving the Water Productivity of Livestock: an Opportunity of Poverty Reduction.

Peden. D (2005). More animal per drop: searching for livestock–water productivity gains in the Nile Basin. Can science defuse conflict over natural resources? CGIAR Challenge Program on Water and Food.

Peden, D., Freeman., Astatke. A. and Notenbaert. A. 2006. Investment Options for Integrated Water-Livestock-Crop Production in Sub-Saharan Africa. Working Paper 1. ILRI, Nairobi.

Peden, D., Tadesse. G., Misra A.K. 2007. Water and livestock for human development. In: David Molden (ed). Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan and Colombo: IWMI. Pp. 485-514

Pond, W.G., D.C. Church, K.R. Pond and P.A. Schoknecht. 2005. Basic Animal Nutrition and Feeding (5th ed). John Wiley & Sons, Inc. USA.

Seré, C., H. Steinfeld and J. Groenewold. 1995. World Livestock Production Systems. Current Status, Issues and Trends. FAO Animal Production and Health Paper No. 127. FAO. Rome.

Shiferaw, G. 2004. Anthrax in Wabessa village in Dessie Zuria district of Ethiopia. Rev. sci. tech. Off. int. Epiz., 2004, 23 (3), 951-956.

http://www.oie.int/eng/publicat/RT/2303/pdf/23-hiferaw951-956.pdf (Accessed on 28-March-2009).

Singh B.B., H.A. Ajeigje, S.A.Tarawali, S. Fernandez-Rivera and M. Abubakar. 2003. Improving the production and utilization of cowpea as food and fodder. Field Crops Research. 84(1): 169-177.

Sileshi. Z, Tegegne. A and Tekle Tsadik. G. 2003. *Water resources for livestock in Ethiopia: Implications for research and development.* In: Integrated water and land management research and capacity building priorities for Ethiopia,eds. McCornick P.G., Kamara A.B. and Tadesse G. Proceedings of a MoWR/EARO/IMWI/ILRI international workshop held at ILRI, Addis Ababa, Ethiopia, December 2–4 2002. Colombia, Sri Lanka: International Water Management Institute (IWMI) and Nairobi, Kenya: International Livestock Research Institute (ILRI).

Solomon. A, Assegid. W, M.A. Jabbar, M.M. Ahmed and Belachew Hurissa. 2003. Livestock Marketing in Ethiopia: A Review of Structure, Performance and Development Initiatives. Socio-Economics and Policy Research Working Paper 52. ILRI (International Livestock Research Institute), Nairobi, Kenya. 35 pp.

Sonder, K., A. Astatke, A. El Wakeel, D. Molden, D. Peden. 2004. Strategies for increasing livestock water productivity in water stressed agricultural systems. http://cpwftheme1.irri.org/documents3.htm. (Accessed on 9 April 2008).

SPSS (Statistical Package for Social Sciences). 2003. SPSS version 13 for windows. SPSS Inc., U.S.A.

Sori. T. 2005. Contagious Bovine Pleuropneumonia (CBPP) Post-Vaccinal Complication in Ethiopia. Intern J Appl Res Vet Med. Vol. 3, No. 4, 2005. http://www.jarvm.com/articles/Vol3Iss4/TESHALE%20IJARVM%20V3N4W.pdf (Accessed on28-march-2009).

WBISPP (Woody Biomass Inventory and Strategic Planning Project). 2002. A Strategic Plan for the Sustainable Development, Conservation, and Management of the Woody Biomass Resources. Amhara Regional State. Final Draft. Addis Ababa, Ethiopia.

Yisehak K. 2008. Gender responsibility in smallholder mixed crop–livestock production systems of Jimma zone, South West Ethiopia. Livestock Research for Rural Development. Volume 20, Article #11. Retrieved March 3, 2009, from http://www.cipav.org.co/lrrd/lrrd20/1/yise20011.htm.

Zar, J.H. 1996. Biological Analysis. 3rd edition. Northern Illinois University. Prentice-Hall International Inc., USA

Zewdu. T, Agidie. A and Sebsibe. A. 2002. Assessment of the Livestock Production System, Available Feed Resources and Marketing Situation in BelesaWoreda: A Case Study in Drought Prone Areas of Amhara Region. In: Yilma Jobreand Getachew Gebru (eds). 2003. Challenges and Opportunities of LivestockMarketing in Ethiopia. 10th proceedings of the Ethiopian Society of AnimalProduction (ESAP) held in Addis Ababa, Ethiopia, August 22-24, 2002. ESAP. Addis Ababa, Ethiopia. 407p.

7. APPENDICES

Appendix 1: Household Questioners

Effect of Grazing Land Exclosure and Feeding Strategy on Livestock Water Productivity in Lencha Dima Watershed, Guba Lafto Woreda, Amhara Region

Household Survey Questionnaire

Questionnaire Number: ______________

1. General

Date of interview: Day: ____________ Month: _____________ Year: ___________

Interviewed by ____

Date checked: Day: ____________ Month: ______________Year: ___________

Checked by: ____

Date entered: Day: ________________ Month: ______________Year: ___________

Entered by: ____

Site name: _______________________________________ Code: ________________

Household head name: _____________________________ Code:________________

2. Household Characteristics

2.0. 2.1. Household Composition

Table 2.1

ID	Name	Sex[1]	Age (Years)	Marital Status[2]	Relation to HH ead[3]	Years of schooling[4]	Major Occupation[5]	Work on the farm[6]
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

[1]Sex: 1=Male; 2=Female

[2]Marital status: 1=Single; 2=Married; 3=Divorced; 4=Widowed; 9=NA

[3]Relation to household head: 1=Husband; 2=Wife; 3=Daughter; 4=Son; 5 = Grandchild; 6=Parent; 7=Labourer; 8=Sister; 9=Brother; 10=Step child; 11=Self

[4]Years of schooling including adult schooling: 0=No schooling; 1=1st grade; 2=2nd grade; 3=3rd grade; 4=4th grade; etc. ; 99=NA

[5]Major occupation: 1=Farmer; 2=Trader; 3=Housewife; 4=Handy craft; 5= Construction; 6=Weaving; 7=Blacksmith; 8=Carpentry; 9=Student; 10=herding; 11=Servant (maid); 12= infant (<6yrs); 13=migrant; 14=old or disabled; 15=others (specify); 99=NA

[6]Working on the farm: 1=Full time; 2=Part time (indicate percentage of time); 3=not; 99=NA

3. Land Holding (Timad/Kert)[1]

[1] One ha of land = ____________ local unit
(Specify the name of the local unit: _________________)

Table 3.1

Plot ID	Size of each plot (local unit[1])	Distance from homestead (walking hours)	Land ownership (code)	Land acquisition (code)	Current land use (for land used by household) (code)

Code table 3.1

LAND OWNERSHIP	LAND ACQUISITION (for family owned land)	LAND USE
1= Family owned 2= Rented in 3= Rented out 4= Sharecropped in 5= Sharecropped out 6= Communal land 7= Other (specify)	1= During the land reclamation 2= during redistribution time 3= Inherited 4= Other (specify)	0= Idle; fallow 1= Crop cultivation; 1a = rain fed; 1b = irrigated 2= Livestock grazing/pasture land 2a = year round grazing ; 2b = not grazed at all ; 2c = grazed for certain months 3= (Fruit) Trees 4= Homestead 5= Unused or abandoned 6= Exclosure 7= Other (specify)

3.0. 3.2. Production and Utilization of Main Products and Residues

(Indicate whether Qt / local unit is used – 1 Qt = __________local unit (name :___________)

(The local unit might be different for the crops and the pastures / if so, indicate both)

Table 3.2

Plot ID	Crops grown last year ('99 – '00)	Main product yield (Qt / local unit) [1]	Main product use				Residues			
			Home consumption (Qt / local unit)	Sold (Qt / local unit)	Time of selling	Kept for seed (Qt / local unit)	Yield (Qt / local unit) [1]	Use [2]	Sold (Qt / local unit)	Time of selling

[1] Yield should be given as the total yield from that plot; not expressed per area unit (e.g. not as Qt/ha)
[2] Residue use: multiple answers are possible; rank according to importance: 1 = aftermath grazing; 2 = collected and given to animals as feed; 3 = treated (e.g. with urea); 4 = left in the field as mulch; 5 = fuel; 6 = thatching; 7 = sold; 8 = other, specify

4. Livestock Information

4.1. Livestock Herd Composition (At The Time Of The Questionnaire)

Table 4.1

Animal type	Number	Major benefits and reasons for keeping livestock [1]
CATTLE		
Lactating cows		
Dry cows		
Oxen		
Fertile bulls		
Calves – female (<1yr)		
Heifers (1-2 yrs)		
Heifers (2-3 yrs)		
Calves – male (<1yr)		
Steers (1-2 yrs)		
Steers (2-3 yrs)		
GOATS		
Dry dams		
Lactating dams		
Rams		
Kids (<1yr)		
Kids (1 – 2 yr)		
SHEEP		
Dry ewes		
Lactating ewes		
Rams		
Lambs (<1yr)		
Lambs (1 – 2 yr)		
EQUINES		
Donkeys – F		
Donkeys – M		
POULTRY		
Chicken – F		
Chicken – M		
CAMELS		
Camels – F		
Camels – M		

[1] list reasons in order of importance for major types only: 1 = meat; 2 = milk; 3 = draft power; 4 = hides/skins; 5 = manure; 6 = transport; 7 = cash income; 8 = insurance; 9 = social, cultural reasons; 10 = others, specify

4.2. Livestock Herd Dynamics

Livestock herd dynamics during the last 12 months (one year period) For each animal type, specify all types of inflow and outflow (can be several lines for each animal type), the month(s) of the year when it happened, the value of the animal and the purpose in case of purchasing or selling. Indicate on 1 line if animals flow in and out in the same year.

Table 4.2

Type of animal [1]	Inflow					Outflow				
	Type [2]	No of animals	Month	Value/price (Birr/animal)	Purpose [3]	Type [4]	No of animals	Month	Value/price (Birr/animal)	Purpose [5]

[1] type of animal: 1=oxen; 2a=milk cow, local; 2b=milk cow, improved; 3=heifer; 4=steer; 5=bull; 6a=female calf; 6b=male calf; 7a=lamb; 7b=ewe; 7c=ram; 8a=kid; 8b=dam; 8c=ram; 9=donkey; 10=horse; 11=mule; 12=chicken; 13=camel; 14=other (specify)

[2] Type of inflow: 1=purchase; 2=born; 3 = gift; 4 = exchange 5 = others(specify)

[3] A purpose should be provided if animals are purchased: 1= Replace animal that died, 2= Increase herd size, 3= For breed improvement, 4= Speculation, 5= Other (specify)

[4] Type of outflow: 1=sold; 2=died; 3=slaughtered; 4=exchanged; 5=gift; 6=lost; 7=predators; 8=stolen; 9=others (specify)

[5] A purpose should be provided if animals are sold: 1=to meet household expenses, 2=business; 3=culling, 4=others

4.2.1. Do you plan to increase your herd size? [0=no, 1=yes]

If yes, why?

____

____

If no, why?

____

____

4.2.2. Do You Plan to Increase Your off Take (Sell More)? [0=No, 1=Yes]

If yes, why?

____

____

If no, why?

____

____

4.3. Feed Management

4.3.1. Animal feeding groups

Table 4.3.1

Feeding groups	Animal types *
A	
B	

* Animal types: check if respondent is not forgetting any animal by referring to the table on herd structure

4.3.2. Feed types

Table 4.3.2

Feed types	Description	Tick if used	Treatment	Specify if appropriate
1	Tef straw			
5	Sorghum Stover			
6	Sorghum green leaves			
12	Other crop residue ________			
13	Other crop residue ________			
14	Aftermath grazing			
15	Hay from private pastures			
16	Hay from private, improved pastures			
17	Hay from exclosure			
18	Green grasses from exclosure			
19	Hay from communal land			
20	Tree fodder			
21	Tree pods			
22	Collected grasses from closed gullies			
23	Collected grasses from farmland, roadsides, homestead			
24	Weeds			
25	Atella			
26	Grain			
29	Grazing & browsing communal grazing land			
30	Grazing & browsing near homestead			
31	Grazing & browsing roadsides			
37	Salt			
39	Forage crop type____________			
40	Improved grass type____________			
41	Improved grass type____________			
42	Others			

If tree fodder is use, indicate the tree species or local names in order of importance:

1)__________________________2)__________________________3)____________________

______4)__________________________5)__________________________6)________________

___________7)__________________________8)__________________________9)__________

____

Indicate where the trees are found (use the above numbers)

Homestead:_________________

Gully:_____________________

Exclosure:__________________

Farmland:__________________

4.3.2.1. Forage crops / fodder trees / improved grasses

Do you plant forage crops? Yes: _______ No: ____________

Table 4.3.2.1

Forage type/species	Where planted	When harvested (month)

If you don't plant forages, why not?

____

____

What are the major constraints?

____

____

4.3.3. Feed Calendar

For each feed type selected in table 6.3.2, indicate to which feeding group it is given and in which months (tick the months)

Table 4.3.3

Feed type [1]	Feeding group [2]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

[1,2] choose number from tables above

4.3.4. Feed availability

Indicate whether kg / local unit is used – 1 kg = ___________local unit (Name :________)

Table 4.3.4.1

Feed type [1]	Unit of meas ureme nt	Total production last year (99-00)	Total production 2 yrs ago (98-99)	Total production 3 yrs ago (97-98)	Total purchase in last year ('00)	Total price	Total purchase in 1999	Total price	Total purchase in 1998	Tota l price

[1] chooses code of feed type from table above. Make sure all feed types from Table 6.4.2. Are included In case of feed purchase:

When did you purchase the feed (months, conditions):

From where?

From whom?

In an arrangement with other farmers? Y/N Specify:

Feed Shortage

Indicate in which months the different feeding groups experience feed shortage and how you cope with that

Table 4.3.4.2

Feeding group	Months with feed shortage	Coping strategy

Other questions related to feed in/outflow

1. Have you sold feed to other farmers in the last three years? Yes?______ No:_________

If yes, to whom?

____

Which feed types?

____

How much?

____

For how much?

____

2. Have you lend feed to other farmer during the last three years time? Yes:___ No:____

If yes, to whom?

____

Which feed types?

____

How much?

____

What is your relation with the borrower?

____

3. Have you borrowed feed from other farmer during the last three years time?

Yes: ___ No: ____

If yes, from whom?

____

Which feed types?

____

How much?

____

What is your relation with the lender?

____

____

4.3.5. Exclosure practices

Are you a member of an exclosure development group? Yes______ No:_________

Indicate type: Hillside_____ Gully________ Plain grazing land_______

Other/specify_______________________________________

Do you have your own private plot in the exclosure? Yes______ No:_________

If yes, how much? _____________________ (ha / local unit_________)

Do you harvest the grass and/or hay from the exclosure? ___________________

When do you harvest the grass and/or hay from the exclosure? _______________

What is the total grass and/or hay yield? ______________(kg or local unit:_________)

What are the main uses of the harvested grass (indicate percentage)?

1= hay for feed (own consumption):______________

2= thatching: _________________

3=for sale: ____________________

4=other (specify):_________________________________

How much do you contribute for the group?

Money____________________ Labor______________________

Other (specify) ____

Did you participate in land management activities in the exclosure?

Yes_______ No_________

If yes, what activities:

(1 = terracing, stone bund building; 2 = gully check dam; 3 = seedling planting; 4 =others (specify)

4.3.6. Livestock services over the last 12 months (one year period)

Table 4.3.6

Animal type	Services	Animal days/year required	Hours/day	Price/day or price/service	Provided by own herd (animal days/yr)	Rented in (animal days/yr)	Borrowed within arrangement	Specify arrangement	Rented out (animal days/yr)	Lended out (animal days/yr)
Oxen	Ploughing									
Oxen	Threshing									
Donkey	Transport crops to									
	Transport water									
	Transport to									
	Transport to mill									
	Transport									
Horse	Transport									
Mule	Transport									
Camel	Transport									
Camel	Ploughing									

4.4. Livestock health

4.4.1. Mortality rate

Estimate the mortality rate (numbers of animals out of 10 that died) in good, average and bad years for the different livestock types

Table 4.4.1 Mortality rate

	Good	Average	Bad	
Cattle				
Goat				
Sheep				
Donkeys				
Horses				
Mules				
Poultry				
Camel				

Table 4.4.1

		Feeding	Animal health	Water	Breeding	Housing	Other:
Cattle	Would you invest? (tick)						
	If yes, level of importance (code)						
	Main constraints						
Goat	Would you invest? (tick)						
	If yes, level of importance (code)						
	Main constraints						
Sheep	Would you invest? (tick)						
	If yes, level of importance (code)						
	Main constraints						
Equines	Would you invest? (tick)						
	If yes, level of importance (code)						
	Main constraints						

Poultry	Would you invest? (tick)						
	If yes, level of importance (code)						
	Main constraints						
Camels	Would you invest? (tick)						
	If yes, level of importance (code)						
	Main constraints						

Code: 1= highly important; 2= important; 3= somewhat important

5. Water

5.1. Water Availability and Access

Indicate the different water sources for human drinking, domestic uses and the different livestock types in the wet and the dry season

Table 5.1 Livestock drinking water.

Source	Animals	Period (months)	Time for	Amount per day	Frequency (times/week)	Problems
Private pond						
Community pond						
River						
Water pump						
Lake/wetland						
Dug well in gully						
Dug well general						
Other:_____________						

6. Interventions

Do you participate in any of the following interventions?

- exclosure: YES/NO date when joined:________
- gully rehabilitation: YES/NO date when joined:________
- water harvesting structure: YES/NO date when joined:________
- goat revolving pond: YES/NO date when joined:________
- Others (specify): date when joined:________

Table 6.1 Effect of interventions on assets

Asset	Ownership before intervention		Ownership after intervention	
	Nr	Value	Nr	Value
Cattle				
Goats				
Sheep				
Equines				
Poultry				
Camels				
OTHERS(list)				

List the benefits of the interventions

____

____

List the disadvantages of the intervention

____

____

____

Appendix 2: Check List for Key Informants

1. General Livestock Information

1.1. Preference And Purposes Of Livestock Keeping

Table 1.1: Livestock preference.

	Oxen	Cows	Goat	Sheep	Chicken	Equine	Camels
Meat							
Milk							
Work/draft							
Transport							
Income source							
Manure							
Hides/skin							
Saving							
Insurance							
Prestige status							
Other(specify)							

Discuss the meat preference of the local population.

1.2. General Livestock Characteristics

Table 1.2: General livestock characteristics

Animal type	Lactation period[1]	Milk prod (1/day)		Milking frequency per day		Weaning age	Age at first parturition	No of parturition year	Parturition interval	No of offspring parturition
		Wet	Dry	Wet	Dry					
Cattle										
Goats										
Sheep										
Equines										
Poultry										
Camel										

Indicate month in which lactation period starts and ends.

2. Production Constraints

Table 2.1: Major livestock production constraints

Problems	Rand before intervention	Rank after intervention	Frequency of occupation
Feed shortage			
Shortage of grazing land			
Disease			
Water scarcity			
Labor shortage			
Cash			
Bad marketing conditions			
Lake of inputs			
Others (specify)			

3. General Questions

3.1. What measure are takes to mitigate the drought incidences and diversify livelihood strategy and cope up with food insecurity in the area?

3.2. How are losses of livestock from disasters such as drought regained?

3.3. Is there any (positive or negative) effect on the loss of livestock due to drought after the development of interventions? Explain.

3.4. What are the major environmental problems in the area?

3.5. Discuss the issues credit facilities, access to modem farm inputs (fertilizer, improved seeds, pesticides, herbicides, veterinary drugs) and marketing?

4. Interventions

4.1. What are the effects of interventions on the livelihood of people? Comment on beneficial and disadvantages.

4.2. What is the role of the community in the maintenance and management of these interventions?

4.3. What livestock and water management activities should be undertaken for optimum and sustainable production? (Comment on the livestock type, number, housing, feeding).

4.4. Do you think livestock production and water development contradict? In what way and how it could be managed?

5. Forages Crops .Fodder Trees/Improved Grasses

Table 5.1: Improved forages

Forage types/species	Where planted	To which feeding group [1]	Inputs used	Price of inputs	From where do you get the inputs[2]

[1] use codes from table 6.41

[2] sources of inputs: 1 = agricultural extension; 2 = local farmers; 3= local authorities; 4 = NGO's, projects, researches; 5 = private sellers and shops; 6 = cooperatives; 7 = others, specify.

5.1. Do you see any effect of the forages on livestock production?

5.2. How much would you estimate you benefit?

5.3. If you don't plant forages, why not?

5.4. What are the major constraints?

6. Grazing And Communal Land Issues

6.1. Where are animals grazing (differentiate between the difference periods in the year)?

6.2. Discuss the changes in grazing land (both area quality, and presence of species) for the following time periods. Relate it also to changes in human and animal population and give reasons for the changes.

6.2.1. Hilesilassie's regime till the start of the Derg regime.

6.2.2. from the start till the end of the Derg regime

6.2.3. From the start of the current government until the start of the AMAWER project.

6.2.4. From the start of the AMAWER project until now.

____

____

6.3. Communal grazing lands in the PA.

List the communal grazing areas that are used by the farmers in the different periods of the year + indicate the time animals spent there for grazing.

Table 6.3: Communal grazing lands in the PA

Name	Area(ha or local unit)	Periods of closing	Rangeland condition[1]	Species present(trees and grasses [2]	System of grass distribution [3]

[1] ranging condition: 1 = very very poor; 2 = poor; 3 = good; 4 = other specify
[2] list of grass and tree/shrub species
[3] if cut and carry of grass is practiced, please specify under what kind of arrangements

6.3.1. Is the communal land well demarcated? Yes_________ No ___________

6.3.2. Is the communal land well protected? Yes __________No ___________

6.3.3. What are the rules and regulations for the use of the communal grazing lands?

6.3.4. Do people take their animals to other village grazing land for grazing and/or drinking? Yes ______________No ___________

If Yes why?

Which villages?

When?

Is this a common practice?

What are the arrangements with the other village?

6.3.5. Where are animals taken for drinking in times of water shortage? What are the coping strategies in times of storage?

7. Livestock Health

7.1. Livestock diseases

Rank the most common diseases (symptoms) and parasites that affect the livestock in the dry season and in the rainy season (code/use local name).

Table 7.1: Livestock Diseases

	Dry season	Rainy season
Cattle		
Goat		
Sheep		
Equines		
Poultry		
Camel		

1 = Fasciola (liver fluke, internal parasite); 2 = Trypanosomiasis; 3 = Anthrax; 4 = Blackleg; 5 = Internal parasite (lung worm, gastro-intestinal parasites); 6 = External parasites (ticks, lice, fleas); 7 = Contagious Ecthyme; 8 = Stangles; 9 = African Horse Sickness; 10 = Coccidiosis; 11 = Newcastle disease; 12 = Skin problem; 13 = Eye problem; 14 = Shivering; 15 = Coughing; 16 = Suddan death; 17 = Diarrhea; 18 = others (specify).

7.2. Livestock housing

Are your livestock penned/housed at night? Tick if yes

Cattle [__] Goat [__] Sheep [__] Equines [__]

Poultry [__] Camel [__]

If YES, provide information on mode of housing and frequency of housing livestock during the dry and rainy seasons.

Table 7.2: Livestock housing

	Dry season			Rainy season		
Animals	Main mode of housing (mode)	Frequency of penning (code)	Category prioritized (code)	Main mode of housing (code)	Frequency of penning (code)	Category prioritized (code)
Cattle						
Goat						
Sheep						
Equines						
Poultry						
Camels						

7.3. Investment Options For Productivity Increase

Identify management components in which you would invest to increase the productivity of your herd?

Table 7.3: Investment options

		Feeding	Animals health	Water	Breeding	Housing	Others
Cattle	Would you inset?(tick)						
	If yes, level of importance (code)						
	Main constraints						
Goat	Would you inset?(tick)						
	If yes, level of importance (code)						
	Main constraints						
Sheep	Would you inset?(tick)						
	If yes, level of importance (code)						
	Main constraints						
Equines	Would you inset?(tick)						
	If yes, level of importance (code)						
	Main constraints						
poultry	Would you inset?(tick)						
	If yes, level of importance (code)						
	Main constraints						
Camels	Would you inset?(tick)						
	If yes, level of importance						

	(code)						
	Main constraints						

Code: 1 = highly important; 2 = important; 3 = somewhat important

8. Price of Main Commodities

Table 8.1: prices of main commodities (complete the table with additional commodity)

	Price		
CATTLE		FEED	
Lactating cows		Tef straw	
Dry cows		Sorghum Stover	
Oxen		Maize Stover	
Fertile bulls		Other crop residue	
Calves-female (<1yr)		hay	
Heifers(1-2yrs)		Salt	
Heifers(2-3yrs)			
Calves-males (<1yr)		Crops	
Steers(1-2yrs)		Tef	
Seers(2-3yrs)		Sorghum	
GOATS		Chickpea	
Dry dams		Wheat	
Lactating dams		Barley	
Rams			
Kids(<1yr)			
Kids(1-2yrs)			
SHEEP		INPUTS	
Dry ewes		Fertilizer-DAP	
Lactating ewes		Fertilizer – Urea	
Rams		Herbicide	
Lambs(<1yr)		Pesticide	
Lambs(1-2yrs)			
EQUINES			
Donkeys – F		Firewood	
Donkey – M		Eucalyptus pole	
Mules – F			
Mules – M			
Horse – F			
Horse – M			
POLUTRY			
Chicken – F			
Chicken –M			
CAMELS			
Camels – F			
Camels – M			
Egg			
Milk			
Butter			
Hides/skins			
Dung cake			

***Thank you**,*

Appendix 3 Table 1: Demographic Characteristics of farm households

Descriptors	Better off Average(SD)	Poor Average(SD)	Very poor Average (SD)	Overall
Family size	5.05 (1.63)	4.95 (1.8)	3.73 (1.54)	4.58 (1.76)
Age of the household	49.6 (16.5)	38.2 (12.45)	44.65 (14.61)	44.15 (15.23)
		Percent		
Family members less than 15	50.00	38.10	43.50	
Family members from 15- 64 years	8.30	19.00	30.40	
Family members > 64 years	41.70	42.90	26.10	
Family composition				
Male	37.50	62.50	51.60	
Female	62.50	37.50	48.40	
Men headed household	85.00	80.00	62.50	
Female headed household	15.00	20.00	37.50	
Educational level of the household				
Illiterate	87.50	82.50	85.00	85.00
1-4th grade	12.50	10.00	2.50	8.3.00
5-8th grade		5.00	7.50	5.00
9-10th grade		-	2.50	0.80
Preparatory		2.50	2.50	0.80
Marital status of the household				
Not married	2.50	2.50	2.50	2.50
Married	85.00	82.50	57.50	75.00
Widowed	12.50	15.00	17.50	7.50
Divorced			22.50	15.00

Appendix 3 Table 2: ANOVA Table of Percentage of different land tenure systems

	Source of variation		Sum of Squares	Df	Mean Square	F	Sig.
Non participants	CLR	Between Groups	27.16	2	13.58	3.51	0.04
		Within Groups	220.69	57	3.87		
		Total	247.85	59			
	SCLR	Between Groups	13.89	2	6.95	1.97	0.15
		Within Groups	201.49	57	3.54		
		Total	215.39	59			
	TCLR	Between Groups	1.43	2	0.72	1.05	0.36
		Within Groups	38.95	57	0.68		
		Total	40.39	59			
	CPCLR	Between Groups	0.16	2	0.08	2.24	0.12
		Within Groups	2.01	57	0.04		
		Total	2.17	59			
Participants	CLR	Between Groups	5.56	2	2.78	2.14	0.13
		Within Groups	73.87	57	1.30		
		Total	79.42	59			
	SCLR	Between Groups	1.58	2	0.79	1.50	0.23
		Within Groups	29.95	57	0.53		
		Total	31.53	59			
	TCLR	Between Groups	1.69	2	0.85	1.39	0.26
		Within Groups	34.65	57	0.61		
		Total	36.34	59			
	CPCLR	Between Groups	0.18	2	0.09	1.67	0.20
		Within Groups	2.99	57	0.05		
		Total	3.17	59			

CLR= total cultivated cropland, SCLR= Sorghum cropland, TCLR= Tef cropland, CPCLR= chickpea cropland

Appendix 3 Table 3:ANOVA table of livestock density

Participation	Sources of Variation		Sum of Squares	Df	Mean Square	F	Sig.
Non participant	LDC	Between Groups	109.93	2	54.97	20.60	0.00
		Within Groups	146.78	55	2.67		
		Total	256.72	57			
	LDGE	Between Groups	0	2	0	0	1.00
		Within Groups	0	56	0		
		Total	0	58			
	LDCGE	Between Groups	26.61	2	13.30	22.98	0.00
		Within Groups	32.42	56	0.58		
		Total	59.03	58			
Participant	LDC	Between Groups	41.21	2	20.60	5.72	0.01
		Within Groups	194.60	54	3.60		
		Total	235.81	56			
	LDGE	Between Groups	31.50	2	15.75	27.04	0.00
		Within Groups	32.04	55	0.58		
		Total	63.54	57			
	LDCGE	Between Groups	7.28	2	3.64	7.88	0.00
		Within Groups	25.41	55	0.46		
		Total	32.69	57			

LDC= Livestock density per cultivated land, LDGE= Livestock density per grazing plus exclosure, LDCGE= Livestock density per cultivated, grazing and exclosure land

Appendix 3 Table 4: ANOVA table for harvested grain, crop residues, available feed from grazing land and exclosures and total available feed

Participation	Source of variation		Sum of Squares	Df	Mean Square	F	Sig.
Non participant	TGY	Between Groups	3.33	2	1.67	0.30	0.74
		Within Groups	317.95	57	5.58		
		Total	321.28	59			
	TCR	Between Groups	5.47	2	2.73	0.52	0.60
		Within Groups	301.50	57	5.29		
		Total	307.16	59			
	TCRB	Between Groups	17.71	2	8.85	0.32	0.73
		Within Groups	1568.56	57	27.52		
		Total	1586.27	59			
	TGYGE	Between Groups	6.39	2	3.19	6.77	0.00
		Within Groups	26.88	57	0.47		
		Total	33.27	59			
Participant	TGY	Between Groups	12.40	2	6.20	4.98	0.01
		Within Groups	71.03	57	1.25		
		Total	83.43	59			
	TCR	Between Groups	25.08	2	12.54	2.31	0.11
		Within Groups	310.09	57	5.44		
		Total	335.16	59			
	TCRB	Between Groups	120.64	2	60.32	5.06	0.01
		Within Groups	679.63	57	11.92		
		Total	800.27	59			
	TGYGE	Between Groups	9.92	2	4.96	11.07	0.00
		Within Groups	25.54	57	0.45		
		Total	35.46	59			

TGY= Total grain yield, TCR= Total crop residue yield, TCRB= Total crop biomass production, and TGYE= Total livestock feed from cropland, grazing and exclosure land

Appendix 3 Table 5: ANOVA Table of Livestock Beneficial output and Livestock products and services

Non participants	Beneficial out put value		Sum of Squares	df	Mean Square	F	Sig.
	Total service value	Between Groups	92717306.16	2	46358653.08	9.25	0.00
		Within Groups	285778167.50	57	5013652.06		
		Total	378495473.70	59			
	Service value from oxen	Between Groups	31403659.03	2	15701829.51	3.72	0.03
		Within Groups	240327300.40	57	4216268.43		
		Total	271730959.50	59			
	Service value from donkey	Between Groups	17283343.58	2	8641671.79	14.60	0.00
		Within Groups	33742442.14	57	591972.67		
		Total	51025785.71	59			
	Value of sold animal	Between Groups	426188608.60	2	213094304.30	1.01	0.37
		Within Groups	12026784644.00	57	210996221.80		
		Total	12452973252.00	59			
	Total meat value	Between Groups	5200317.85	2	2600158.93	6.22	0.00
		Within Groups	23814467.50	57	417797.68		
		Total	29014785.36	59			
	Hide skin value	Between Groups	57698.03	2	28849.02	4.62	0.01
		Within Groups	355745.90	57	6241.16		
		Total	413443.93	59			
	Total annual off take value	Between Groups	522287266.60	2	261143633.30	1.24	0.30
		Within Groups	11969433639.00	57	209990063.80		

		Total	12491720905	59			
	Total milk yield value	Between Groups	48699630.00	2	24349815.00	15.12	0.00
		Within Groups	91802970.00	57	1610578.42		
		Total	140502600.00	59			
	Nitrogen value	Between Groups	744185.53	2	372092.77	45.57	0.00
		Within Groups	465475.20	57	8166.23		
		Total	1209660.74	59			
	Phosphorus value	Between Groups	83544.00	2	41772.00	45.68	0.00
		Within Groups	52128.52	57	914.54		
		Total	135672.51	59			
	Manure value	Between Groups	1326416.71	2	663208.36	45.60	0.00
		Within Groups	828983.21	57	14543.57		
		Total	2155399.92	59			
	Beneficial out put value	Between Groups	65255206.37	2	32627603.19	3.40	0.04
		Within Groups	546843577.60	57	9593746.98		
		Total	612098783.9	59			
Participants	Total service value	Between Groups	63469480.95	2	31734740.47	12.46	0.00
		Within Groups	145201179.50	57	2547389.11		
		Total	208670660.40	59			
	Service value from oxen	Between Groups	8191637.25	2	4095818.62	2.12	0.13
		Within Groups	110353896.20	57	1936033.27		
		Total	118545533.40	59			
	service value	Between	26884672.50	2	13442336.25	15.19	0.00

from donkey	Groups					
	Within Groups	50448262.50	57	885057.24		
	Total	77332935.00	59			
value of sold animal	Between Groups	19971599.69	2	9985799.84	9.46	0.00
	Within Groups	60183832.91	57	1055856.72		
	Total	80155432.60	59			
Total meat value	Between Groups	5378149.45	2	2689074.73	8.83	0.00
	Within Groups	17351954.43	57	304420.25		
	Total	22730103.88	59			
Hide skin value	Between Groups	39159.63	2	19579.82	4.80	0.01
	Within Groups	232325.30	57	4075.88		
	Total	271484.93	59			
Total annual off take value	Between Groups	45472559.19	2	22736279.60	21.00	0.00
	Within Groups	61741008.92	57	1083175.60		
	Total	107213568.10	59			
Total milk yield value	Between Groups	15836310.00	2	7918155.00	5.15	0.00
	Within Groups	87695055.00	57	1538509.74		
	Total	103531365.00	59			
Nitrogen value	Between Groups	526496.86	2	263248.43	29.60	0.00
	Within Groups	507160.36	57	8897.55		
	Total	1033657.22	59			
Phosphorus value	Between Groups	233493.55	2	116746.77	3.60	0.03

	Within Groups	1854404.55	57	32533.41		
	Total	2087898.10	59			
Manure value	Between Groups	1295030.41	2	647515.21	14.43	0.00
	Within Groups	2557563.45	57	44869.53		
	Total	3852593.90	59			
Beneficial out put value	Between Groups	913738756.30	2	456869378.10	1.96	0.150
	Within Groups	13294042013.00	57	233228807.20		
	Total	14207780769.00	59			

Appendix 3 Table 6: ANOVA Table of livestock products

Non participants	Livestock product (Kg)		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
	Total milk Production	Better off	20	409.50	308.30	68.94	265.21	553.79	0.00	945.00
		Poor	20	173.25	160.78	35.96	98.00	248.50	0.00	315.00
		Very poor	20	47.25	115.40	25.80	-6.76	101.26	0.00	315.00
		Total	60	210.00	257.20	33.20	143.56	276.44	0.00	945.00
	Total meat Production	Better off	20	35.68	31.82	7.11	20.80	50.57	0.00	110.25
		Poor	20	19.44	15.79	3.53	12.05	26.83	0.00	58.50
		Very poor	20	11.44	16.82	3.77	3.57	19.31	0.00	67.91
		Total	60	22.19	24.51	3.16	15.86	28.52	0.00	110.25
	Total manure Production	Better off	20	8248.68	3181.24	711.35	6759.81	9737.54	1964.43	15320.66
		Poor	20	4670.80	978.78	218.86	4212.72	5128.88	2416.30	6130.25
		Very poor	20	1885.45	1517.83	339.40	1175.08	2595.81	0.00	6770.39
		Total	60	4935.00	3347.80	432.20	4070.15	5799.80	0.00	15320.66
	Total nitrogen Production	Better off	20	150.34	58.00	12.97	123.20	177.49	35.95	280.05
		Poor	20	85.13	17.71	3.96	76.84	93.42	43.97	110.50
		Very poor	20	34.36	27.82	6.22	21.34	47.38	0.00	123.90
		Total	60	89.95	61.034	7.88	74.18	105.71	0.00	280.05
	Total phosphorus Production	Better off	20	37.34	14.40	3.22	30.61	44.08	8.84	69.060

		Poor	20	21.15	4.49	1.00	19.05	23.25	10.963	28.210
		Very poor	20	8.54	6.81	1.52	5.35	11.73	0.00	30.47
		Total	60	22.34	15.15	1.96	18.42	26.26	0.00	69.060
Participants	Total milk Production	Better off	20	204.75	256.01	57.25	84.94	324.57	0.00	630.00
		Poor	20	220.50	230.80	51.61	112.48	328.52	0.00	630.00
		Very poor	20	31.50	970	21.68	-13.88	76.88	0.00	315.00
		Total	60	152.25	220.78	28.50	95.21	209.28	0.00	630.00
	Total meat Production	Better off	20	31.60	26.18	5.85	19.35	43.86	0.00	81.00
		Poor	20	21.26	17.12	3.83	13.25	29.27	0.00	78.75
		Very poor	20	7.76	11.36	2.54	2.45	13.0864	0.00	33.75
		Total	60	20.21	21.30	2.75	14.71	25.71	0.00	81.00
	Total manure Production	Better off	20	7221.35	2378.45	531.84	6108.20	8334.50	3125.86	12696.53
		Poor	20	5843.61	2473.66	553.13	4685.90	7001.32	3119.66	13104.38
		Very poor	20	2042.49	1708.28	381.98	1242.99	2841.99	0.00	6962.01
		Total	60	5035.82	3100.00	400.20	4235.01	5836.62	0.00	13104.38
	Total nitrogen Production	Better off	20	131.78	43.43	9.71	111.45	152.10	56.96	232.35
		Poor	20	106.27	44.50	9.95	85.45	127.098	57.09	235.46
		Very poor	20	37.25	31.36	7.01	22.57	51.93	0	127.40
		Total	60	91.76	56.42	7.28	77.20	106.34	0	235.46
	Total phosphorus Production	Better off	20	36.82	22.27	4.98	26.40	47.25	14.157	119.75
		Poor	20	57.35	95.87	21.43	12.48	102.21	14.03	387.83

		Very poor	20	9.23	7.65	1.71	5.66	12.81	0.00	31.33
		Total	60	34.470	59.44	7.67	19.11	49.82	0.00	387.83

Appendix 3 Table 7: ANOVA Table of Livestock Service (in Days)

participation	Service		Sum of Squares	df	Mean Square	F	Sig.
Non participants	Total donkey service day	Between Groups	6747.73	2.00	3373.87	12.00	0.00
		Within Groups	16027.20	57.00	281.18		
		Total	22774.93	59.00			
	Total oxen service day	Between Groups	78509.15	2.00	39254.57	3.72	0.03
		Within Groups	600818.25	57.00	10540.67		
		Total	679327.40	59.00			
Participants	Total donkey service day	Between Groups	12866.03	2.00	6433.02	15.26	0.00
		Within Groups	24034.95	57.00	421.67		
		Total	36900.98	59.00			
	Total oxen service day	Between Groups	20479.09	2.00	10239.55	2.12	0.13

	Within Groups	275884.74	57.00	4840.08
	Total	296363.83	59.00	

Appendix 3 Table 8: ANOVA Table of Physical water productivity (Kg DM per m^3)

Source of variation		Sum of Squares	Df	Mean Square	F	Sig.
livestock feed kg DM/ m^3	Between Groups	5.03	2.00	2.52	4.66	0.01
	Within Groups	63.17	117.00	0.54		
	Total	68.20	119.00			
Crop residue kg/m^3	Between Groups	1.55	2.00	0.77	0.60	0.55
	Within Groups	130.92	101.00	1.30		
	Total	132.47	103.00			
Grazing land kg/m^3	Between Groups	0.04	2.00	0.02	5.68	0.00
	Within Groups	0.40	114.00	0.00		
	Total	0.44	116.00			
grass kg/m_3	Between Groups	0.02	2.00	0.01	6.41	0.00
	Within Groups	0.16	116.00	0.00		
	Total	0.18	118.00			

Appendix 3 Table 9: ANOVA Table of Financial water productivity (ETB per m^3)

Participation	Source of variation		Sum of Squares	Df	Mean Square	F	Sig.
Non participant	Feed ETB/ m^3	Between Groups	13.03	2.00	6.51	4.71	0.01
		Within Groups	78.80	57.00	1.38		
		Total	91.83	59.00			
	Crop residue birr/m^3	Between Groups	0.10	2.00	0.05	0.12	0.89
		Within Groups	19.22	48.00	0.40		
		Total	19.32	50.00			
	Grazing land Birr/m^3	Between Groups	0.00	2.00	0.00	0.00	1.00
		Within Groups	0.00	56.00	0.00		
		Total	0.00	58.00			
Participants	Feed birr/ m^3	Between Groups	0.04	2.00	0.02	0.38	0.69
		Within Groups	3.31	57.00	0.06		
		Total	3.35	59.00			
	Crop residue birr/m^3	Between Groups	3.00	2.00	1.50	0.45	0.64

	Within Groups	167.39	50.00	3.35		
	Total	170.39	52.00			
Grazing land Birr/m^3	Between Groups	0.12	2.00	0.06	27.04	0.00
	Within Groups	0.13	55.00	0.00		
	Total	0.25	57.00			

Appendix 3 Table 10: ANOVA table of livestock water productivity in ETB/m^3

Participation		Sum of Squares	Df	Mean Square	F	Sig.
Non participant	Between Groups	25.96	2.00	12.98	2.19	0.12
	Within Groups	337.38	57.00	5.92		
	Total	363.34	59.00			
Participants	Between Groups	10.52	2.00	5.26	22.84	0.00
	Within Groups	13.13	57.00	0.23		
	Total	23.66	59.00			

Appendix 3 Table 11: Animal days used for threshing and ploghing

Type of crop	Ploghing (oxen/ day)	Threshing oxen/day
Sorghum	32.00	16.00
Chickpea	40.00	16.00
Tef	48.00	24.00

Appendix 3 Table 12: Tropical Livestock Unit (TLU) equivalent conversion factors

Livestock Type	TLU
Cattle	
Calf (<12 months)	0.25
Heifer	0.55
Steer	0.70
Mature cow: dry	0.78
Mature cow: lactating	0.98
Oxen	0.98
Sheep	
Lamb (<12 months)	0.04
Mature ewe/ ram	0.13
Goats	
Kid	0.06
Mature dam/ ram	0.1
Camel	1
Donkey	0.51

Appendix 3 Table 13: Livestock dressing percentages

Livestock Type	Dressing %	Source
Cattle	50	Nega et al.(2002)
Sheep	45	Ermias et al. (2000), Negussie et al. (2004), Jemal (2004), Moses (2006).
Goat	45	Adissu et al. (2002), Moses (2006), Mesfin Taddesse (2007).

Appendix 3 Table 14: Average manure production and nutrient composition

Livestock Type	Manure yield kg DM TLU^{-1} day^{-1}	Nutrient composition (%)		Sources
		N	P	
Cattle	3.3	1.83	0.45	Haileselassie et al. (2006); Lupwayi et al. (2000)
Sheep	2.48	1.56	0.55	FAO (2004)
Goats	2.48	1.56	0.55	FAO (2004), Workneh et al., (2003)
Equines	2.4	1.83	0.45	Haileselassie et al. (2006); Lupwayi et al. (2000)

Appendix 3 Table 15: Conversion factors used to estimate crop residues from grain

Crop Types	Conversion	Sources
Tef	1.5	FAO, 1987; Tessema et al., 2002
Sorghum	2.5	Tessema et al., 2002
Chickpea	1.2	FAO, 1987; Tessema et al., 2002

Appendix 3 Table 16: Average market prices (ETB) in the study areas

Description of items	Unit of measure	Price (ETB) per kg
Crop residue	Kg	1.2
Grass land feed	Kg	1.2
Urea	Kg	5.1
DAP	Kg	6.9
Meat from cattle	Kg	40
Meat from sheep/ Goat	Kg	25
Hides	One piece	43
Sheep skin	One piece	25
Goat skin	One piece	15
Milk	liter	6
Donkey	N	744
Camel	N	2000
Goat	N	229
Sheep	N	219
Cattle	N	1478
Ploughing service	Pair Oxen per day	40
threshing service	Animal per day	20
Transportation Donkey service		
For crop transport to house or mil	Animal per day	15
For fetching water	Animal per day	3
For marketing	Animal per day	7.5

ETB= Ethiopian birr

Appendix 3 Table 17: Dry matter of selected trees

Type of tree (local name)	DM kg per tree
Ziziphus .spina-christ (Kurkura)	0.12
Flakourtica indica (Akoko)	0.65
Cordia africana (Wanza)	2.75
Acacia asak (Sebensa)	5.89
Acacia latai (Doret)	0.33

Appendix 3 Table 18: Monthly mean climatic data values

Kobo Station (Mekete, 2008)

Altitude: 1530masl, Latitude: 12.036 N, Longitude: 39.637 E

Elements	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RF (mm)	33.4	12.3	20.9	63.4	36.9	19.2	173.9	226.9	38.3	62.7	77.4	64.3
Max (oc)	22.8	25.7	26	30.8	33.4	34.4	31.7	34	30.8	29.5	28.1	26.8
Min (oc)	12.9	12.5	15.1	16.8	17	18.5	18	16.6	14.7	12.8	11.6	10.7
RH (%)	68.5	57.3	54.7	54.2	54	39.1	52.9	64.6	64.8	52.6	49.4	59.4
WS (m s-1)	2.5	1.8	2.1	2.1	2.3	2.2	2.1	1.6	1.2	1.2	1.4	2.2
Sunshine	8	8.3	9.1	7.9	10	7.6	5.6	6.6	6.7	9.7	9.5	9
ETo(mm d-)	4.06	4.66	5.39	5.83	6.31	6.21	5.13	4.62	4.62	4.66	4.29	4.27

Appendix 4: Photos illustrating livestock services and water use in the study area

Cultivated sorghum cropland

Cultivated tef cropland

Cultivated chickpea intercropped with "Tinkesh" cropland

Cultivated maize cropland

Tef hip ready for threshing

Threshing tef crop

Transporting fuel wood

Transporting water


Aftermath grazing


Providing drinking water for goats


Providing drinking water for oxen


Feeding "Tinkesh" to oxen


Hillslop free for grazing


Hillslop restricted from grazing


Kolokobo Grazing land , called Wurenew


Akoko in tef cropland

8. BIOGRAPHICAL SKETCH

The author was born in June 21, 1982 Dessie, South Wello, in Amhara Region. She attended her senior secondary school at W/o Siheen Technical and vocational. Then she joined Debub University and graduated with B.Sc. degree in Animal Production and Rangeland Management in 2004. After her graduation, she was employed by Dessie Urban Agricultural Office.

She joined the school of graduate studies at Hawassa University in 2007/08 to follow her study for the degree of Master of Science in Animal and Range Sciences with specialization in Animal Nutrition.