EVALUATING GREENHOUSE GAS EMISSIONS AND IDENTIFYING INTERVENTIONS FOR INTENSIFICATION OF DAIRY VALUE CHAINS IN WUKRO-KILTEAWLAELO DISTRICTS NORTHERN ETHIOPIA

M.Sc. THESIS

TEAME HAILU GEBRETEKLE

HAWASSA UNIVERSITY, WANDO GENET COLLEGE OF FORESORY AND NATURAL RESOURCE, WONDO GENET, ETHIOPIA

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TEAME HAILU GEBRETEKLE

A THESIS SUBMITTED TO THE

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DECLARATION

I declare that this MSc. Thesis entitled" Evaluating Greenhouse Gas Emissions And Identifying Interventions For Intensification Of Dairy Value Chains In Wukro-Kilteawlaelo Districts Northern Ethiopia " is my original work and has not been submitted for the degree of award in any other university, and all sources of material used in this thesis have been duly acknowledged.

Teame Hailu Gebretekle	______________	____________
Name of student	Signature	Date

ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled "Evaluating Greenhouse Gas Emissions And Identifying Interventions For Intensification Of Dairy Value Chains In Wukro-Kilteawlaelo Districts Northern Ethiopia" submitted in partial fulfillment of the requirements for the degree of Master's with specialization in climate smart agricultural landscape assessment, the Graduate Program of the Department of Agroforestry, and has been carried out by Teame Hailu Gebretekle Id. No, GPCSALR/016/011 under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Tefera Belay (PhD)		10/10/2020
Name of major advisor	Signature	Date

EXAMINERS' APPROVAL SHEET

We, the undersigned, members of the board of examiners of the final open defense by Teame Hailu Gebretekle have read and evaluated his thesis entitled "Evaluating Greenhouse Gas Emissions And Identifying Interventions For Intensification Of Dairy Value Chains In Wukro-Kilteawlaelo Districts Northern Ethiopia" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of climate smart agricultural land scape assessment.

______________________________,	______________	___________
Name of the Chairperson	Signature	Date
Tefera Belay (PhD)		26/11/2020
Name of Major Advisor	Signature	Date
______________________________.	____________	__________
Name of Internal Examiner	Signature	Date
______________________________.	____________	___________
Name of External examiner	Signature	Date
______________________________,	____________	__________
SGS Approval	Signature	Date

ACRONYMS AND ABBREVIATIONS

BAU	Business-As-Usual
CSA	Central Statistical Agency of Ethiopia
CB	Cross breed
CH_4	Methane
CO_2	Carbon dioxide
N_2O	Nitrous oxide
CO_2eq	Carbon dioxide equivalents
CRGE	Climate Resilience Green economy
DA	Development Agent
DPS	Diary production system
EI	Emission Intensity
GDP	Gross Domestic product
GHGs	Greenhouse gases
GIS	Geographic Information System
Gt	Giga ton
GLEAM	Global Livestock Environmental Assessment Model
GWP	Global Warming Potential
HF	Holstein Friesian
FAO	Food and agriculture of organinsation united nation
LB	Local Breed
LCA	Life Cycle Assessment
Mt	Metric ton
IPCC	Intergovernmental Panel on Climate Change

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Evaluating Greenhouse Gas Emission and Identifying Interventions for Intensification of Dairy Value Chains in Wukro - Kilteawlaelo Districts Northern Ethiopia

By Teame Hailu Gebretekle Email ashenafi1271990@gmail.com

Advisor: Tefera Belay (PhD) Hawassa University, Ass professor in forestry, forest products and ecosystem services

ABSTARACT

The dairy sector in Ethiopia has a large potential due to the country's large livestock population and ample market opportunities for its value chain development. On the other hand, the large population, with low productivity attributed to unproportioally higher greenhouse gas emissions. However, the quantity of greenhouse gases emissions from dairy cattle of the study area associated with practices and technologies used to reduce greenhouse gas emission were not assessed. The study intended to estimate greenhouse gas emissions and identify interventions for enhancing dairy value chains. The study used multistage random sampling to select 183 sampled household heads. GLEAM-i procedures for data analysis and SPSS version 20 was applied for statistical analysis. The result of the study revealed that the total greenhouse gases, total CH_4 *emission, methane emission from enteric fermentation and* N_2O *emissions from fertilizer applied to feed crops and from the decomposition of crop residues were significantly higher* ($p < 0.05$) *in rural than the peri-urban and urban dairy production system. Genetic limitation and a low number of improved genotypes, reproductive inefficiency, and poor quality feeds were mainly drivers of greenhouse gas emission. This finding estimated greenhouse gas Emission per Kilo gram of Fat and Protein Corrected Milk approximately 18.7, 7.9, and 5.4 in kg* CO_2*- equivalent/kilo gram protein in rural peri-urban and urban dairy cattle production system respectively. Interventions consist of use of high quality improved forage, improve the local low quality of feeds, and supplement dry and wet industrial by-products, use of animal health improvement, and use breeding improvement. The combined effect of carried out interventions also reduced total GHG emission by 8.2%. Comparable reduction across each dairy production, the combined effect of the carried out interventions resulted in 14%, 5.3%, and 2.2% reduction in total GHG emission in urban, peri-urban, and rural respectively. Similarly, the combined effect of carried out interventions resulted in 7% reduction in emission intensity of milk. The combined effect of the interventions results in 11.4%, 5.3%, and 2.1% reduction in emission intensity of milk in urban, peri-urban, and rural respectively. Moreover, sample households milk supply to market, satisfaction by the animal health services, use of breeding improvement and* credit access *were significantly* ($p<0.05$) *higher in urban than peri-urban and rural dairy production systems. Interventions used to reduce greenhouse gas emissions along the dairy value chain were more effective in urban dairy cattle holders than the other dairy production systems. Support on-farm production of high quality improved forage, improve the local low quality of feeds, promote dry and wet industrial by-products, and promote breeding improvement practices. This study concludes that interventions were appropriated for reducing greenhouse gases emissions while increasing milk production and make adopts overall the dairy production in Wukro-Kilteawlaelo districts northern Ethiopia.*

Key words: Emission Reduction, Ethiopia, GLEAM, GHG, Milk Value Chain

1. INTRODUCTION

1.1. Background

The dairy sector in Ethiopia has a huge potential and role in the commercialization of the agriculture sector due to the country's large human and livestock population. Other contributing factors to dairying are the favorable climate for improved, relatively disease-free highland environment with potential for animal feeding, and a huge gap between demand and supply of milk (Ali *et al.*, 2017; Brhane *et al.*, 2019).Also, Ethiopia has a substantial potential for dairy value chain development opportunities (Tsega *et al.,* 2017) and it is endowed with large and diverse dairy animal genetic resources, which are cosmopolitan across the varied agro-ecologies. Total cattle population of Ethiopia was about 60.39 million and included the female and male cattle 33.02 million (54.68%) and 27.37 million (45.32%) respectively estimated by CSA Ethiopia in the year of 2017/18 Gorgerin calendar.

Both, growing population and incomes are expected to drive total consumption higher with milk consumption doubling by 2050 compared to 2000 (FAO, 2010; Gerber, 2017) and resulting in the more rapid growth of global demand for milk. More than 80% of population growth occurs in cities and towns of developing countries (Gerber, 2017). The demand for food in general and protein in particular of these people will present an enormous challenge to African farmers. Much of the increased demand for dairy products will be concentrated in urban and peri-urban areas (Yitaye *et al.*, 2011). The livestock sector is expected to expand even faster than human population growth (Gerber *et al*., 2011).The annual rate of growth in milk production of 1.2 percent falls behind the annual human increase estimated at 3 percent (Zelalem *et al.*, 2011).

A large share of GHG emissions originates within the livestock sector, and therefore the sector is predicted to expand even faster than population growth. The bulk of GHG emissions originate from four main categories of processes: enteric fermentation, manure management, feed production, and energy consumption of the livestock sector *(Gerber* et *al.,* 2013a). Animal production systems are complex sources of greenhouse gas (GHG) emissions, mainly, methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2(Gerber *et al.,* 2011). The dairy sector produces GHG emissions in many ways: direct emissions by livestock (from manure and enteric fermentation), and indirect emissions from the assembly of livestock feed, energy use in fertilizer manufacture, farm operations, and transport, and post-production transportation, processing, and retailing (FAO and GDP, 2018). Gerber *et al.,* (2013b) was reported the livestock sector plays an important role in climate change which emissions estimated at 7.1 gigatonnes CO_2 -eq per annum, representing 14.5 percent of human-induced GHG emissions globally. From livestock, ruminant contributes about 81% of GHG thanks to massive methanogens by rumen microbes, which produce 90% of total CH_4 production from ruminants. Globally, CH_4 emissions of dairy cattle represent 30% of the livestock sectors' emissions (Islam and Lee, 2019).Cattle milk production account for the majority of emissions contributing 20% of the sector's emissions followed for beef production (41%) (Gerber *et al.*, 2013b). Greenhouse gas (GHG) emissions represent a challenge, as cattle production in the developing region typically has high emissions intensity (EI), i.e., high rates of GHG emissions per unit of output(Gerber *et al.*, 2013).

Gerber *et al.* (2013a) point out specific mitigation opportunities in tackling climate change through livestock like improving production efficiency, improving breeding and animal health, using manure management practices to recycle and recover nutrients and energy contained in manure. High-yielding animals producing more milk per lactation exhibit lower emission intensities Gerber *et al*., 2013). Concurrently, in dairy cattle production system interventions used to reduce GHG emission potentials without significantly reducing productivity were identified and compared across the dairy production of the study area

1.2. Statement of the Problem

The dairy sector GHG emission and its potential effect on the environment has become an important international and national issue (Gerber, 2017) is the most contributor to climate changes which emits GHGs globally, regionally and national. The dairy sector in Ethiopia is challenged by GHGs emissions associated with low productivity and production (CRGE, 2011).The cattle population is expected to increase from close to 50 million today to more than 90 million in 2030 that would be the reason increase in emissions from 65 Mt CO_2eq today to more 125 Mt in 2030 from which cattle released would be 84%.FAO & New Zealand Agricultural Greenhouse Gas Research Centre, (2017) identified factors that influenced GHG emissions and emission intensities of milk from dairy production in Ethiopia. These factors were low-quality feed, animal health, reproductive inefficiency, and genotypes. Further, animal health affects emission intensity through the unproductive emissions associated with morbidity and mortality. The poor reproductive performance in the Ethiopian dairy herd was manifested by low fertility rates (50%), delayed time to reach puberty and to age at first calving in rural mixed crop-livestock(FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2017).

However, a limited study is conducted in Ethiopia regarding the production intensity and emission reduction. This study will fill this gap by assessing the extent of emissions and plausible emission reduction intervention for climate-smart dairy value chain development.

1.3. Objectives

General Objective

General objective of the study was to estimate GHG emissions and identify potential interventions for mitigating GHG emissions and intensify dairy value chains in dairy cattle production.

Specific Objectives

- Estimate emissions and share of total GHG emissions by emission gases and sources
- Estimate emission intensity of milk
- Identify interventions to reduce GHGs emissions and emission intensity of milk
- Assess existing dairy value chains and map the milk value chain actors

1.4. Significance of the Study

The study emphasized on greenhouse gas emission associated with diary value chain in dairy cattle. It used explored the role of dairy sector on environmental impact locally. The study will used to apply the Global Livestock Environment Assessments (GLEAM) model locally to make the dairy sector climate smart (environmental friend). Also, it will be used to carry out the locally and practically mitigation strategies to overcome global warming due high GHG emission along the dairy value chain. Furthermore, the plans of the dairy sector would be explained how in the right or wrong way regarding the environmental with the production of the study areas. Therefore, this study insights into the current interventions to mitigate GHGs emissions for future climate-smart dairy cattle production. Moreover, the findings of this study may help in enhancing, improving, managing and strengthening the existing practice in the study site and expansion of the practice to the other sectors and areas. This study will help to inform the community debate on GHG emissions, and will support research, development and extension efforts to improve the sustainability performance of dairy farming. It also contributes to developing ideas for designing the production plan and management of the dairy sector as a technical guidelines in the country and Tigray region in general and Wukro-Kilteawlaelo districts in particular. It also provides an organized document for researchers, decision-makers, government and non-governmental organizations and other concerned bodies actions for climate change mitigation while enhancing dairy value chain.

2. LITERATURE REVIEW

2.1. Definitions of Terms

Greenhouse gases (GHGs): the variation in temperature is as a result of a group of gases known as greenhouse gases that have an effect on the general energy balance of the Earth's system by absorbing infrared radiation. Because of greenhouse gases, the atmosphere absorbs a lot of infrared energy than it re-radiates to area, lead to warm the world atmosphere system and of surface temperature (Solomon and IPCC, 2007).

Emissions: are reported as CO_2 equivalent emissions, based on 100-year Global Warming Potential (GWP100) conversion factors, estimate the impact of climate change (IPCC, 2014).

Emission intensities: are expressed per kilogram of fat and-protein corrected milk (FPCM) (FAO and GDP, 2018).

Global Livestock Environmental Assessment Model (GLEAM):quantifies GHG emissions arising from production of the main livestock commodities like meat and milk from cattle (FAO, 2010).

The functional units: used to report GHG emissions in GLEAM are expressed as kg of carbon dioxide equivalents (CO_2-eq) per kg of protein in animal product (FAO and GDP, 2018)**.**

Tier levels: according to the IPCC, correspond to a progression from the use of simple equations with default data (Tier 1 emission factors), to country-specific data in more complex national systems, (Tier 2 & 3 emission factors)(FAO, 2010).

The system boundary: is defined from Cradle-to-retail of processed animal products (FAO, 2017).

Holder: A holder is a person who exercises management control over the operations of the agricultural holding and takes the major decision regarding the utilization of the available resources, also has technical and economic responsibility for the holding (CSA, 2018).

Dairy Cow: refers to any type of cow used to give milk previously and/or provide milk currently or have never given milk before and pregnant now (CSA, 2018).

Milking Cow: refers to cows actually milked during the year(CSA, 2018).

Value chain: a value chain describes the full range of activities required to bring a product or service through the different phases of production, including physical transformation, the input of various producer services, and response to consumer demand which include the vertically linked interdependent processes that generate value for the consumer (MacCormick and Schmitz, 2002).

Value chain supporters: The services provided by various actors who never directly deal with the product, but whose services add value to the product(Ali *et al.*, 2017).

Production of cows feed: The dairy supply chain begins with growing of feed sources such as corn, alfalfa hay, grass, and soybeans, etc. to feed dairy cows.

Milk production: Dairy cows are housed, fed, and milked on dairy farms(Land O'Lakes, 2010).

Retail: Milk and dairy products are available at certain number of retail outlets(Rodríguez-Enríquez *et al.*, 2015).

2.2. Dairy Cattle Production system and Its Roles in Ethiopia

In Ethiopia, a different type of dairy production system was identified based on various criteria (De Vries *et al.*, 2016; Daniel *et al.*, 2017; FAO & New Zealand Agricultural Greenhouse Gas Research Centre., 2017a). According to Ali *et al.*, (2017) dairy production are categorized as an urban system, peri-urban system, and rural systems. Individually distinct by its location, agro-ecology, their main production benefits, resource use, the scale of production and management, market orientation, and access to inputs and services. Similarly, Brhane *et al.,* (2019) were classified as dairy production systems as small-scale rural; peri-urban, and urban-based on climate, landholdings, and integration with crop production.

Urban Dairy Production System: It is located in cities and/or towns and focuses on the production and sale of fluid milk, with little or no land resources, using the available human and capital resources mostly for specialized dairy production under stall feeding conditions. It has more access to inputs and services(Brhane *et al.*, 2019) such as improved genotypes, artificial insemination (AI), improved forage production, improved housing, concentrate feeding, and Veterinary care among others are used.

Peri-Urban Dairy Production System: It is mostly working in areas where the population density is high agricultural land is decreasing owing to expanding urbanization. Such producers are mainly found around cities like regional and smaller towns. They may or may not have access to cultivable or pastureland and some of them are usually seen grazing the few animals they have by the roadside. In genotype, the animals they keep range from 50% crosses to high-grade black-and-white Friesian. Their main source of animal feed is home-produced hay for some and purchased hay for others with or without an additional supplemental feed. Similarly, Yitaye *et al.,* (2011) were reported that, this system is raising cross-bred or both cross-bred and local cattle and having access to milk collection centers or co-operatives. Furthermore, it contains the production, processing, and marketing of milk and milk products that are channeled to urban centers. It plays a vital role in the lives of the urban and peri-urban poor by providing a source of subsistence through household nutrition like milk and supplementary income and generating employment opportunities. Special inputs are associated with the type of genotype and involve artificial insemination and supplementary feed to grazing and stall-fed roughages is used.

Rural dairy production system: Part of the subsistence farming system and included mixed crop-livestock producers mainly in the highland areas of Ethiopia. Smallholder mixed farming systems in the highlands using indigenous breeds (Tadele *et al.*, 2014).The system is not market-oriented and most of the milk produced is taken in-home consumption and contributes 98% of the total milk production (Land O'Lakes, 2010). In the rural areas of the highlands, producers keep mostly zebu cattle which have lower milk production. The surplus is mainly processed using traditional technologies and processed milk products such as butter, ghee, ayib, and sour milk are usually marketed through the informal channels after the households satisfy their needs (Brhane *et al.*, 2019).

2.3. GLEAM and the LCA framework

GLEAM is a process-based model based on a Life Cycle Assessment (LCA) framework (Gerber *et al.*, 2013a; FAO, 2017). A life cycle assessment (LCA) was used (De Vries et al., 2016) to quantify environmental impacts of dairy value chain products (milk, beef and traction),.Furthermore, the LCA method was used to quantify emissions from all processes associated with the dairy production system up to the point that milk is sold from the farm (O'Brien *et al.*, 2012).

2.4. Dairy Cattle Emission Processes and Its Dynamics

GHGs emissions are the product of many complex physicals, chemical and biological processes which vary in time and space depending on the ambient conditions (e.g. temperature, wind); the surroundings (e.g. soil, type of building); livestock characteristics (e.g. physiological stage) and farming practices (Opio *et al.*, 2012; FAO, 2016; FAO and GDP, 2018) in dairy production. The amount of CH_4 emissions from enteric fermentation is determined by the animal's digestive system, food and management applies (FAO and GDP, 2018) and released as a by-product of the digestion process. Furthermore, the same source assessed, in the rumen (stomach), microbial fermentation breaks down carbohydrates into simple molecules that can be digested by the animals. Poorly digestible (i.e. fibrous) rations cause higher CH_4 emissions per unit of ingested energy.

Manure contains two chemical components that can lead to GHG emissions during storage and processing: organic matter that can be converted into CH_4 and N that leads to nitrous oxide emissions. CH_4 is released from the anaerobic decomposition of organic material, which occurs mostly when manure is managed in liquid forms, such as in deep lagoons or holding tanks. During storage and processing, nitrogen is mostly released in the atmosphere as ammonia (NH_3) that can be later transformed into N_2O (indirect emissions(Gerber et al., 2013a).

CO_2 and N_2O emissions from feed production, processing, and transport. Carbon dioxide emissions originate from the expansion of feed crops and pasture into natural habitats, which causes the oxidation of C in soil and vegetation. They also originate from the use of fossil fuel to manufacture fertilizer, and process and transport feed. The emissions of N_2O come from the use of fertilizers (organic or synthetic) for feed production and the direct deposition of manure on pasture or during the management and application of manure on crop fields. Direct or indirect N_2O emissions can vary greatly according to temperature and humidity at the time of application and their quantification is thus subject to high uncertainty (Gerber *et al.*, 2013a).

2.5. Contribution and Drivers of Greenhouse gas Emission in Dairy production.

Dairy cattle products are responsible for more GHG emissions behind beef products than most other food sources (FAO and GDP, 2018).Accordingly, dairy production systems being accountable for about 30% (2.1 gigatonnes of CO_2) of these emissions per year (Gerber *et al*., 2013a).Gerber *et al*. (2013) dairy cattle production has emitted three main GHG gases which are nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2). The sector release significant amounts of two potent GHGs (methane and nitrous oxide) (FAO and GDP, 2018).The developed world has high absolute emissions but significantly lower emissions intensities than the developing world due to improved livestock diets, genetics, and health and management practices. Many parts of the developing world have high emissions from livestock, which are produced at high emissions intensities due to low productivity and huge numbers of animals (Herrero *et al.*, 2016).Moreover, FAO, (2010) was reported, methane is the most accountable to the global warming impact of the dairy value chain approximately 52 percent of the GHG emissions from both developing and developed countries. Also, Nitrous oxide emissions account for 27 and 38 percent of the GHG emissions in developed and developing countries, respectively, while CO_2 emissions account for a higher share of emissions in developed countries (21 percent), compared to developing countries (10 percent).

On average, the non-CO_2 emissions intensity of dairy products is estimated at 44 kgCO_2eq per kg of milk, with a large range between 9–500 kg CO_2 per kg of milk globally (Gerber et al., 2011). FAO, (2017) was reported a large proportion of the dairy herd comprises of non-productive stock (bulls, replacements, and dry cows) important for more emissions per kg of milk produced in Ethiopia.

Feed production contributes to 48 % of emissions from which about 27% of emissions are related to the production of fertilizers, the use of machinery and transport for feed production and about 17% of emissions are caused by fertilization (emitting N_2O) with both synthetic fertilizers and manure(Gerber *et al.*, 2013) and Carbon dioxide emissions from energy use in feed supply chains represent about 10 percent of overall emissions.

Manure storage and processing are the third sources of emissions, representing 27.4 percent of emissions. During manure management 2.2 Gt CO_2-eq, mainly through manure storage, application, and deposition (CH_4, N_2O).

In Ethiopia dairy value chain of all processes, methane from enteric fermentation contributed most to chain GWP followed by feed production. Furthermore, De Vries et al., (2016),was estimated 40% of total farm GHG emission was caused by male stock in rural SHF[1] of Ethiopia. This was caused by a relatively high number of the ox in rural SHF and a relatively high emission of methane per animal from oxen. Besides, rural SHF, GHG from feed production were mainly emitted on the farm, whereas feed-related GHG was mainly emitted off-farm in specialized farms and urban SHF. Total GHG emissions per kg of milk and milk products at post farm chain (without retail and consumer) were 6.2 kg CO_2eq per kg milk for the rural SHF and 4.5 and 4.8 for the specialized farms and the urban SHF was estimated by (De Vries *et al*., (2016). Compared to specialized farms and urban SHF, cradle to farm-gate resource use and GWP was highest among rural SHF in milk (De Vries et al., 2016) . Daniel *et al.*, (2017) was found that the main hotspot of LU was land used for feed production which was roughages (74%, 64%, and 81% of the total LU for large-scale, (peri-) urban and rural farms, respectively) and wheat bran (15%, 26%, and 8%, respectively).

2.6. Reducing GHGs Emissions while Enhancing Dairy Value Chain

Dairy farmers are part of the solution to limit climate change (FAO and GDP, 2018).Main GHG emission reduction strategies for dairy products like optimize feed digestibility and feed balancing, achieve better animal health, and improve performance through breeding

[1] SHF refers for Small holder farms

(Gerber, 2013). Better animal feeding and nutrition reduce CH_4 and manure emissions (lower release of N and volatile solids).

Legume silages have benefited over grass silage due to their lower fiber content and the additional benefit of replacing inorganic nitrogen fertilizer. Proper silage conservation will increase forage value on the farm and decrease GHG emission intensity. Introducing of a leguminous plant into grassland pastures in warm climate areas offer a mitigation prospect, while more investigation is needed to address the related agronomic challenges and comparative N_2O emissions with equivalent production levels from nitrogen fertilizer (Gerber, 2013).Improving feed digestibility and energy content, and better matching protein supply to animal requirements can be achieved through improved pasture species, changing forage mix, and greater use of feed supplements to achieve a balanced diet, including cropping by-products and processing of crop residues. These processes increase nutrient uptake, increase animal efficiency and fertility, and thus lower emissions per unit of product (Andeweg *et al*., 2014).

Reducing the incidence of common infections and pests would reduce emissions intensity as healthier animals are more prolific, and consequently produce lower emissions per unit of output(Andeweg *et al.*, 2014).The same source indicated education and availability of efficient animal health diagnostic tools are a key part to improve animal health. These measures can increase productivity, reduce mortality rates, and reduce the age of first reproduction and replacement rates.

Improved manure storage facilities; with proper floors and coverage to prevent run-off to the surrounding environment and customized technologies to apply manure would enhance the production of food and feed crops. Besides, improved manure storage improves the hygienic conditions for animals and humans and enables the recycling of nutrients.

Incorporating livestock dung waste management systems, including compost and biogas making and utilization, for reductions of CH_4 anN_2O could result in greater demand for farmyard manure and create income for the animal husbandry sector where many poor are engaged (Andeweg *et al.*, 2014).

2.7. Dairy Cattle Value Chains

Ethiopia has a substantial potential for dairy production and dairy value chain development opportunities (Tsega *et al.*, 2017). With continued urbanization, growing population size, demand for and consumption of milk, income generation, and employment opportunity (Brhane *et al.*, 2019). Of the total cattle population in the year of 2017/8 G.C, dairy and milking cows were estimated around 6.66 (11.03%) and 12.39 (20.52%) million heads in the country (CSA, 2018).

Even though, the huge livestock resource and great potential for increased livestock production, the productivity is disproportionately lower due to some economic, technical, policy, and institutional challenges (Land O'Lakes, 2010). CSA Ethiopia (2018),surveyed milk production per cow is too low an average (1.371litters) per day and most of the dairy products were for home consumption. Approximately 6% of the total milk production, 35.5% of butter production, and 15.2% of cheese production were sold in the market whereas the remains are not sold (Mengistu *et al.,* 2016).In addition to the low production and productivity of milk in the country, value addition is still a pertinent strategy as dairy product consumption is highly seasonal, and as most farmers are far from market access for their milk(Tsega *et al.,* 2017).Moreover, the majority of the milk consumed by most urban and semi-urban homes is supplied through the informal segment (Land O'Lakes, 2010). De Vries *et al.*, (2016) studied in Ethiopia dairy value chain, almost all farmers sold 50% or more of the milk, and 47% (rural) to 81 % (specialized) sold 100% of the produced milk. As a result, milk sales are much lower in rural farms compared to specialized and urban farms.

Abebe *et al.,* (2014) revealed that the main limitations facing dairy farmers were lack of land (45 %) feed shortage (41%), inefficient artificial insemination (AI) service (11%), and water shortage (0.8%) of the respondents in Ezha District of the Gurage Zone, Southern Ethiopia. Furthermore, development of the livestock sector is challenged by many constraints such as limited supply of inputs (feed, breed, stock, and water), poor extension service, high disease prevalence, poor marketing, infrastructure(Brhane *et al.*, 2019).Milk losses in the commodity chain were 11, 16, and 16% respectively. The large fraction of sold fresh milk is responsible for the relatively large loss in the peri-urban and urban commodity chains (De Vries *et al.*, 2016).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was employed in Wukro town and Kilteawlaelo Wereda[2]. Wukro is among the twelve (12) towns that encompasses three urban stations (kebelles[3]). Similarly Kilteawlaelo has a total nineteen stations (kebelles), from these ten are rural, seven peri-rban and two urban found nearby Wukro town. The study area is found 43 km and 823km northern of Mekelle (capital city of Tigray regional state) and Addis Ababa (capital city of Ethiopia) respectively .The study sits are located between longitudes 39^o12`-$39^o48$`E and latitude 13^o30`-$13^o54$`N in the Eastern zone of Tigray, Ethiopia. Further, it is bordered by five Wereda these are Enderta to south, Degua Temben to Southern west, Hawzen to northern west, Saesi Tsaeda-emba to north, and to Atsbi- Wenberta east direction (WOANRD, 2019) Agro ecology of the study area is midland 91936.63ha (90.34 %) and highland 9821ha (9.65%) with range annual rainfall 350-450 mm, temperature estimated ranges from 17^0C to 23^0C and its altitude ranges from 1900-2460 meter above sea level (WOARD, 2019).

Based on the 2007 E.C national census conducted by the Central Statistical Agency of Ethiopia the study areas have a total human population of 135,501 of these 66198(49%) are males and 69302(51%) females (WoANRD, 2019). Total area of the study area is estimated 1010.28 square kilometer of which 21% is cultivated land, 4.5% is grazing land, and 21% is by covered forest and shrubs while 53.5% is not used for production purpose due to different reasons. The average landholding of the household is 0.64 ha. As common in many parts of Ethiopia, agriculture is the main occupation of population in the rural

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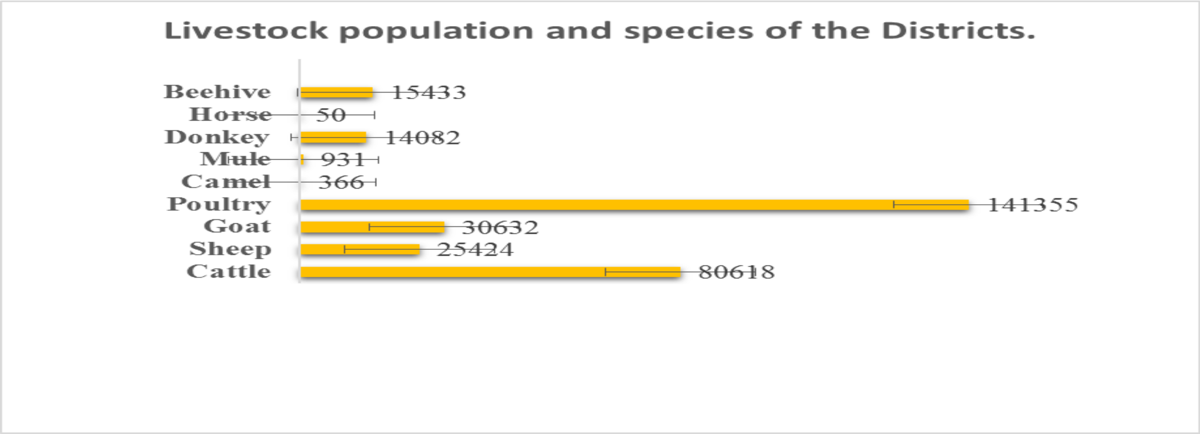
[2] Wereda represent an administrative division within contains stations, equivalent to district

[3] Kebelle represent an administrative division equivalent to station

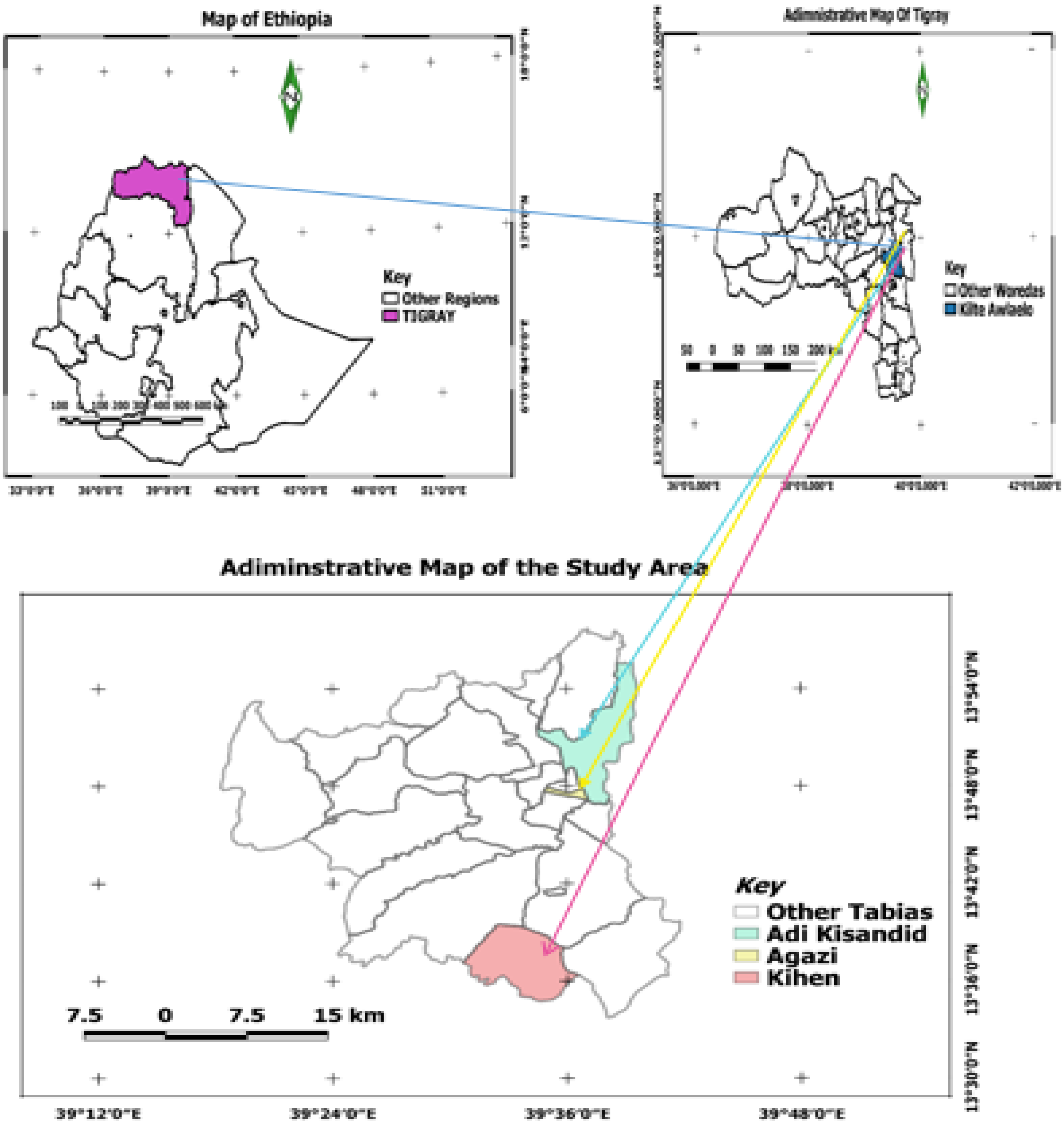
district which the most common farming system is mixed farming. Both crop and livestock production system are undertake. It involves subsistence rainfall cultivation of crops and breeding of livestock. The most occupied by numbers of cattle and poultry followed by goats, sheep. Livestock population of weredas is estimated below.



Sources (WOARD 2019).

Figure 1: Livestock population in number and species of the woreda

The dominant crops in the area coverage and production in the study area are cereals, pulse and such as maize, sorghum, teff, wheat, peas (WOARD, 2019 G.C).



Source: (WOANRD, 2019)

Figure 2: Map of the Study Area

3.2. Sampling Techniques and Sampling Size Determination.

3.2.1. Sampling Techniques

The study used multi-stage sampling. Wukro town and Kilteawlaelo Wereda were selected purposively based on potential of dairy cattle production activities. Taherdoost, (2016) supposed that, stratified sampling possible to use, where the population is divided into strata (or subgroups) and a random sample is taken from each subgroup. Thus, stratified sampling technique was employed to select sites/stations based on dairy cattle production system (urban, pri-urban and rural).Consequently, to evaluate the study area evenly, a simple random sampling technique was used to select three sites from each dairy production systems namely Ag-azi from 5 sites of urban dairy production which is from Wukiro town, Adi-kesandid from 7 peri-urban sites and Kihen from 10 rural sites dairy production from Kilteawlaelo Wereda randomly selected.

A systematic sampling technique was employed to select sampled household heads (CSA, 2018). Subsequent participants were selected using a fixed sampling interval, i.e. every nth person(Mathers *et al.*, 2009) and, households who have cattle were all listed and total population size were about 1806 in the selected Tabias. Accordingly, the study used systematic random sampling technique in selecting sampled dairy cattle holders in the selected sites.

3.3.2. Sampling Size Determination

The sample frame for this study was comprises of dairy cattle owner household heads in the selected sites. According to Israel, (1992) method of sample size determination virtually the entire population would have to be sampled in small populations to achieve a desirable level of precision. Sample size for at Precision Levels ±7% where confidence level is 95% (P= 0.05). To determine representative sample size for the study was using a simplified formula provided byYeman *et al.*, (1967), $n = \frac{\mathrm{N}}{1+\mathrm{N}(\mathrm{e}^2)}$ $(eq. 1)$.

Where N =total population (1806 dairy cattle holder household heads) and n= sample size e= 7% sampling error. Accordingly, from total population of 1806 and 41 dairy cattle owner household heads and milk traders respectively selected total sample size of 183 and

29 household heads using the above equation (1). According to (Israel, 1992) there is a possibilities to use equal size samples. Equal size stratified sample would produce statistics with the same precision for each group (assuming equal variances), and for the total population. Hereafter, the study was used to sample households from dairy cattle holders from each Stations/ sites) were selected using equal samples size technique. The sample size of each study sites was as follow.

Table 1: Sample summary of milk producer households heads in study areas

production system	Station	Dairy cattle owner Household Heads	
		Household Heads	Sample size
Peri urban	Adi-kesandd	614	61
Rural	Kihen	706	61
Urban	Aga-zi	486	61
Total		1806	183

While for milk traders from urban were selected using proportional sampling technique**.**

Table 2: Sample summary of milk trader households heads in study areas

Type of milk traders		Total traders	Sample size
From Urban	Wholesalers	6	4
	Snack bars, Cafe and Restaurants	30	22
	Collectors	5	3
Total		41	29

3.3. Data Collection Methods

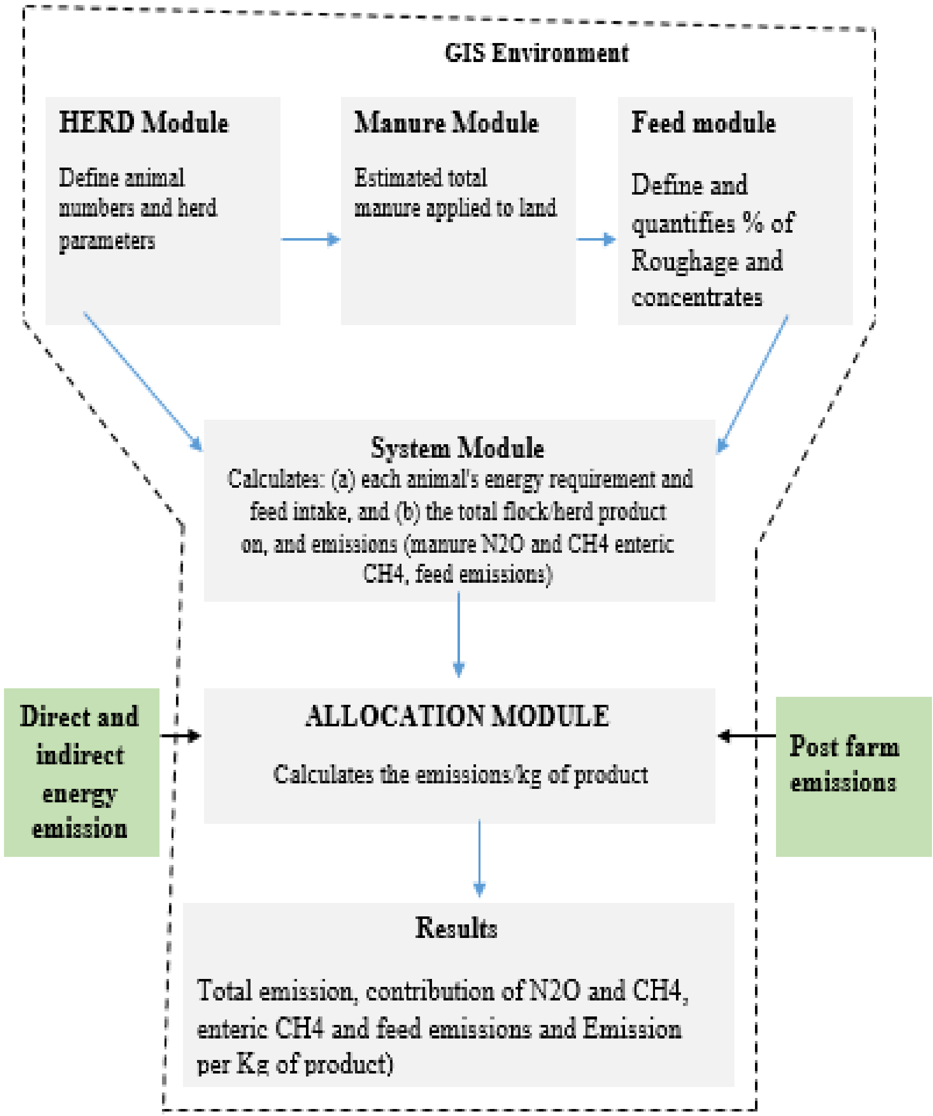
Data collection method of this study was focused on estimating of Greenhouse gas emission along dairy value chain assessment. Many scholars were collected data using interviews and observations of farming households to use in the different modules of the GLEAM-i tool in herd module, feed module, manure module, system module and allocation module(e.g. Weiler *et al*., 2014; Gaitán *et al*., 2016a; Amanuel *et al*., 2020). A structured interview contained a greater proportion of closed questions with pre-coded answers, whereas a questionnaire or topic guide for use in a semi structured interview contain more open-ended questions(Mathers *et al.*, 2009).Accordingly, data of this study was collected using both structured interview contained more closed questions and semi structured interview containing less open-ended questions which were translated to local language that is Tigrigna. Also, sources of data were from both primary and secondary to employ the study. Consecutively, primary data were collected through interviews, observation and taken measurement on farms. Furthermore, the interviews included farms households on cattle feeds, number of cattle, reproductive efficiency and manure management systems. Moreover, data related to reproductive performances (e.g. age at first calving, fertility of adult females, and mortality of young and adult animals, adult female's replacement, and annual milk yield) also, data related to manure management (e.g. in Pasture, daily spread, solid storage, dry lot, burned for fuel, Pit storage) interview with dairy cattle holders and changed to percent. Similarly, data related to weight at birth, weight of adult females and males was measured for relevant cattle age categories on farm of dairy cattle holder of household heads using Heart-girth tape and for the daily feed ration of the dairy cattle using spring weight scale 20kg size. Beside, primary data related to dairy value chain were collected through interviews with farmers and traders.

At the same time, secondary data were collected from different published and unpublished materials like books, journals, office reports and websites which relevant to the study. Mainly, data were collected obtained from Wukro-Kilteawlaelo Wereda office of Agriculture and Rural Development (WOARD) reports (e.g. Number of cattle, production and feeds) before 2010 of the study sites. Also, dry matter content of available feeds of the study area was used from table of (CCOF, 2015). Moreover, from FAO the Global Livestock Environmental Assessment Model (GLEAM) version 2.0 dataset captured and data reference year is 2010 (FAO, 2010).

3.3.1. Descriptions of Global Livestock Environmental Assessment Model

The GLEAM model runs in a Geographic Information System (GIS) environment and provides spatially disaggregated estimates on greenhouse gas (GHG) emissions and commodity production by production system, thereby enabling the calculation of the emission intensity for any combination of commodity and farming systems at different spatial scales(FAO, 2017). It is provides disaggregated and spatially explicit estimations of livestock production and GHG emissions based on Tier 2 methodologies of the Intergovernmental Panel on Climate Change (IPCC). Tier levels, according to the IPCC, correspond to a progression from the use of simple equations with default data (Tier 1 emission factors), to country-specific data in more complex national systems (Tier 2 and 3 emission factors). Tiers implicitly progress from least to greatest levels of certainty, as a function of methodological complexity, regional specificity of model parameters, spatial resolution and the availability of activity data (FAO, 2010).Further, the model was developed to assess livestock's impacts, adaptation and mitigation options at (sub) national, regional and global scale and assesses the adaptation and mitigation scenarios in a more sustainable agenda(Opio *et al*., 2012; FAO and GDP, 2018).

GLEAM is built on five modules reproducing the main elements of livestock supply chains: the herd module, the feed module, the manure module, the system module and the allocation module. The overall structure of GLEAM is shown in Figure 3. It is also a representation of the calculation sequence(FAO, 2017).The herd module starts with the total number of animals of a given species and system within a GIS grid cell and the characteristics of the average animal in each cohort (e.g. weight and growth rate). The herd structure and animal characteristics are subsequently used in the system module to calculate the energy requirements of each animal type, and the total amount of milk produced in the GIS cell each year. Herd module information is also used in the manure module to produce estimates of manure production. In parallel, the feed module calculates key feed parameters, i.e. the composition, nutritional content and emissions per kg of feed ration(Gerber *et al*., 2013).Furthermore, information on herd structure, manure, animal and feed characteristics is then used in the system module to calculate the total annual production, as well as emissions arising from manure management, enteric fermentation and feed production. The total emissions at the farm gate are calculated by adding the energy use emissions arising from direct on-farm energy use, the construction of farm buildings and manufacture of equipment. The total emissions at the farm gate are then allocated to co-products and services in the allocation module, and emission intensities at farm gate are then calculated. The post farm emissions are computed separately and finally added to the latter to obtain overall emissions intensities(Gerber *et al*., 2013). GLEAM estimates GHG emissions from manure storage and management, and from its application on crops used as livestock feed and on pastures(FAO, 2017).



Source: Gerber *et al.*, (2013)

Figure 3: Overview of GLEAM-i model and computation flows

3.3.2. Input parameters used in GLEAM

Mainly feeds and feeding management, manure management and animal husbandry. Particularly, feeds and feeding management component which is defined the average share of each feed material in the feed basket for cattle present on-farm, and for each feed material, inputs for field work (e.g. fertilizer; fuel use), feed processing and transport, feed characteristics (e.g. digestibility, and dry matter, nitrogen, phosphorus, and gross energy content), and yield and economic information for allocation of emissions.

The average dairy herd composition (i.e. male and female adult, replacement, and surplus stock), live and slaughter weights, death rates, percentage of cows lactating, age at first calving, fertility rates, replacement rates, animal activity (i.e. grazing and stall time), labor, and milk production

Table 3: Summary of input parameters using in GLEAM

List of parameters	Unit
Herd parameters	
Total animal number	No.
Adult reproductive females	No.
Age at first calving	Month
Fertility of adult females	%
Mortality of young Females per year	%
Weight at birth	Kg
Weight of adult female	Kg
Milk yield annual	Liter
Feeds	
Fresh grass	% / DM intake
Fresh mixture of grass and Legumes	% / DM intake
Crop residues from wheat.	% / DM intake
Crop residues from maize	% / DM intake
Molasses	% / DM intake
Manure management systems	
Dry lot	% /total manure
Burn for fuel	% /total manure
compost making	% /total manure
Biogas making	% /total manure

Source: (FAO, 2017)

3.3.3. Variables for milk value chain analysis

The study was identified variables used for milk value.

Table 4: Summary of Variable for Milk Value Chain

List of dependent variables	**Variable type**	Independent variable DPSs
Sex of the household head (SexHH)	Dum.	
Marital status of the house hold (MSHH)	Dum.	
Age of the household (AgeHH)	Cont.	
Educational level of the household (EDLHH)	Cont.	
Family size of the household (FSHH)	Cont.	
Age at first calving (AFC)	Cont.	
Membership to milk producers' cooperative (Mcoop)	Dum.	
Access to Credit Service (ACS)	Dum.	
Breeding Improvement (BIABS)	Dum.	
Decision of participation in milk market supply (DPMMMS)	Dum.	
Satisfaction by animal health services (SAHS	Dum.	
Supplement with industrial by-products (SIbp)	Cont.	

Dairy production systems (DPSs)
Dum represents for dummy variables
cont. represents for continuous variables

3.4. Methods of Data Analysis

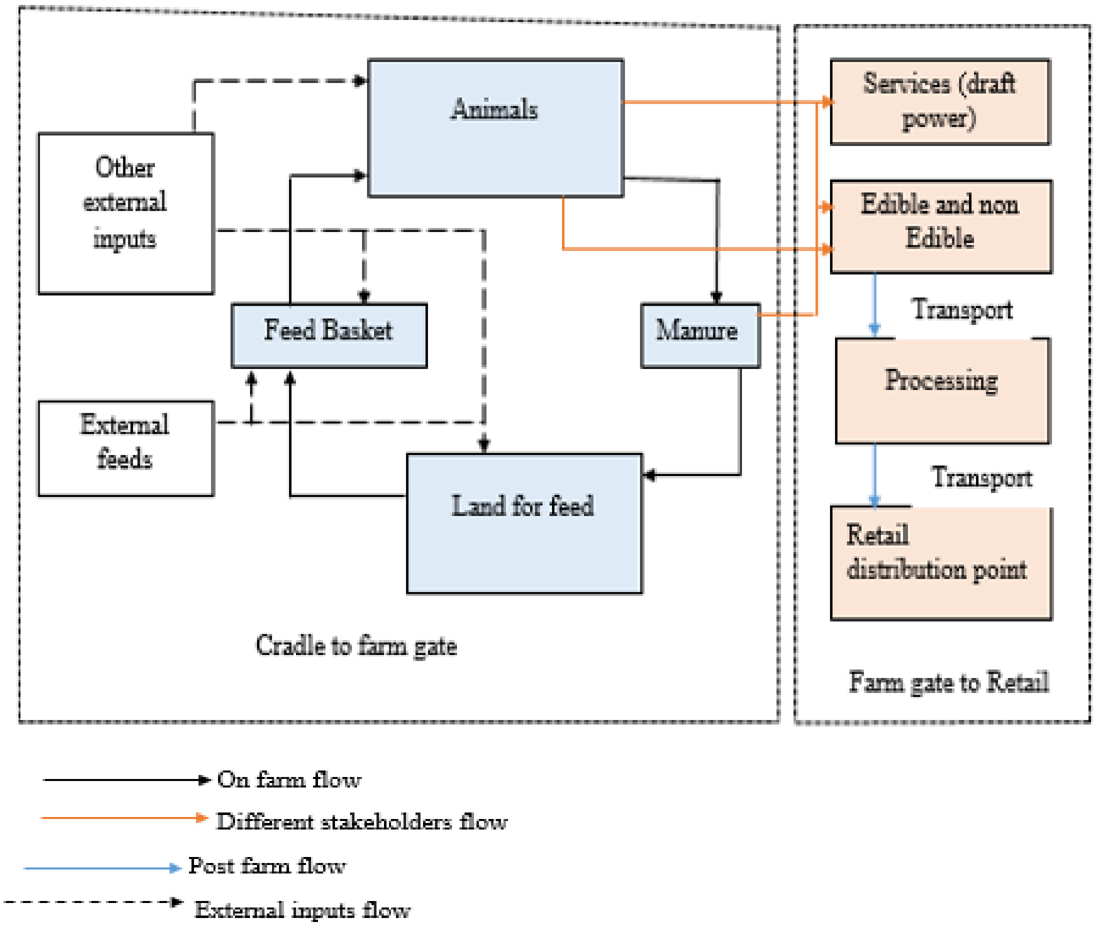
3.4.1. Descriptive analysis

The collected data were analyzed using descriptive statistics and summarized by their means, percentages and map the value chain also presented using tables and figures based on their relevance.

3.4.2. Data Analysis Using GLEAM-i

The greenhouse gases were assessed using GLEAM- i, a component of the Global Livestock Environmental Assessment model. Shown in figure 4, GLEAM covers the entire livestock production chain, from feed production to the retail point(FAO, 2017). The system boundary is defined from Cradle-to-retail of processed animal products. The model also covers other external inputs such as energy, fertilizers, pesticides and machinery use(Gerber *et al*., 2013b; FAO, 2017). Data relating to five modules of livestock production were entered in to GLEAM-i model to quantify the GHG emission of dairy production systems(FAO, 2017; Amanuel *et al*., 2020).

However, all emissions occurring at the final consumption are outside the defined system boundary, and are thus excluded from this assessment(FAO, 2010, 2017). It also does not consider the CO_2 from respiration of livestock. This is because CO_2(FAO, 2017, 2010) from respiration of livestock can be approximated to be equal to the CO_2 uptake or sequestration by plants for photosynthesis process. Therefore, collected data related to the system boundary (Cradle-to-retail) in dairy farms was entered to GLEAM 2.0 excel file (GLEAM-i, version 2) for analysis and the calculations was executed twice, first for the baseline scenario and then for the current scenario.



Source:(FAO, 2017)

Figure 4: The system boundary in this assessment

3.5. Statistical Analysis

The data collected from the study areas were coded stored and analysed in Microsoft Excel 2013 spread sheet and transferred to SPSS version 20 for statistical analysis. The study was using Chi-square for categorical variables. Chi-square test was used to compare number of some categorical variables among the dairy production systems of sampled household heads. Likewise, Tukey's standardized range test was used for comparisons of means through ANOVA.

4. RESULTS AND DISCUSSIONS

4.1. Demographic and Socioeconomic Characteristics of HHs

Across all dairy production systems, sex of the respondents were male 137(75%) and females 46(25%). According to the survey findings, from the total household respondents of male 24%, 25.1% and 25.7% and female respondents 9.3%, 8.2% and 7.7% were found in urban, peri-urban and rural respectively. Sex of the households was statically not a significant (P>.05) difference between the three dairy production systems (Table 5) which implies that the participation in dairying of male and female not different across the dairy production systems.

Table 5: The Categorical Variables on Demographic Characteristics

Variables		Type of Dairy Production System				
		Total (N=183)	Urban	Peri-urban	Rural	P-Value
		N	%	%	%	
SexHH	Female	46	9.30	8.20	7.70	0.81606
	Male	137	24	25.10	25.70	
MSHH	Single	7	2.20	1.10	0.50	0.427
	Married	138	25.10	23.50	26.80	
	Widowed	24	4.40	4.40	4.40	
	Divorced	14	1.60	4.40	1.60	

Note:Sex of the Household (SexHH)
Marital status of the Household (MSHH)
Source: own computation from data(2020)

The marital status of stamped household heads were 75.4%, 13%, 7.7% and 4% married, widowed/r, divorced and single respectively. Through, the dairy production systems (DPSs) the result shown from the total respondents who found in Urban, Peri-urban Rural were not married (single) observed the smallest proportion about 2.2%, 1.1% and .5% respectively. In all types of DPSs, married households where the highest share about 25.1%, 23.5%and 26.8% respectively. Based on the statistical result on (Table 5), marital status was a statically insignificant difference among three groups of dairy production systems. Therefore, similar to the present study, the finding of Tegegne *et al*. (2017) reported the marital status of sample households were 5% single, 77% married, 12% divorced and 6% widowed and there was no statically significant difference between the two groups of participants and non-participants of both milk market supply and value addition.

Across all dairy production system, sampled household heads age in years, number of family size and educational level in grade was 45.8, 5.78, and 3 respectively in average. The result shown in (Table 6) mean of age of sampled household heads was 45, 48 and 45 years found in urban, peri-urban and rural respectively. As a result, mean (arithmetic mean) age of sampled household heads was statically not significant (P>.05) mean difference among the three dairy production systems (Table 6). Through, the dairy production systems (DPSs) mean value of educational level (EDLHH) of sampled household heads was 4, 3 and 1 in grade found in urban, peri-urban and rural dairy production system respectively. As the result, the highest educational level in grade was shown in urban dairy production system while the lowest educational level in mean was shown in rural dairy production system.

Table 6: The interval variables in demographic and socioeconomic

Variables	Type Dairy Production System				
	AM	Urban	Peri-urban	Rural	P-value
AgeHH	45.8	45	48	45	0.669
EDLHH	3	4	3	1	0
FSHH	5.78	6	6	6	0.991

Unlike the present study, (Yitaye *et al.*, 2011) level of education of sampled household was found no significant (p>0.05) differences between urban and peri-urban areas. Result shown in (Table 6) number of family size was the equal mean value (6 person) in all dairy production (urban, peri-urban and rural). As a result, arithmetic mean number of family size per sampled household heads was statically not significant (P>.05) mean difference among the three dairy production systems (Table 6). Unlike the present study, the finding of (Yitaye *et al.*, 2011) average family size in peri-urban farms had significantly ($p<0.05$) more household members than urban farms.

4.2. Factors of GHG Emissions and Emission Intensities

Factors influence emissions and emission intensities from dairy production in Ethiopia, were poor quality feed, genetic limitation, reproductive efficiency) (FAO & New Zealand Agricultural Greenhouse Gas Research Centre., 2017a).This study was assessed factors influence emissions and emission intensities from dairy production of the study area.

Genetic limitation and a low number of improved Genotypes: Compared the dairy production systems, the average number of local cattle owned by sampled households was 2 and 6 cattle respectively in peri-urban and rural dairy production, while not available in urban. As a result, mean of overall number of local cattle per sampled household had statically significant (P<.001) difference among the three (urban, peri-urban and rural) dairy production systems (Table 7). This implies that overall number of local cattle in sampled household were more available in rural than respective dairy production systems. This study was supported by Yitaye *et al*., (2011) who found crop-livestock farmers owned larger herds than urban and peri-urban. On the other hand, average Number of Cross and HF Breed milking cows per sampled households was about 2, 1 cattle in urban, peri-urban respectively while not available in rural dairy production. As a result, overall number of cattle per households significantly (P<.001) higher in urban than peri-urban and rural dairy production systems (Table 7). This implies that overall Number of Cross and HF Breed milking cow per household found in urban more than peri-urban and rural dairy production systems.

Reproductive inefficiency: Across all dairy production systems, an average age at first calving (AFC) and caving interval (CI) per cow was 37 and 18 months respectively of the sampled households. Compared dairy production system, age at first calving (AFC) per cow was about 26, 38, 48 months of the sampled households in urban, peri-urban and rural respectively.

Table 7: Factors of Emissions and Emission Intensities

Variables	Type of Dairy production				
	OVM	Urban	Peri-urban	Rural	P-value
LB	3	0	2	6	0
NCRHFBC	1	2	1	0	0
Dcsd	3	0	3	5	0.006
Oxen	1	0	1	1	0.297
AFC	37	26	38	48	0.001
CI	18	13	19	22	0.002
SIbp	2.34	5.55	1.39	0.07	0.021
DRF	11.24	9.77	9.84	14.11	0.053
PofBiproducts	15.95	36.66	10.62	0.58	
PofRoughages	84.05	63.34	89.38	99.42	

Note: Local Breed (LB)

Number of Cross and HF Breeds milking cow/s (NCRHFBC)

Dairy cow stayed Dry in months (Unproductive) (Dcsd)

Age at first calving in months (AFC)

Caving interval in months (CI)

Supplement with industrial by product (SIbp)

Daily roughage feed (DRF)

Percentage of Bi-products

Percentage of Roughages

Over all mean (OLM)

Source own computation, 2020

Besides AFC, caving interval (CI) per cow was 13, 17, 22 months in sampled households in urban, peri-urban and rural respectively. In Table 7, average both age at first calving

(AFC) and caving interval (CI) per cow was statically significant ($p<0.001$) difference among the dairy production systems. The implication that age at first calving (AFC) and caving interval (CI) was better (shortest) in urban than respective DPSs. Another factor was dairy cow continued with unproductive was observed in average 2 and 5 months per cow was revealed respectively in both peri urban and rural of the sample household while nothing observed in urban dairy production systems. Compared the diary production, Shown in Table 7, average unproductive of dairy cattle per cow in months was statically significant ($P<.05$), difference among the three (urban, peri-urban and rural) dairy production systems. This implies that unproductive dairy cow was shown more in rural and peri-urban disproportionate (5 and 2 months respectively) and none in urban dairy production systems.

Poor quality feed: Shown in Table 7, across all dairy production associated all sampled dairy farmers, an average feeding with roughage was about 11.24kg per day/ cow. The proportion of roughages on daily feed per cow was statically insignificant ($p>.05$) difference among three dairy production systems (9.77, 9.84 and 14 .11 in kg per day/cattle in urban, peri-urban and rural dairy production respectively). On the other hand, across all dairy production associated all sampled dairy farmers, an average daily supplement with industrial by- product was about 2.34kg per cow on average. Compared among the dairy production, the proportion of daily feed supplement with industrial by-product was significantly ($p<.05$) lower in rural than the respective dairy production systems (5.55, 1.39 and .07 in kg per day/cattle in urban, peri-urban and rural dairy production respectively) (Table 7).The implication was farmers in urban better supplement with industrial by-product in daily feed than the respective DPSs (peri-urban and rural).

The study was assessed the manure management system of the study area. Shown in Table 8, across all dairy production, overall sampled farms (183) in an average 42.08% of their manure used for burning fuel. Furthermore, sample households who found in urban dairy production were used more share of manure for burning fuel in average 55.74% significantly higher (P<.001) in urban than respective dairy production systems (23.03% and 47.46% in peri-urban and rural respectively). This indicated that farmers of urban dairy production were used more manure for burning purposes for themselves and by selling to others.

Figure 5: Types of Manure Management Systems in the study areas

Particularly, some sampled households found in the peri-urban (26HHs) were used more manure for compost making on average (66.92%) of their manure. Manure for compost making was significantly higher (P<.05) in peri-urban than respective dairy production systems. This indicated that farmers of peri-urban dairy production were more manure for compost making.

Table 8: Manure Management System

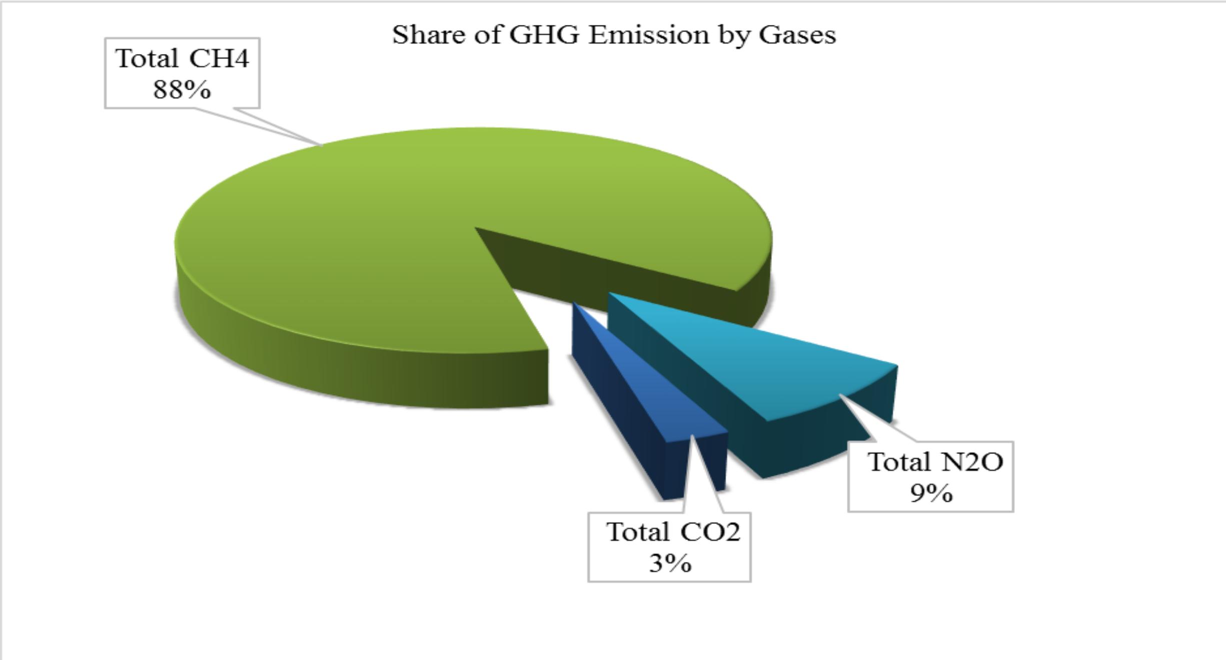
Share of Manure management systems in % of Dairy Production Systems				p-value
MMSs	DPSs	N	Mean	
Manure used for fuel	Urban	61	55.74	.000
	Peri-urban	61	23.03	
	Rural	61	47.46	
	Total	183	42.08	
Manure used for biogas making	Urban	0		.078
	Peri-urban	3	5.00	
	Rural	0	0.00	
	Total	3	2.48	
Manure used for compost making	Urban	0		.040
	Peri-urban	26	66.92	
	Rural	13	49.23	
	Total	39	61.03	
Manure managed in pasture/range	Urban	1	80.00	.000
	Peri-urban	37	69.86	
	Rural	55	46.64	
	Total	93	56.24	
Manure used as Dry lot	Urban	45	29.56	.007
	Peri-urban	1	70.00	
	Rural	0		
	Total	46	30.43	

Note: MMS refers for manure management systems
DPS refers for Dairy production systems
N refers for number of household/farms
Source own data computation, 2020.

4.3. GHG Emission and EI along the Dairy supply chain

4.3.1. Share of Total GHG Emissions by Emissions Gases

Across all dairy production of the study area, sampled dairy farms contributed about 2581.6 tons of CO_2eq.Also, share of total GHG emission by gases mainly CO_2, CH_4 and N_2O was accountable for about 81.5, 2268.28 and 231.8 tons of CO_2eq or 3%, 88% and 9% respectively shown in (Figure 6) as estimated in this study. According to this finding, share of methane gas was the major (88%) GHG emission in the study area. This finding was supported by scholars of FAO, (2010); Gerber et al., (2013b); FAO & New Zealand Agricultural Greenhouse Gas Research Centre., (2017); Amanuel et al., (2020).The reasons were due to low quality and quantity forages, which require longer retention time in the rumen. Moreover, activities and processes that contributed towards the GHG emissions from dairy cattle in Ethiopia the GHG summary which is dominated by methane (97.3%), while the contribution of nitrous oxide (N_2O) and carbon dioxide (CO_2) is negligible (2.1% and 0.5% of the total, respectively(FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2017).

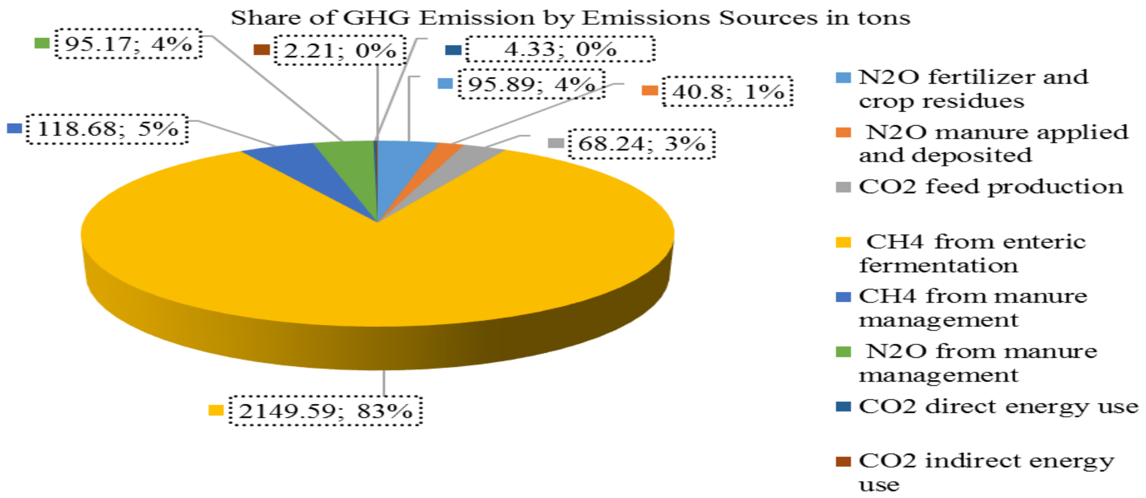


Source: Own by GLEAM, 2020.

Figure 6: Share of the total GHG Emission by Gases

4.3.2. Share GHG Emissions by Emissions categories (sources)

Across all dairy production systems, share of GHG emission by emissions categories (sources) in sampled dairy farms of the study area was estimated in this study. Emissions categories (sources) related to animal feed production was assessed. N_2O emissions from fertilizer applied to feed crops and from the decomposition of crop residues was contributed from sampled dairy farms contributed about 95.89 tons of CO_2eq (3.7%). Also, N_2O emissions from manure applied to feed crops and grazing land or directly deposited on grazing land by animals released about 40.8 tons of CO_2eq (1.58%).In addition, CO_2 emissions from the production, processing and transport of feed were released about 68.24 tons (2.54%).



Source: Own by GLEAM, 2020

Figure 7: Share of GHG Emission by Emissions Sources

At the same time, the study assessed CH_4 emissions from enteric fermentation was shared of sampled dairy farms about 2149.60 tons (83.26%). Similar to the present assessment of FAO & New Zealand Agricultural Greenhouse Gas Research Centre, (2017) enteric methane more than the present study represents about 87 %(101.2 million tons CO_2 eq) of the total GHG emissions from dairy production.

CH_4 and N_2O emissions during manure storage and processing were released about 118.68 tons of CO_2 eq. (4.6%) and 95.2 tons of CO_2 eq. (3.68%) respectively shown in (Figure 7).Furthermore, CH_4 emissions from manure storage and processing found in the present study was lower than of (FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2017) share of CH_4 emission from manure management was reported about 10.5% of from the total GHG emission. On the other hand, Nitrous oxide (N_2O) emission from fertilizer and crop residues (95.2 of CO_2 eq. or 3.68%) result in the present study was higher than of (FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2017) who reported the share of N_2O emission from fertilizer and crop residues was 0.001% from the total GHG emission of Ethiopia dairy sector. Moreover, direct and indirect energy;

CO2 emissions from energy use on animal production unit (heating, ventilation, etc.); and CO2 emissions related to the construction of the animal production buildings and equipment were contributed 4.3 tons (.17%) and 2.21 tons (0.085%) respectively.

4.3.3. Comparing the Contribution of dairy production systems to Total GHG Emissions

Through each dairy production systems, the total GHGs emission was estimated approximately 2924.7, 2369 and 1794 tons of CO_2 eq in rural, peri-urban and urban respectively. The total GHGs emission was significantly higher ($p < 0.05$) in rural than peri-urban and urban dairy production system (Table 9). This was caused by a relatively high number of the ox and unproductive female cow in rural and a relatively high emission of methane per animal from oxen.

The maximum share of GHG emission by emission gases was methane emission through and within dairy production systems. Across each the dairy production system, total CH_4 emission was accountable for 2391.87, 1726.59 and 1471.98 tons of CO_2 eq. in rural, peri-urban and urban DPSs respectively (Table 9). As a result, the total CH_4 emission was significantly higher ($p < 0.05$) in rural than peri-urban and urban DPSs. Besides, through each dairy production system the share of GHG emission by emission sources; methane emission from enteric fermentation accountable 2264.66, 1605.26 and 1144.16 tons of CO_2 eq in rural, peri-urban and urban respectively (Table 9). Compared to the peri-urban and urban dairy production systems; in the rural dairy production system methane emission from enteric fermentation was statistically significant higher ($p<0.05$) than the peri-urban and urban dairy production system.

The main reasons for more GHGs emission were associated with drivers of GHG emission. These are genetic limitation and a low number of improved genotypes, reproductive inefficiency, and poor quality feeds were assessed by this study. Furthermore, the total number of local cattle per sampled household was statically significant higher (P<.001) in rural dairy production systems than the respective dairy production, that was an average number of local cattle owned by respondent farmers were 6 cattle in rural dairy farmers. Similarly, reproductive inefficiency (the extended age at first calving and calving interval per cow was 48 and 22 months respectively in rural dairy farmers of the sampled households) . As a result, an average of age at first calving (AFC) and calving interval (CI) per cow, both were statically significant higher (p<0.001) in the rural than respective dairy production system (Table7).Also, an average unproductive of dairy cattle continued without production and reproduction about 5 months per cow of sampled farmers was statically significant higher (P<.05) in rural dairy production systems. Also, averagely high number of oxen owned of the sampled households in rural than urban dairy production systems (Table 6) of this study. The proportion of roughages on daily feed per cow was the higher 14 .11 in kg per day/cattle (99.42%) in rural dairy production which was poor quality feed.

This study was similar to the findings of FAO & New Zealand Agricultural Greenhouse Gas Research Centre, (2017) was reported in Ethiopia, the rural mixed crop-livestock system is responsible for a large share of total GHG emissions which was contributing 56% of total emissions. The same source indicated that, digestibility of average feed ration was in 45% rural mixed crop-livestock and 49% in the market-oriented systems. These limitations caused for short lactations and low milk yields, high mortality of young stock, longer parturition intervals, low animal weights and high enteric methane emissions per unit of metabolizable energy. Also, this study was similar to the study of De Vries *et al*., (2016) was quantified in rural dairy farms 40% of total farm GHG was caused by male stock and was caused by a relatively high number of oxen in rural farms and a relatively high emission of methane per animal from oxen. Unlike, the present study, total CH_4

emission was significantly higher ($p < 0.05$) in urban production system than mixed crop-livestock (Amanuel *et al*., 2020).

Across each dairy production, CH_4 emission from manure storage and processing was the lowest GHG emission in peri-urban (Table 9). The reason was out of 100% of their manure, sampled households found in peri-urban was managed as a compost 28.5% and biogas 5% making while lacking of those manure management in urban and rural (Table 8) of this study. On the other hand, in urban dairy production system methane (CH_4) emission from manure storage and processing was estimated higher (327.81) tons of CO_2 than rural (127.21 tons) and peri-urban (121.32 tons) dairy production system (Table 9). The reasons were related to dairy cattle holders (farms) who found in this(urban) system was faced too many problems related to manure management which lack of land and space to manage manure.

Table 9: Comparison of GHG emission across the dairy production

	Type of Dairy Production System			P-value
GHG Emission in tons	Mean value UDPs	PuDPs	RDPs	
Total GHG emissions	1794.1540	2368.5050	2924.6880	0.019
Total CO_2	104.3698	96.8292	81.0734	.005
Total CH_4	1471.987	1726.591	2391.8741	.021
Total N_2O	217.7971	545.0852	451.7404	.053
CH_4 from EF	1144.1692	1605.2678	2264.6623	.036
N_2O fertilizer and CR	85.40713	104.7225	121.17081	.010
N_2O man /applied and deposited	58.5154	80.1030	207.8310	.131
CO_2 feed production	74.3804	77.9309	73.1239	.000
CH_4 from manure management	327.8181	121.3228	127.2118	.105
N_2O from manure management	73.8745	360.2597	122.7386	.171
CO_2 direct energy use	27.2160	16.4317	4.3335	.137
CO_2 indirect energy use	2.7735	2.4667	2.2163	.004

EF represents for enteric fermentation and CR represents for crop residues and man refers for manure

UDPs represents for Urban dairy production systems

PuDPs represents for peri-urban dairy production systems

RDPs represents for Rural dairy production systems

N_2O emissions from fertilizer applied to feed crops and from the decomposition of crop residues (Table 9). N_2O emissions in each dairy production system by emission source was estimated about 85.4, 104.72 and 121.17 in tons of CO_2eq in urban, peri-urban and rural respectively. The N_2O emissions from fertilizer applied to feed crops and from the decomposition of crop residues were statistically significant ($p<0.05$) in rural, than peri-urban and urban dairy production system. The reasons were associated with sampled household heads (farms) in rural using more fertilizer and manure for their cultivated land for the purpose of crop growing used for human and animal feed. The finding of Amanuel *et al*., (2020) was not similar to this finding, which N_2O from crop residue and fertilization was significantly higher ($p <0.05$) in urban production system than mixed crop-livestock systems.

On the other hand, N_2O emissions from manure applied to feed crops and grazing land or directly deposited on grazing land by animals. Across each DPSs N_2O emissions from manure applied to feed crops and grazing land or directly deposited on grazing land by animals was 58.51, 80.1 and 207.83 in tons of CO_2eq in urban, peri-urban and rural dairy production systems respectively. (Table 9), the N_2O emissions from manure applied to feed crops and grazing land or directly deposited on grazing land by animals was not significant ($p>0.05$) difference across the three dairy production system.

Through each dairy production systems, total CO_2 emission in tons of CO_2 eq about 104.37, 96.82 and 81.07 in urban, peri-urban and rural respectively was estimated by this study. (Table 9), the total CO_2 emission was significantly ($p<.05$) higher among urban than peri-urban and rural dairy production systems. The reasons were associated with farming activities used energy in urban. Further, CO_2 emissions from feed production in each DPSs

74.38, 77.93 and 73.12 in tons of CO_2eq in urban, peri-urban and rural dairy production systems respectively) was significantly ($p<0.05$) different in peri-urban and urban than rural dairy production system. Dairy cattle holders in this systems (peri-urban and urban) used more energy to processing animal feeds than rural. This finding was supported by Amanuel *et al*., (2020) in which CO_2 from feed production and from direct and indirect energy use was significantly higher ($p < 0.05$) in urban production system than mixed crop-livestock and pastoral production systems.

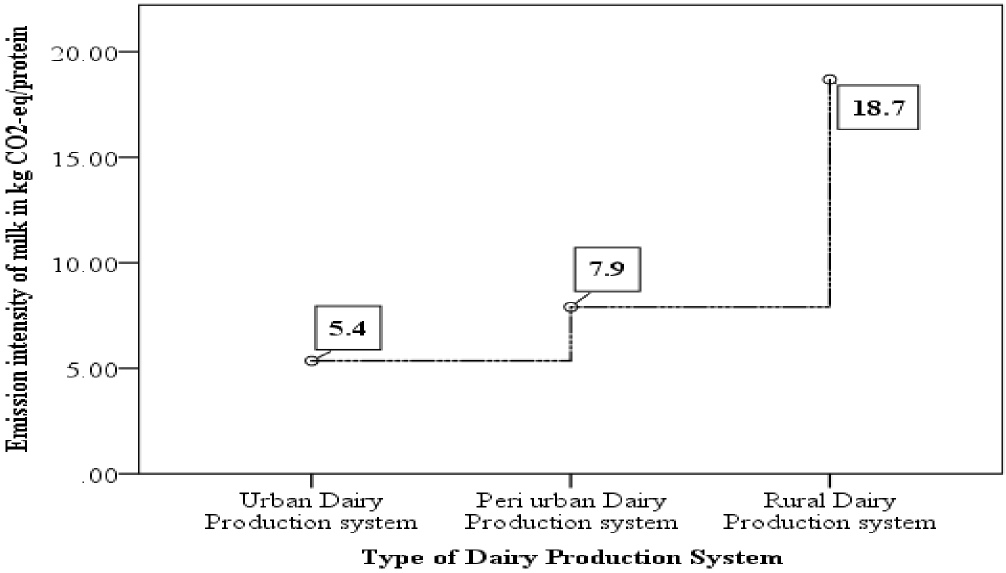
Similarly, CO_2 emissions from construction of the animal production buildings and equipment; in each DPSs was about 2.77, 2.46 and 2.21 in urban, peri-urban and rural respectively. It was significantly ($p<0.05$) varied between the three dairy production system and higher in urban than the respective dairy production systems. Dairy cattle holders in urban system used more energy than respective dairy production system particularly form rural for milk processing. This finding was supported by Amanuel *et al*., (2020) who found that CO_2 from direct energy use was significantly higher ($p < 0.05$) in urban production system than mixed crop-livestock systems.

Whereas, CO_2 emissions from processing and transport of feed, energy use on animal production unit in each DPS was estimated about 27.21, 16.43 and 4.33 in tons of CO_2eq in urban, peri-urban and rural dairy production systems respectively (Table 9). Although it did not show statistically significant ($p>0.05$) difference across the three dairy production system. Unlike the present study, the finding of Amanuel *et al*., (2020) was estimated that CO_2 from indirect energy use was significantly higher ($p < 0.05$) in urban production system than mixed crop-livestock.

4.3.4. Comparing the Contribution of Dairy Production Systems to EI of Milk

Emission intensity of milk and its variability among dairy production systems was estimated by this study. The result in figure 8 indicated that; greenhouse gas emission per Kg of Fat and Protein Corrected Milk (FPCM) was estimated approximately 18.7 kg CO_2-eq/kg protein in rural dairy cattle production system. This was the highest value from all dairy production system in the study area. This result was similar with the findings of FAO & New Zealand Agricultural Greenhouse Gas Research Centre, (2017) that was reported on average 18.9 kg CO_2 eq./kg FPCM in rural mixed crop-livestock in Ethiopia.

Likewise, Greenhouse Gas Emission per Kg of Fat and Protein Corrected Milk (FPCM) approximately 7.9 kg CO_2- eq/kg protein was assessed in peri-urban DPS (figure 8). This result was similar to the findings of FAO (2017) that was reported the emission intensity (EI) of milk produced was on average 8.7 kg CO_2 eq./kg FPCM in small-scale dairy cattle holders in Ethiopia.



Source: Own computation using gleam, 2020.

Figure 8: Emission intensity of milk

Emission intensity (Greenhouse Gas Emission per Kg of Fat and Protein Corrected Milk (FPCM)) was assessed on average 5.4 in kg CO_2- eq/kg protein in urban DPS system. Figure 8, as the lowest EI from all dairy production system in the study area. The finding of Amanuel *et al*., (2020) was supported for this study, in which GHG emission per unit of milk produced was significantly lower ($p < 0.05$) in urban production system than mixed crop-livestock systems. However, the result of this study was higher than the findings of FAO & New Zealand Agricultural Greenhouse Gas Research Centre, (2017) that were reported the emission intensity of milk produced on average 3.8 kg CO_2 eq./kg FPCM in medium-scale commercial systems in the country Ethiopia. The reasons were associated with better dairy cattle management system. Likewise, the present study was shown higher EI than the study of (Daniel et al., 2017) was reported the GWP estimates per kg milk 1.75, 2.25 and 2.22 kg CO_2 equivalents per kg milk in the large-scale, (peri-) urban and rural farms respectively in milk shade area at Mekelle Ethiopia.

Furthermore, FAO & New Zealand Agricultural Greenhouse Gas Research Centre, (2017) reported in Ethiopia the emission intensity of milk produced was on average 24.5 kg CO_2 eq. /kg FPCM. The result was relatively due to large amounts of low quality feeds fed genetic limitation and poor reproductive performances associated with cattle inappropriate management. The quality of cattle management practices seems more important than the choice for a specific cattle keeping system in reducing environmental impacts of milk production. Nevertheless, at the national level in Kenya, the emission intensity of milk produced on average 3.8 kg CO_2eq. /kg FPCM; the highest values were estimated for extensive grazing systems and the lowest in semi-intensive systems. Emissions were on average, 7.1, 2.1, and 4.1 kg CO_2 eq. /kg FPCM for extensive, intensive, and semi-intensive systems, respectively((FAO & New Zealand Agricultural Greenhouse Gas Research Centre., 2017b).Whereas, the regional emission intensity of milk from cattle ranges from 1.6 kg CO_2-eq/kg FPCM to 9.0kg CO_2-eq/kg FPCM was worldwide(Opio et al., 2012).

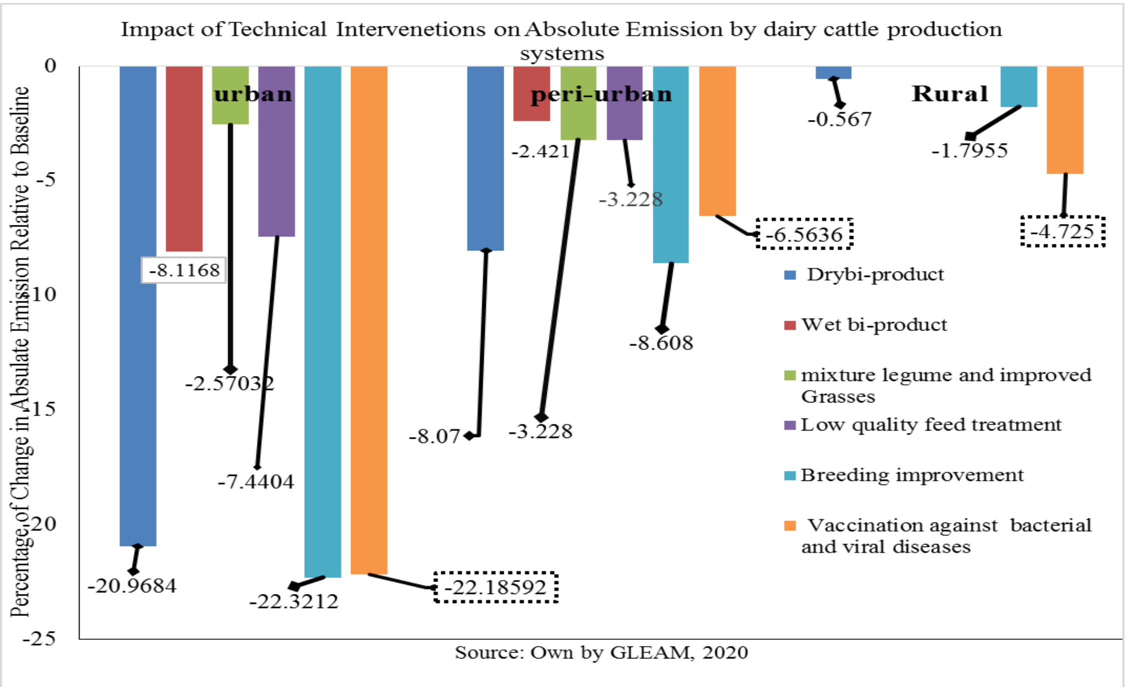
4.3.5. Interventions used to reduce total GHG emission

Six interventions used to improve dairy cattle productivity while reducing the total GHG emission were identified by this study (Figure 9). There was a range of reduction potential for total GHG emission depending on the interventions and dairy production systems. Thus, total GHG emission was reduced from 0.56% in rural, supplement by wheat bran (dry by-product) to 22.32% in urban, using breed improvement relative to baseline. Furthermore, carried out interventions in each dairy production systems had different ranges of reduction potential for total GHG emission which were 2.6% to 22.32% in urban, 2.4% to 8% in peri-urban and 0.56% to 4.7% in rural dairy production (Figure 9) . The combined effect of carried out interventions also reduced the total GHG emission by 8.2% in the study area. Comparable reduction also have been observed across dairy production that carried out interventions had reduced for total GHG emission by 14%, 5.3%, and 2.2% in urban, peri-urban, and rural respectively, was revealed in this study. Interventions used to improve dairy cattle productivity while reducing the total GHG emission were identified by this study presented as follow.

I. **Use of Breed improvement**: a result of the GLEAM model showed that breeding improvement associated with decreasing animal numbers had a reduction potential of absolute GHG emission. Comparable reductions have been observed across dairy production; the absolute GHG emission was reduced by 22.3%, 8.6%, and 2% in urban, peri-urban, and rural dairy production systems respectively by using breeding improvement (Figure 9).

II. **Supplement with improved forages**: as a result of the GLEAM model showed that feeding the improved forages (legume and grasses) has an effect on the quantity of GHG emission. Thus, feeding the improved forages resulted 2.5% and 3.2% reduction in absolute GHG emission in urban and peri-urban respectively, while it was overlooked in rural dairy production systems (Figure 9).

III. **Treated with urea for straw**: Shown in figures 9 below, the study revealed that improving the low quality feeds through urea treatment, has an inverse relationship with the GHG emission. Furthermore, it had a reduction potential of absolute GHG emission by 7.4% and 3.2% in urban and peri-urban dairy reproduction systems respectively; whereas it was also overlooked in rural dairy production systems.



Source: Own Computation Using GLEAM, 2020

Figure 9: The Reduction potential of Interventions on Absolute Emission

IV. **Supplement with dry by-product**: The result of the GLEAM model indicated that supplement with dry by-product (wheat bran, nuts cake) has an inverse relationship with the GHG emission. Supplement with dry by-product resulted 21% and 8.4% reduction of absolute GHG emission in urban and peri-urban dairy reproduction systems respectively, compared with not supplement with dry by-product in rural dairy production system.

V. **Supplement with wet by-product**: the study revealed that, supplement feeding with wet by-product (atela[4], molasses) had an effect on the volume of GHG emission. It had a reduction potential of absolute GHG emission by 8%, 2.4% in urban and peri-urban dairy reproduction systems respectively; against, not supplement wet by-product (atela, molasses) in rural dairy production system.

VI. **Use of vaccination and treatment against bacterial and viral diseases**: Shown in figures 8 below, the result of the GLEAM model indicated that activities like vaccinations and disease treatment against diseases have an inverse relationship with GHG emission. Consequently, it had a reduction potential of GHG emission by 22.2%, 6.5%, and 4.7% in urban, peri-urban, and rural dairy reproduction systems respectively.

Further, the study revealed that interventions (feeding with improved forages e.g. Legume and grasses, improving the low quality feeds through urea, and supplement with wet by-product (atela, molasses)) were not used completely in rural dairy production. Moreover, the study showed that breeding improvement, supplement feeding with dry by-product (wheat bran, nuts cake) were slightly used in rural dairy production than the other respective dairy production systems.

The result of present study for treated straw with urea practice had lower reduction potential than the assessment of (FAO & New Zealand Agricultural Greenhouse Gas Research Centre., 2017) dairy cattle supplemented by treated straw with urea had reduction potential on absolute emission by 8.4% and 10.5% and in small scale, medium commercial

[4] Atela refers for by-product of local brewery

dairy respectively. Also, the same source reported that, dairy cattle supplemented by legume grasses shrubs and treated straw with urea had reduction potential by 20.4% and 8.5% respectively on absolute emission in rural mixed crop-livestock dairy; However, these were overlooked in the rural dairy production system of the study area. Adoption of modern reproductive management technologies, targeting increased conception rates estimated that these improved animal management practices could reduce emissions in the livestock sector by 0.2 Gt CO_2eq per year by 2050 in Ethiopia (FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2017). Such interventions should be strengthen and intended by dairy holders', expertise and Das to more adopt and use than to day in the study area specifically in rural dairy production systems; because they have a couple of purposes which enhancing reproductive performance while GHGs emission reducing indicated by this study.

4.3.6. Interventions used to reduce Emission Intensity of milk

The study was assessed six interventions used to improve productivity while reducing the emission intensity. Overall, analysed showed in Figure 10, there was a range of reduction potential on emission intensity of milk (Kg CO_2 eq. /kg FPCM) depending on the interventions and dairy production systems. Thus, emission intensity of milk was reduced from 0.50% in rural, supplement by wheat bran (dry by-product) to 18.2% in urban, using breed improvement relative to baseline. Furthermore, carried out interventions in each dairy production systems had different ranges of reduction in emission intensity of milk; these were 6.6% to 18.2% in urban, 2.4% to 8.5% in peri-urban and 0.5% to 4.2% in rural dairy production (Figure 10).

All carried out interventions resulted in 7% reduction in emission intensity of milk. Comparable reduction have been observed across dairy production through carried out interventions results in 11.4%, 5.3%, and 2.1% respectively in urban, peri-urban, and rural dairy cattle production system reduction in emission intensity of milk. Thus, six interventions used to improve productivity while reducing the emission intensity was presented in this study as follows.

1. **Use of Breed improvement**: Use of breed improvement results in 18%, 8.5%, and 2% reduction of emission intensity (kg CO_2- eq per kg of FPCM) in urban, peri-urban, and rural dairy production systems respectively (Figure 10).This result was lower than the finding of FAO & New Zealand Agricultural Greenhouse Gas Research Centre, (2017) in reduction of emission intensity of milk; was estimated the use of improved breeds results in 62% reduction in emission intensity in the rural mixed crop-livestock system of Ethiopia. This implies that, the study area needs breed improvement activities particularly, in rural dairy production systems. This assessment was supported by (Herrero et al., 2016) improving the genetic potential of animals for production, their reproductive performance, health and live weight gain rates are among the most effective approaches for reducing GHG emissions per unit of product.
2. **Supplement with improved forages**: dairy cattle feeding with the improved forages (legume and grasses**)** results in 2% and 3.2% reduction in emission intensity of milk respectively in urban, peri-urban dairy production systems (Figure 10).
3. **Treated with urea for straw**: The study revealed that improving the low quality feeds through urea, has an inverse relationship with the EI. Furthermore, use of urea treated straw results in 6%, and 3% reduction potential in emission intensity of milk in urban and peri-urban dairy production systems respectively. De Vries et al., (2016) assessed in three types of dairy farms in Ethiopia, improving the

digestibility of forage had the largest effect on reduction of environmental impacts, reducing GHG by 24% to 29% per kg of milk.

4. **Supplement with dry by-product**: supplement feeding with dry bi-product (wheat bran, nuts cake) results in 17%, 8%, and 0.5% reduction in emission intensity of milk respectively in urban, peri-urban, and rural dairy production systems (Figure 10).
5. **Supplement with wet by-product**: the study revealed that supplement feeding with wet by-product (atela, molasses) had a reduction potential of emission intensity of milk by 6.6% and 2.4% respectively in urban and peri-urban dairy reproduction systems.

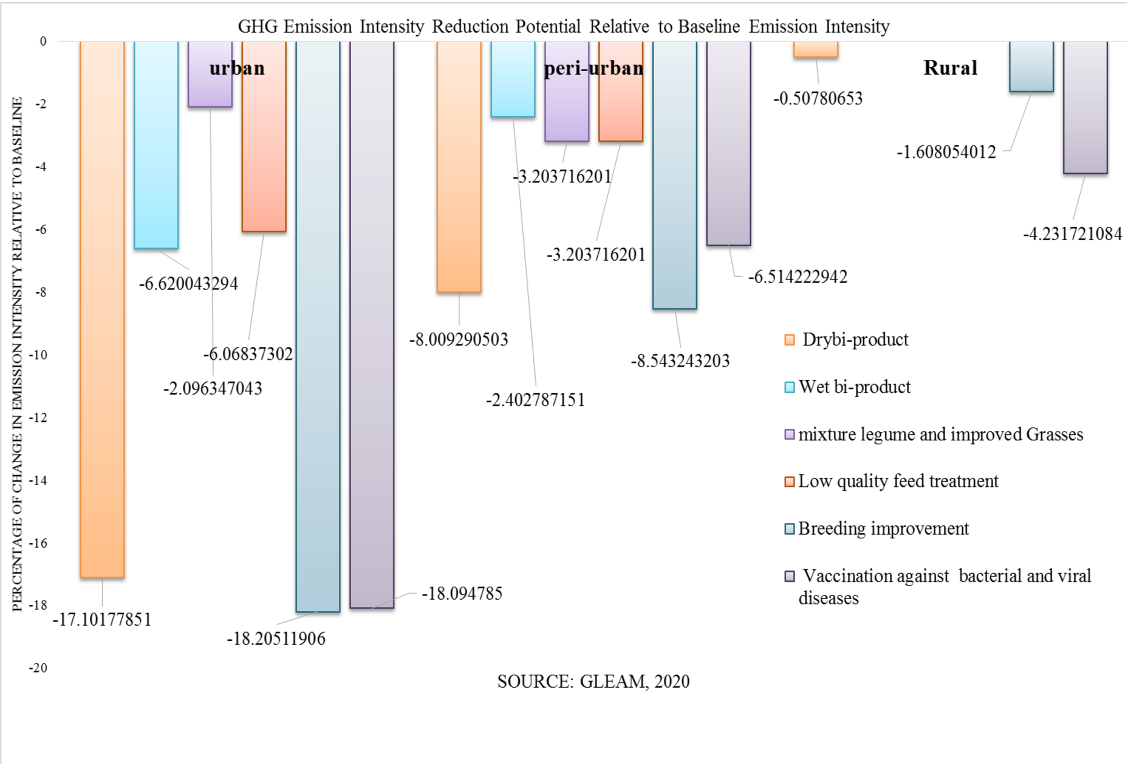


Figure 10: The Reduction potential of Interventions on Emission Intensity

6. Use of Vaccination and Treatment against diseases: the result of the GLEAM model indicated that activities like vaccinations and treatment against bacteria and virus diseases have an inverse relationship with the EI. Consequently, use of vaccinations and disease treatment against diseases results in 18%, 6.5%, and 4. 2% reduction potential in emission intensity of milk respectively, in urban, peri-urban, and rural dairy reproduction systems. Further, the study revealed that, feeding with improved forages (legume and grasses), improving the low quality feeds through urea, and supplement feeding with wet by-product (atela, molasses) were overlooked in rural dairy production of the sampled households. Moreover, this study showed that breeding improvement, supplement feeding with dry by-product (wheat bran, nuts cake) were slightly intervene in rural dairy production of the sampled households than the other respective dairy production systems.

The range of emission intensity (EI) of milk of the present study lower than the findings of FAO & New Zealand Agricultural Greenhouse Gas Research Centre, (2017) who reported use of interventions result in 15% to 62% reduction in EI of milk; depending on the intervention and dairy production system. Similarly, the same source indicated that in Ethiopia dairy cattle by use of improved breeds, supplemented legume grasses, shrubs, treated straw with urea, treated straw with concentrate, and control of Trypanosomiasis results in 61.5% and 27.6%, 43.7%, 43.6% and 30.2% in rural mixed crop-livestock reduction in EI of milk which was higher than the present study. The result obtained in the present study was less effective to reduce EI of milk than the findings of FAO & New Zealand Agricultural Greenhouse Gas Research Centre, (2017) who reported in Ethiopia, dairy cattle feeding by treated straw with urea, treated straw with concentrate had reduction potential in emission intensity (EI) by 26.7% and 25.7% in Small-scale commercial dairy respectively.

Figure 11: Examples of interventions in study area

4.4. Factors of the Milk Value Chain

4.4.1. Accesses to market and input services

Accesses to market: across all dairy production, Out of 183 sampled households 78(42.6%) were participants in milk supply to market while the others were non-participants 105(53.4%). As shown in Table 10, there was a statistically significant ($p<.001$) difference among the three dairy production systems in milk supply to the market. This implication was from sampled households of dairy cattle owners found in urban more participate in milk supply to market than the rural dairy production system. Similar to this study, the study of Yitaye *et al.*, (2011) reported that the number of milk sales was significantly higher in urban systems than in peri-urban and mixed crop-livestock systems. This study also, supported by Sintayehu *et al.*, (2008) the majority of urban dairy farmers (89%) primarily produced whole milk for sale.

The dairy cattle holders decided on participation in milk value addition was assessed in the study area. Out of 183 sampled households, the groups of the participant and non-participant in milk value addition respectively were 85 and 98 households. Moreover, participants in milk value addition were 2 (3 %), 45 (74%), and 38(62%) respectively from the sampled households in urban, peri-urban, and rural dairy production systems. On the other hand, non-participants sampled households in milk value addition were 59 (98%), 16 (26%), and 23 (38%) respectively from the sampled households in urban, peri-urban, and rural dairy production systems. As shown in Table 10, was a statistically significant ($p<.001$) difference among the three dairy production systems in milk value addition. This implication was from sampled households of dairy cattle owners found in peri-urban and rural were better participate in milk value addition than the urban dairy production system. This study was comparable with the assessment of Sintayehu *et al*., (2008) the majority (62.5%) of dairy farmers produced butter was the main dairy product for sale while 20.6% of households produced sour buttermilk for sale and 14.3% of households sold whole milk and the rest sold cottage cheese and ergo.

Animal health services: The survey result revealed that from total sampled households 103(56.3%), 44 (24%), and 36 (20%) responded satisfied, good and poor by animal health services respectively in the study area. Accordingly, among urban, peri-urban, and rural of sampled household heads, in the urban dairy production system 53(29.0%), 8 (4.4%) replied satisfied and good respectively no one replied poor by the animal health services which was provided in the study area. In the peri-urban dairy production system, about 24(13.1%), 7 (3.8%), and 30 (16.4%) of sampled households were replied satisfied, good and poor respectively by the animal health services which was provided in the study area. In the rural dairy production system, about 26(14.2%), 29 (15.8%), and 6 (3.3%) of sampled households were replied satisfied, good and poor respectively by the animal health services which were provided in the study area. There was statistically significant ($p<0.001$) difference among the three dairy production systems for the respective level of satisfaction (dairy owners replied satisfied were 29%, 13%, and 14 .2% in urban, peri-urban and rural dairy production respectively) (Table 10). As a result, more sampled household heads who replied satisfied, by the animal health services delivered were found in urban, whereas, more sampled household heads who replied poor services, by the animal health services provided were found in peri-urban.

Table 10: Factors of Milk value chain

Variables	Responses	Respondents		Dairy Production systems						P-value
				Urban		Peri-urban		Rural		
		N	%	N	%	N	%	N	%	
SAHS	satisfied	103	56.30	53	29.00	24	13.10	26	14.20	.000*
	Good	44	24.00	8	4.40	7	3.80	29	15.80	
	Poor	36	19.70	0	0.00	30	16.40	6	3.30	
BI	No	86	47.00	0	0.00	32	17.50	54	29.50	.000*
	Yes	97	53.00	61	33.30	29	15.80	7	3.80	
ACS	No	56	30.60	6	3.30	16	8.70	34	18.60	.000*
	Yes	127	69.40	55	30.10	45	24.60	27	14.80	
Mcoop	No	144	78.70	24	13.10	59	32.20	61	33.30	.000*
	Yes	39	21.31	37	20.20	2	1.10	0	0.00	
DPMMS	NP	105	57.40	0	0.00	44	24.00	61	33.30	.000*
	P	78	42.60	61	33.30	17	9.30	0	0.00	
DPMVA	NP	98	53.60	59	32.20	16	8.70	23	12.60	.000*
	P	85	46.40	2	1.10	45	24.60	38	20.80	

Note: Breeding Improvement (BI)
Satisfaction by animal health services (SAHS)
Accesses of credit services(ACS)
Membership to cooperative(Mcoop)
Decision of participation in milk market supply (DPMMS)
Decision of participation in milk value addition (DPMVA)
Non participants (NP)
Participants' (P)
*. The Chi-square statistic is significant at the .05 level.

N stands for total observations
n stands for each dairy production observations
Source: Own computation, 2020

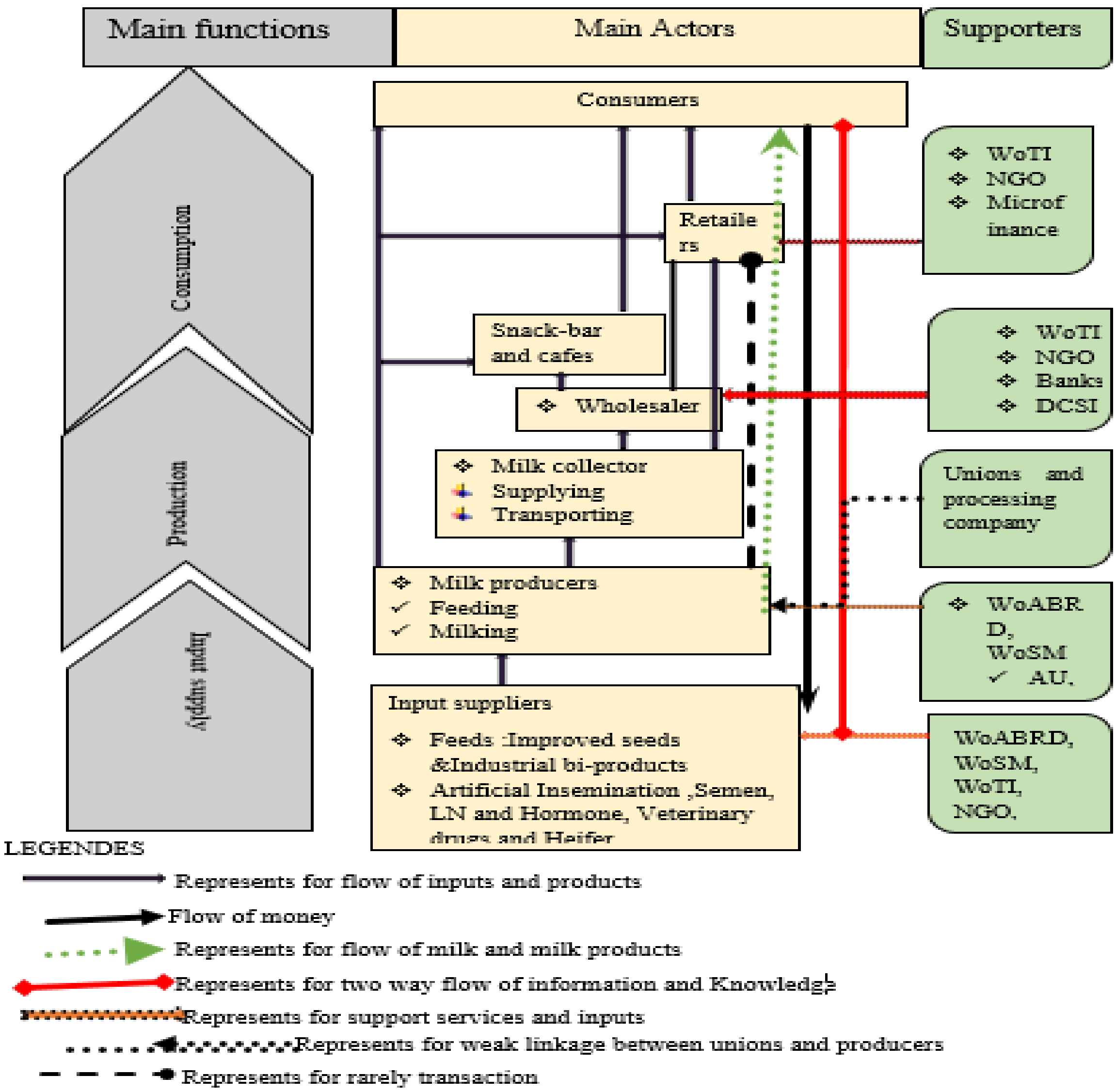
Breed improvement services: Of the total sampled dairy cattle holders about 53% used breeding improvement. Pairwise comparison showed statistically significant ($p<0.001$) among the three dairy productions (dairy cattle holders used breeding improvement were 33.3% 15.8% and 3.8% in urban and peri-urban and rural of the sampled household heads respectively). As a result, more sampled household heads who used breeding improvement were found in urban whereas, the smallest number of households used breeding improvement found in rural.

Accessed to credit services: across all dairy production, 127 (69.4%) of the total sampled households were accessed to credit while 56 (30.6%) did not access. Shown in Table 10 there was statistical significance ($p<0.001$) the difference between both groups of accessed to credit and not accessed and among the three dairy production systems. This implied that more credit accessed in urban and peri-urban than rural. Unlike the present study, Yitaye *et al.,* (2011) who found credit access did not vary significantly ($p>0.05$) between dairy production systems.

Access to cooperative (Mcoop): The results showed 39 (21.3%) from the total (183) sampled households had membership of milk collector cooperative. Most sampled household heads who were members found in urban 37(20.2%) there was a statistically significant ($p<.001$) difference among dairy production systems (Table 10).

4.4.2. Milk Value chain map

The milk and milk products pass through different marketing agents before reaching the end-users. The study was identifying the main value chain actors and functions involved in the entire value chain. The main functions in the milk value chain are input supply, production, collection, wholesaling, processing, retailing, and consumption whereas the major actors in the milk value chain are input suppliers, producers, traders (collectors, wholesalers, retailers, and Snack-bar and Cafe/Hotel owners, and consumers. Based on the roles and functions, the major milk value chain actors and their relationship in the Wukiro-Kilteawlaelo district is shown using value Chain mapping (Figure 12). Value chain mapping is important to easily understand the movement of the product from beginning to end consumers via various actors (MacCormick and Schmitz, 2002) .



Source own data assessment, 2020

Figure 12: The map of milk value Chain in the study area

4.4.3. Milk value chain actors

Dairy cattle inputs and services suppliers: the major input supplier encompassed animal feeds, veterinary drugs, artificial insemination inputs like semen, liquid Nitrogen, and heifers. Mainly, animal feed suppliers consist of 42 in industrial by-product and 4 in improved forage seed supply have been registered in the study area. Mainly, suppliers of animal feed, sold such as concentrate, wheat bran, and molasses, different type's grass of seeds, hay, and straw are supplied to the dairy farmers.

Drug suppliers are divided into public and private. The number of private owners, only drug suppliers and drug and service supplier were 5 and 3 respectively. Unlike animal health service, artificial insemination inputs and services controlled by the public (governmental institution) not privatized which consists of semen, liquid nitrogen, and hormone for synchronization.

Producers carry out many activities within the production stage. Mainly these working activities are milking, selling, forage management and harvesting, feeding of cows, housing etc.

Collectors are those actors who were collecting marketed surplus of milk from smallholder milk producers to resell it in the nearby urban milk market center for the wholesaler, processors, and retailers café and snack-bar. They used Lactometer to differentiate the milk quality whether it is fresh or not before they buy. They were collecting on average daily 1450, 597 liters of milk from producers at none and fasting seasons respectively, and reselling to their respective wholesalers (505.5, 260 liters) and Snack-bar and Cafes (669.5,277 liters) in none fasting and fasting seasons respectively. Collectors packed the milk they bought using the plastic container (Jarikan) and used horse cart and Bajaj for transportation to nearby market centers (Wukro town) and used car transport to Mekelle city which paid 10 Et.birr for 24 liters plastic container (Jarikan).

Wholesalers are actors that are identified in the study area who purchase a large volume of milk directly from producers and resell to Snack-bars, Cafeterias /Restaurants. They were collecting on average daily 1450, 597 liters of milk from producers at none and fasting seasons respectively, and reselling to Snack-bar and Cafes (505.5, 260 liters) and (669.5, 277 liters) at none and fasting seasons respectively.

Retailers are those which include milk retailing Snack-bar, Café, and Restaurants. They brought from collectors, wholesalers, and directly from producers and they resell mostly to respective consumers. They were collecting on average daily 558, 143 liters of milk from producers at none and fasting seasons respectively, and reselling to customers (162, 29 liters) in fresh form through heating and 396 liters was converted to Ergo[5] selling to consumers at none fasting season.

5. SUMMARY AND CONCLUSIONS

5.1. Conclusions

This study mainly focused on factors of Greenhouse gas emission along the dairy value chain in dairy cattle holders in Wukro-Kilteawlaelo District, Northern Ethiopia. Based on the major findings of this study concluding remarks can be reached respected to identify objectives of the study.

Based on the result obtained, factors of dairy value chain were effective in urban dairy cattle holders than the respective dairy cattle holders found in (peri-urban and rural). The dairy value chain improvement of the dairy cattle holders in urban includes; more educating, use of more Cross and HF Breed milking cows, breeding improvement, credit access, and better participation in milk supply to the market.

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[5]It is a local language refers for soured milk

Regarding animal feeds, dairy cattle holders in urban; use the more industrial by-product in daily feed, improving the low quality feeds, planting improved forages, and feeding with byproducts. Besides, the reproductive performance (age at first calving (AFC) and calving interval (CI) was better (shortest) in urban than respective DPSs) also more milk per cow/day was produced.

On the other hand, dairy value chain improvement was ineffective in rural dairy cattle holders than the respective dairy cattle holders found in (urban and peri-urban).Thus, consist of less educating, use less Cross and HF Breed milking cow while more local breed, breeding improvement, credit access, and not participate in milk supply to the market. Regarding animal feeds, dairy cattle holders in rural; useless industrial by-product in daily feed, improving the low quality feeds, planted improved forages, and feeding with by-products while using more roughage feeds. The reproductive performance (age at first calving (AFC) and calving interval (CI) was longest in rural than respective DPSs) also less milk per cow/day was produced.

Depending on the above factors, the study estimated the share total GHG emission by gases mainly CO_2, CH_4, and N_2O which responsible for about 81.5 (3%), 2268.28 (88%), and 231.8 (9%) tons of CO_2eq respectively. Likewise, the study estimated share of GHG emissions by emissions categories (sources) in sampled dairy farms in the study area. Each emissions categories (sources) by adding was assessed subtotal contributed in tons of CO_2eq about 204.93(7.82%), 2149.6(83.26%), 213.88(8.28%), and 6.51(.255%) related to animal feed production, from enteric fermentation, from manure management and direct and indirect energy respectively.

Across the dairy production systems total GHGs emission was estimated approximately 2924.7, 2557 and 1794 tons of CO_2 eq in rural, peri-urban, and urban dairy production system respectively. The total GHGs emission was significantly higher ($p < 0.05$) in rural than peri-urban and urban dairy production systems. The total CH_4 emission, methane emission from enteric fermentation, and N_2O emissions from fertilizer applied to feed crops and from the decomposition of crop residues were significantly higher ($p < 0.05$) in rural DPS than in peri-urban and urban dairy production system. Similarly, Carbon dioxide (CO_2) emissions from feed production and construction of the animal production buildings and equipment share of total GHG emissions had statistically significant ($p<0.05$) difference across the three dairy production system. This implies that CO_2 emissions from feed production were higher in peri-urban than the respective dairy production while CO_2 emissions from construction of the animal production buildings and equipment higher in urban than the respective dairy production systems.

Although the CH_4 emission from manure management, N_2O emissions from manure applied to feed crops and grazing land or directly deposited on grazing land by animals, and CO_2 emissions from processing and transport of feed, energy use on animal production unit share of total GHG emissions were not statistically significant ($P > 0.05$) among the groups of the dairy production systems.

The finding estimated Greenhouse Gas Emission per Kg of Fat and Protein Corrected Milk (FPCM) were approximately 18.7, 7.9, and 5.4 in kg CO_2- eq/kg protein in rural peri-urban and urban dairy cattle production system respectively.

Six interventions used to reduce the total GHG emissions and EI were evaluated that in this study. These interventions consist of use of high quality improved forage, improve the local low quality of feeds, and supplement dry and wet industrial by-products, use of animal health improvement, and use breeding improvement. The use of different interventions results in 0.56% to 22.32% a range of reduction in total GHG emission across all dairy production systems. Comparable reduction across each dairy production of the Carried out interventions results in 2.6% to 22.32% in urban, 2.4% to 8% in peri-urban and

0.56% to 4.7% in rural dairy ranges of reduction potential in total GHG emission. Also, the combined effect of carried out interventions had reduced the total GHG emission by 8.2%. Comparable effect across each dairy production, due to the combined effect of the carried out interventions resulted in 14%, 5.3%, and 2.2% reduction in total GHG emission in urban, peri-urban, and rural respectively. Similarly, use of different interventions resulted in 0.50% to 18.2% of reduction in emission intensity of milk across all dairy production systems. Comparable reduction across each dairy production of the carried out interventions results in 6.6% to 18.2% in urban, 2.4% to 8.5% in peri-urban and 0.5% to 4.2% in rural dairy production ranges of reduction potential in emission intensity of milk. The combined effect of carried out interventions also resulted in 7% reduction in emission intensity of milk. The combined effect of the carried out interventions resulted in 11.4%, 5.3%, and 2.1% reduction in emission intensity of milk in urban, peri-urban, and rural respectively.

Furthermore, breed improvement had a reduction potential of absolute GHG emission by 22.3%, 8.6%, and 2% and of emission intensity (kg CO_2- eq per kg of FPCM) reduced by 18%, 8.5%, and 2% in urban, peri-urban and rural dairy reproduction systems respectively. A mixture of improved legume and grasses had a reduction potential of absolute GHG emission by 2.5% and 3.2% in urban and peri-urban dairy reproduction systems respectively and of emission intensity reduced by 2% and 3.2 % in urban, peri-urban dairy reproduction systems respectively. Improving low quality feeds had a reduction potential of absolute GHG emission by 7.4% and 3.2% and emission intensity by 6%, and 3% respectively in urban and peri-urban dairy reproduction systems.

Supplement feeding with dry by-product had a reduction potential of absolute GHG emission by 21%, 8.4% in urban and peri-urban respectively while absence in rural. It had a reduction potential of emission intensity by 17%, 8%, and 0.5% in urban, peri-urban, and rural dairy reproduction systems respectively. Wet by-product had a reduction potential of absolute GHG emission by 8%, 2.4%, and emission intensity reduced by 6.6% and 2.4% in urban and peri-urban dairy reproduction systems respectively. Vaccination against bacteria and virus diseases had a reduction potential of GHG emission by 22.2%, 6.5%, and 4.7%, and the reduction potential of emission intensity by 18%, 6.5%, and 4. 2% respectively in urban, peri-urban, and rural dairy reproduction systems.

Moreover, sample households milk supply to market, satisfaction by the animal health services, use of breeding improvement and credit is access were significantly ($p<0.05$) higher in urban than peri-urban and rural dairy production systems.

5.2. Recommendations

- ❖ Support on-farm production of high quality improved forage and solve the lack of land for improved forage development in all dairy production systems.
- ❖ Improve local low quality of feeds especially, digestibility, palatability and nitrogen content.
- ❖ Promote dry and wet industrial by-products in dairy cattle production.
- ❖ Promote breeding improvement activities through improved AI and Bull services and make it privatized.
- ❖ Replace unproductive female animals with young productive females
- ❖ Reduce the use of dung for fuel, and introduce biogas as an alternative source of energy and animal manure / bio-slurry as a fertilizer and support selling of manure as a fertilizer in urban and peri-urban farms to prevent accumulation of manure.
- ❖ Strengthening and promoting education level of the milk producers should get an attention by the government sector of capacity via formal schooling building to enhance their dairy value chain

❖ Promote input supply in animal feeds and milk processing machine in small scale dairy farms to increase availability and reduce the high cost of feeds and reduce loss of milk through milk value addition.

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APPENDICES

Appendix 1: Field Survey questionnaires used for Data Collection

Hawassa university wondo Genet College of forestry and natural resources

Department of Agroforestry

MSC Programme in climate smart agricultural land scape Assessment

The title of this study to evaluate green gas emission and analyses milk value chain in dairy cattle households.

Survey questionnaire for smallholder milk producers' households

Questionnaire serial No ___________

Name of interviewer _________________ Date of interviewing _______Signature ______

Part 1: Questionnaire for field data collection and interview for estimating GHGs emission.

1 Name of respondent kebelle ______kushet_____
2 Sex: 0= female; 1= male _____ Age (yrs.') ________
3 Educational level (Regular schooling): 0= Illiterate; 1= If regular schooling, mention grade __
4 Marital status of the household: 1= single; 2= Married; 3= widowed/widower; 4= Divorced; 5= other specify_____
5 Household size total ____ (Male_______Female —) below 5 yrs. __________.
6 If yes for Q5 how much hectares of land do you have? (Total farm size) including none cultivated ---- ha. Cultivated----ha, Grazing ------ha.
7 Which type of farming activities do you practice? 1= Cropping and Livestock 2=Raising Livestock only 3=natural resources
8 How long you have been farming livestock? (Years) _______________
9 Which type of livestock activities do you practice? 1= dairying, 2=Feedlot 3= poultry 4= Beekeeping, 5= both 1&2 6=1, 2, &3, 7= all, except 1&2
10 What grazing type you have? 1= private free grazing, 2=private area closure, 3=communal free gazing 4= communal closed grazing.
11 Do you have land for planting animal forage? 1=yes, 2=No
12 If your answer is yes Q14 source of you forage land you have? 1= mine ---ha, 2= rent –ha, 3= others----ha.
13 Which forms grazing system do you use? 1= cut and carry 2=partially grazing 3= free grazing 4= others
14 Do you have improved forage development practices? 1=yes, 2=No
15 Which type of forage development do you practice? 1= Backyard 2=alley cropping 3= Inter cropping 4= 10% from irrigated land 6= water shade development
16 Farmer owns based on breed and age categories in the following table.

Types of breed	age categories							
	Adult female		Heifer	bull	Ox	calf	other (specify)	Total
	Dairy	Non dairy						
Hf= Holstein f >50%								
Hc=Holstein crossbred<50								
2= Jersey cross breed								
3= local breed								

17 Do you change the low quality feeds? Yes=1 no=0
18 If your answer is yes how 1 = through urea treatment

2= through urea molasses block 3= through silage making 4 = others

19 Do you use feed preservation? Yes=1 no= 0
20 If your answer is yes how? 1 = hay

2= through silage making 4 = others

1. Herd parameters that fitted to GLEAM Model fertility and production each breed in the following table.

Fertility and production each breed and unit,			
	Holstein crossbred	Jersey cross breed	local breed
AC =Age at first calving in month			

FA =Fertility of adult females in %			
Myf= Mortality of young females in %			
mym =Mortality of young males in %			
maa =Mortality of adult Animals in %			
6h=Adult females Replacement in %			
8h= Weight at birth in Kilogram			
9h= Weight of adult females in Kilogram			
10h= Weight of adult males in Kilogram			
13h= Milk yield Annual in %			
14h= Milk fat in %			

2. **Feeds and feeding management**

List of feed items that used for GLEAM Model will be assessed in following table

feed items and unit which is provide per cow per day	Types of breeds		
	Holstein cross bred	Jersey cross breed	local breed
R1=Fresh grass in % over dry matter			
R2=Hay or silage from grass in % over dry matter			
R3= Fresh mixture of grass and Legumes in % over dry matter			
R4=Hay or silage from grass and Legumes in % over dry matter			
R5= Hay or silage from alfalfa in % over dry matter			
R6= Silage from whole grain Plants in % over dry matter			
R7= Silage from whole maize plant in % over dry matter			
R8= Crop residues from wheat in % over dry matter			
R9= Crop residues from maize in % over dry matter			
AI1=Molasses in % over dry matter			
AI2=Dry by-products from grain industries brans in % over dry matter			
AI3=Wet by-products from grain Industries as biofuels, distilleries, breweries in % over dry matter			

3. **Manure management systems field observation to fitted GLEAM Model**

Manure management type	Unit
1m=Pasture/Range/Paddock	Percentage over total manure
2m=Daily spread	Percentage over total manure

3m=Solid storage	Percentage over total manure
4m=Dry lot	Percentage over total manure
5m=Liquid/Slurry	Percentage over total manure
6m=Uncovered anaerobic Lagoon	Percentage over total manure
7m=Burned for fuel	Percentage over total manure
8m= Pit storage	Percentage over total manure
9m= Anaerobic digester	Percentage over total manure
10m= Pasture/Range/Paddock	Percentage over total manure

Part 2: Questionnaire for field data collection and interview for analysis of milk value chain

1. Occupation/Livelihood (circle the answer) 1= farmer 2= Trader; 3= Peasant + Trader; 4= civil servant 5= other (specify) __________

2. If your answer is farmer in what type of agriculture participate 1=Mixed 2=livestock 3=Livestock and other off farm activity4=Mention other

3. How many years of dairying experience/ milk production do you have? _________
4. Which breed do you prefer? 1= Holstein crossbred; 2= local breed;

31. If you prefer Holstein crossbred, why? 1=high yield; 2=relatively larger body size;3= better draft power; 4= All; 5= other (specify) __________

5. If you prefer local cows, why? 1=high yield; 2=resistance to disease; 3= low consumption of feeds and water; 4= others (specify) __________

6. Do you supply milk to the market? 1= Yes; 0= No

7. If your answer is yes in Q6, to whom or what channel and at what price do you sell your milk? Sell to whom? Possible fluid milk marketing outlet choices1=for retailers 2=For Cafes or Restaurants3=for collectors 4= for wholesalers 5=for processors 6= for consumers 7= Specify if any other difference Milk price per litre

8. Are you member of any of the cooperatives? 1=Yes; 0= No.

9. If yes, to which cooperative? (Encircle the best match) 1= Member of milk producer cooperative 2= member of milk retailer cooperative 3= member of milk processor cooperative

10. If you are a member to either of one, for how many years are you engaged in as a cooperative member ____ Give the benefit you get from being a member 1= bargaining power;

2= better profitability, 3=able to process into different milk products; 4= other specify __

11. If you are not a member, specify the reason: 1= not profitable and no fair price;

2=cooperative is not well established; 3=no difference between members and nonmembers;

4=other specify______

12. Do take your animals to veterinary clinics for the health care of your cows/animals? 0=

No, 1= yes. If yes, from where do get the services 1= from government 2= private

13. How do get the animal health services 1= satisfied 2= =Good 3= poor

14. Do you use AI services? 0=No, 1= yes. If yes, for what breed do use? 1= crossbreed 2 = local breed 3= other (specified).

15. From where do get the services 1= from government 2= private

16. What type of breeding do you use for your dairy animals? 1=government AI service; 2= locally by bull; 3= private HF bull AI service; 4= other specify___

17. How do get the AI services 1= satisfied 2= Good 3= poor

18. Do you feed your animals supplement/concentrate feed? 0=No, 1= yes. If, yes what are the concentrate feed types you feed? Specify ……………………………………….

19. Are there financial institutions in your locality that provide you credit access? 1=Yes; 0= No If yes, who is more important creditor? 1= Dedebit micro finance of Tigray 2=Bank; 3= relatives and friends; 4= other (specify) ______________

68. Is milk value chain linkage among the actors improved? 1= Yes; 0= No.

Part 3: QUESTIONS FOR MILK TRADERS

1) How many years of milk trade experience do you have? _____________

2) From whom do you regularly buy milk for trade purpose? 1= from milk producers; 2=other (specify) ______

3) When you are buying your milk, who decides the price? 1= myself; 2= producers;3= brokers; 4=other (specify) ___________

4) At what price do you buy a liter of milk? _______________.

5) To whom do you sell your milk? 1= to retailers; 2=to wholesalers; 3=other (specify) _____

6) At what price do you sell a liter of milk? _____________. What is the marketing cost for a liter of milk? ____________.

7) When you are selling your milk, who decides the price? 1= myself; 2= to retailers;3= wholesalers; 4= Brokers; 5=other (specify) ___________

8) How many liters of milk do you buy per day? ____? Per month? ______? Per year? _____

9) Where do you take your milk after you buy? 1=I store for a while to wait good price;2= I sell it immediately; 3=other (specify) ___________

10) If you store your purchased milk, do you have storing facilities such as refrigerator and room? 1= Yes; 0=N

11) Is there any credit access to support your milk trade? 1= Yes; 0=No

12) If your answer is yes, who is more important creditor? 1= Dedebit credit and saving institute Tigray 2=Bank; 3= relatives and friends; 4=other (specify) ______________

13) Do you have market information for your milk marketing? 1= Yes; 0=No