LIVESTOCK DYNAMICS, FEED BALANCE AND COPING STRATEGIES OF ENSET BASED AGRICULTURAL SYSTEM OF GURAGE ZONE: PROSPECT TOWARDS ENSET WILT

MSc. THESIS

BY

DEREJE FELEKE

Major Advisor: Minyahel Tilahun (Asst. Prof.)

Co-advisor: Shiferaw Mulugeta (Asst. Prof.)

ATHESIS SUBMITTED TO THE DEPARTMENT OF ANIMAL PRODUCTION AND TECHNOLOGY, COLLEGE OF AGRICULTURE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF THE MASTER OF SCIENCE INANIMAL PRODUCTION

June, 2022

WOLKITE, ETHIOPIA

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ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled **LIVESTOCK DYNAMICS, FEED BALANCE AND COPING STRATEGIES OF ENSET BASED AGRICULTURAL SYSTEM OF GURAGE ZONE: PROSPECT TOWARDS ENSET WILT"** submitted in partial fulfillment of the requirements for the degree of **Master's**with specialization in **Animal Production,** the Graduate Program of the **Department/School of Animal Production and Technology,** and has been carried out by **Dereje Feleke** Id. No **AGPGR 009/12** , under my/our supervision. Therefore I/we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Minyahel Tilahun	_____	_____
Name of major advisor	Signature	Date
Shiferaw Mulugeta	_____	_____
Name of co-advisor	Signature	Date

DEDICATION

I dedicate this manuscript to my mother W/o Tadelech Weldesenbet, for the foundation they laid in the success of my life, and my wife w/o Shega Belay who sacrificed all her time, love and benefits for my success.

STATEMENT OT THE AUTHOR

First, I declare that this dissertation is my bona fide work and that all sources of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirement for a MSc degree at Wolkite University, College of Agriculture and Natural resources and is deposited at the University/ College library to be made available to borrowers under rules of library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award ot any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The author, Dereje Feleke, was born on July 2, 1971 in Merabicho Kebele of Endegagn District, Gurage Zone, Ethiopia. He attended his elementary to Primary education in Merabicho School. His Secondary High School was attended at Wachamo Comprehensive Higher School in Hossana town.

He joined the then Wolayta Sodo Agricultural College in 2005 and graduated with diploma in Animal production in 2007. Soon after graduation, he joined the then Endegagn district Agricultural office served as Animal production kebele agent and cluster supervisor simultaneously for nine month.

From June 5, 2007 he transferred to Endegagn woreda Agriculture served as three years head of office. On June 2010 he joined Haramaya University, Department of Animal Science in Animal and Range Science and graduated in September 2014.From 2015-2019 served as Justice office, livestock and fishery office and Culture truism and Administrative communication office head. In November 2019 he joined the school graduate studies of Wolkite University College of Agriculture and Natural resources Department of Animal production and Technology.

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List of Acronyms

ANOVA	Analysis of Variance
CSA	Central Statistical Agency
CR	Crop Residue
DCP	Digestible Crude Protein
DM	Dry Matter
DMD	Dry Matter Demand
BMI	Dry Matter Intake
EXW	Enset Xanthomonas Wilt
FTC	Farmers Training Center
FGD	Focus Group Discussion
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GZSAD	Gurage Zone Statistical Abstract Document
Ha	Hectare
HHs	Households
IVDMD	In Vitro dry Matter Digestibility
KII	Key Informant Interview
ME	Metabolizable energy
MCL	Mixed Crop Livestock
SNNP	Southern Nation Nationality People
SD	Standard Deviation
PRA	Participatory Rural Appraisal
TLU	Tropical Livestock Unite
USAID	United States AID

ABSTRACT

Enset wilt problem has been becoming a significan challenge to the expected level of food and feed produced from Enset plant in Enset producing areas of Ethiopia. Numerous studies have been done but it is difficult to get studies that evaluate its impact and indicate strategies that have been used to cope with this production system. A descriptive and explanatory cross-sectional survey research design was employed. Multi stage sampling was employed to select the districts, PAs and households. Five districts of Gurage zone namely Endegagn, Enemor Ener, Gumer, Cheha and Geto were selected based on the degree and experience of the areas with Enset wilt disease. The formal survey, focus group discussion, field monitoring and secondary data collection methods are employed and gathered qualitative and quantitative data. The formal survey focused on livestock and feed resources of Enset wilt -affected areas and livestock feed balance of the area. Furthermore, a chemical analysis of sample feeds was done to determine the nutritive value of available feed resource. Chi-square was employed for mean and mean comparison using an independent sample T-test and percentages. Indices were also estimated to calculate farmers' various choices and preferences. The average land holding per household in highland and midland was 1.15 and 1.52 ha, respectively. Natural pasture ((689(0.47)) was the primary feed resource followed by ((300(0.21)) mixture of natural pasture and Enset. A decadal livestock population from the zonal level indicated that a significant cattle population increase was observed compared to other livestock species. Average livestock holding of respondents confirmed that a significant difference ($p<0.05$) was observed only in the number of sheep (0.173±0.97; 0.068±0.13) and equine (0.58±0.66; 0.15±0.39) between the two agro-ecologies. Shortage of land was ranked first among other feed resource availability challenges in both agro-ecologies. The estimated annual DM supply was 524.65 and 901.38 ton/year for livestock maintenance of highland and midland agro ecologies. Feed DM requirement only satisfy 85.23%. Estimated annual Metabolizable energy available for livestock maintenance in the highland and midland agro ecology were 2095097 and 6217406.35 MJ/kg for highland and midland, respectively. Feed ME requirement only satisfy 59.2% and 84.27% in highland and midland agr-ecologies. There are four major coping strategies i.e., feeding enset parts, feed conservation vs. enset, renting grazing land and selling livestock were identified. Due to enset wilt disease higher prevalence rate, using Enset crop as livestock feed was becoming a challenge, and the livestock species population dynamics is changing due to various factors that hinder livestock production coupled with enset wilt disease. Farmers are still dependent on enset plant to cope up with dry season feed shortages. Implementation of feed resource rehabilitation program is a must for this production system. Farmers should search for other locally adaptable forage species to fulfill the observed deficit at DM and nutrient base.

Keywords: *Coping strategies; Enset wilt disease; Feed balance; Gurage; Livestock dynamics*

1. INTRODUCTION

Ethiopia has the largest livestock population in Africa based on the 2020/21annual livestock sample survey in the sedentary areas of the country (USAID, 2018; CSA, 2020/21). Livestock production contributes 15-17% of national gross domestic product (GDP), 35-40% of agricultural GDP and 37-87% of the household incomes (Tahir, M.B., Wossen, A.M. & Mersso, B.T, 2018). Particularly, cattle play critical role in mixed crop-livestock production system and can provide, milk, fertilizer, income and saving to the community and further supports agricultural sustainability and food security (Demam, 2019).

The major livestock feed resource in Ethiopia are natural pasture and crop residues (Mengistu, 2017). Contributions of natural pasture as a feed resource have shown a significant declining trend in the past thirty years from 85 to 57 %. Even, areas that have been known for their resilience in dry periods are now showing signs of feed shortage in similar manner (Hassen *et al.,* 2010). The midlands dependency on crop residue has shown a significant increase in the past few decades (Hussain, 2021). Moreover, the nutritive quality of natural pasture is low especially in the dry season and it is much worse for crop residues (CR) owing to the lower content of digestible nutrients (Tahir *et al.,* 2018).

Enset (*Ensete ventricosum*) is the traditional staple food of most of the community in the southern part of Ethiopia. It is thus widely cultivated across the region and highly contributes to improving food security for more than 20 million Ethiopians (Yemataw *et al.,* 2017). The crop and Gurage people relationship who live in southwest part of Ethiopia is source of food (FAO, 2019; Tilahun, 2017). Enset has several uses, including food and non-food application, and is highly incorporated within the economic, social and cultural life of Enset-growing societies (Nega, 2001; Tilahun, 2017). It is drought-resistant plant that matures slowly between 3-12 years. Therefore, it needs substantial manure inputs requirement and intensive processing while harvesting Enset food parts (Quilan *et al.,* 2015).*Kocho* is human food prepared from mature Enset plant corm and pseudo stem leaf sheath extract. The protein value of Kocho is low i.e., 0.037kg and

generated from the corm and pseudo stem compared to the leaf part which is 0.16kg per kilogram of dry matter (Yilima, 2001). The leaf part is the major feed resource that provids to livestock year-round. The leaf has particular importance in the dry season of the year when other feed sources are missing (Tilahun, 2017; Demam *et al*., 2019).

The Enset farming system, where Enset is cultivated as perennial plantation in a homestead ring in association with other companion crop species growing on main agricultural land, is rich in inter-specific and intra-specific diversity (Tsegaye and Struik, 2002). Particularly for Enset producing areas of the country, livestock provides a colossal function in addition to the basic uses known in another production system by becoming the solo soil fertilizer source for Enset growth (Tilahun *et al*., 2017). Farmers grow their Enset crop closest to their houses as compared to cereals, root and tuber crops for easier fertilization with livestock dung and household refuse. An Enset garden is thought to require heavy applications of organic fertilizer sources from livestock mainly cattle, to cope with food and feed shortage in the dry season (Elias *et al*., 1996). Smallholder farmers in the mixed crop-livestock system keep some form of livestock in conjunction with crop production. However, better soils are allocated for food-feed crops, where as mountainous, sloppy and less fertile marginal lands, which are naturally vulnerable for soil erosion and land degradation, are left for livestock grazing (Tahir *et al*., 2018).

Previous drought history of Ethiopia indicates that Enset producing communities of the country have been able to stand alone even in the acute forms of droughts (Gashu, 2020). The majority of the SNNPRS zones, particularly the Gurage zone have shown resilience in the major historic famines that occurred at the national level (Mekuria, 2016). Drought-resistant nature of a community coincides with long years of experience in adapting and using the Enset crop in a majority of the community activities (UNDP, 1996). However, lately, frequent drought is becoming common in areas that have been commonly drought pron and in areas like southern Ethiopia that have been known for their drought resistance in a varing degree between areas, altitudes and production systems (Hellen, 2015).

A combination of household resources, cultural background, population pressure, new technology, and agro-ecological change determine the production systems shift and cope with feed and food shortages and sustain household's livelihood(Yilma, 2001; Demam, 2016. Moreover, a progressive Enset wilt disease transmission in many Enset producing areas of the country have resulted in great Enset production losses (Carter *et al.,* 2010; Blomme *et al*., 2017; Yematew *et al*., 2017; Muzemil *et al*., 2020). In crucial food and feed shortage moments, assessing and recommending available food and feed resources at smallholder farm level can suggest possible use of available resources for sustainable productivity, and food security (Kassa *et al.,* 2002). However, the damage that has been exerted on livestock potential of the area due to the production loss of major feed resource of the area can easily be seen in the trend of livestock production of the study area.

Even though there are studies that focus on food and feed insecurity in different production systems of the country. It is challenging to get studies that associate Enset production level and livestock production from different Enset producing areas of the country. Farmers can acquire new techniques for minimizing damage and sustain within the ever continuing adverse environment changes (Angassa *et al.,* 2012). The extent and persistency of feed deficit in rain-fed Mixed Livestock systems in the highlands of Ethiopia described in several previous reports (Wondatir, 2011; Assefa *et al.,* 2013) are formidable in a challenge for sustained livestock production. A negative feed balance in the mixed crop-livestock system disrupts the interaction among system components, impairs livestock performance, and compromises livestock's potential roles in driving economic development.

1.1. Statement of the Problem

Ethiopia is considered to be a country rich in biodiversity. However, holding ample of natural resource in hand, agricultural productivity has been showing no sign of growth to fulfill even the increasing demand of the population, and the country is still among the most food insecure in the world. Despite the huge number of possession, the current contribution of livestock to the producers and to the national economy is dismal to its

size. It has increasingly been unable to meet the demands of the rapidly growing population (Asresie, 2010; Swanepoel *et al.*, 2010; Shapiro et al., 2015).

Inimitably, south and southwest part of the country has been known for withstanding the majority of drought that has been occurred in Ethiopia. The major reason for their drought resistance nature of the zone is its strong economic, social and cultural bond with Enset plant. Moreover, the current active infection of Enset wilt and its dissemination in most of the western part of the zone put in danger the primary beneficiaries of the plant i.e., livestock. Therefore, it is anticipated that the analysis at the farm scale that constitutes the major available feed and the livestock resources would unveil the prevailing status and hint strategies to address feed shortage problems encountered in the mixed farming systems.

In the study area like most other production systems areas of Ethiopia, the ongoing land-use change from grazing land to other land uses mainly to cropland resulted in shortage of grazing lands. However, little research and development work has been done on Enset production systems despite its importance for food security and environmental sustainability. On the other hand, feed obtained as a by- product from crop production on converted land from grazing to cropland is not likely to compensate the feed supply due to crop residues inherently low feed value. In addition, the current Enset wilt problem has been becoming a big challenge to the expected level of food and feed produced from the Enset plant.

Numerous studies from all direction of the country and different communities have identifying strategies to cope up with feed insecurity (Megersa *et al.,* 2014). However, it is difficult to get studies that evaluate and indicate strategiesused to cope with feed shortage in the country's highlands. Majority of feed scarcity related studies have been done in the lowlands of the country that hosts pastoral production system (Ayana et al., 2013; Tilahun *et al.,* 2016). Feed from other alternative feed sources is limited. The present study is aimed to assessment of the potential feed resources supply for the prevailing livestock feed demand and evaluate the annual feed in the Ense- based crop-livestock system.

1.2. General Objective

This study is initiated to assess the impact of enset wilt disease copying mechanisms on livestock productivity and feed availability of Enset-based agricultural system of Gurage zone.

1.3. Specific Objectives

1. To assess the last decade livestock population trends of the study area.
2. Evaluate feed balance under the Enset livestock production system of the study area.
3. Assess major feed scarcity coping mechanisms of the study area.

1.4. Research Questions

1. What is the livestock population trend of districts which are affected by Enset wilt disease of Gurage zone for the past decades?

2. What is the status of the feed balance of the study area under Enset livestock production system of Gurage zone?

3. What major feed shortage coping strategies used by households of the study area?

2. LITERATURE REVIEW

2.1. Livestock Population Dynamics

Livestock are kept for various purposes including production of stock, source of food for the family (mainly milk and milk byproducts), draught power, transport, income generation (sale of products and live animals), soil compaction for planting small cereal crop and manure production for soil fertility management. They are the drivers of crop production mainly as draught power sources and manure provision for soil fertility restoration. Livestock in Ethiopia are as they serve a wide variety of functions in society from social to subsistence purposes (Kassahun *et al.,* 2008). The economic importance of livestock provided more than 45% of agricultural Gross Domestic Product (GDP) in 2008-2009 (Behnke, 2010). With 60-70% of the population's livelihoods dependent on livestock in one way or another, livestock provide both food and income (Kimball, 2011).

Ethiopian herd comprises 57 million cattle, 30 million sheep and 23 million goats, and 57 million chickens. Most animals are raised in the highlands, where also most of the populations live. Due to technical, economic and institutional constraints, livestock productivity is generally low. Total production of milk, meat and eggs amounts to 5.6 billion liters, 1.1 million tones and 419 million eggs per year. Statistics on total production level, depending on the source, can however vary significantly. Statistics on the value of production, which also are highly varied, do not account for the value of organic fertilizers (68 million tons) and that of draft power provided by animals (617 million days per year)(FAO, 2019).

For many small-holder farmers livestock provide draught animal power, transportation and manure for fertilizing croplands. Livestock are also socially and culturally important in Africa for payment of dowry, celebrations and gift to family members and also as a source of savings that is often safer, despite diseases and drought, than banking systems and easier to manage for farmers living in remote areas (Abela, 2005). Throughout their long history, Ethiopia has constantly relied on livestock in order to survive. Ethiopia is generally recognized to have the largest population of livestock of any other African nation. Ethiopia's huge livestock population (Halderman, 2004) and dependency on

livestock production has in turn created a need to expand livestock production, to help feed and support the population that is growing at a rate of 2.56% as of 2010 (CRGE, 2011).

Rain fed mixed crop livestock (MCL) farming is the dominant system carried out primarily to meet subsistence requirements for most of the farmers with their families in the study area (Assefa *et al.,* 2013). Small-scale irrigated farming is limited to few farmers with small patchy areas mainly for vegetables. The principal rain fed food-feed crops include barley, wheat, faba bean and field pea. The cereals which covered the largest portion of cropped areas are the major sources of crop residue for livestock feeding cultivation of teff (*Eragrostic tef*), lentils, chickpea, oats, linseed and vegetables are intermittent on small plots of cropland. Natural grass land and crop residue are the major livestock feed resources, while fallow land crop aftermath grazing and concentrates are occasionally used feed (Hassen *et al.,* 2010; Bekele *et al*., 2017). The livestock species reared include cattle, sheep, goats, donkeys, horses, mules and poultry. Cattle production with indigenous and cross-breed animals predominate the livestock production followed by sheep production.

2.2. Crop Production

2.2.1. Major crops produced in the Enset based agricultural system

Ethiopia's agricultural history is characterized by the domestication of cultigens including Barely, Wheat Field pea, Fava bean,Teffand Khat coffee and enset (Harlan, 1969, 1971; Khoury *et al.,* 2016).

Enset is a crop that tolerates prolonged drought and provides a year-round source of staple nutritious food and feed. Enset is a diploid (2n=18), herbaceous, perennial monocarp crop belonging to the family Musaceae. Enset is often referred to as false banana, due to its phenotypic resemblance to a banana (Musa Species). The crop is cultivated exclusively in Ethiopia, where it has a considerable economic and social importance for millions (Brandt *et al.,* 1997; Borrel *et al.,* 2019).It is thus widely cultivated across the south and southwestern Ethiopia (Yemataw *et al*., 2017) and it is more than a year-round staple food. The multipurpose benefits are derived from different

Enset landraces that are particularly suited for feed, fiber, packaging and construction material and provide a medicinal role (Brandt et al., 1997; Yematawa *et al.,* 2017). Due to its long history of cultivation across diverse ethnic, Enset has significant cultural and socio-economic value in Ethiopia (Olango *et al*., 2014; Borrell et al., 2019).

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2.3. Feed Resources

In Ethiopian, central high land area livestock feed resources are natural pasture (54.59%), crop-residue (31.06%), improved pasture forage (0.31%) and agro-industrial by product (1.53%), of which the first two (natural pasture and crop-residue) are the most important contributors (Tolera *et al.,* 2012). Comparing agro industrial's natural pasture and crop-residue contribution by product feed has been much lower (Berhanu *et al*., 2009).

Feed availability and quality are not predictable year round and hence gains made in the wet season are totally or partially lost in the dry season in different parts of Ethiopia (Dereje *et al.,* 2014; Kassahun, 2016; Tibebu, 2018). The essential feed nutrients of the herbaceous plants declines during the dry season, leading to prolonged periods of under-nutrition of livestock reared in such environmental conditions. The availability of feed resources and the nutritional quality of the available feeds are the most important factors determine livestock productivity. One of the major problems of low production in the country is the shortage of livestock feeds both in quantity and quality, especially during the dry season (Zewdie, 2010). The role of natural pasture is diminishing from time to time due to shrinking grazing land size and the use of native hay is limited in coverage (Yayneshet, 2010). Even during years of good rainy season, forage is not sufficient to feed livestock in the highlands for reasons associated with restricted grazing land and

poor management (Melese *et al.,* 2014

Sufficient and quality feed resources availability are major determinants of livestock productivity (Eba *et al.,* 2013). Seasonality in feed availability and lack of knowledge on feed conservation has created feed shortage both in the highland and lowland ecologies of Ethiopia (Tesfaye *et al.,* 2010). Feed supply was erratic and seasonal. There was severe shortage during the dry season from January to the beginning of the small rain (ESAP, 2009)

2.3.1. Natural pasture

Natural pasture has the primary sources of feed resources in Ethiopian. Expansion of crop production in different parts of the country, population pressure, urbanization, expansion of cities and communal lands distribution to investor and cooperative youth and women (Berhanu *et al.,* 2009) have been the major factor for the decrease in the dependency of different livestock production systems on natural pasture and the share of natural pasture as livestock feed has been decrease from 87% in the year 1998 to 57% in the year 2013 (Mengistu, 2017). This decline in natural pasture leads feed resources force farmer to focus merely on any available feed resource by disregarding the quality of the feed. The situation become worse on dry seasons hence, most farmers have not developed feed conservation techniques (Bereda *et al*., 2014; Tilahun *et al.,* 2016; Tilahun, 2017).

2.3.2. Crop residue

Crop residues possess immense global potential as livestock feed resource (Mahesh and Madhu, 2015) with estimated global level of about 1.14 billion (FAO, 2017) and local 30 million (Tolera *et al*.,2012) t of DM, of which 70% is utilized as livestock feed. Crop residues provide considerable quantity of dry season feed in most farming areas of the country (Gurmessa *et al.,* 2015, 2016; Demeke *et al.,* 2017; Gashe *et al*., 2017)and contributes up to 30-80% of the total feed DM available in the highlands of Ethiopia (African RISING, 2014). However, crop residues are fibrous and limited by their low value of voluntary intake, digestibility, nitrogen, energy, mineral and vitamin (Chalchissa *et al.,* 2014; Hailemariam *et al.,* 2017). There is limited experience in treatment and processing methods to improve crop residues national value (Abera *et al*., 2014).

Crop residue has the second major feed resources next to natural pasture (Dawit *et al.* 2013). The known crop residue in the area has wheat straw, barely straw, pea and bean straw obtained after crop harvesting. Those crop residues are deficient in nutrients (nitrogen, sculpture, minerals, phosphorous etc) essential for microbial fermentation, consequently, the digestibility and intake of digestible nutrients are low. Current studies reported in certain areas crop residue lead primary livestock feed resources, due to the decline natural pasture, increased population number expansion of urbanization (Tesfaye and Wondossen, 2019).

2.3.3. Enset as a feed resource

Enset is a significant plant that can be used in different activities of Gurage peoples. Enset plant as livestock feed on different agro ecology of the area, there are different Enset parts leaf from this commonly used once are pseudo stem, corms, root, midrib and leaft over (Tilahun, 2017). Gurage zone is part and parcel of this as feed livestock system of production where enset and livestock have highly been integrated. The integral production components of this Enset livestock-based production system of the study areas of the Gurage zone are milk and manure production followed by meat, draught power and cash income(Demam, 2018).

2.4. Livestock keeping Experience of Gurage Community

The livestock keeping system is predominantly extensive, with indigenous breeds and low-input/low output husbandry practices. Animals graze on pasture along roads and rivers, and around homesteads in mixed farming areas (Abate, 2012, Duressa *et al.*, 2014; Feyissa *et al.*, 2014; Tegegne *et al.*, 2013). Mixed crop-livestock production systems of the highland areas has a vital role in contributing to the food security and generating cash income in Ethiopia in general, in Gurage zone in particular. There is high integration between enset and livestock production in enset-cattle based mixed production system of Gurage zone which has a strong bond in determining the livelihoods and food security of the rural farming families (Wonchesa *et al*., 2019)

Animals are tethered during crop cultivation but freely graze after the harvesting season (Hussen *et al*., 2008; USAID, 2021).

At midland, cattle particularly livestock in general are kept for milk, meat, manure, draught and as a source of cash livestock in general. Milk cows are particularly valued

and milk products are being increasingly commercialized. Feeding livestock is primarily the responsibility of the women of the household. Despite the decline in the grazing area due to the expansion of cultivation, the major source of feed is grass, most being cut and carried either green or dry. Cattle particularly livestock in general in the highlands are kept for draught, milk and milk products cash and manure (Barry and Ejigu, 2006).

2.5. Major Challenges of Livestock Production

2.5.1. Genetic limitation

The main problem of livestock production in the country is that the poor genetic potential of the indigenous cattle (Ayalew *et al.*, 2015, which gives rise to low milk output. Milk production is as low as 0.5 to 2 liters per day over a lactation period of 160 to 200 days (Gebreselassie, 2020). The current specialized livestock breeds result from a long period of selection program. If improvement of the local Ethiopian breeds for meat and milk production is targeted, then it is important to have a well designed selection program in place for a few selected promising breeds (Ayalew and Feyissa, 2017).

2.5.2. Inadequate animal feed resources

The primary constraints to increased production under all livestock production systems are inadequate feed resources, poor pasture development, and the ever-increasing feed prices. Farmers tend to keep cattle at stocking rates that far exceed the carrying capacity of their\ grazing lands (Asaminew and Eyasy, 2009). This has resulted in degraded pastures and eroded soils. Stock numbers are not typically reduced in the dry season leading to progressively over grazed grazing lands (Tilahun *et al.*, 2016). In addition, (Ayalew and Feissa, 2017) indicated that the primary reason for the low productivity of livestock under smallholder managements condition was lack of proper supplementary feeding for the dairy cattle, the poor nutritive value of pastures and forages offered to the animals. In the dominating crop/livestock production system, producers supplement the feeding of their dairy cows with crop residues and farm by-products from their farmers. In some cases, during the dry season, these feedstuffs can be the only feeds available to the animals. However, the improvement of the utilization of these feedstuffs through physical and chemical processing methods to increase the availability of nutrients is only practiced on a limited number of farms.

2.5.3. Inadequate veterinary service provision

The prevalence of various animal diseases, tick-borne diseases, internal parasites and infectious diseases affect dairy development programs in varying scales, depending on ecological zones and management levels. The animal health services provided are inadequate; the cost of drugs and ascaricides is very high, while the diagnostic services are not readily available to the dairy farmer (Jergena *et al.,* 2013). This is partly attributed to the insufficient budget allocation to veterinary services (GRM International BV, 2007). Lema *et al.,(*2000) reported an overall disease occurrence of 46.8 and 33.6 % in urban and peri-urban dairying in the centeral highlands, respectively.

The same authors also reported the overall disease prevalence rates of 20.8, 13.1 and 10.7% during the dry, short and long rainy seasons, respectively with an overall annual mortality rate of 4.2%. Weak linkages between research, extension, and technology users are critical factors that have hindered dairy development in the country. This weakness stems partially from the absence of sound linkage policies in the agricultural knowledge generation and transfer systems.

2.5.4. Inadequate extension and service

Effective and adequate extension services and advice on animal nutrition and feeding management, reproduction, hygiene, farm management and dairy production efficiency are not always available to the dairy farmer (Mohammed *et al*., 2007; Ayalew and Feyissa, 2017).

2.6. Enset Bacteria Wilt Disease

The Enset wilt bacterial disease was first reported in the Kaffa district of Ethiopia in 1960s initially on Enset (Yirgou and Bradbury, 1968) and subsequently on bananas (Yirgou and Bradbury, 1974). However, the first observation of the bacterial disease of Enset in Ethiopia dates back to 1930s (Blomme *et al*., 2017; Studholme *et al*., 2019), though it is not clear whether this represents the emergence of the disease, or simply the first scientific documentation. During the 1960-80s the pathogen spread rapidly in Enset

and banana (Musa sp), in Ethiopia (Yemataw *et al.,* 2017) and is now a threat to smallholder banana cultivation throughout central and eastern Africa (Carter et al., 2010).

Enset production is affected by multiple pests and pathogens of varying severity. Significant biotic constraints include Enset Xanthomonas Wilt (EXW), bacterial rots (Erwinia sp) and root mealybugs (Blomme *et al.,* 2017). EXW is caused by Xanthomonas vasicola pv musacearum (Xvm)formerly X campestris pv. musacearum). Mammal pests that directly damage the plants include porcupine, mole rats, wild pigs and monkeys (Bobosha, 2003), and these are also suspected vectors of disease transmission, especially EXW, are included in this study (Hunduma *et al.,* 2015).

Among these pests pathogens, EXW is frequently cited as the most significant concern for farmers, generating a large number of studies that seek to identify tolerant or resistant Enset landraces (Hunduma *et al.,* 2015; Haile *et al.,* 2020), Xvm infects the vascular system of Enset damage the harvestable tissue, causing permanent wilting and eventually death. It is transmitted by contaminated tools and infected planting material, and potentially biotic vectors, such as wild and domesticated animals that browse part of the corm or pseudo stem (Yemataw *et al*., 2017).

In a previous study across 320 farmers in eight district, 40% of respondents reported EXW in their field (Mcknight-CCRP2013), though this varied by region from 3.3% (Kembata Tembaro) to 95.7% (Gedeo), and the authors suggest that the actual infection rate (farm prevalence) could be as high as 80%.Some authors claim that EXW has forced farmers to abandon enset production (Spring 1996; Tadesse *et al*., 2003). EXW is also speculated to be a possible driver for a reported major historic decline in enset agriculture in the North of Ethiopia (~200 years b.p.), though there is a lack of evidence to support or refute this (Brandt *et al.,* 1997).

Figure 1 Enset wilt damage (Source: Yematawet *al.*, 2017)

2.7. Different Strategies to Tackle Feed Shortage

In many developing countries like Ethiopia livestock production is challenged by feed shortage (Mengistu, 2017). Feeds are either unavailable in sufficient quantities due to fluctuating weather conditions or are available but of such poor quality that they do not provide adequate nutrition (Gebremedhin, 2003). Many strategies have been reported by different studies that indicated various feed shortage tackling strategies in different agro-ecologies of Ethiopia. Fodder conservation to help eliminate seasonal feed-supply fluctuations is rarely practiced. The main sources are natural pastures forages conserved in the form of hay, crop residues, and other feeds derived from the cropping systems such as leaf striplings of maize, enset leaves and shrubs (Tolera, 2012). The availability of feed resources and the nutritional quality of the available feeds are the most important factors

that determine the productivity of livestock. One of the major constraints to low production in the country is associated with shortage of livestock feeds both in quantity and quality, especially during the dry season (Zewdie, 2010). Fodder conservation to help eliminate seasonal feed-supply fluctuations is rarely practiced

2.8. Importance of Feed Resource Assessment

Livestock feed resources in Ethiopia are mainly obtained from natural, crop residues, forage crops, agro-industrial by-products and non-conventional feeds (CSA 2012). The contribution of these feed resources, however, depends up on the agro-ecology, the type of crop produced, accessibility and production system (Seyoum *et al.* 2001; Ahmed et al. 2010).

Natural pasture is the major source of livestock feed in Ethiopia. However, its importance is gradually declining because of the expansion of crop production into grazing lands, redistribution of common lands to the landless and land degradation (Berhanu *et al.* 2009) as cited by (Duguma, 2016).Understanding the various feed resources used by farmers to overcome feed shortage is essential to identify appropriate research and development interventions to enhance the health and performance of livestock.

2.9. Indicator of feed balance of an area

Under nutrition of tropical ruminant is a major area of study (Yeshitila, 2008). The study indicated that the livestock feed supply accesses quality and quantity different in different season of the year, in some season of the year there were excess feed available and there were also some seasons in which livestock face dearth feed shortage (Jimma *et al*., 2016) as cited in (Sefa,2017). Animals are undernourished because of fluctuating supply of nutrients, insufficient intake of available feeds or from inherent deficiencies in the available feeds (Yeshitila, 2008) as cited in (Sefa, 2017). The dry season is characterized by inadequacy of grazing resources as a result of which animals are not able to meet even their maintenance requirements and lose substantial amount of their weight which is an indicator of feed shortage (Endale, 2015; Funte *et al.,* 2010) as cited (Sefa Salo,2017).

3. 12MATERIALS AND METHODS

3.1. Description of the Study Areas

The study was conducted in Gurage Zone, central highlands of Ethiopia. The zone is found in the southern Nations, Nationalities and peoples' Region (SNNPR) of Ethiopia. It is located between 7°.28'' and 8°.37' latitude and 37°.28'' and 38'.38' longitude. The zone borders with Oromiya Region in the north, northeast and northwest, Silti Zone in the southeast, Hadiya Zone in the southeast and Yem Special Woreda the west. Wolkite is the capital city of the Zone, and it is 156 km southwest from Addis Ababa i.e., the capital city of Ethiopia, covering an area of 6373 km^2. The Zone has 16 administrative districts with 412 kebeles and 5 town administrations (GZSAD, 2019),

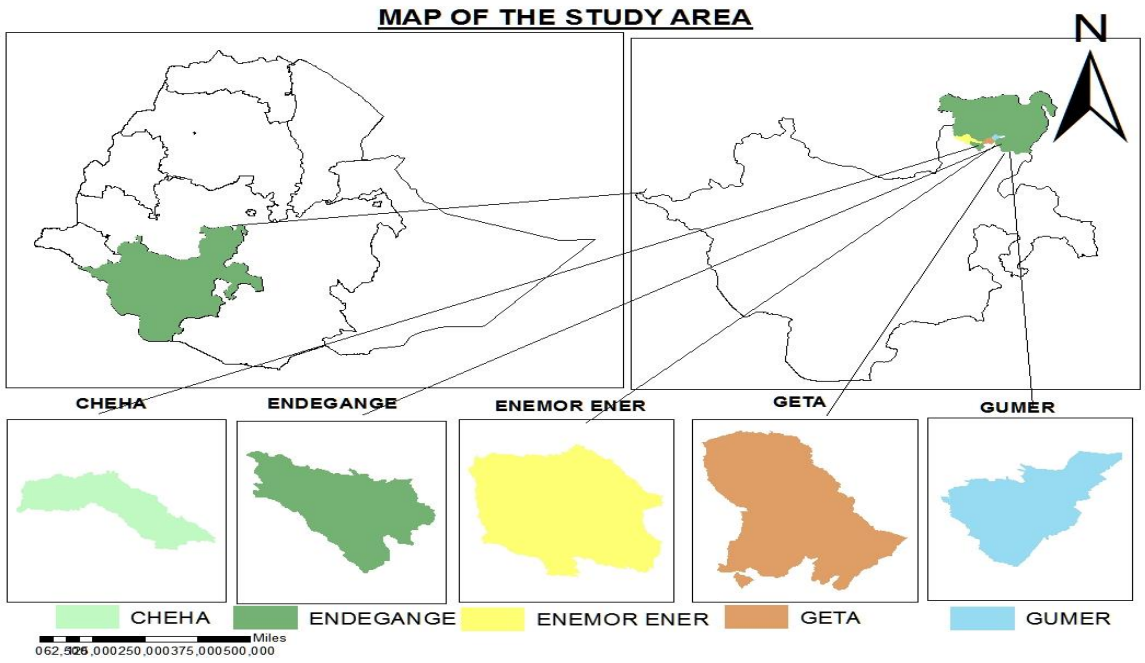

Figure 2 map of the study area

The human population size of the Zone is estimated 1,832,286 (51.45%women and 48.55%men) 88.2%of the population are farmers entirely dependent on subsistent agriculture (CSA, 2013; SAD, 2019). The Zone has 4 main agro ecologies, 4.1% (Extreme cold-*Wirch*), 27 5 %(Highland-*Dega*), 65.3% (midland-*Weynadega*) and 3.1%(Lowland-*Kola*) climate. The average annual rain fall of the area is estimated from 800-1,400 mm and the average annual temperature of the Zone7.5-25℃. The current land use pattern of

the zone indicates that 471223.32 hectare of land allocated for crop production, 26196 hectare of land for grazing, 3528.2 hectare for forest and 128,118 hectare Enset cultivated land(25,624 hectare Enset wilt prevalence). The total estimated livestock population of the zone is 6, 0970, 320 heads and composed of 1,810,820cattle, 685,855 sheep, 569,420goat, 2,886,267chicken95, 808horses26, 877mules aswellas22, 285donkeys (CSA, 2021).

Table 1 Description of the study area of Gurage Zone

SN	Study Districts	Human population	Number of HHs`	Distance from Addis Ababa (km)	Enset cultivated land /ha	Enset wilt disease prevalence	Average temperature (^{0}C)	Average rainfall (mm)
1	Gurage zone	1,832,286	337,400	156	128,118	25,624	7.5-25	800-1400
2	Gumer	10988	22533	221	8433	1687	12.6-22.5	1001-1200
3	Geto	95741	22039	248	5519	1104	7.5-20	801-1400
4	Endegagn	63635	13266	234	4575	915	10.1-17.5	1001-1200
5	Cheha	146003	27801	186	12940	2588	17.6-20	801-1400
6	Enemor Ener	23607	19038	198	14637	2927	12.6-25	801-1200

Source:- Gurage Zone Statistical Abstract Document,2020.

3.2. Research Design

This study employed descriptive and explanatory research design through a cross-sectional survey design. Multi-stage sampling was employed to select the districts, PAs and households. Participatory Rural Appraisal (PRA) tool was employed to triangulate the accuracy of the collected data using different data collection techniques in addition to the formal survey Focus Group Discussion (FGD), Key Informant Interview (KII) and Researchers observation.

3.3. Sampling Technique and Sample Size Determination

In this study multi-stage sampling design was adopted. Initially, study districts were selected purposively based on their experience with enset crop cultivation intensity,

managing Enset wilt disease and agro-ecologies. Enset plant is majorly grown in the high and mid land agro-ecologies. Therefore, this stage, five districts Endegagn, Enemor Ener, Gumer, Cheha and Geto were were selected. Then, purposive two kebeles were selected from each of the selected districts. Finally, using a list of households who have experience i.e., more than 15 years in crop production especially enset cultivation was used as criterias to selects the household and experience in managing Enset wilt disease and keeping livestock were considered for the household survey. Subsequently, 80 households were purposively selected from each of the selected districts, and a total of 400 households i.e. 280 HHs from midland and 120 HHs from highland, were selected from the 5 districts for the formal survey.

3.4. Data Type and Data Collection Method

A formal survey, focus group discussion (FGD), field monitoring and secondary data collection methods were employed to gather qualitative and quantitative data. Effect of Enset wilt disease prevalence on the availability of feed was the primary assessment area and feed resources composition change and farmers coping strategies on the bases of livestock herd composition were simultaneously assessed.

This study used primary data collected from selected respondents and discussants in the FGD and KII and Secondary data collected from Gurage zone plan and economy development department and the central statistical Agency of Ethiopia. The data collected from the secondary data sources were focused on livestock population and different crop coverage in the study area. These data were used to estimate annual livestock population change in the study area with respect to the size of Enset crop production in the past ten years. The ten years demarcation was done due to the absence of information before 2011.

Three FGDs with 8-10 participants were undertaken for this study and 8 KII was held with Extension Agents and administrative officers and elders selected from the study districts. .

3.5. Sample Size Determination

The appropriate sample size was determined by considering the recommended level of precision (α=0.05). Thus, it was determined using a simplified formula (Yemane, 1967).

$$n = \frac{N}{1 + N(\varepsilon)^2}$$

where; n is sample size, N is the total population (households), 1 is the constant e= margin of error (e=0.05), because this study a (5%) margin of error considering calculation of households whose experience in managing EWD within the district were considered to determine sample size (N) considering above listed problem this study was used margin of error (5%).

Accordingly, the sample size is determined following the total population of the study area which is 104,677 households (GZSAD, 2020)

$$N = \frac{104677}{1+104677*0.05^2} \approx 400$$

3.6. Livestock Feed Balance

Livestock feed balance at the individual farmer level in 2021 was determined by considering the difference between supplied feed DM, ME and DCP and demand for major feed resources at individual farmers.

3.7. Estimation Livestock Feed Requirements (demand)

Livestock holdings per household were aggregated into Tropical Livestock Unit (TLU) considering the annual average livestock ownership derived based on the number of animals at the beginning and end of the study year. This was done to account for the annual inflow and outflow dynamics of livestock at the farmer level. Species-specific TLU conversion factors of 0.7 for cattle, 0.1 for sheep and goats, 0.01 for chicken, 0.5 for donkeys and 0.8 for horses were used(Gryseels, 1988) and (Bekele, 1991).

The dry matter demand (DMD) was estimated based on the expected daily dry matter intake (DMI) suggested for the standard TLU of 250 kg at 2.5% of the body weight, equivalent to 6.25 kg/day or 2280 kg/year. The comparable rate of DMI, ME and DCP requirements for maintenance was calculated as suggested by Kearl (1982). Based on daily nutrient requirement of livestock per species, 33, 29.7, 21.7, 13, 4.3 and 5 and 2.86, 1.72 and 2.51 g of DCP/$W^{0.75}$ kg per dry for cattle (Ox, cow, heifer and calves), sheep and

goats, respectively were used to estimate the annual ME and DCP. In the case of donkey and horses, the daily ME and DCP maintenance requirements of 14.9 and 27.6 MJ and 0.18 and 0.37 kg recommended by (McCarthy, 1986).Was used, respectively. Then, farm level DM, ME and DCP requirements for maintenance per year was extrapolated relative to the livestock ownership per household.

3.8. Estimation of Annual Feed Availability (supply)

The quantity of feed DM available per year was estimated from the major feed resources including natural pasture, crop-residues and enset. Crop residues DM obtained was derived from grain yield, harvest indices and area of cropland cultivated conversion factors was derived from harvest indices, 1.5 t/ha for wheat and barley and 1.2 t/ha for faba bean and field pea (Kossile, 1988), was used to estimate crop residues from grain yields. The amount of crop residue DM collected per year by an individual farmer was quantified based on the size of cropland plot allocated for growing a particular crop type during the cropping season. Given the feed shortage and farmers' priority to use CR in the highland MCL system, it is assumed that about 90% of the crop residue is used as feed and 10% for other purposes and wastage (Tolera and Seid, 1992).

The feed DM productivity on natural pasture was estimated based on 2t/ha multiplier established from previous grazing land (GL) condition and productivity studies (FAO, 1992). A utilization factor of 75% as suggested by (WBISPP, 2002) for extensive grassland was used to quantify the DM that would be utilized by livestock.

The feed DM from enset leaf and leaf midribs used for animal consumption was estimated by assuming a mean of 8 ton per hectare of enset garden as reported by (FAO, 1987), and (BoARD, 2009) of SNNPR as cited by (Dirsha, 2019).

Metabolizable energy (ME) and digestible crude protein (DCP) content of feed resources was estimated from (IVDMD) and (DCP) contents, respectively, as following equations;

1. ME(MJ/kg DM)=0.015*IVDMD(g/kg) (MAFF, 1984)
2. DCP(g)=0.929*CP(g/kg)-3.48 (Church and Pond, 1982)

3.9. Chemical Analysis of Ample Feeds

Representative samples of major feed resources of the study area,, i.e., natural grasses, crop residues (straws) and leaf and leaf midribs of Enset were collected, bulked, sub-dried, sub-sampled, grounded, packed and stored until required for determination of DM and CP. The DM and CP content sample feed was determined in an oven at 135℃ for two hours to dry to remove the moisture and until constant weight before chemical analysis. Chemical analysis each feed sample for DM, CP and IVDMD were performed Holeta Agricultural Research Center Animal Nutrition Laboratory following the procedure for DM procedure described by (AOAC, 2001).Procedure for CP estimated by the Kjeldahi Laboratory procedure, which measure the total nitrogen content in the feed, and IVDMD following the modified Tilley and Tarry method (Van Soet and Robertson, 1985).

3.10. Statistical Analysis

Means, standard deviation and percentages were to describe variance observed among farmers stratified in potential and experiences. To compare the differences across farmer from different agro-ecological in terms of harvested grain yields, net feed supply, net demand and feed balance, mean comparison independent sample T test and percentages Chi-square were used.

The test was used done at 95% level of confidence (α = 0.05). Turkeys HSD mean comparison procedure was used to test mean differences.

Rank was calculated using the formula:

$$\text{Index} = \frac{R_n * C_n + R_{n-1} * C_2 + \cdots + R_n * C_n}{\sum R_n + C_1 + R_{n-1} * C_2 + \cdots + R_n * C_n}$$

Where R_n=value given for the least ranked level (example, if the least rank is 5^{th}, then R_{n-1}=4, and ---R_1=1); C_n=count of the least ranked level (in the count of the 1^{st}rank=C_1).

To compare the differences across farmer from agro ecological difference in terms of harvested grain yields, net feed supply, and net demand and feed balance, a one-way analysis of variance (ANOVA) was used

$$Y_{ij} = \mu_i + f_i + \varepsilon_{ij}$$

The one-way ANOVA model is given by; where *yij* is the *jth* observation in the *i*th agro ecology group and μi is the common effect for the whole Enset wilt, *fi* is the effect of the *i*th enset wilt group and εij is the random error associated with the *j*th observation in the *i*th enset wilt disease assumed to be normally and independently distributed, with mean zero and variance $\sigma 2\varepsilon,i$ designates the Enset wilt, and *j* denotes a specific observation. The analysis was carried out using SPSS statistical software version 23 produced in 2014.

4. RESULTS

4.1. Socio-economic Characteristics of Households in the Study Area

Socio-economic characteristics of the household respondents in the study areas are presented in Table 2. The proportion (n (%)) of male-headed households in the study areas were 76(63.3) and 175(62.5) in highland and midland agro ecologies, respectively. The rest proportion was female headed households. Average (mean) age of respondents in the study districts were 51.62 and 51.37 for highland and midland agro ecology, respectively. The majority (80 %) of the respondents from both agro ecologies were married. Higher proportion (> 60%) of respondents in both agro-ecologies did not get formal education. The average family size of household in the study districts were 5.28 and 4.53 for highland and midland agro-ecologies, respectively. Average family size showed a significant difference ($p<0.05$) between highland and midland Enset producing respondents of this study.

Table 2 Characteristics of the household used in the study areas

Variable		Agro ecologies		Overall	P value
		Highland	Midlands		
Sex (%)	Male (HH)	63.3	62.5	62.75	0.00
	Female(HH)	36.6	37.5	37.25	
Age (Mean± SD)		51.62±12.36	51.37±14.58	51.44±13.94	0.87
Education Level (%)	Illiterate	60	67.5	65.25	0.00
	Can R and W	21.6	14.28	16.5	
	Primary	3.33	6.07	5.25	
	Junior	11.6	8.57	9.5	
	Secondary	2.5	2.85	2.75	
	Collage	0.83	0.71	0.75	
Family Size (Mean± SD)		5.28±2.06	4.64±1.72	4.84±1.84	0.001
Marital Status (%)	Married	80.83	78.57	79.25	0.00
	Widow	15.83	17.14	16.75	
	Widower	3.33	2.14	2.5	
	Single	-	2.14	1.5	

SD=standard deviation; R stand for read; W stand for write; For highland (n=120); For midland (n=280); Overall (N=400)

4.2. Land Holding and Land Use Pattern

Land holding and land use pattern of Enset wilt affected areas of Gurage zone is presented in Table 13.The average land holding per household in highland and midland was 1.15and 1.52 ha, respectively. The average land allocated for annual crop production, vegetable, Enset crop cultivation, perennial crops, grazing and forest were 0.63, 0.04, 0.21, 0.16, 0.31 and 0.15 hectares in midland, and the average land allocated for annual crop production, vegetable, potato, Enset crop cultivation, perennial crops, grazing and forest were 0.50, 0.05,0.05, 0.22, 0.005, 0.29 and 0,03 hectares in the highland. A significant difference ($p<0.05$) was observed between the two agro ecologies land use pattern. Annual crop production and grazing land between midland and highland showed highly significant difference ($p<0.05$) for forest holding (Appendex2).

The average grain yield per ton in the highland (157.6) was higher than in the midland (132.94). Similarly, the crop residue produced in the two agro ecologies showed a difference i.e., 267.08 for the highland and 193.22 tons fort the midland. The crop residue was mainly sourced from two crops in the highland (Wheat; Barley) agro-ecologies and midland (Wheat; Barley). Other crops (Teff; Faba bean; Field pea) contribution was compared to the above- mentioned cereal crop contribution as crop residue (Appendex2).

4.3. Herd Size and Species Composition

Herd size and species composition in highland and midland in the study areas are presented in Table3.The average livestock number in the study area was 6.91 with a SD of 7.47. The average cattle population of the two agro-ecologies was 3.63 (2.86) and 3.49(2.61) highland and midland, respectively. A significant difference ($p<0.05$) between the two agro ecologies was observed in the number of sheep (0.173±0.97; 0.068±0.13) and equine (0.58±0.66; 0.15±0.39). However, there were no significant difference was observed for the rest of the livestock species (Cattle; Goat; Chicken; Horse; Donkey).

Table 3 Mean (±SD) herd size (TLU) and species composition per household in highland and midland agro ecology in the study area.

Live stock Species	Agro ecology (Mean± SD)		Overall	**P value**
	Highland	Midland		
	TLU	TLU		
Total livestock	3.64±3.03	2.87±1.92	3.14±2.48	0.19
Cattle	2.86±1.33	2.61±1.29	2.69±1.30	0.08
Sheep	0.173±0.97	0.068±0.13	0.13±0.55	0.000
Goat	0.013±0.05	0.026±0.08	0.02±.07	0.08
Chicken	0.015±0.02	0.02±0.03	0.02±0.03	0.82
Equine	0.58±0.66	0.15±0.39	0.28±0.53	0.000

SD= Standard Deviation; TLU=tropical livestock unit;for highland (n=120); midland(n=280); Overall (N=400)

4.4. Farmers' Perception of Livestock Population Trend in the Last Decade

Farmer's perception towards different livestock species population and composition in last decade were estimated and presented in table 4. Respondents selected from enset wilt affected area of Gurage zone declining 143(51.07%) and 46(38.3%) was sheep and goat ranked first in midland and highland, followed by 84(30%) and 46(38.3%) chicken, 29(10.35%) and 21(17.5%) equine and 24(8.57%) and 17(14.16%) cattle were ranked second, third and fourth respectively in midland and highland agro ecologies. A significantly ($p<0.21$) higher decline in sheep and goat population ownership was observed between the two agro-ecologies.

On the other hand, livestock species population size trend increased 54(45%) and 76(27.14 %) was cattle ranked first in highland and midland followed by 58(48.3%) and 63(22.5%) no change, 5 (4.16%) and 40(10%) equine were ranked second and third in highland and midland agro ecologies. Increment of cattle in the current study was no significant difference ($p<0.05$) between highland and midland. Trends of livestock species population size in past decade decrease main reason on Enset affected current the study areas were 267(95.35%) and 108(90%) feed shortage was ranked first in midland and highland agro ecologies followed by 12(10%) and 7(2.5%) were feed shortage and wild animal ranked second in highland and midland agro ecologies, the reason of

livestock population decrease feed shortage was no significant difference ($p<0.05$) between highland and midland.

Table 4 Livestock species population size trends in the last decade on enset wilt affected areas n(%)

Livestock species population trend		Agro ecology		Overall	p-value
		Highland	Midland		
Decrease	Cattle	17(14.16)	24(8.57)	41(10.25)	0.006
	Small ruminant	46(38.3)	143(51.07)	189(47.25)	
	Chicken	36(30)	84(30)	120(30)	
	Equine	21(17.5)	29(10.35)	50(12.5)	
Increase	Cattle	54(45)	76(27.14)	130(32.5)	0.21
	Small ruminant	3(2.5)	31(11.07)	34(8.5)	
	Chicken	5(4.16)	40(10)	45(11.25)	
	Equine	0	1(0.35)	1(0.25)	
No Change		58(48.3)	63(22.5)	121(30.25)	
Main reason for livestock species population decrease	Feed shortage	108(90)	267(95.35)	375(93.75)	0.09
	Disease	-	6(2.14)	6(1.5)	
	Feed shortage and wild animals	12(10)	7(2.5)	19(4.75)	

For highland (n=120); midland (n=280); Overall (N=400)

4.5. Annual Livestock Population Trend and Species Composition Change in Major Enset Wilt Affected Areas of Gurage Zone (2012-2020 GC)

Livestock population dynamics of Enset wilt affected areas of the zone is presented in figure 3. Farmers in the study area kept different livestock species such as cattle, sheep, goat, chicken, horse, donkey and mule. The population structure of livestock holding in the study area is majorly covered by cattle (853.75) TLU followed by chicken (6.97) TLU and sheep 62.4 TLU. The finding regarding population dynamics at the specie level

indicated that only cattle showed an increasing trend and the rest species showed no change in the last decade except donkey and mule that showed a slight increase.

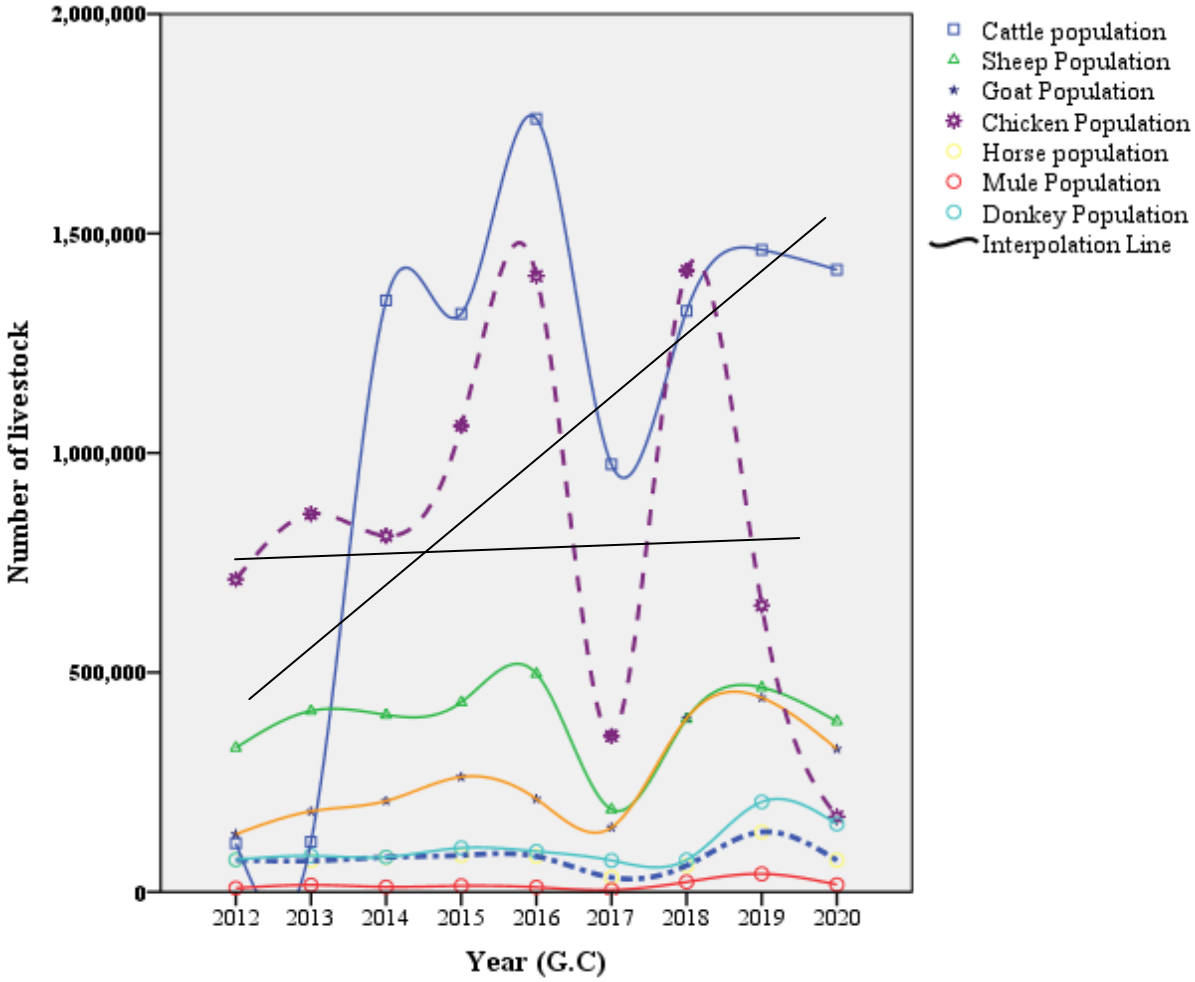

Figure 3livestock population dynamics in Enset wilt affected areas of Gurage zone

4.6. Feed Resources Availability in the Study Area

Feed resource availability of Enset wilt affect areas of the zone is presented in table 5. The overall respondents of the study are indicated that natural pasture ((689(0.47))is the primary feed resource of the study area followed by mixture of natural pasture and Enset ((300(0.21)) However, in highland agro ecology, mixture of natural pasture and crop residue ((170(0.41)) is the primary available feed resource followed by mixture of natural pasture and enset ((120(0.29)) Enset plant mixed with natural pasture is ranked second feed resource available in both highland((120(0.29)))and midland ((180(0.174)) agro-ecologies.

Table 5 Ranks of available livestock feed resources in Enset wilt affected area of Gurage zone

Feed resources	Agro ecology				Overall	
	Highland		Midland			
	N(Index)	Rank	N(Index)	Rank	N(Index)	Rank
Natural pasture	69(0.168)	3	620(0.602)	1	689(0.47)	1
Crop residues	34(0.083)	4	123(0.12)	3	157(0.12)	4
Enset	16(0.039)	5	74(0.072)	4	90(0.06)	5
Natural pasture and crop residue	170(0.41)	1	33(0.032)	5	203(0.14)	3
Natural pasture and enset	120(0.29)	2	180(0.174)	2	300(0.21)	2

For highland (n=120); midland (n=280); Overall (N=400)

4.7. Enset Cultivation and its Population Dynamics

Table 6 presents the average Enset crop cultivated in the two agro-ecologies. The average (mean± SD) enset land owned by households per hectare was 29.09± 0.24 and 56.52 ±0.21 in highland and midland agro ecologies, respectively. The overall average (mean± SD) was 42.80± 0.11. All (100%) respondents of this study agreed that Enset population dynamics had been showing a declining trend. The reason behind the declining population dynamics of enset(Ensete ventricosum) was primarily due the Enset diseases (88.25 %) particularly Enset wilt followed by mixed factors effect(11.75 %). There was no significant difference observed between the two agro ecologies in relation for the declining nature of enset population.

Enset in the study areas highland and midland used multipurpose for food and feed and traditional medicine, also HHs reported that different races (Colony) of enset such as Agade, Nemare, Yeshire fire (kinike), Badet, Eniba, Bosore, Tereriye, Shawar, Gibuwe, Nechuwe, Kanchuwe and Shertiye are common in current study areas, the dominate race or colony of enset were Agade, Eniba and Namare , followed by Nechuwe, Bosore, badet and eniba. On the other hand, some race (colony) enset such as Astare, Guarye, Kibnar, Ameratye and Derye are mainly used as traditional medicine for humans and animals towards healing broken and fractured bones of legs and arms, curing wounds, reducing pain of damaged bone (Appendix 2).

Table 6 Enset cultivation and its population dynamics in the study area n (%).

Owner		Agro ecology		Overall	P value
		Highland	Midland		
Own enset farm?	Yes	120	277	99.46	
	No	-	3	0.53	
Cultivation(ha)		29.09± 0.24	56.52± 0.2	21.40± 0.11	0.000
Enset cultivated started year	Before 30 years	54(45)	150(53.57)	51	0.005
	30-20 years	42(35)	50(17.85)	23	
	20-10 years	20(16.70	53(18.9)	18.25	
	10-5 years	4(3.3)	27(9.64)	7.75	
Dynamics of enset	Increased				
	Decreased	120 (100)	280 (100)	400(100)	
Reason for declining	Disease	104(86.6)	249(88.9)	88.25	0.000
	Mixed effect	16(13.3)	31(11.07)	11.75	
Ecotype based endangerment	Yes				
	No	120(100)	280(100)	400(100)	

For highland (n=120); midland (n=280); Overall (N=400); Other=Do not have Enset currently; Mixed effect represents effect of disease, wild animal and poor management

4.8. Major Livestock Production Challenges in the Study Area

Major livestock production challenges are presented in table 7. Even though more than ten livestock-related technical and non technical constraints were identified, the analysis picked out only 5 of the major livestock-related constraints in this study. Overall in adequate feed resource 1012(0.76) followed by veterinary service181 (0.135) and poor livestock production performance 104(0.078) were ranked first; second and third major challenging factors for livestock production in enset wilt affected areas. The similarity was observed on the ranks of identified challenges in both the agro-ecologies.

Table 7 Major challenge of livestock production

Major challenges	Agro ecologies				Overall	
	Highland		Midland			
	n(index)	Rank	n(index)	rank	N(Index)	Rank
Poor breed performance	30(0.075)	3	74(0.078)	3	104(0.078)	3
Inadequate feed	300(0.75)	1	712(0.75)	1	1012(0.76)	1
Inadequate vet. service	52(0.131)	2	129(0.137)	2	181(0.135)	2
Inadequate extension service	13(0.032)	4	22(0.023)	4	35(0.026)	4

For highland (n=120); midland (n=280); Overall (N=400)

4.9. Major Feed Related Challenge of Livestock Production in Enset Wilt Affected Areas

Major feed-related challenges of Enset wilt affected areas of the Gurage zone is presented in figure 3. Shortage of land was the primary challenge of feed resource availability problem followed by dry time shortage of feed in both agro ecologies of the study area. Declining grazing land and Enset wilt disease prevalence were ranked 3rd in the highland and midland, respectively.

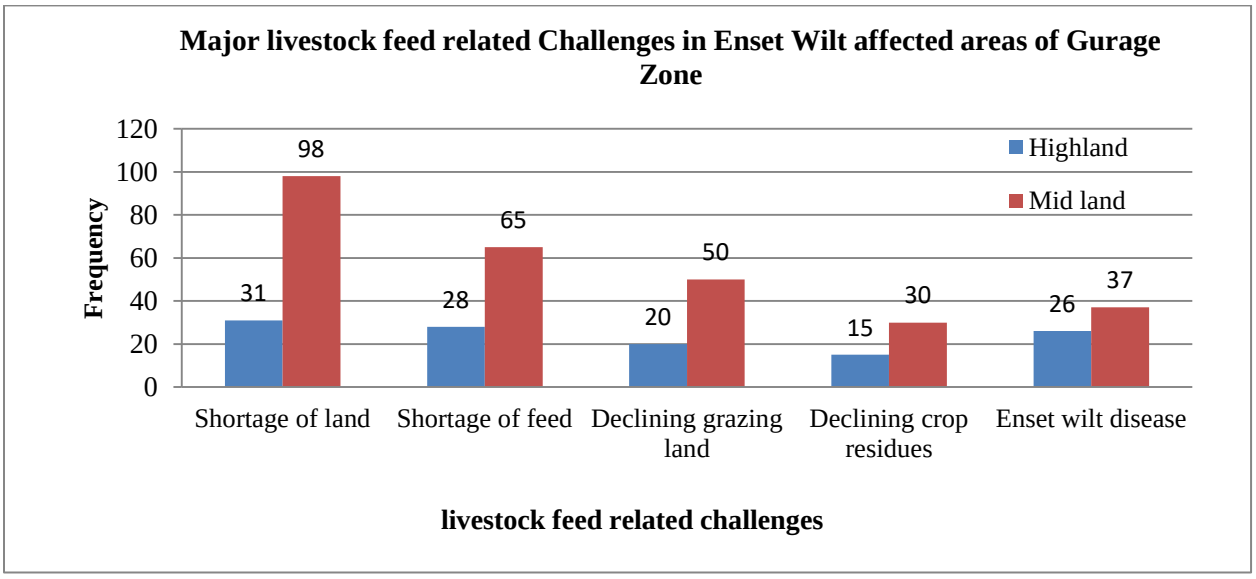

Figure 4major livestock feed related challenges in the study area

4.10. Seasonal Feed Availability (supply)

Feed DM availability of highland and midland agro ecologies in the study selected districts are strongly influenced by different seasonality of the year. DM available (supply) from Enset 452.16 and 232.72 from the months of October to May for eight months was ranked first and second in midland and highland, followed by DM available (supply) from natural pasture 256.16 and 69.4 from September to December and steadily decline from January to June were ranked second and third in midland and highland and DM available (supply) from crop residue 222.53 and 193.22 December to-February steadily decline from March to April were first and third in highland and mid land agro-ecology. The contribution of natural pasture is increase from September to November; Enset from January to May and crop residues from December to February (Table 15) Appendex2.

4.11. Chemical Composition and Nutritive Value of Available Feed Stuff

The Chemical composition and nutritive value of the identified feed stuff utilized for livestock feeding in the selected study districts were indicated in (Table8).The dry matter (DM), The crude protein (CP), Digestible crude protein (DCP) content and in vitro dry matter digestibility (IVDMD) and energy content of identified feeds available for livestock feeding in the two ago ecologies were assessed. The available livestock feedstuff DM content of highland was ranged from 90.72 to 93.34% and midland 89.2-94.86%.

The crude protein (CP) content over minimum level and minimum level (10.52%and 7.13%) was from field pea and natural pasture in highland and mid land. The crude protein (CP) content of available livestock feed varied from 4.32% wheat straw, 4.91% Enset and 5.28%barley straw in highland and 4.4% teff, 4.68% wheat straw and 5.67% barley straw in midland. The percentage of CP obtained from natural pasture, Enset, wheat straw, barley straw, field bean in highland and Enset, wheat straw, barley straw and teff straw in midland was that are considered as available feed resources for livestock feeding in the current study area is lower than that set as a minimum level of nitrogen (7%) to limit intake (Milford and Minson, 1966; VanSoest, 1982).

Digestible crude protein(DCP) content of natural pasture and Enset current study was ranged from 58.02to 42.13 and 62.76 to 54.49 in highland and midland, respectively.DCP content of annual crop residues in current study was ranged from 36.65 to 39.99% and 45.57 to 49.20% wheat and barley straw in highland and midland.

The in vitro dry matter digestibility (IVDMD) from identified feed resources in the study area ranged from 67.89 to 48.46 field pea straw and wheat straw in highland and 63.08 to 53.06 from Enset and wheat straw in midland. The IVDMD content of identified feed resources were 67.89, 65.43, 62.45, 52.89, 48.46 and 53.09 were from field pea straw, faba bean straw, Enset, natural pasture and wheat straw and barley were respectively in highland and 63.08, 55.16, 54.08, 53.64 and 53.06 were from Enset, teff straw, barley straw, natural pasture and wheat straw was respectively in midland.

The energy content of identified feed resources in the current study area were ranged 10.2 MJ/kg DM to 7.3 MJ/kg DM from field pea straw and wheat straw in highland and 9.4 MJ/kg DM to 7.9 MJ/kg DM from Enset and barley straw in midland. Metabolizable energy content of identified feed resources were 7.3 MJ/kg DM, 7.9 MJ/kg DM, 7.9 MJ/kg DM, 9.4 MJ/kg DM, 9.8 MJ/kg DM was from wheat straw, natural pasture, barley straw, Enset and faba bean straw respectively in highland and 7.9 MJ/kg DM, 8.04 MJ/kg DM, 8.1 MJ/kg DM, 8.3 MJ/kg DM and 9.4 MJ/kg DM was from wheat straw, natural pasture, barley straw, teff straw and Enset were respectively in midland

Table 8 Chemicalcomposition and nutritive value of feed stuffin the study area

Feedstuff	Highland					Midland				
	Chemical composition		**Nutritive value**			**Chemical composition**		**Nutritive value**		
	DM%	CP/g/kg	DCP/g/kg	IVDMD%	ME(MJ/kg DM)	DM%	CP%	DCP/g/kg	IVDMD%	ME(MJ/kg DM)
Natural pasture	90.72	6.62	58.02	52.89	7.9	89.27	7.13	62.76	53.64	8.04
Enset	93.11	4.91	42.13	62.45	9.4	90.23	6.24	54.49	63.08	9.4
Wheat straw	93.27	4.32	36.65	48.46	7.3	93.12	4.68	39.99	53.06	7.9
Barley straw	93.34	5.28	45.57	53.09	7.9	93.86	5.67	49.20	54.08	8.1
Field pea straw	92.01	10.52	94.25	67.89	10.2	93.12*	4.44*	41.25*	55.16*	8.3*
Teff straw*										
Faba bean straw	93.12	5.08	43.71	65.43	9.8					

For highland (n=120); midland (n=280); Overall (N=400); P=crude protein, DCP=digestible crude protein, DM-dry matter, ME=metabolizable energy

4.13. Estimated Annual Feed Supply, Demand and Balance

The estimated maintenance requirement of identified feed nutrients to the total livestock population for highland and midland study areas the annual total DM, DCP and ME maintenance requirement for total livestock 1032.15 in TLU were total maintenance requirement was 1673.07 ton DM. Whereas total feed supply was 1426.01 ton DM, feed DM satisfied (met) in the current study area was 85.23%. Feed DCP maintenance requirement for total livestock was 95169.33g. Whereas total feed DCP supply was 72994.69g, feed DCP in the current study area maintenance requirement for total livestock satisfied (met) 76.69%. Total ME maintenance requirement for total livestock in the study area was 10916095.82MJ/kg DM. Whereas total feed ME supply was 8312503.35 MJ/kg DM, feed ME in the current study area maintenance requirement for total livestock satisfied (met) 76.14%.

Table9. Estimated annual DM DCP and ME supply, requirement and feed balance

Variables	Agro ecology		Overall(N=400**)**
	Highland(n=120)	Midland(n=280)	
Annual feed DM supply/t	524.65	901.38	356.50
for maintenance DM/t	615.96	1057.11	418.26
Balance of requirement DM/t	-91.31	-155.73	61.76
Annual feed DCP supply	23979.86	49014.83	18248.67
Requirement DCP	32164.82	63004.51	23,792.33
Balance	-8184.96	-13989.68	5543.66
Annual ME supply	2095097	6217406.35	2078,125.83
Requirement of ME	3538749.82	7377346	2729,023.95
Balance	-1443,652.82	-1,159,939.65	650,898.11

DM=drymatter; DCP=digestible crude protein; ME=metabolizable energy;for highland (n=120); midland(n=280); Overall (N=400)

4.14.Coping Strategies towards Feed Shortage in Enset Wilt Affected Area

Coping strategies towards feed shortage in enset wilt affected areas of Gurage zone is presented in table 11. Four major coping strategies i.e., feeding enset parts, feed conservation vs. enset, renting grazing land and selling livestock were identified in the study area. Majority of respondents indicated that feeding enset parts was the primary coping strategy when feed was short followed by different enset parts with conserved feed and selling their livestock/renting grazing lands. The last choice of the respondents was selling their livestock to the nearest market and renting grazing land. The only observed difference between coping strategies used by farmers from the two agro-ecologies was that farmers from midland prefer selling their livestock (30(10.71)) to cope up with feed shortages rather than renting a grazing land (24(8.57)). The majority of the respondents (88%) reported that they made themselves ready for the dearth period before the occurrence of feed shortage. Only a few respondents reported that they tried to cope up with the feed shortage after or during its occurrence. No significant difference ($p>0.1$) was between the two agro-ecologies in the time used to cope with the feed shortage in their village. Respondents from highland agro-ecologies preferred to cope with the feed shortage they faced after or during its occurrence

Table 10 Coping mechanisms and time of implementation towards feed shortage

Overtime		Agro ecology		Overall	P value
		Highland	Midland		
Coping mechanism	Feeding enset	78(65)	183(65.35)	65.25	0.91
	Feed conservation Vs Enset	18(15)	43(15.35)	15.25	
	Renting grazing land	13(10.83)	24(8.57)	9.25	
	Selling livestock	11(9.16)	30(10.71)	10.25	
Coping time	Before occurrence	97(80.83)	255(91.07)	88	0.06
	After feed shortage	11(9.16)	10(3.57)	5.25	
	During feed shortage	12(10)	15(5.35)	6.75	

4.15. Enset Wilts Disease Prevalence and Experience

Enset wilt disease prevalence and farmers experience is presented table 10. All (100%)HHs respondents reported prevalence enset wilt disease in the study selected districts(Table11).A significant difference ($P<0.05$) was observed between the two agro ecologies in the enset wilt disease prevalence and seriousness. Similarly, a significant difference ($P=0.000$) in the occurrence of productivity and livelihood related challenges in the households of the two agro ecologies was observed. Farmer's knowledge and experience of enset wilt disease in year also showed a significant difference between the two agro ecologies. The result indicated that majority of the respondents (>95%) observed the disease starting from 30 years back. The prevalence of the disease was majorly stayed with experience and knowledge Regarding the Seriousness of enset wilt disease in the study selected districts highland was 12(10%) high, 32(26.6%) moderate, 43(35.83%) less and 33(27.5%) already recovering respectively. In the case of midland was 42(15%) high, 76(27.14%) moderate, 122(43.57%) less and 40(14.28%) already recover respectively. seriousness of enset wilt disease 42(15%) was higher midland when it with 12(10%) high highland. The seriousness of enset wilt disease was high a significant different ($p<0.05$) between highland and midland but moderate and less were no significant ($p>0.05$) between highland and midland.

Household's respondents in the study selected district highland and midland 100% realized livestock productivity affected by enset wilt disease, due to enset attacked by wilt disease and livestock no available to feed enset part, reduced productivity of manure, milk and meat. Impact of enset wilt disease on livestock production and productivity study districts highland was 97(80.83%) livestock productivity, 23(19.16%) increase producers (farmers) effort (search other feed resources), whereas, 236(84.28%) livestock productivity, 44(15.71%) increase producers (farmers) effort (search other feed resource), livestock productivity 236(84.28%) in midland is a bit higher as compared 97(80.83%) in highland(Table14).

Households respondents study districts highland and midland realized 100% enset wilt disease attacked all growth stage of enset plant. The pathogens attacks enset plants at any

stage including full maturity, the disease make the edge of enset leaf yellow and then wilting the leaves, and progressively all the leaves wilt, bend and decline finally it kill the enset plant (Table14). The consequence done enset wilt disease in the study areas were 85(70.83%) shortages of food-feed, 11(9.16%) decrease income, 9(7.5%) shifts to other income source and 15 (12.5%) decrease livestock productivity in highland. On the other hand, 206(73.57%) shortage of food-feed, 27(9.64%) decrease income, 20(7.14%) shift to other income source, 27(9.64%) decrease livestock productivity in midland (Table 14). The consequence done enset wilt disease was significant different ($p<0.05$) shortages of food-feed between highland and midland but no significant ($p>0.05$) decrease livestock productivity, decrease income and shifts to other income source between highland and midland.

Transmission of enset wilt disease by contamination 238(85%) was higher in midland than 95(79.16%) in highland, while 18(15%), 7(5.83%) and 23(8.21%), 19(6.78 %,) wind and other in highland and midland agro ecologies (Table11).

The existence time of the enset wilt disease at farm level highland was1-3 year 24(20%), 5-10 year 77(64.16%), 12-15 years 14(11.6%), 20 -30 years 3(2.5%), above 50-70 years 2(1.6%) respectively. In the case of midland was 1-3 year 47(16.78%), 5-10years 126(44.3%), 12-15 years 32(11.4%), 20-30 years 62(22.14%), above 50-70 years 13(4.64%) respectively (Table11).

Control method (experience) of enset wilt disease in the study districts in highland and midland were 88(73.3%) 32(26.6%) and 202(72.14), 78(27.78) sanitary and shifting fallow land. Control method was significant different ($p<0.05$) sanitary between highland and midland. There is no effective chemical bio control agent against enset wilt for farmers, the only wilt control method available sanitary including cutting and burring infected plant, restricting the movement of infected plant materials and use of clean farm tool.

Table11 Enset wilt disease prevalence, impact, consequences and experience in the study area (%)

Prevalence		Agro ecology		Overall	P value
		Highland	Midland		
Enset wilt disease degree of prevalence	High	12(10)	42(15)	13.5	0.017
	Moderate	32(26.6)	76(27.14)	27	
	Less	43(35.83)	122(43.57)	41.25	
	Already recover	33(27.5)	40(14.28)	18.25	
Impact of enset wilt disease on livestock	On livestock productivity	97(80.83)	236(84.28)	83.25	0.39
	demand for additional human power	23(19.16)	44(15.71)	16.75	
Different Enset disease related consequences	shortage of food-feed	85(70.83)	206(73.57)	72.75	0.00
	decrease income	11(9.16)	27(9.64)	9.5	
	shift to other income source	9(7.5)	20(7.14)	7.25	
	decrease livestock productivity	15(12.5)	27(9.64)	10.5	
Existence time of the disease at farm level	From1-3 years	24(20)	47(16.78)	17.75	0.00
	From5-10 years	77(64.16)	126(44.3)	50.75	
	From12-15 years	14(11.6)	32(11.43)	11.51	
	From 20-30years	3(2.5)	62(22.14)	16.25	
	Above 50-70years	2(1.66)	13(4.64)	3.75	
Transmission means	Contamination	95(79.16)	238(85)	83.25	0.000
	Wind	18(15)	23(8.21)	10.25	
	Other	7(5.83)	19(6.78)	6.5	
control method (experience)	Sanitary	88(73.3)	202(72.14)	72.5	0.000
	Shifting fallow lands	32(26.6)	78(27.78)	27.5	

Other=tundra, able eye; For highland (n=120); midland (n=280); overall=N=400)

5. DISCUSSION

5.1. Socio Economic Characteristics of Households

The observed proportion of male (63%) to female (37%) headed households in the study areas is lower than the average (75.9%) observed in Jimma town (Belay and Jansses, 2016). However, it is slightly higher (52.3%) than Haile et al. (2012) reportsin Hawassa town. Almost similar marital status proportion was observed in the two agro ecologies of the study area. The result is comparable with CSA 2020 report of the country i.e., above 60 % of the respondents are illiterate. When we compare the two agro-ecologies literacy level, the proportion of respondents from the highland areas (60%) show a significant difference as compared to midlands (70%). The observed difference might arise due to acquiring better education opportunities. The overall average of 32.5% in current study for education HHs much lower than the result 56.3% reported by (Selamawit et al., 2017) in north Achefer district of Amhara region, 90% reported by (Beriso et al., 2015) from Aleta Chukko woreda of Sidama zone in southern Ethiopia and 98.1% reported by (Belay and Janssens, 2016) Jimma town.

The average of age of respondents in the highland and midland agro ecology is similar (50 years). The observed average age (51.44±13.94) of respondent in the current study districts is higher than the result of 45.32±0.88 of Mohammed et al. (2016) from Omonada and Tiro Afata districts of Jimma zone (45.99±14.23) and from Biratu and Haile(2017) from south western Ethiopia. The overall average family size of household headsin the current study(4.95) is lower than a result reported Ahmed (2006), Kassa et al. (2015) and Asrat et al. (2016)which was 6.2 7.45 person per HH reported by 6.02 reported by (Belay and Janssens, (2016) from Jimma town and Wolaya Sodo town.

5.2. Land and Livestock Holding of the Study Area

All (100%) household respondents reported Enset cultivation farm owned in highland and midland agro-ecologies. The average enset cultivated farm per a current household study in highland and midland agro-ecologies was 29.09(0.24) and 56.52 (0.21) with overall 42.79(hectares) respectively. The estimated overall average land holding per household in this study i.e., 1.15 hectare is slightly higher than Belay and Negesse et

al.(2019) report i.e., 0.84 hectare. Similarly, the current finding was higher than the national average 1.06 ha/HH (CSA, 2016) and also of those reported by (Debela et al., 2017) and (Emana et al., 2017). But, it is less than the result of Demeke et al. (2017)in North Achefer; Geremew et al., 2017; Biratu and Haile, (2017) in Chire districts south western Ethiopia and Jimma Zone; Gurmessa et al., 2015) and Sinana districts (Yasar et al., 2016) in Amhara, SNNP and Oromia Region State. Who reported more than 2 hectare per HH.

The finding of this study indicates that the total average household level livestock holding (TLU) in highland and midland agro-ecology are 3.64 and 2.87, respectively. The overall average TLU is 3.14. The average cattle population holding / HHs/TLU in the current study area is lower than the Getachew and Tegene (2019) and Biratu and Haile et al. (2017). Regarding the availabilities of livestock feed resource the overall respondents of the study are indicated that natural pasture ((689(0.47)) is the primary feed resource of the study area followed by mixture of natural pasture and Enset ((300(0.21)); this study finding is In line with what has been reported by Selamawit et al. (2017) from watersheds of north Achefer district of Amhara region, and Abera et al. (2018) from selected districts of Sidama zone, southern Ethiopia as primary livestock production constraint. A significant proportion ($p<0.05$) of respondents confirmed that in the past decade, livestock species population trend on enset wilt affected area of Gurage zone shows a declining trend. This change might be associated with grazing and forest land changed to crop production land. On the other hand, an insignificant number of respondents agree on the increasing trend of cattle separately as compared to other livestock species. A significant population decrease is observed in the number of sheep both in the highland (35%) and midland (50.35%). Based on the researcher's observation, communal grazing land has been transferred to woman and youth crop production cooperative, FTC and schools.

Livestock holding of the Enset wilt affected areas showed a significant increase for the cattle and a constant population trend for sheep, goat and donkey. This might be due to various challenges on livestock production activities might force households to shift to other livestock keeping strategies. This can only be visible through studies that use long

years of population data and follow the trends of population structure and composition change due to different factors.

Livestock holding per household in numbers and in TLU in the study districts were 381.1total livestock, 271.8 cattle, 40.5 sheep and goat(shoat) and 68.8 equine respectively in highland and 643.67 total livestock, 522.82 cattle, 34.9 sheep and goat and 43.2equine respectively, in midland. From total TLU 1032.15 livestock annual DM required an estimated 1673.07 ton DM. Feed supply were 1470.58 ton DM. Feed DM satisfactory 85.1%, the result of current study area 85.1% was slightly higher than 80% available feed meet DM of the annual maintenance requirement of livestock in highland of Ethiopia reported by (Gizaw et al., 2017) but higher than 63% of national level reported by (Salo, 2017) (Table12)

5.3. Food and Feed Production Status of the Study Area

Adequate availability of quality food and feed is a basic requirement for human beings and livestock to perform well. Total grain yield 157.65 ton was ranked in highland followed by 132.94 in midland. and total crop residue267.08 ton was ranked first in highland followed by193.22 ton was ranked second in midland. Total grain yield 157.65 ton was higher in highland, when it with 132.94 ton compared in midland and total crop residues 267.08 ton was higher in highland when it with 193.22 ton compared in midland. The difference might be agro ecological production potential and land use crop production

The finding of this study indicated that the major feed resource in the study area is still natural pasture though various challenges decline in the production and quality of the available feed. Farmers' use a natural pasture and enset mix to solve a slight feed shortage challenge. This finding in agree with result of Menbere (2014) and CSA (2020), Gashe et al.(2017), Gashaw and Defar (2017), Megersa et al.(2017) and Belay and Negesse et al.(2019). Feed (DM) availability in a different season of the year highland and midland in the study selected districts are strongly influenced by different seasonality of the year. In the study area of highland and midland agro-ecologies natural pasture 69.4 ton and 256 ton, Enset232.72 ton and452.16 ton and crop residues222.53 ton and 193.22

ton were major livestock feed resources in different seasons. Other feeding resource constraints included a scarcity of grazing land, land degradation and low biomass yield, low quality and variable feed across the season, low adoption of improved forage production, labor shortage, limited access to the feed market, and inadequate extension service in both agro-ecologies of the study district have been reported by Ayele et al. (2021) as major constraint of feed availability in western Ethiopia.

All (100%) household reported feed supply shortage observation in the study areas highland and midland agro ecologies. Main reason livestock feed supply shortage in current study selected districts was 254(90.71%) and 85(70.83%) declining communal land and grazing lands in highland and midland, while 19(15.83%) and 12(4.28) was declining crop-residue by climate change and yellow rest.

Livestock production in the study area was majorly constrained in adequate feed resource (1012(0.76)), followed by vet.service (181(0.135)) and poor livestock production performance ((104(0.078)) were ranked first; second and third major challenging factors for livestock production in enset wilt affected areas. In line with this Duguma and Janssen (2021) study in Gilgel Gibe Catchment, Southwest Ethiopia Feed shortage, high prevalence of diseases, and poor genetic potential of the local livestock breeds were reported to be the major challenges to livestock production.

5.4. Major Feed Related Challenge of Livestock Production in Enset Wilt Affected Areas

Major feed related challenges of Enset wilt affected areas of Gurage zone is presented in figure 3. Shortage of land was the primary challenge of feed resource availability problem followed by dry time shortage of feed in both agro ecologies of the study area. Declining grazing land and Enset wild disease prevalence were ranked third in the highland and midland, respectively. This might be increasing human population,grazing land changed to crop land, Enset product as livestock feed dameged by enset wilt disease.

5.5. Enset as Feed Resource

Important of cultivated enset in the study selected districts was 217(77.5%) and 87(72.5%) multipurpose nature for food-feed, 28(10%) and 14(11.6) used as livestock feed, 27(9.64%) and 16(13.3%) resistance to natural hazarded (drought, flood) and 8(2.86%) and 3(2.5%) source of income in midland and highland. The result of current study corresponds with the result of Mulugeta(1996), Brandt et al. (1997), Nurfeta et al.(2008) and Dirsha et al. (2019) who stated that Enset is a multipurpose crop including human food, animal feed, fiber(industrial crop), construction materials and traditional medices. Enset plant mostly used as livestock feed season in current study area was 116(96.66%) and 267(95.35%) dry season in highland and midland and 13(4.42%) and 4(3.33%) year round in midland and highland. Similar statement was made by Dereje(1996) and Menber(2014) who reported that Enset parts major source of feed during dry season.

Majority of household respondents reported Enset population dynamics in highland and midland agro ecologies was declining. The current result agreement with reported by(Yemataw et al., 2016)

The reason of declining enset population current study ranked first 249(88.9) and 104(86.6%) with overall (353)88.25 were disease (Enset wilt), followed by 31(11.07%) and 16(13.3%) with overall (47)11.75% were a combination of disease, wild animal and poor management in midland and highland agro ecologies. The current result agreed with reported by(Tariku Hunduma et al., 2015)

Enset races (Colony) in the study areas highland and midland used multipurpose for food and feed, and traditional medicine. Households reported that different races (Colony) of enset such as Agade, Nemare, Yeshire fire (kinike), Badet, Eniba, Bosore, Tereriye, Shawar, Gibuwe, Nechuwe, Kanchuwe and Shertiye are common in current study areas highland and midland agro ecology, the dominate race or colony of enset were Agade, Eniba and Namare , followed by Nechuwe, Bosore and badet. On the other hand, some race (colony) enset such as Astare, Guarye, Kibnar, Ameratye and Derye are mainly used as traditional medicine for human and animal towards healing broken and fractured bones

of legs and arms, curing wounds, reducing pain of damaged bone. The result of the current study is some Enset race (colony) used traditional medicine and agreed with the reported (Getahun et al., 2020).

5.6. Impact of Enset Wilt Disease on Feed Availability

The relation between livestock composition and Enset wilt diseases prevalence on the livelihood of respondents in the current study selected districts household indicated 100% livestock composition size decrease, livestock performance and production decreased (body lost and shrink, manure, milk and meat), livestock production shifting to crop production. Enset wilt disease prevalence attacked enset (decreased enset population), decreased enset products (leaf, leaf and midribs, pseudo stem and corms) livestock feed,, and shifted enset production to crop production and lack organic fertilizer manure to fertilizing soil.

Household respondents in the study selected district highland and midland 100% realized livestock productivity affected by enset wilt disease, due to enset attacked by wilt disease and livestock not available to feed enset part, reduced productivity of manure, milk and meat. Impact of enset wilt disease on livestock production and productivity study districts highland was 97(80.83%) livestock productivity, 23(19.16%) increase producers (farmers) effort (search other feed resources), whereas, 236(84.28%) livestock productivity, 44(15.71%) increase producers (farmers) effort (search other feed resource), livestock productivity 236(84.28%) in midland is a bit higher as compared 97(80.83%) in highland. This might be enset wilt disease severity a bit higher midland than highland.

Households respondents study districts highland and midland realized 100% enset wilt disease attacked all growth stage of enset plant. The pathogens attacks enset plants at any stage including full maturity, the disease make the edge of enset leaf yellow and then wilting the leaves, and progressively all the leaves wilt, bend and decline finally it kill the enset plant.

The consequence done enset wilt disease in the study areas were 85(70.83%) shortages of food-feed, 11(9.16%) decrease income, 9(7.5%) shifts to other income source and 15

(12.5%) decrease livestock productivity in highland. On the other hand, 206(73.57%) shortage of food-feed, 27(9.64%) decrease income, 20(7.14%) shift to other income source, 27(9.64%) decrease livestock productivity in midland. This might be Enset product as livestock feed damaged by Enset wilt.

Transmission of enset wilt disease by contamination 238(85%) was higher in midland than 95(79.16%) in highland, while 18(15%), 7(5.83%) and 23(8.21%), 19(6.78 %,) wind and other in highland and midland agro ecologies. This might be Farm tool contamination and movement of insid Enset filed browsing wild animals

Existence time of the enset wilt disease at farm level were 1-3year 24(20%), 5-10year 77(64.16%), 12-15years 14(11.6%), 20-30years3 (2.5%), above 50-70 years 2(1.6%) respectively in highland. In the case of midland was 1-3 year 47(16.8%), 5-10years 126(45%), 12-15 years 32(11.43%), 20-30 years 62(22.14%), above 50-70 years 13(4.64%) respectively. This could be farmers were not know as the cause of problem

Control method (experience) of enset wilt disease in the study districts in highland and midland were 88(73.3%) 32(26.6%) and 202(72.14), 78(27.78) sanitary and shifting fallow land. The result was agree with reported by (F.handoro,2017)

There is no effective chemical bio control agent against enset wilt for farmers, the only wilt control method available sanitary including cutting and burring infected plant, restricting the movement of infected plant materials and use of clean farm tool.

Enset destroyed by enset wilt disease household done in the study districts was 64(53.3%) replaced by cereal crop, vegetable, potato and cabbages, 2(1.66%) shifting fallow land, 50(41.66%) no replaced and 4(3.33) other (replace enset) in highland. Similarly 148(52.86%) replaced by cereal crop, vegetable, potato and cabbages, 23(8.21%) shifting fallow land 99(35.36) no replaced and10 (3.57) other (replace enset) in midland.

Key informants report witnesses that household respondents in the study districts highland and midland back yard destroyed by enset wilt replaced cereal crop, vegetable, potato and cabbage for 1-3years56(46.6%), 4-6 year 10(8.3%), 10 years7(5.83%) and

54(45%) other (free and replaced the previous hole) respectively in highland. Whereas, replaced by cereal crop, vegetable, potato and cabbage for 1-3 years 107(38.21%), 4-6 year 41(14.64%), 10 years 1(0.36%) and 124(44.28%) other (free and replaced the previous hole) respectively, in midland.

5.7. Chemical Composition and Nutritive Value of Feed Resource in Enset Wilt Affected Area

The Chemical composition and nutritive value of the major feed stuff utilized for livestock feeding in the selected study districts were indicated in (Table8) and the dry matter (DM) content of the feeds available for livestock feeding in highland ranged from 90.72 to 93.34. Whereas, DM content of the feed available for livestock feeding in midland was ranged from 89.27 to 94.86. DM content of the feed available for livestock feeding varied highland and midland. The variation observed could be attributed to difference environmental condition (climate, soil type, rain fall and temperature) of the tow agro-ecologies.

The crude protein (CP) content over minimum and minimum level (10.52% and 7.13%) was from field pea and natural pasture in highland and mid land. Crude protein from natural pasture study district highland and midland agro-ecologies, respectively, had content of 6.62% and 7.13%. The value for crude protein content of natural pasture from midland was a bite higher than that of highland. Such a bite difference may be associated with the reduction in the proportion of legumes in the pasture with a decrease in altitude and this is in line with the finding of Mekuanint and Girma (2017). The crude protein (CP) content of available livestock feed ranged from 4.32% wheat straw, 4.91% Enset and 5.28% barley straw in highland and 44.4% teff, 4.68% wheat straw and 5.67% barley straw in midland. The percentage of CP obtained from natural pasture, Enset, wheat straw, barley straw, field bean in highland and Enset, wheat straw, barley straw and teff straw in midland was that are considered as available feed resources for livestock feeding in the current study area is lower than that set as a minimum level of nitrogen (7%) to limit intake (Milford and Minson, 1966; VanSoest, 1982).

Digestible crude protein (DCP) content of natural pasture and Enset current study was ranged from 58.02to 42.13 and 62.76 to 54.49 in highland and midland. DCP content of annual crop residues in current study was ranged from 36.65% to 39.99% and 45.57% to 49.20% wheat and barley straw in highland and midland.

The in vitro dry matter digestibility (IVDMD) from identified feed resources in the study area ranged from 67.89 to 48.46 field pea straw and wheat straw in highland and 63.08 to 53.06 from Enset and wheat straw in midland. The IVDMD content of identified feed resource were 36.65, 52.89, 53.09, 62.45, 65.43 and 67.89 were from wheat straw, natural pasture, barley straw, Enset, fabab pea straw and field bean was respectively in highland and 53.06, 53.64, 54.08, 55,16 and 63.08 were from wheat straw, natural pasture, barley straw, teff straw and Enset was respectively in midland.

The energy content of identified feed resources in the current study area was ranged from 10.2 MJ/kg DM to 7.3 MJ/kg DM from field pea straw and wheat straw in highland and 9.4 MJ/kg DM to 7.9 MJ/kg DM from Enset and barley straw in midland. The energy content of natural pasture in current study district was 7.9 MJ/kg DM in highland and 8.04 MJ/kg DM in midland which is comparable with the report of Demam (2018) 8.39 MJ/kg DM and 8.15 MJ/kg DM. Metabolizable energy content of identified feed resources were 7.9 MJ/kg DM, 9.4 MJ/kg DM, 7.3 MJ/kg DM, 7.9 MJ/kg DM and 9.8 MJ/kg DM was from natural pasture, Enset, wheat straw, barley straw and faba bean straw respectively in highland and 8.04 MJ/kg DM, 9.4 MJ/kg DM, 7.9 MJ/kg DM and 8.3 MJ/kg DM from natural pasture, Enset, wheat straw and teff straw were respectively in midland. Ayele et al. (2021) on his study finding indicated that almost all accessible feed supplies are chemically and nutritionally deficient, especially during the dry season.

5.8. Feed Balance of the Study Area

The feed requirement of livestock in terms of DM, DCP and ME per TLU for maintenance were estimated based on the recommendation by Kearl(1982) and McCarthy(1986) for TLU. The estimated annual DM, DCP and ME available (supply) for maintenance of this study in highland and midland agro ecologies i.e., 524.65 and 901.38ton/year feed DM satisfy(met) 85.23%, 23979.86 and 49014.83g/year feed DCP

satisfy (met) 76.96% and 3538749.82 and 7377346 MJ/kg DM/year feed ME satisfy (met)76.14%, respectively is in contrast with report of Tahir et al., (2018) in mixed crop livestock system of Ethiopia which was only about 49, 81 and 62% of DM, ME and DCP requirements are fulfilled, respectively, with the current amount of feed supply from on farm production combined with purchased feeds. In addition, several previous study findings (Wondatir et al., 2011; Amsalu and Addisu, 2014) in the MCL system support the present report which confirms the limited nutrient level supplied for livestock in the system.

5.9. Feed Shortage Coping Strategies

All respondents from the highland and midland agro ecologies of this study have the experience of conserving livestock feed conservation current study highland and midland; HHs respondents reported 100% practiced of livestock feed conservation, to reduce the shortage and problem of feed supply in dry and extreme drought season.

In the current study area coping strategies towards feed shortage in enset wilt affected area practiced 183(65.35%) and 78(65%) with overall 261(65.25%) was ranked first feeding enset, followed by 43(15.35) and 18(15%) with overall 61(15.25%) was ranked second feeding conserved feed and enset in midland and highland. Ranting grazing land and sealing their livestock (livestock to alleviated the feed shortage problem) was 13(10.83), 24(8.57) and 11(9.16), 30(10.71) in highland and midland. In line with this study finding, an inflow from natural perpetuation and purchase of animals, and an outflow due to death, sell and slaughter, and shared rearing of animal in either case could all happen within the year following the scarcity and availability of feed at household level (Tahir et al., 2018).The report of Ayele et al. (2021) in Kellem Wollega Zone, Western Ethiopia also indicates that there has been seasonal fluctuation in the feed availability. The feed supply in terms of DM, ME, and DCP per household per year was 118.7 kg, 74,781 MJ/kg, and 118.61kg, respectively similarly showed a negatively associated and substantially different all across ecologies. It is an established fact that quantity and quality of feed available from natural pasture are affected by season nutritional composition and quality, and in individual animal body and in the livestock herd in the annual production process (Moore et al., 2009).This study finding also

indicated that coping strategies implementation difference also host a difference in study selected districts highland was 97(80.83%) before emergency of feed shortage, 11(9.16%) after emergency of feed shortage and 12(10%) during emergency of feed shortage, and it was midland 255(91.07%) before emergency of feed shortage, 10(3.57%) after emergency of feed shortage and 15(6%) during emergency of feed shortages. In contrast with this study, a study by Duguma and Janssen (2021) reported that conserving crop residues and hay, purchasing roughages, reducing herd size and renting grazing land were the major coping strategies to feed scarcity in Gilgel Gibe Catchment, Southwest Ethiopia.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

Livestock's are the major source of food, feed, manure and power in different societies of the Ethiopia. It is also source of immediate income and insurance to the households and further support agricultural sustainability and food scarcity. After long years of adaptation and experience with enset crop, Gurage community further associated livestock with the existence and productivity of enset crop. The mutual benefit between livestock and crop basically in the mixed crop livestock system can robustly visible in Enset based agricultural system where livestock manure is the only source organic fertilizer used for production of enset crop. The study concludes that natural pasture 689(0.47) is still the major feed resource but in the declining nature and the role of crop residue and enset crop as feed resource was showing a significant increase both in the midland and highland agro ecology. The crop residue was majorly sourced from two crops (Wheat; Barley) both in the highland and midland. Significant Enset based crude protein supply difference was observed between highland and midland agro ecologies. Other crops (Teff; Faba bean; Field pea) contribution was very low as compared to the above mentioned cereal crop contribution as crop residue. At present, the available annual livestock feed dry matter 85.23%, metabolizable energy76.96% and digestible crude protein 76.14% supplies to livestock by enset wilt affected areas of the zone did not match the required demand. Comparably, higher DM/tone based feed supply deficit (-155.73) was seen in the Midland agro ecology. Similarly, a higher feed supply and demand difference was observed when we compare highland (-1,443,652.82) and midland (-1,159,939.65) agro ecology. Even though cattle population trend of the study area on a decadal base showed an inclining nature, the feed insufficiencies affected all the livestock species. However, the finding can witness the impact of Enset wilt disease on livestock species dynamics and population. Feed shortage at dry season and dearth periods of Enset wilt affected areas of Gurage zone was tackled by trusting on feeding Enset plant, feed conservation and selling livestock, respectively.

Livestock feed supply and demand Even so natural pasture crop residues and enset were declining in different factors such as grazing land gradually changed to crop production,

crop residues productivity decreased by environmental change yellow rest and enset product (leaf, leaf and mid ribs) feed as livestock destroyed by enset wilt disease. However, feed balance underway deficit feed balance. Seasons have own factor for feed supply dry season sever feed scarcity and shortage ,farmers have experience coping feed shortage and scarcity before and during emergency of feed shortage conserving hay, crop residues and feeding enset part. The observed feed deficiency in the study area was impairing livestock productivity in the area. Moreover, the available feed resources hampered utilization efficiency. Thus, post-harvest management expertise must be paired with improving feed resource use efficiency.Livestock population trends in the past decade in the study area shows that cattle population continuous increase.

6.2. Recommendations

Based on the finding of the stud authors recommend the following points that it was help to improve the feed availability of the areas under similar circumstance. Interventions that focus on rehabilitation grazing lands by implementing different rehabilitation techniques and introducing and promoting well known locally adaptable leguminous forages and fertilization with livestock manure and droppings can enhance the feed availability of the area under enset wilt infection. For more efficient utilization of the available feed resources such as crop residues, trainings that understanding towards feed treatments should be introduced and practiced. Validated Enset wilt disease controlling mechanisms should be introduced and implemented. Well-developed database regarding livestock and crop species population and their production level at zonal and district level is very crucial for areas like Gurage zone that are significantly dependents on livestock in addition to the intensity other mixed crop-livestock production systems provide.

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8. APPENDICES

Appendices1(Taken Pictures)

***Appendices1* (QUESTIONNAIRE)**

Thank you for being willing to take part in this interview, which is the key input for this research. The research is mainly for the fulfillment of MSc. degree in Animal Production. In doing so, it will attempt **"LIVESTOCK DYNAMICS, FEED BALANCE AND COPING STRATEGIES OF ENSET BASED AGRICULTURAL SYSTEM OF GURAGE ZONE: PROSPECT TOWARDS ENSET WILT"** Thus, the output of the research will be a key input for livestock producers livelihood. The quality of this research is heavily depends on the quality of information you provide here. I first assure you that the information you provide is kept confidentially and only used for research purpose. Therefore, could you please give me a couple of your time and give answers for the questions I will ask you!
Once again, thank you very much!

1. Personal Information

1.1. Name of enumerator ----------
1.2. Name of respondent (optional) ----------
1.3. PA/Kebele ----------
1.4. Village (Got) ----------
1.5. Sex ----------
1.6. Age ----------
1.7. Marital status 1.Single 2.Married 3.Divorced 4. Widow 5. Widower
1.8. Education of the interviewee 1. Illiterate 2. Can read and write 3. Primary education (1-4) 4. Junior (5-8) 5. Secondary education (9-12) 6. College 7. Other (specify) -------
1.9. Total family size 1= below 3 2 = 3-8 3= Above 8

SECTION1

Landholding and its use pattern

1. Total area of land owned by the household,----------ha
2. Allocation of land by household for different uses
   1. Annual crop-----ha, 2. Enset-------ha, 3. Perennial crop-------ha, 4.Graging land------ha, 5.Forest------ha, Garden potato and vegetable---------ha

SECTION 2

Livestock related questions

1. Do you own livestock? 1. Yes 2. No
2. When did you start keeping livestock?
   1. 10 years before 2. 10-20 years 3.20-30years 4. Above 30 years
3. If yes, how many livestock's in terms of species?

Species		Total number of animals
Cattle	Dairy cow---------,bull/ox----------,heifer----------,calves---------	
Sheep	Ewe----------, ram----------, lamb----------	
Goat	Nanny---------, Buck----------, kid----------	
Chicken		
Horse		

Donkey		

4. Does the livestock composition difference with in some periods? 1. Yes 2. No
5. If your answer is yes, what is the reason?
   1. Declining of communal and grazing land 2. Predator 3. Absence of managing man
6. When do you think the composition transition or difference started observing?
   1. 10 years before 2. 10-20 years 3.20-30years 4. Above 30 years
7. What is the reason shifting?
   1. Declining grazing land
   2. Disease
   3. Wild animal attacked
   4. Shortage of feed in dray season
   5. Shortage of feed in wet season.
   6. Others_____
8. From which species to which species have you been shifted?
   1. From cattle to small ruminant and chicken
   2. From small ruminant, chicken and equine to cattle
   3. From equine to small ruminant and chicken
   4. From small ruminant and chicken to cattle 5. No compost ion shift
9. How is the trend in the of livestock population size after past three decades?
   1. Increasing.
   2. Declining
   3. No change
10. If your answer is declining, what is the main reason?
    1. Feed shortage 2. Disease. 3. Drought. 4. Wild animals 5. Other(specify)----------
11. What does feed shortage mean for you?
    1. Inadequate feed supply 2. Inadequate grazing land 3. Inadequate feed conserved 4. Others----------
12. Which livestock species population declining?
    1. Cattle 2. Sheep and goat 3. Chicken 4. Equine
13. Which livestock populations have been showing an increasing trend?
    1. Chicken 2. Cattle 3. Sheep and goat 4. Equine

Section 3

Status of feed balance under Enset livestock production system

1. What is the major livestock feed resources in your village?
   1. Natural pasture 2. Crop-residue 3. Improved forage 4. other(specify)----
2. What is the major annual crop in your farm/village? 1. Wheat 2. Barley 3. Teff 4. Maize 5. Pea 6.Bea
3. What is the major challenge of livestock production? Monition1,----------,2,----------3,----------4,----------,
4. What kind of livestock keeping system you have been using?
   1. Extensive, communal land
   2. Extensive, with no communal land
   3. Intensive(Indoor), with feed from back yard
   4. Intensive(Indoor), with purchased feed
5. Do you have communal grazing land in your village? 1. Yes 2. No
6. How far is the communal land from your house? _____ km/ local measure
7. Do you know your livestock feed demand based on your livestock species? 1. Yes 2. No
8. If yes, How much/day

SN	Species	Demand/ kg	Supply per available measuring material

1	Cattle		
2	Sheep		
3	Goat		
4	Chicken		
5	Horse		
6	Donkey		

Estimate the equivalence used for material used for measurement

9. If your answer is No, what is the reason?
   1. Shortage of feed supply 2. Increment of feed demands 3. Other_____
10. Have you been observed feed supply shortage? 1. Yes 2. No
11. What is the reason for feed supply shortage?
    1. declining grazing and communal land 2. Declining crop-residue by climate Change and yellow rust 3. Others_____
12. Does Enset used as livestock feed in your village? 1. Yes. 2. No.
13. If your answer is yes, which part of the Enset is mostly used as livestock feed?
    1. Leaf 2. Mid ribs 3. Pseudo stem and leaf 4. Corms.
14. Do think feed supply shortage is associated with more use Enset availability and productivity?
    1. Yes 2. No
15. If your answer is Yes, How?
    1. Livestock productivity declines with it
    2. Shortage of livestock product supply
    3. Increased feed purchasing cost
    4. Increased seal of livestock at the time
    5. Others_____
16. Reason for the importance of cultivating Enset plant in your farm?
    1. Resistance to natural hazard (drought, flood)
    2. Its multipurpose nature (food and feed)
    3. Its use as livestock feed
    4. Source of income
17. In which season of the year Enset plant used as livestock feed?
    1. Dry season 2. Wet season 3. Year round
18. Do enset parts have association with season? 1. Yes 2. No
19. If your Answer is yes, please associate. ----------
    ----
20. Do livestock importance in the production and productivity of Enset? 1. Yes 2. No
21. If yes, mention its importance and Prioritize? ----------
    ----

SECTION 4

Feed shortage coping strategy used by householder

1. Have you been faced feed shortage in your past? 1. Yes 2. No
2. When was that? Specify using year. _____
3. Do you have the experience of livestock feed conservation? 1. Yes 2. No
4. If yes, what type of feed conserved? 1. Hay 2. Crop-residue 3. Other(specify)----------
5. When do you think livestock feed is surplus? Please write the seasons/ months_____
6. What does it mean by Dry season and wet season?

1. Dry season? ----------
2. Wet season? ----------

7. Please, Specify each season in terms of months.
   1. Dry From_____ to _____
   2. Wet From _____to_____
8. Which season of the year feed shortage is sever? 1. Dry B, Wet
9. If your answer is dry, mention the month ----------
10. In what season do you experience feed shortage? 1. Dry. 2. wet
11. If your answer is dry season, please specify the reason?
    1. Shortage of land
    2. Shortage of water
    3. Availability of forage variety
    4. Disease
    5. Climate change
12. Do you observe shortage feed in wet season? 1. Yes 2. No
13. What is the reason? 1. Water logging 2. Draught 3. Other(specify)
14. When do you adopt coping strategies?
    1. Before emergence of feed shortage
    2. During emergence of feed shortage
    3. After emergences of feed shortage
15. What kinds of livestock feed coping mechanisms have you been tried?
    1. Feeding Enset plant
    2. Feeding conserved feed
    3. Feeding conserved feed and Enset
    4. Purchasing agro-industrial by product
    5. Sealing your livestock
    6. Change your livestock composition (Cattle; Sheep; Goat)
    7. Others_____

SECTION 5

Effect of Enset wilts disease on feed availability

1. Do you have own Enset plant farms? 1. yes 2.No
2. If yes, how many hectare/ *tamed*----------
3. Which variety of Enset? And how many? (prioritize)----------
4. From where you brought the seedlings?
   1. From my own nursery
   2. From market
   3. From neighbor
   4. Far from other village
   5. Improved from agricultural centers
   6. Others_____

5. When did you start cultivating Enset plant?
   1. before 30 years
   2. 30-20 years
   3. 20-10
   4. 5-10
6. Does all enset landraces use as livestock feed? 1. Yes 2. No
7. Indicate the dynamics of Enset plant population in your yard? 1. Increasing 2. Declining

8. If your answer is declining, what is the reason? (Rank)
   1. Disease
   2. Wild animals attack
   3. Drought (water shortage)
   4. Poor management 5. Others (specify) ----------
9. Do all varieties of Enset declines similarly? 1. No 2. Yes
10. If your answer is No, please indicate which varieties of enset have been showing a declining effect in the past few years.----------
11. Do you have occurrence of Enset wilt disease on your farm/village 1. Yes 2. N0
12. If yes, what is the transmission of Enset wilt disease? 1. Contaminated farm tool and livestock movement inside Enset field 2. Wind 3. Wild animal
13. How to control transmission of Enset wilt disease?
    1. Sanitary measurement 2. Chemical measurement 3. Shifting fallow lands 4. Others----------
15. For how many years does Enset wilt disease appeared on your farm/village? -----
16. Is your farm currently affected by Enset wilt? 1. Yes 2. No
17. Seriousness of Enset wilts disease on your farm?
    1. Highly 2. Moderate 3. Less 4. Already recovered
18. Do you think Enset wilt disease affect livestock productivity? 1. Yes 2. No
19. What is the impact of Enset wilt on livestock production and productivity?
    1. Livestock productivity
    2. Livestock composition (Availability of different feed types)
    3. Increase Producers(farmers) effort(search for other feed source)
    4. Others_____
20. Enset wilt disease attacks all growth stage of Enset plant? 1. Yes 2. No
21. What consequences do Enset wilt disease has brought to your village and house?
    1. Food Shortage
    2. shortage of feed
    3. shortage food-feed
    4. Decrease income
    5. Shift to other production system
    6. Shift to other income source
    7. Decrease livestock productivity
22. If Enset wilt disease destroyed Enset in your back yard, what will you do?
    1. Replaced by cereal crop, vegetable and potato 2. Shifting fallow land 3. Other(specify)-----
23. If your answer is, replaced by cereal crop, vegetable and potato? For how many years ----------

Appendices2 (Tables)

Table 13. Mean (±SD) land holding; Cultivation and land cover HH in the study area

Land allocation for different activity	Agro ecology				Overall average	
	Highland		Midland			
	Mean (±SD)	Rank	Mean (±SD)	Rank	Mean (±SD)	Rank
Landholding/ HHs	1.15±0.47	**	1.52±0.28	**	1.34 ±0.37	**
Annual crop	0.50±0.11	1	0.63±0.33	1	0.59±0.29	1
Vegetable	0.05±0.01	4	0.04±0.05	6	0.04±0.04	6
Potato	0.05±0.005	4	0.02±00	7	0.03±0.01	7
Enset	0.22 ±0.97	3	0.21±0.08	3	0.21±0.08	3
Perennial crop	0.005±0.09	6	0.16±0.11	4	0.11±0.12	4
Grazing	0.29±0.057	2	0.31 ±0.086	2	0.31±0.08	2
Forest	0.03 ±0.01	5	0.13 ±0.052	5	0.10 ±0.06	5

SD=standard deviation; ** mean not considered for ranking

Table 14. Grain and crop residue yield in the study areas (Area/ha; yield /ton)

Major crop type	Agro ecology									
	Highland(n=120)					Midland(n=280)				
	Cultivated area	Productivity	Total grainyield	Conversion factor	residue yield/ha	Cultivated area in ha	Productivity per ha	Total grain yield Per ton	Conversion factor	residue yield per ton
Wheat	12.5	41.35	51.68	1.5	77.52	17.5	41,35	72.36	1.5	108.54
Barley	18	33.5	60.3	1.5	90.45	12	33.5	39.96	1.5	59.94
Teff	-	-	-	-		14.3	14.42	20.62	1.5	24.74
F pea	6.99	18.9	13.21	1.2	15.85	-	-	-	-	-
F bean	14.8	21.8	32.26	1.2	38.71	-	-	-	-	-
Total	62.48	-	157.6	-	222.53	31.8	-	132.94	-	193.22

F pea=faba pea, F bean=field bea

Table15. Feed (DM) availability (supply) on different season of the year in the study area

DM availability	Agro ecology					
	Highland(n=120)		Midland(n=280)		Total	
	n(index)	Rank	n(index)	rank	N(Index)	
Natural pasture(Sept-Jun)	69.4(0.12)	3	256(0.27)	2	325.4(0.21)	2
Crop residue(Dec-Feb)	222.53(0.48)	1	193.22(0.26)	3	415.75(0.34)	3
Enset(Oct-May)	232.72(0.39)	2	452.16 (0.47)	1	684.88(0.44)	1
Total	524.65	2	901,38	1	1543.98	1

DM=dry matter, t=represent of dry matter per ton

Table 16 Estimated annual feed supply from identified feed resource in the study area

Feed stuff	Agro ecologies					
	Highland			Midland		
	DM(t)	DCP(kg)	ME(MJ)	DM(t)	DCP(kg)	ME(MJ)
Natural pasture	69.4	4026.59	54862	256	16066.56	2058240
Enset	232.72	9804.5	218756	452.16	24638.2	4250304
Wheat straw	77.52	2841.11	565,896	108.54	4340.5	857466
Barley straw	90.45	4121.80	714,555	59.94	2949.05	5994
Field pea straw	15.85	1493.86	161670	-		
Faba bean straw	38.71	1692	379358	-		
Teff straw	-			24.74	1020.52	205342
Total	**524.65**	**23979.86**	**2095097**	**901.38**	**49014.83**	**7377346**

Table 17. Farmers coping strategies towards Enset wilt disease impact management

Strategies and implementation		Agro ecology		Overall%
		Highland(n=120)	Midland(n=280)	
Farmers' coping strategies towards Enset wilt disease	Replaced	64(53.3)	148(52.86)	53
	Shifting to fallow land	2(1.6)	23(8.21)	5.75
	no replace	50(41.6)	99(35.36)	37.25
	Other	4(3.3)	10(3.75)	3.5
If your answer is, replace, for how many years	Fo1-3 years	56(46.6)	107(38.21)	40.75
	For4-6 years	10(8.3)	41(14.64)	12.75
	For10years	7(5.83)	1(0.36)	2
	Other	54(45)	124(44.28)	44.5

Other= free and replaced the previous hole

Table18.Enset part used as livestock feed season of the year and relationship in the stud area

Variables		Agro ecology		Overall %
		Highland(n=120)	Midland(n=280)	
Important of cultivated enset	resistance to natural hazarded(drought)	16(13.3)	27(9.64)	10.75
	Its multipurpose nature(Food and feed	87(72.5)	217(77.5)	76
	it is used as livestock feed	14(11.6)	28(10)	10.5
	source of income	3(2.5)	8(2.86)	2.75
Enset part used as livestock Feed?	Yes	120	280	100
	No	0	0	0
Part of Enset used as livestock feed	Leaf	-	-	-
	Leaf and midribs	96(80)	217(77.5)	78.25
	Whole part of enset	24(20)	63(22.5)	21.75
Season of the year enset plant used as livestock feed	Dry	116(96.66)	267(95.36)	95.75
	Wet	-	-	-
	Year round	4(3.33)	13(4.64)	4.25
The relation between livestock and enset (Ensete ventricosum) production and productivity	Enset serves as sourc e of livestock feed	120	280	100
	Some verity enset medicine for livestock	120	280	100
	Enset product fiber tethering with home and outside livestock	120	280	100
	Livestock provide manure to fertilize enset fields	120	280	100

Numbers in bracket represent numbers of percentage per agro ecology

Appendices3 Figurs

Figure2. a, b, c and d indicates enset part used as livestock feed.

a,

b,

c,

d,

Figure3. a and d indicates experience of livestock feed conserved in shade and picture b and c indicates experience of feed conserved without shade.

a,

b,

c,

d,

Ficgure4. a, and b, indicates adopt coping strategies and picture c and d indicates coping mechanism.

a, b,

c, d,

Figure5. a, b. c and d indicates occurrence of enset wilt on their farms and seriousness of enset wilt disease .

a, b,



d

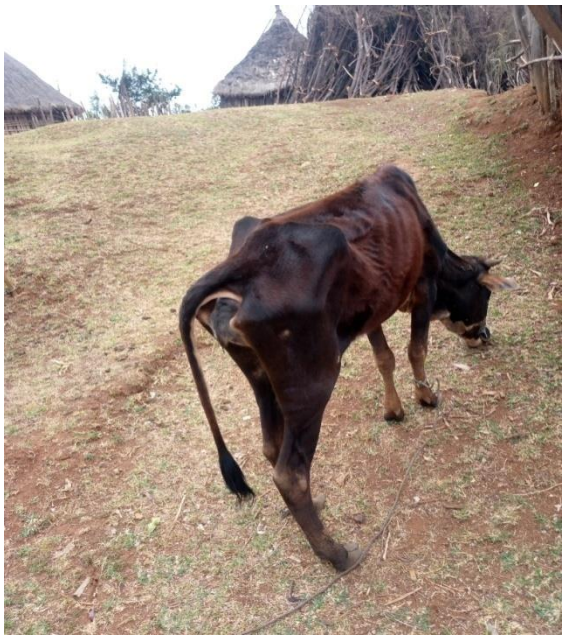
c


C, d

Figure6. e, f, g and h indicates impact of enset wilt disease on livestock production and productivity.

e,

f,



g,

h,

Figure 7 Laboratory feed DM,CP and IVDMD

Figure . undertaking laboratory feed sample analysis procedure at Holleta