LIVESTOCK GHG INVENTORY DATA ANALYSIS REPORT IN OROMIA REGION

Submitted to:

Oromia Environmental Protection Authority (OEPA)

Submitted by: JaRco Consulting

June 23, 2023
Finfinnee

Table of Contents

List of Table

List of Figures

Acknowledgements

JaRco consulting and the study team would like to acknowledge the contributions of numerous stakeholders that directly and indirectly contributed to the accomplishment of this study. The broader team who contributed to the study including certain aspects of the methodology are Shimeles Sima and Hailu Tefera from World Bank; Taye Dugassa, Dereje Likissa, Getu Shiferaw, Seifudin Mehadi, Bona Yadessa, Olika Belachew and Mohammed Abarago are from Oromia Environmental Protection Authority (OEPA); Shimels Wassie (PhD) and Andreas Wilkes are from UNIQUE. They have contributed to the research, findings, analysis and reviews but are too numerous to mention.

The inputs of many other Oromia Agricultural office staff at regional, zonal and woreda level who spent considerable time gathering data, providing administrative and logistical support are acknowledged with thanks from the study team.

Finally, we would like to acknowledge individual farmers, feedlot and commercial dairy farm owners, who provided valuable input that went into this report. Without their cooperation, this research would not have been possible.

Study team members:

Tsegahun Tessema, Evaluation Manger
Million Tadesse, PhD, Team Leader
Fekadu Shemekite, PhD, Senior Natural Resource Management Expert
Shigdaf Mekuriaw, PhD, Senior Animal Feed and Nutrition Expert
Mustefa Abu, Senior Animal Science Expert
Ali Abdulhakim, Statistician
Hanna Hailu, PDA Programmer

1. INTRODUCTION

The agriculture and livestock sectors are major contributors of global greenhouse gases (GHG), not only in terms of their carbon footprints but also as a result to the threat they pose with regards to deforestation and land degradation due to overgrazing and landholding capacity (Gołasa et al., 2021). The livestock production system contributes to global climate change directly through the production of methane (CH_4) from enteric fermentation and manure management and nitrous oxide (N_2O) emission from manure management (Dourmad et al., 2008). Among Ethiopian livestock species the major contributor to GHGs emission are cattle, which are used for meat, dairy products, as draught animals and are treated as financial assets (Wilkes et al., 2020). There is a growing need for evidence-based information about changes in agriculture, forests, and other land uses (AFOLU) to guide land use management and planning and to track and meet emissions reductions associated with Nationally Determined Contributions (NDC) to the Paris Agreement and other sustainable development goals (Rose et al., 2021).

In line with this, the World Bank Bio-Carbon Fund Initiative for Sustainable Forest Landscapes (ISFL) has been developing the Oromia Forested Landscape Program (OFLP) in Oromia Region, Ethiopia. The ISFL was committed to promoting the reduction of GHG emissions from the land sector (including agriculture and livestock) in developing countries. For this, the ISFL entered into an agreement with Ethiopia to establish a jurisdictional results-based payment scheme to pay for emissions reductions in order to incentivize and sustain program activities that would improve low emission land-use at a landscape level. The project design was structured in such a way that the results-based payment under the OFLP would be implemented in two phases. The first phase has focused on the reduction of emissions through avoided deforestation and forest development. In addition, ISFL was keen to include payments for emission reductions from the livestock sector and from forest degradation in the second phase, which was in line with the ISFL methodology for comprehensive landscape carbon accounting.

In this study, the GHG inventory covered four cattle production systems (i.e., mixed-crop livestock, pastoral/agro-pastoral, commercial intensive dairy, and smallholder intensive production systems). The previous draft GHG inventory of Oromia used the best available data but faced challenges with respect to missing data in some areas (i.e., population, herd structure in

large commercial dairy and feedlot farms) and poor-quality data (diet composition, milk yield, live weight, manure management system in all production systems). In addition, UNIQUE/CCAFS have developed and tested data collection protocols to collect the missing data required for inventory improvement.

2. OBJECTIVES OF THE ASSIGNMENT

The overall objective of the project was to collect greenhouse gas (GHG) emission estimation input data and to estimate parameters required for GHG emission estimations in cattle species of different production systems.

3. SCOPE OF THE STUDY

To achieve the above objective, the required data for the inventory improvement plan was collected using methods that meet IPCC requirements. The survey was conducted in four cattle production systems. For each system, sampling strategies enabled the estimation of the key parameters to a 95% confidence level for a given level of precision. Data collection tools previously developed and tested by UNIQUE/CCAFS were incorporated in the survey tools. The JaRco team worked closely with the Oromia REDD, Coordination Unit (ORCU) and other relevant institutions including but not limited to: the Ministry of Agriculture's Environment and Climate Change Coordination Directorate (ECCCD) MRV Unit; the Ethiopian Institute of Agricultural Research (EIAR), the Central Statistical Agency; and UNIQUE to finalize this assignment. In particular, with support from the Silva Carbon program, UNIQUE provided technical backstopping to the Consultants to ensure that the survey tool and sampling was adequate; to support the training of enumerators as needed; and to support data analysis to ensure that the outputs were aligned with Oromia regional GHG inventory requirements.

4. STUDY METHODOLOGY

4.1 STUDY DESIGN

This study was designed to collect relevant data input for GHG emission accounting in Oromyia National Regional State (ONRS) Ethiopia, following the IPCC Guideline, i.e. '*2019 Refinement to the 2006 IPCC guidelines for National Greenhouse Gas Inventories*'. The guideline suggests either Tier 1 or Tier 2 could be used as a methodology of GHG emission accounting. Tier 1 would be simply calculated by multiplying population data with default emission factors developed grossly for the African countries. It was understood that Tier 1 could not reflect the real situation of Ethiopian production system (Ethiopian CRGE, 2011) because emission factors inherently vary from one country to another depending on existing livestock population, feed characteristics (feed composition and nutritive values), variation in animal breeds, difference in productivity parameters, difference in manure management systems, and manure characteristics.

Tier 2 was, however, designed to mine country specific data that could better reflect management practices, diets, and animal productivity in different production systems. This is because emissions per animal estimated could also be changed over time if data on management practices or productivity were updated (IPCC 2006, FAO put year, UNIQUE). A Tier 2 approach was, therefore, universally accepted method for capturing the effects of livestock development and climate change mitigation policies on emissions from the sector and to implement carbon credit system for farmers. The IPCC Tier 2 guidelines could also provide different coefficients (such as for estimating feed intake in enteric and manure management system (MMS) emissions, coefficients for estimation of CH_4 and N_2O emission) depending on production system, animal sub-categories (IPCC 2006/2019) that cannot be obtained from other methodologies.

For this study, cattle population was divided into four categories by existing production systems of the country: 1) Mixed Crop Production (MCL) System; 2) Pastoral and Agro-Pastoral (PAP) system; 3) Small and Large Commercial Dairy Production (SLCDP) system; and 4) Commercial Feedlot (CFL) system. It was further classified based on age and sex. Then, high and low productivity systems were defined based on relevant attributes such as feed base, genetics (local and cross/pure breed), production purpose (milk, meat, both). Within each production system, livestock management practices, feed utilization, animal productivity, and manure management

practices were used as important parameters to understand the contribution of the existing cattle production system in the region on GHG emission accounting. These would help to calculate GHG emission using country specific population, production systems, productivity, feed characterization and manure management systems. For creating homogenous sub groupings, herd composition was divided into local and pure/cross breed cattle within each production system. Except the feedlot production system, cattle were sub categorized based on age, sex and production purpose as:

a) Bulls (>3years);
b) Oxen (>3years);
c) growing males (1<3years);
d) dry & lactating cows;
e} post weaning calves (between 6 months and <1 year) male and female
g) Heifers (female (1 ≥ 3 year);
h) Pre weaning calves (< 6 months) male and female

For the feedlot production system, herd composition was defined as growing males within 1-3 and males > 3 years of age for both local and pure/cross breeds.

Since Tier 2 emissions estimates require 'feed intakes' for a representative animal in each subcategory, detailed animals' typical diet for each production system were defined. Broadly, animal diets were classified as 1) Natural grazing; 2) Crop residues; 3) Improved forages; 4) concentrates; and 5) Others, including household leftovers. Under each feed category, feed type which might be provided from within the feed menu to each subcategory were exhaustively listed out. As feeds given to animals differ in volume, quality, availability and price, feed types and its proportion in the "feed basket" to specific subcategory of animal were defined for farmers to recall of feeding practices and volume. 'Proportional piling' technique were used to capture farmers' recall in estimating the proportion of feed given to each subcategory of cattle.

To estimate feed intake, live weight data were required for each animal subcategory. Heart Girth measurement was used to estimate proxies for live weight of the representative sample animal using a 'Heart Girth Measurement Tape'. Depending on genetics (local or pure/cross breeds), the circumference or heart girth estimation varied. For local breeds, HG was measured from a point

slightly behind the shoulder blade, down the fore-ribs andunder the body behind the elbow all the way around. Because data collection targets individual animals, one animal for each subcategory was measured, but number of animals was increased for animal less common in the total herd so that rare animal subcategory does not end up with very low sample size. After the measurement, the live weight was calculated using the method described in Goopy et al. 2017. For pure or cross bred animals, the tape reading for live weight were directly recorded. Then, live weight was calculated using the BOX COX linear regression equation: $LW^{0.3595} = 0.02451 + 0.04894 * HG$. Heart Girth measurement and live weight with Mean and Standard Deviation (SD) or Median as needed were reported.

4.1.1 Sampling procedure

Oromia regional states have twenty-one (21) administrative zones. Out of this, nine (9) potential administrative zones were selected based on security and potential livestock production system in consultation with the client (OEPA/ORCU) and livestock sector representatives from the Bureau of Agriculture for this survey (Table-1). The selected zones were: 1) Ilu Aba Bora; 2) Jimma; 3) East Harrarge; 4) East Shoa; 5) North Shoa; 6) Oromia special zone surrounding Finfinee; 7) Arsi; 8) East Bale; and 9) Borena.

Table1-Selected areas and households for the survey

S. No.	Zone	Wereda	Sample Kebeles	No of House Holds
1	East Bale	Ginir, Gololcha	4	20
2	Arsi	Degelu Tijo, Hetosa, Lemo and Bilbilo, Tiyo	8	120
3	East Harerge	Haro Maya, Jarso	4	106
4	Borena	Diree(Mega), Dubuluk, Yabelo	6	30
5	Ilu Abba Bora	Metu, Yayyo	4	40
6	Jimma	Gomma, Kersa, Seqa Cheqorsa	6	90
7	North Shoa	Kimbibit, Wuchale	4	59
8	Oromia Special Zone Surrounding Finfine	Sululta, Welmera	4	19
9	East Shoa	Ada'a, Lume	4	62

S. No.	Zone	Wereda	Sample Kebeles	No of House Holds
	Total	**22**	**44**	**546**

The sampling frame was classified based on production system (mixed crop-livestock, pastoral and agro-pastoral systems, commercial dairy production, smallholder dairy production, and commercial feed lot systems). For MCL and PAP, 22 Woredas were selected purposely from each of the nine zones selected in consultation with client. Two (2) Kebeles from each woreda were also purposely selected due to accessibility, potential production system making a total of 44 surveying kebeles. Households for this production system were selected in a systematic random sampling method. A total of 540 HHs were interviewed in this survey. A list of household names was gathered from woreda administrative office and used for sampling. The sampling technique was using a five (5) household range in which a sample household selected first was used as reference household. The sampling protocol was designed to achieve a precision level of at least ±5% at 95% confidence interval.

For feedlot farms, eight (8) Weredas were selected purposefully from eight zones, and a total of 69 feedlot farms were interviewed. For small dairy farms located in Urban and Peri-Urban areas, ten (10) weredas were selected from the sample frame list obtained from UNIQUE/CSA. Whenever farms in the list could not be available during the survey time, other farms were replaced to meet the planned number of farms. Therefore, a total of 122 farms were interviewed. Similarly, fifteen (15) weredas in nine (9) zones were selected from the sample frame list obtained from UNIQUE/CSA. And a total of 99 medium and dairy large farms were included for interview (Table 2).

Table 2: Number of selected farms for feedlot, small dairy, medium & large dairy farms survey

S. No	Wereda	Feedlot farms	small dairy farms	medium and large dairy farms
1	Bedelle	4	15	10
2	Jimma	3	6	16
3	Shashemene	-	15	2
4	Metu	3	-	-
5	Goma	1	-	-

6	Adama	20	24	6
7	Ada'a/Dukem	6	12	23
8	Lume	29	6	3
9	Lemo and Bilbilo	3	-	1
10	Kimbibit	-	1	12
11	Sululta	-	3	13
12	Goba	-	15	3
13	Robe	-	25	1
14	Wuchale	-	-	2
15	Sebeta Hawass	-	-	2
16	Welmera	-	-	5
17	Ginir	-	-	1
		69	122	99

4.1.2 Sampling design

Calculating the sample size was a critical step in the survey design. It could ensure the production of reliable statistics by keeping the sampling errors to a minimum. The recommended approach was the one that considered the analytical requirements of the survey, i.e., it ensured the reliable estimation of key variables of interest. The variable of interest could be chosen among the key variables necessary for the calculation of the most important indicators expected from the survey operation. A measure of statistical dispersion (coefficient of variation, variance, standard error, etc.) of the variable of interest in the population was calculated using census data.

Thus, three sampling frames were used in order to consider different framing systems. These included mixed farming, pastoral and agropastoral framing system as well as commercial faming system.

4.1.3 Sample size design for mixed, pastoral and agropastoral system

Standard errors, coefficients of variation and design effects for a key indicator from the previous similar study were used to study the sample size and level of precision for the mixed system in the rural part of Oromiya region. Sample size was fixed to 10 agricultural households per kebele based on the review result, to be selected randomly, in each rural sample kebele/EA.

The design follows two stages that stratifies cluster sampling. Given that the rural kebeles/EAs in the frame were stratified by zone within Oromiya region, sample kebeles/EAs were selected within each stratum using systematic PPS sampling. As mentioned previously, the 10 agricultural sample

households in each rural kebele/EA for the sample were selected for interview, which brought the total number of households that were included in the sample to 540(after cluster adjustment). The allocation of households to each of the selected woredas within each zone, was based on the PPS sampling methods. Similarly, kebeles were selected within woredas based on their different farming systems (mixed, pastoral and agropastoral farming system).

- The minimum sample size was determined by the following formula:

Where,

- n = required minimum sample size.
- D = design effect of 1, with the assumption high Intraclass Correlation Coefficient (ICC) close to 1 indicates high similarity between values from the same group - between two respondents from the same enumeration area to minimize.
- P = the estimated level of a key survey indicator. In the absence of relevant indicator data which would enable the specification of a P value, this was set at 50% (0.5) in order to maximize the sample size and thereby avoid sampling error.
- Zα = the z-score corresponding to the confidence interval of 95% with a corresponding tabular value of 1.96.
- nr = an estimate of non-response which can be used to mitigate against attrition risk. This was set at 10% (with a corresponding formulaic value of 1.1)
- e = margin of error (MOE) = 5% (corresponding formulaic value 0.05)

Based on the above parameters, the initial sample size is 423. Using cluster adjustment, the total sample size will be 540. The distribution of the samples across the selected zone is done using PPS sampling methods. The survey will cover a total of 54 kebeles in 22 woredas across 9 zones of Oromia region (Table 3 and Table 4).

Table 3: Sample size determination for MCL and PAP

P	Nonresponse rate	MOE (e)	Zα	D	Initial sample size	Adjusted sample size for clustering
0.5	0.1	0.05	1.96	1	423	540

Table 4: Mixed, pastoral and agropastoral farming system sample distribution

Selected zone	updated woredas in zone	Sample woreda	Population	Initial sample distribution	Initial Sample kebele (considering 10 HH per Kebele)	No Sample kebele per woredea	Number of kebele	Final sample size after cluster adjustment
East Bale	8	2	617417	13	2	1	2	20
Arsi	25	4	3894248	81	9	3	12	120
East Harerge	16	2	3954416	83	9	5	10	100
Borena	10	3	1402530	30	3	1	3	30
I/A/Bor	24	2	1861919	39	4	2	4	40
Jimma	17	3	3568782	75	8	3	9	90
North Shoa	18	2	2100331	44	5	3	6	60
Oromia Special Zone Surrounding Finfine	10	2	855676	18	2	1	2	20
East Shoa	13	2	2126152	45	5	3	6	60
Total	141	22	20381471	428	47		54	540

4.1.4 Sample size design for the dairy and feedlot commercial farms

To determine the required dairy and feedlot commercial farms sample size needed to achieve the objectives of the OFLP survey, major indicators are measured as totals (pure or cross cows/cattle size) and considered the reporting levels and desired level of precision. The table below summarizes the dairy and feedlot farms in the Oromia region and the respective recommended sample size.

The minimum sample size n, was determined by:

$$n = \frac{n_o}{1+\frac{n_o}{N}} * \frac{1}{R}$$

where $$n_o = \frac{S^2/\bar{Y}^2}{CV_o{}^2}$$

S = Population standard deviation

$\overline{Y}$= Population means

R= expected response rate (90 % from previous similar study)

CV_o= Desired level of coefficient of variation (0.05)

4.1.5 Sampling frame for the dairy and feedlot commercial farms

The sampling frame for the dairy and feedlot commercial farms (Table 5) was determined based on the list of farms with their livestock numbers collected in 2021/22 in the Oromia region by Ethiopian Statistical Service in collaboration with UNIQUE and Oromia Regional Livestock Resources Development Agency. The data was collected both in rural and urban parts of the Oromia region. The collected farm list was comprised of all of the commercial livestock farm types; urban, peri-urban dairy farms; medium and large commercial farms and feedlot farms.

Based on the total number of livestock holdings, commercial farms are divided into three categories, including small, medium and large farms using a preset cut-off point. With due consideration of the advises given by the Oromia Regional Livestock Bureau, commercial dairy farms were categorized into small dairy farms with 1-5 pure/cross cows, medium commercial dairy farms with 6-20 pure/ cross cows, and large dairy farms with more than 20 pure/cross cows. In this study, two separate sample designs were employed for the commercial farms due to the variation in the number of farms and the number of livestock holdings. Farms having a total number of livestock above the cutoff point will be selected with certainty whereas farms having a total number of livestock below the cutoff point were sampled using probability proportional to its size (size being the total number of livestock in the farms). As such, farms with 20 pure/cross+ cows were taken as a 'take-all stratum': added to the sample with a probability of selection equal to one.

Table 5: Sample size for commercial dairy and feedlot farms in Oromia region

Farm Type	**Population (N)**	**Population Mean ($\bar{Y}$)**	**Population**	**R**	**CV_0**	**n_0**	**N+n0/N**	**Calculated Sample size**	**Final sample size**	**Cut off point**

Small holder dairy farm (urban per urban dairy)	716	2.24	1.21	0.9	0.05	116.7	1.16	112	112	<= 5 pure/cross cows
Medium dairy Commercial farms	213	9.89	3.84	0.9	0.05	60.3	1.28	52	52	6-20 pure/cross cows
Large dairy Commercial farms	66	56.7	53.91	0.9	0.05	361.6	6.48	62	66 (take all stratum)	>20 pure/cross cows
Feedlot farms	72	73.96	88.91	0.9	0.05	578.1	9.03	71	72 (Census)	>= 10 cattle

4.2 DATA COLLECTION TOOLS AND METHODS

Two methods of data collection were used to collect the required data in this survey: primary and secondary data sources. The first was a document review in which GHG emission inventory, Data improvement plan, statistical documents, data collection protocols, policies (CRGE and Livestock Master plans), livestock MRV development documents, and various scientific reports relevant to the study objective were assessed. The second was on demonstrating a closed end survey questionnaire at selected household level that serves as primary source of data.

a) **Reviewed information from the secondary sources**

   For calculating livestock performance, it was necessary to review published documents. On the basis of this idea, the following information were thoroughly reviewed and used for the intended purpose. These include nutritive value of feeds by feed type (DM, DOMD, ME, etc.), average milk fat (%) and protein (%) content of milk, etc.

b) Household survey and observation: Primary source

Data at the household level were collected across various parameters using a specific data collection tool for each of the parameter. These parameters include bodyweight, diet composition, manure management system, milk yield, heard composition, etc... Details on the data collection and analysis for each of the parameters are presented in each section in the report.

5. RESULT OF THE SURVEY

5.1. HERD COMPOSITION

Herd composition data was collected across all production systems; and the average animal holding was calculated by different production systems and presented hereunder (Table 6). In addition, cattle population was calculated and presented based on production system, age, sex, and breed for MCL, PAP, smallholder dairy, large commercial dairy and commercial feedlot.

5.1.1 Mixed crop livestock:

Mixed crop livestock production system is one of the livestock production systems in which milk production is an integral part of the system of small-scale noncommercial subsistence farms. This system represents 84% of the population and is responsible for 98% of the total milk produced (Tadesse et al, 2017). Indigenous stock are the typical animals maintained within this system; and the stock are for the most part expected to feed for themselves, making the best of natural pasture and crop residues.

5.1.2 Smallholder dairy:

Smallholder dairy is developed in urban and peri-urban areas where the human population density is high and agricultural land is shrinking due to urbanization. It possesses animal types ranging from 50% crosses to high grade Friesian in small to large sized farms and contributed only 2% of the total milk production of Ethiopia. This sector owns most of the country‘s improved dairy stock (Gebre et al, 2000). The main source of feed is both home produced and purchased hay and the primary objective is to get additional cash income from milk sale. For this survey, , the following sub categories were used to estimate herd composition of cross & pure breed: adult pure exotic dairy cows (3-10 years), adult pure exotic males (3-10 years), adult ox > 3 years age pure exotic calves (<6 months, male and female), pure exotic calves (6 m – <1 year, male and female), pure exotic growing males (1-<3 years) and pure exotic growing females (1-<3 years).

5.1.3 Large Commercial dairy cattle sub-category populations:

The commercial dairy production system is defined as dairy cattle on urban and peri-urban farms and on medium or large commercial farms. Farmers use commercial feed for the most part for their dairy cattle. Milk is the main source of farm income. The herd is dominated by improved/cross breed dairy

cattle and the production system is market oriented and milk production is for sales. Compared to other systems they have relatively better access to inputs (e.g. feeds) and services (e.g. artificial insemination) provided by the public and private sectors and use intensive management system (Siegefreid and Berhanu, 1991). In this survey, dairy farms with 6-20 crossbred animals were determined as medium farms; and those farms having more than 20 crossbred animals were regarded as large farms. Indigenous cattle/ other cattle; Other cattle include dual purpose cattle (i.e. indigenous breeds) in the mixed crop-livestock production system and the pastoral/agro-pastoral production system. A total of 16 sub-categories were defined.

5.1.4 Average number of cattle holding:

a) Cattle holding in MCL production system

Average number of cattle holding in MCL, PAP, Small dairy, and Medium & Large dairy production system was depicted in Table 6.

In MCL, the highest average number of indigenous cattle holding was found to be oxen (2 heads per HH), followed by lactating cows and bulls (i.e. 1,5heads/HH). The average holding of preweaning males and preweaning female calves was small (around 1 head per HH). The highest and the lowest average crossbred animal holding was 2 animal/HH and 1 animal/HH for preweaning calves and post weaning calves, respectively.

5.1.5 Cattle holding in Pastoral and Agropastoral production system:

In PAP, preweaning males, dry and lactating cows and oxen were subcategories with the highest average cattle holding. i.e 6 animals per HH for each the lowest holding was observed for preweaning females and growing heifer, around 3 animals/HH (Table 6).

5.1.6 Cattle holding in Smallholder dairy production system

The highest average holding was for Oxen and dry and lactating cows, 4 and 2 animals per HH, respectively. The highest bull holding in smallholder was related to the small number of HH, only 7 HHS were reported which had a higher standard error. Although smallholder farms tend to keep bulls for breeding purpose the figure was higher than expected. The average number of holding for preweaning and growing males was lowest, around 1 animal/HH (Table 6).

5.1.7 Cattle holding in Medium and large commercial dairy production system

The average animal holding in medium and large commercial farms was highest for dry and lactating cows at 10 and 46 heads per farm, followed by growing females or heifers (1-3 years) 4 and 14 heads per farm, female calves (6 months-1 year) 3 and 11 heads per farm, and preweaning females (< 6 months) 3 and 9 heads per farm, respectively. The lowest average holding was for bulls, preweaning males, growing males and male calves (Table 6).

Table 6: Number of Households who owns various subcategories of indigenous and crossbred dairy cattle

Production system	Subcategory	No of Animal	Mean no of animal/hh	SE
Indigenous cattle MCL	Dry and Lactating cows	364	1.5	0.044
	Bulls	175	1.5	0.062
	Oxen	209	2.1	0.087
	Preweaning females and male calves (< 6 months)	177	1.15	0.04
	Male and female calves (between 6 month &<1yr)	199	1.25	0.07
	Growing male (1-< 3 years)	140	1.3	0.047
	Growing females/heifers (1-< 3 years)	150	1.3	0.049
Indigenous cattle in Pastoral and agro-pastoral	Dry and Lactating cows	24	5.7	2.660
	Bulls	13	3.2	1.449
	Oxen	10	5.9	3.814
	Preweaning males & females (< 6 months)	9	4.67	2.5
	Male & female calves (between 6 month &<1yr)	8	4.25	2.97
	Growing male (1-< 3 years)	18	4.8	1.809
	Growing females/heifers (1-< 3 years)	24	3.3	1.069
Crossbred in MCL	Dry and Lactating cows	251	2.0	0.074
	Bulls	87	1.5	0.098
	Oxen	72	1.8	0.140
	Preweaning males & female (< 6 months)	111	1.2	0.070
	Male & female calves (between 6 month &<1yr)	181	1.25	0.12
	Growing male (1-< 3 years)	96	1.3	0.052
	Growing females/heifers (1-< 3 years)	128	1.4	0.059
	Dry and lactating cow	132	2.24	0.106

Production system	Subcategory	No of Animal	Mean no of animal/hh	SE
Smallholder dairy	Bulls	9	3.67	3.189
	Oxen	3	1.3	0.000
	Preweaning males & female calves (< 6 months)	68	3.24	0.09
	Male & female calves (between 6 month &<1yr)	94	1.49	0.13
	Growing male (1-< 3 years)	37	2.26	0.11
	Growing females/heifers (1-< 3 years)	69	1.5	0.094
	Dry and lactating cow	58	10.29	0.54
	Bulls	11	1.7	0.396
	Oxen	5	2.0	0.43
	Preweaning males & female (< 6 months)	49	2.0	0.25
	Post weaning male & female calves (between 6 month &<1yr)	76	2.6	0.30
	Growing male (1-< 3 years)	30	2.23	0.38
	Growing females/heifers (1-< 3 years)	36	4.0	0.61
Large commercial dairy	Dry and lactating cow	31	45.9	4.364
	Bulls	16	2.6	0.677
	Oxen	4	3.5	1.041
	Preweaning males & females(< 6 months)	35	6.47	1.98
	Male & female calves (between 6 month &<1yr)	41	7.49	1.89
	Growing male (1-< 3 years)	20	4.4	0.941
	Growing females/heifers (1-< 3 years)	25	14.4	2.832

The proportion of the cattle subcategory in each production system is depicted in Table 7. Despite the fact that the proportion of each sub-category varied among the production system, the trend looked similar. The proportion of dry and lactating cows in the herd ranked higher compared to the other subcategories across all four production systems. Dry and lactating indigenous breed cows accounted for 27% and 29% of total indigenous cattle in MCL and PAP herds. Dry and lactating crossbred cows were the main animal holding across all production systems, followed by growing males and females (1-3 years). Adult dry and lactating cows accounted for 36%, 43%, 56% of the crossbred herd in MCL, smallholders and large commercial herds, respectively (Table 7).

Table 7: proportion of each subcategory to total herd in different production system

	Indigenous cattle in MCL		Indigenous cattle in PAP		Crossbred cattle in MCL		Smallholder		Medium commercial		Large commercial dairy	
Subcategory	N	%	N	%	N	%	N	%	N	%	N	%
Dry and Lactating cows	555	27.31	137	29.149	507	35.629	333	43.644	597	52.05	1423	56.02
Bulls	270	13.29	42	8.936	131	9.206	41	5.374	19	1.66	41	1.61
Oxen	429	21.11	59	12.553	128	8.995	3	0.393	10	0.87	14	0.55
Calves (< 6 m) male and female	158	7.78	37	7.872	134	9.417	89	11.664	105	9.15	251	9.88
Calves (6 m-< 1 year) male and female	247	12.16	30	6.383	227	15.952	143	18.742	203	17.70	365	14.37
Growing male (1-< 3 years)	177	8.71	86	18.298	122	8.573	49	6.422	67	5.84	87	3.43
Growing females/heifers (1-< 3 years)	196	9.65	79	16.809	174	12.228	105	13.761	146	12.73	359	14.13
Total	2032		470		1423		763		1147		2540	

5.1.8 Total cattle number estimation by type of animal and farm for Oromia region level

This section presented the estimated total population of different types of cattle by farming type (small dairy farms, medium and large dairy commercial farms as well as feedlot farms) across the Oromia region. The total number of each type of cattle was recorded by interviewing each herder within the selected farms, after which point the estimated total population of the animals is calculated based on the Horvitz-Thompson estimator method. The Horvitz–Thompson estimator is frequently applied in survey analyses and can be used to account for missing data, as well as many sources of unequal selection probabilities. Horvitz-Thompson estimator methods is a method for estimating the total1 and mean of a pseudo-population in a stratified sample. Inverse probability weighting is applied to account for the different proportions of observations within strata in a target population (Table 8 & 9).

[1] Horvitz, D. G.; Thompson, D. J. (1952) "A generalization of sampling without replacement from a finite universe", *Journal of the American Statistical Association*, 47, 663–685,

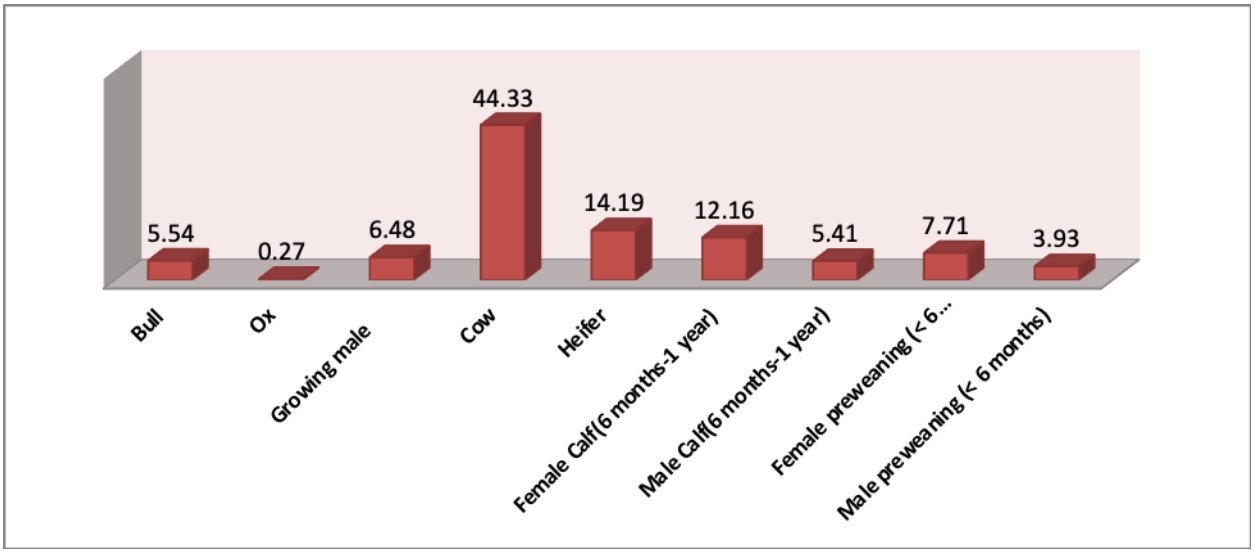
5.1.9 Total number of cattle by different animal type in small dairy farms

The survey collects information regarding the number of cattle at small dairy farms and estimations were made on the total population for each type of animal subcategory across the Oromia region. As shown on the table 8 and figure 1 the total cattle population of smallholder dairy in urban and peri-urban was estimated to be 4,785. Out of this total cattle population, the total number of dry and lactating cows was about 44 percent, heifers accounted for 14 Percent, the percentage share of female calves was 12 percent and ox made up less than 1 percent (Table 8).

Table 8: Small Dairy Farms Herd Structure

Cattle type	NO HHs	Unweight	Weighted	SE
Bull	9	41	265	185.57
Ox	3	3	13	
Growing male	37	49	310	26.23
Cow	132	333	2121	89.64
Heifer	69	105	679	41.81
Calves (6 months-<1 year)	94	143	841	52
Calves (< 6 months) male & females	68	89	557	35
Total	**412**	**763**	**4785**	

Figure 1: Distribution of cattle by type in percent



5.1.10 Total number of cattle by different animal type in medium and large dairy farms

The estimated numbers and percentage distributions of cattle by type of cattle for medium and large dairy farms in the Oromia region is presented in Table 9.

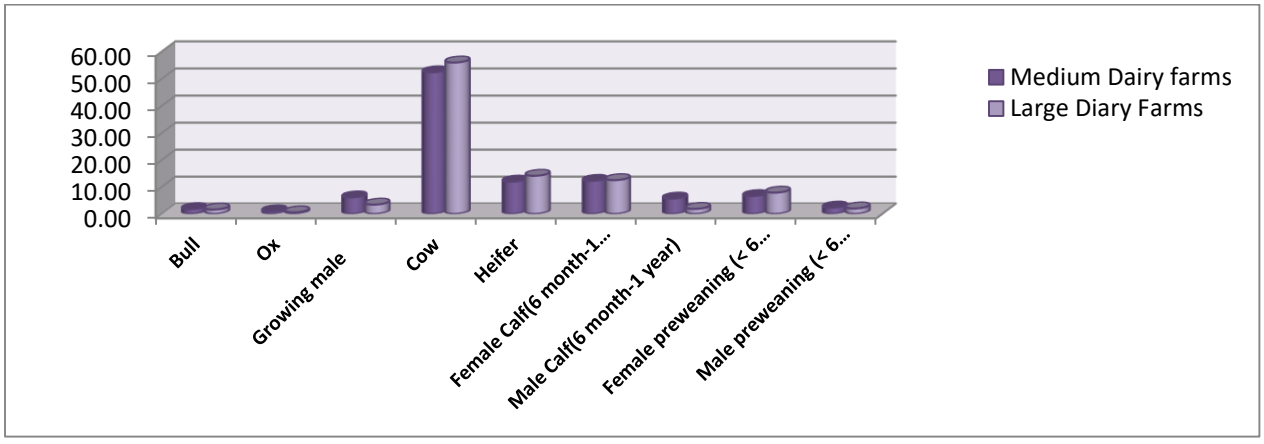
In a medium dairy farm about 5,105 cattle were estimated to be found in the region out of which about 52 percent were cows, 12 percent were female calves and heifers; and ox took the lowest share of the cattle population at less than 1 percent.

In large dairy farms, the number of animals estimated in the region was about 6883 head. Out of this total cattle population, 56 percent were cows, about 14 percent were heifers, 12 percent were female calves. Female pre-weaning calves made up about 8 percent. (see Table 9 and Figure 2).

Table 9: Medium and large dairy farms herd structure

		Medium Diary Farms			Large Dairy Farms		
Cattle type	**N**	**Unweight**	**Weighted**	**SE**	**Unweight**	**Weighted**	**SE**
Bull	11	19	87	20.17	41	111	28.95
Ox	5	10	48	13.65	14	38	10.36
Growing male	76	67	314	51.07	87	236	50.22
Cow	58	597	2644	136.43	1,423	3856	362.75
Heifer	36	146	649	95.10	359	973	189.64
Calves (6 months-<1 year)	76	203	897	49.09	365	989	250.77
Calves < 6 months	49	105	466	28.225	251	680	214.18
Total	**311**	**1147**	**5105**		**2540**	**6883**	

Figure 2: Cattle distribution in medium and large dairy farms



5.1.11 Total number of cattle for feedlot farms

The survey collected information regarding the number of feedlot cattle by age and breed. The numbers and percentage distributions of feedlot cattle in the study area as well as number of feedlot males in the region was indicated in Table 10. The number of feedlot males is estimated to be 7,817 head in sampled farms and this was projected to be 9380 feedlot males for Oromia region per fattening cycle, out of which about 21 percent were pure/crossbreed, and about 79 percent were local breed.

Pertaining to the age distribution of feedlot cattle, the largest portions were in the age group of cattle greater than three years, which was followed by cattle between the age of one to three years with nearly 94 percent and 7 percent, in that order.

Table 10: Distribution of feedlot cattle by age and by breed type projected to 72 HHs

Estimate for sampled HHS						
Age	Total Number	%	Pure/Cross breed		Local breed	
			Number	%	Number	%
Feedlot cattle	7817		1645	21	6172	79
cattle 1-3 yrs	508	6.5	230	14.0	278	4.5
cattle > 3 yrs	7309	93.5	1415	86.0	5894	95.5
For total HHS in Oromia region (72)						
Age	Total Number	%	Pure/Cross breed		Local breed	
			Number	%	Number	%
Feedlot cattle	9380		1974	21.0	7406	79
cattle 1-3 yrs	638	6.80	276	13.98	333.6	4.50
cattle > 3 yrs	8771	93.50	1698	86.02	7073	95.50

5.1.12 Reanalysis of livestock data for mixed system

One of the deliverables for this assignment was reanalysis of livestock data for mixed farming systems by breed, age and sex of cattle using the data obtained from Ethiopian Statistics Service, ESS (formerly Central statistics agency of Ethiopia) and annual livestock sample survey data. The team investigated the data collection tool used by ESS and the data itself to extract the information needed for the analysis. However, the data was not collected and categorized by breed, age and sex of the cattle. As such it is not suitable to do the analysis requested.

ESS conducts livestock sample surveys annually, regardless of the type of breed, age, purpose and sex. Although ESS has collected information on livestock based on breed, age and sex as a pilot in the past two years, the data has not been realized officially for the public. The sample data collection tool used by ESS to collect data on the livestock sample survey. It is presented here to show the micro data structure of the survey tool.

Number of Cattle by Age and Purpose on Nov 10, 2022

	None		Total		Male		Female	
1. Cattle of all ages _____			1		2		3	
a. Cattle less than 6 months _____			4		5		6	
b. Cattle 6 months and less than 1 year_____			7		8		9	
c. Cattle 1 year and less than 3 years _____			10		11		12	
d. Cattle 3 years and less than 10 years _____			13		14		15	
1. Beef Cattle_____			16		17		18	
2. Cattle for breeding _____			19		20		21	
3. Dairy cows_____			22				23	
4. Cows that gave milk for the last 12 months_____			24				25	
5. Draft cattle_____			26		27		28	
6. Cattle for other purposes_____			29		30		31	
e. Cattle 10 years and older_____			32		33		34	
f. Grand Total_____			35		36		37	
1. Local breed_____			38		39		40	
2. Exotic_____			41		42		43	
3. Hybrid_____			44		45		46	

5.2. LIVE WEIGHT AND GROWTH RATE OF CATTLE

5.2.1 Average live weight of cattle

The live weight was calculated for indigenous cattle in MCL and indigenous cattle in PAP for 9 sub-categories of cattle using the following heart girth measurement data linear regression equation:

$$LW0.3595 = 0.02451 + 0.04894 * HG, \quad \text{where}$$

LW is live weight in kg and HG is heart girth measurement reading.

For crossbred in MCL live weight was calculated from the heart girth measurement reading for 7 sub-categories of crossbred cattle. For preweaning crossbred calves live weight was not estimated

because the live weight reading on the heart girth measurements were not available in the standard heart girth tape.

Average live weight (kg/head) and age in months (months/head) of adult indigenous cattle in MCL was highest (Table 11) for Ox (at 328 kg), followed by bulls (270 kg) and dry and lactating cows (259 kg). Similarly, the average live weight and age increased from pre-weaning calves to adult male and females.

Table 11: Live weight of indigenous cattle in MCL

Subcategory	Live weight in kg				Body condition status			
					Not poor		Poor	
	N	Average	SE	Median	N	% of HH	N	% of HHs
Preweaning male and female < 6 months	141	60	2.94	52	112	79	29	20
Post weaning Male and female 6m-1 yr	199	89	3.84	79	162	81	37	19
Growing male 1-3 years age	140	146	4.39	142	107	76	33	24
Heifers/growing females 1-3 years	150	157	4.44	156	120	80	30	20
Adult breed oxen	207	328	8.15	325	174	84	33	16
Adult breed bulls	175	270	8.33	258	155	89	20	11
Adult breed dry and lactating cows	353	260	5.46	240	292	83	61	17
Mature weight								
Ox 3-≥10 years age class	174	345	8.67	342				
Breeding bull 3-≥10 years age	155	282	8.43	263				
cows 3-≥10 years age	292	271	6.1	244				

N=Number of animals and SE=standard error

The median live weight (kg/head) and age in months (months/head) of adult indigenous cattle in PAP was highest (Table 12) for Ox (254 kg), followed by dry and lactating cows (205 kg). Similar to MCL, the average live weight and age in PAP cattle increased from pre-weaning calves to adult male and female cattle.

Table 12: Live weight of PAP cattle

Sub-category of PAP cattle	Live weight in kg				Body condition			
					Good		Not good	
	N	Average	SE	Median	N	%	N	%
Male and female < 6 months	9	73	13.07	63			9	100
Male and female (6- <1 year)	7	66	8.94	65			7	100
growing male (1-< 3 years)	18	124	13.10	104			18	100
heifers (1-< 3 years)	24	121	10.21	108	1	4.17	23.00	95.83
Adult oxen (3 to ≥10 years)	10	270	25.10	254			10	100
breed bulls (3 to ≥10 years)	13	261	55.47	189			13	100
dry and lactating cows (3 to ≥10 years)	24	208	5.24	205	1	4.17	23	95.83
Mature weight of adult animal								
Mature Ox	-	-	-	-	-	-	-	-
Mature breed bulls	-	-	-	-	-	-	-	-
Mature Dry and lactating cows	1	218		218				

N=Number of animals and SE=standard error

The median live weight (kg/head) adult crossbred cattle in MCL was highest (Table 13) for Ox (at 432 kg), followed by bulls (370 kg) and dry and lactating cows (364 kg). Similarly, the average live weight and age increased from post weaning calves to adult male and females. Crossbred animals in MCL had a higher live weight compared to indigenous cattle in MCL at all age classes/subcategories.

Table 13: Average live weight of crossbred cattle in MCL, kg/head

	N	Average	SE	Median
Male and female calves (6 months- <1 year)	181	120	3.70	110
crossbred male cattle (1-< 3 years)	96	186	6.64	181
Crossbreed female cattle (1-< 3 years)	128	191	6.69	182
Crossbred oxen (≥3 years)	72	430	11.04	432
Crossbred bulls (≥3 years)	87	387	11.19	384
Crossbred dry and lactating cows (≥3 years)	249	370	5.68	364

N=Number of animals and STD=standard deviation

5.2.2 Daily average growth rate of cattle

Live weight gain per day was calculated as the change in weight between initial weight at the subcategory and final weight of the same subcategory divided by the number of days between the

initial weight age class and the final weight age classes. For example, live weight gain for calves < 6 months old was calculated as live weight at 0 months old and live weight at the 5th month was divided by the number of days between the two ages class (5 months). Weight gain for calves ages 6 months to < 1 year was calculated as the difference between the initial weight (6 months old weight) and final weight (weight at 11 months age weight) divided by difference in number of days between the initial weight and final weight (Table 14 and Table 15).

The average daily growth rate for indigenous cattle in MCL was 0.122, 0.189, 0.096 and 0.028 kg per day for calves < 6 moths), calves between 6- < 1 years, growing males and heifers respectively. Average daily growth rate decreased with age except for a slight increment at early age. There was also a small number of animals available for heart girth measurements in each subcategory, in some cases only one or two animals. The body weight growth rate for PAP cattle was estimated to be 0.322, negative 0.233, 0.113 & 0.019 kg per day for calves < 6 moths, calves between 6- < 1 years, growing males and heifers, respectively. Both body weight and average growth rate for PAP are not representing the normal condition mainly due to the long drought period at the time of survey in the area and small number of observations (Table 14).

Table 14: Initial weight, final weight and average daily weight gain of indigenous cattle in MCL

		N	Average	SE	Median	AWG, kg/day
Indigenous cattle in MCL						
Indigenous breed Male and female < 6 months	Starting weight age= month 3	13	34.31	3.55	34	
	final weight age=5 months	66	69.73	5.24	56	0.122
Indigenous breed Male and female 6m- < 1 yr	Starting weight age =7 months	13	64.1	4.76	62	
	final weight age=month 10	25	113.7	17.26	96	0.189
Indigenous breed male 1-< 3 years age	Starting weight age=12 months	7	97.43	10.14	107	
	final weight age=32 months	10	176.2	19.17	176	0.096
indigenous breed female 1-< 3 years	Starting weight age=12 months	3	142.5	10.21	143	
	final weight age=35 months	20	169.65	11.22	163	0.028
Indigenous cattle PAP						
Indigenous breed Male and female < 6 months	Starting weight age =3 months	3	51	27.06	34	
	final weight age=5 months	2	63	0.00	63	0.322

		N	Average	SE	Median	AWG, kg/day
Indigenous breed Male and female 6m-< 1 year	Starting weight age 7 months	3	71	4	75	
	final weight age=10 months	3	48	11.619	54	-0.233
Indigenous breed male 1-< 3 years age	Starting weight age=12 months	6	97	8.49	93	
	final weight age=32 months	2	171	45.42	174	0.113
Indigenous breed female 1-< 3 years	Starting weight age=12 months	6	106	13.51	107	
	final weight age=35 months	3	118	11.67	121	0.019

N=Number of animals and SE= standard error

For crossbred in MCL the average daily growth rate (kg/head/day) was highest (0.228 kg) for crossbred calves between 6 months to < 1 year age followed by crossbred growing females the median weight was 0.03 kg (Table 15)

Table 15: Initial weight, final weight and average daily weight gain (kg/head) of crossbred cattle in MCL

Subcategory		N	Average	SE	Median	AWG, kg/head/day
Male and female (6 months- <1 year)	Starting weight age 5 months	21	91.67	5.76	89	
	Final weight age=11 months	18	144.11	10.14	130	0.228
crossbred male (1-<3 years)	Starting weight age=12 months	6	144.67	20.85	153.5	
	Final weight age=32 months	6	181.33	8.54	184	0.046
Crossbreed female (1-<3 years)	Starting weight age=12 months	5	166.20	12.02	166	
	Final weight age=35 months	5	202.20	16.70	188	0.030

N=Number of animals and standard error

5.2.3 Commercial feedlot

Data on feedlot systems were collected from a total of 60 feedlot farms. The present average number of local males ages 1-3-years old, the average number of local males > 3 years old, the average number of crossbred males 1-3 years old and average number of crossbred males > 3 years old were estimated to be 29, 102, 26 and 74 animals per farm per cycle (Table 13). The average cycle length was 120, 120, 120 and 180 days (median value), respectively for local breeds 1-3 years old, local breeds > 3 years old, crossbreds 1-3 years old and crossbred > 3 years old,

respectively. The average daily growth rate, kg/day was estimated based on data of average initial weight and final body weight divided by the difference in cycle length (duration of fattening) in days. Average daily weight gain was estimated to be 1.1, 1.35, 1.67 and 1.39 kg/head/day for local males of 1-3, local male > 3 years, crossbred male 1-3 years and crossbred male > 3 years old, respectively. The values obtained for average daily weight gain was slightly higher and may be overestimated. The purchase/initial weight as well as the finishing weight were collected via interview using a recall system since there was no measured data available as data recording systems are not practiced in all commercial feedlot farms. This could potentially have led to an overestimation or an under estimation of the initial purchasing weight and final weight and hence average daily growth (Table 16).

Table 16: No of animal, no of cycle and daily growth rate of feedlot males

	Parameters	N *	Average	SE	Median
Local breed 1-3 years age	No of animal per cycle	10	29	7.94	24
	No of cycle per year	10	3	0.17	3
	Cycle length in days	10	137	9.43	120
	Initial weight kg/head	10	167	7.68	158
	Final weight kg/head	10	309	25.24	310
	Average daily growth rate, kg/day/head	10	1.020	0.11	**1.097**
Local breed > 3 years age	No of animal per cycle	58	102	3.30	50
	No of cycle per year	58	2	0.08	2
	Cycle length in days	58	138	5.23	120
	Initial weight kg/head	58	189	4.37	193
	Final weight kg/head	58	375	7.17	357
	Average daily growth rate, kg/day/head	58	1.40	0.06	**1.348**
Crossbred 1-3 years age	No of animal per cycle	9	26	7.70	15
	No of cycle per year	9	3	0.24	2
	Cycle length in days	9	144	11.44	120
	Initial weight kg/head	9	262	22.66	280
	Final weight kg/head	9	483	24.27	450
	Average daily growth rate, kg/day/head	9	1.71	0.22	**1.667**
	No of animal per cycle	19	74	14.60	70.00
Crossbred > 3 years age	No of cycle per year	19	2	0.14	2.00
	Cycle length in days	19	163	7.00	180.00
	Initial weight kg/head	19	245	12.22	230.00
	Final weight kg/head	19	493	17.06	460.00

	Parameters	N *	Average	SE	Median
	Average daily growth rate, kg/day/head	19	1.68	0.16	**1.39**

***= number of feedlot farms**

5.3. MANURE MANAGEMENT SYSTEM

Manure management data was collected for mixed crop livestock, pastoral, smallholder dairy, commercial dairy and commercial feed lot systems. First, farmers were asked to identify the wet and dry season of the months in a year, and also to tell us how many months are dry and how many are wet. Then, they were asked about the proportion of manure managed in each season (dry and wet seasons) under different manure management systems. Farmers were asked supplementary questions to better characterize specific manure management practices and manure residence/storage time in different manure management systems. The percentage of each manure managed practice per household was estimated using frequency distribution. The average and standard error were calculated for each of the manure management practices (Table 16).

Once data on the proportion of manure managed in each manure management system was obtained for the dry and wet seasons, the next step was to calculate the annual weighted average MMS value for each MMS, following the estimation formulae below.

Annual Weighted average MMS value = (Proportion of manure managed in Pasture drops during dry season * (number of months in dry season/12) + (Proportion of manure managed in pasture drop MMS during wet season * (number of months in wet season/12)

Statistical analysis:

Data on MMS from each household was entered into an Excel spreadsheet, edited, segregated and transposed into SPSS and SAS software. The proportion of manure managed in different manure management systems was estimated using mean and standard error. Data on manure storage time/residence time in main management systems was calculated using mean and standard

deviation. SPSS computer software was used for data analysis. Data quality was checked for normality (Histogram), abnormal values or outliers using statistical distribution (minimum, maximum, range etc.).

5.3.1 Manure management practices

Two out of twelve MMS were found to be commonly practiced by sampled HHs whether seasons are dry or wet under all production systems (MCL, PAP, Small Dairy, Large commercial dairy, and feedlot). Regardless of season, MMS such as drop in public area, water way, and dump in toilet were the rarest manure management systems practiced by smallholder, large commercial and feedlots farms.

In MCL, the most common practice was ‘pasture drop’ in dry season (303 HHs); and ‘stored in a pit’ in wet season (296 HHs). Households that used manure for fuel in dry season were more than two and half times higher than those HHs with the same practice in wet season. Unusually, composting was practiced by comparable number of HHs during wet and dry seasons (114HHs, wet Vs 158HHs, dry seasons). More number of HHS (66) used ‘stored manure as a liquid or slurry’ MMS during wet season than HHs (26) used this practice in dry season. The use of biodigester was the rarest practice in all seasons.

In PAP, as expected, practices such as ‘pasture drop’ and ‘collected and spread on pasture or crops the same day’ were popular MMS while all other practices were never available. The most expected practice i.e., ‘left in the area where the cows are kept’ was not reported except one HH in dry season.

5.3.2 MMS in MCL

Overall, a total of 516 households has given their manure management practice in MCL production system. There were some significant differences between the dry and wet seasons, with a greater deposit on pasture for MCL, significantly more liquid storage found (pit and slurry) during the wet season than the dry season. Additionally, in the dry season there was a higher proportion of manure collected dried/sold for fuel than wet season (Table 17).

Table 17: Proportion of manure managed (%) in each MMS in MCL production system

Manure management system (MMS)	Dry season			Wet season			**Annual weighted average**		
	Average	**SE**	**N**	**Average**	**SE**	**N**	**Average**	**SE**	**N**
Number of months in the season	**7.78**	**0.05**	**516**	**4.22**	**0.06**	**516**			
Left where deposited	18.67	0.98	303	17.75	1.01	293	18.37	0.99	333
Collected and spread on pasture	15.29	1.05	239	11.77	0.95	202	14.12	1.02	271
Left in area where kept	7.17	0.61	201	6.11	0.51	192	6.81	0.58	226
Stored in a pit	8.89	0.96	122	33.34	1.64	296	17.04	1.19	305
Collected and stored in a pile	15.86	1.28	206	17.82	1.29	223	16.52	1.28	260
Composted	8.80	0.81	158	4.82	0.57	114	7.48	0.73	189
Stored as a liquid	0.49	0.12	26	2.01	0.28	66	1.00	0.17	70
Biodigester	1.70	0.40	26	1.94	0.43	28	1.78	0.41	28
Collected dry/used for fuel	23.12	1.31	280	4.44	0.55	109	16.89	1.05	283
	100.00			100.00			100.00		

N= number of households

5.3.3 Smallholder dairy production MMS

Total number of households who reported their manure management practices was about 132. This study revealed that in the dry season the proportion of manure collected, dried/sold for fuel was higher followed by pit and pile storage systems compared to other MMS. Alternatively, in the wet season the proportion of manure managed in pit and pile storage systems was higher compared to other MMS. It was found that there was a larger proportion of manure stored in liquid slurry form during the wet season in comparison to the dry season. A very small proportion of manure was dropped into public areas and public water ways located in urban areas (Table 18).

Table 18: Proportion of manure managed (%) in MMS by smallholder dairy in urban and peri-urban

MMS	Dry season			Wet season			Annual weighted average		
	Average	N	SE	Average	N	SE	Average	N	SE
Number of months in the season	7.206		0.08	4.79	136	0.07			
Left where deposited on pasture	3.088	17	0.80	3.93	16	1.03	3.40	21	0.81
Collected and spread on pasture or crops the same day	9.412	29	1.90	8.68	24	1.95	9.01	35	1.70
Left in the area where cows are kept	1.507	14	0.48	1.51	12	0.49	1.50	14	0.47
Stored in a pit	12.059	34	2.25	18.38	44	2.76	14.51	55	1.98
piles system	16.838	48	2.38	21.14	49	2.92	18.43	69	2.23
Composted (piles with turn and mixing)	3.235	16	0.93	4.12	15	1.29	3.59	24	0.95
Stored as a liquid or slurry	2.353	11	0.92	8.71	23	1.98	4.91	28	1.07
Bio digester	2.096	7	0.89	2.35	8	0.97	2.26	10	0.88
Collect dried & used for fuel or sold for fuel	42.199	95	3.23	15.85	51	2.34	31.86	97	2.49
Dump manure in public area	1.581	5	0.90	4.67	14	1.50	2.72	16	0.99
Dump manure in public water way	5.632	14	1.69	10.11	38	1.89	7.57	45	1.43
Dump manure in toilet	0.000	0	0.00	0.55	3	0.39	0.23	3	0.16
Total MMS	100		0	100			100.00		

N=number of households (farmers not used particular MMS was given zero value and counted)

5.3.4 Medium-Large commercial dairy MMS

Total number of households who reported their manure management practices was about 99**.** During the dry season for large commercial dairy farms more manure was stored in piles, pits, composted and collected dried/sold for fuel making. A very small proportion of manure was left in areas where animals were kept, dropped into public areas or in public water ways (Table 19). While during the wet season the proportion of manure managed in pit and pile storage systems was higher compared to other MMS. A larger proportion of manure was stored in liquid slurry form during the wet season compared to the dry season.

Table 19: Proportion of manure managed by MMS in medium-large commercial dairy farm

	Dry season DC, %			Wet season DC, %			Annual weighted average DC, %		
MMS	Average	N	SE	Average	N	SE	Average	N	SE
Number of months in the season	7.73	89	0.15	4.26	89	0.15			
Left where deposited on pasture	4.41	20	1.18	4.85	19	1.52	4.55	24	1.06
Collected and spread on pasture or crops the same day	7.29	20	1.94	4.41	16	1.20	6.12	25	1.40
Left in the area where cows are kept	1.18	13	0.35	1.12	12	0.40	1.19	14	0.33
Stored in a pit	20.98	35	3.35	35.12	49	3.94	25.43	52	3.20
Collected and stored in piles for several months (no turning or mix manure)	16.91	38	3.02	19.06	32	3.38	17.65	45	2.92
Composted (piles with turn and mixing)	17.13	34	3.10	9.27	23	1.95	14.74	36	2.49
Stored as a liquid or slurry	2.29	14	0.66	8.24	20	2.31	4.40	25	0.95
Bio digester	6.06	13	1.75	5.47	11	1.68	5.97	13	1.78
Collect dried & used for fuel or sold for fuel	19.67	36	3.22	4.06	10	1.62	14.45	37	2.29
Dump manure in public area	2.65	5	1.33	2.12	6	1.63	2.33	8	1.23
Dump manure in public water way	1.42	6	0.94	6.29	14	2.03	3.17	16	0.98
Dump manure in toilet	0.01	1	0.01	0.00	0	0.00	0.01	1	0.01
Total	100.00			100.00			100.00		

5.3.5 Commercial feedlot MMS

A total of 69 feedlot farms have reported about their MMS. Large commercial feedlot farms managed a higher proportion of manure in dry lots or that had been left in areas where animals were kept or pile and pit storage systems in both dry and wet seasons (Table 20). During the dry season a higher proportion of manure was also collected and sold for fuel making in comparison to the wet season. A small proportion of manure was composted, used for biogas, dropped into public areas or into public water ways in both seasons (Table 20). The proportion of manure dropped into public areas, public water ways and stored in slurry or bio-digester was higher during the wet season compared to the dry season.

Table 20: Proportion of manure managed by MMS in Commercial feedlot

MMS	Dry season			Wet season			Annual weighted average		
	Average	N	SE	Average	N	SE	Average	N	SE
Number of months in the season	7.80	60	0.09	4.20	60	0.09			
Collected and spread on pasture or crops the same day	11.23	17	2.94	15.14	20	3.60	12.49	22	2.46
Left in the area where cows are kept	27.61	35	4.47	13.62	25	2.85	23.45	40	3.37
Stored in a pit	18.48	20	3.92	25.80	27	4.58	20.20	33	3.25
Collected and stored in piles	10.00	18	2.28	7.17	14	2.07	9.02	18	2.10
Composted	5.22	10	1.90	4.71	8	2.00	5.07	13	1.67
Stored as a liquid or slurry	0.29	2	0.23	9.86	16	2.78	3.48	17	0.94
Dump to public areas	1.67	3	1.16	3.62	4	1.89	2.32	5	1.24
Dump to public water way	2.17	4	1.51	4.71	14	1.43	3.02	15	1.14
Bio digester	0.22	2	0.16	8.77	14	2.74	3.07	14	0.92
Collect fresh manure dried or sold for fuel	23.12	29	4.15	6.59	14	1.90	17.88	30	3.00
Total	100			100			100		

5.3.6 Pastoral and agro-pastoral system

Thirty (30) households have been reporting on their manure management practices. The majority of cattle manure that was produced in pastoral and agro-pastoral systems were dropped by animal in a range land during daytime while left in areas where animal kept/dry lot both in dry and wet season, especially at night manure left in crush as dry lot (Table 21). Very small proportion < 1% of total manure collected dried fuel.

Table 21: Proportion of manure managed by MMS in pastoral and agro-pastoral system (PAP)

	Dry season			Wet season			Annual weighted average		
MMS	Average	N	SE	Average	N	SE	Average	N	SE
Number of months in the season	7.93	30	0.249	4.07					

	Dry season			Wet season			Annual weighted average		
Left where deposited on pasture	40.167	30	2.242	47.500	30	3.086	42.597	30	1.709
Left in the area where cows are kept	59.500	30	2.241	52.500	30	3.086	57.153	30	1.740
Collected fresh Collect fresh manure dried or sold for fuel	0.333	1	0.333	0.000		0.000	0.250	1	0.250
	100			100			100		

5.3.7 Manure residence time

Table 22 presents the number of times the manure was in the storage place. The length of time that the manure had been left in the area where the animals were kept before being cleaning ranged from 57 days in commercial feedlots to 4 days in smallholder dairy farms located in urban and peri-urban areas (Table 22). The longer the manure stayed in storage places the higher CH_4 and N_2O emission.

Table 22: average number of days manure left in area where animals kept (dry lot)

Number of days left in area where cows are kept			
Production system	N	Mean	SE
MCL	226	7.77	1.19
smallholder dairy	12	4.0	1.57
Large commercial dairy	14	9.00	3.20
Large commercial feed lot	35	57.34	8.15
Pastoral & Agro-pastoral	30	15.83	1.73

The average length of time the manure had been left before it was stored in a pile storage system for commercial feedlots, large commercial dairy farms, smallholder dairy farms and MCL systems was 24. 13, 8 and 12 days respectively (Table 23). A higher proportion of manure stayed before being cleaned for pile storage for large commercial feedlot production systems compared to other production systems. Most commercial feedlot farms did not clean the manure from the feedlot frequently.

Table 23: Average time manure left before storing in pile storage system

	Number of days the manure left before storing in a pile		
	N	Mean (day)	SE
MCL	305	11.5	1.3
smallholder dairy	55	7.51	2.46
Large commercial dairy	52	12.98	4.23
Large commercial feed lot	30	24.23	4.4

The average length of time that manure was stored in a pile storage system was about 15, 6.40, 5.91 and 7.11 months in commercial feedlot farms, large commercial dairy farms, smallholder dairy farms in urban and peri-urban settings and MCL systems, respectively (Table 24). Manure that was stored in solid/pile systems were there for a longer duration of time (15 months on average) in large commercial feedlot production systems compared to other production systems.

Table 24: Average time manure stored in pile storage system

Manure stored in pile	**Number of months the manure stored in the pile**		
Production system	**N**	**Mean (months)**	**SE**
MCL	305	7.11	0.94
Smallholder dairy	55	5.91	2.38
Medium-Large commercial dairy	52	6.40	1.63
Feedlot	30	15.10	5.46

The average length of time that the manure was composted was 3.4, 2.78, 2.8, 4.4 months for commercial feedlot farms, large commercial dairy farms, smallholder dairy in urban-peri-urban and MCL systems, respectively (Table 25). The reason for the longer duration of time that the manure was composted for in large commercial dairy farms could be due to the use of compost for fertilizer for their integrated vegetable farms.

Table 25: Average number of months manure composted

Production system	Number of months the manure composted		
	N	Mean (months)	SE
MCL	189	4.4	0.77
smallholder dairy	22	2.8	0.22
Large commercial dairy	23	2.78	0.21
Large commercial feed lot	13	3.4	0.38

Manure that was stored in liquid slurry form was done so for an approximate average duration of 7.8, 13, 9.15 & 2.6 months in commercial feedlot, large commercial dairy, smallholder dairy and MCL systems respectively (Table 26). A higher storage time of liquid slurry for smallholder commercial farms (medium and large commercial dairy farms) was expected as a result of these farms washing/draining the liquid form of the manure from the animal's houses with the addition of water.

Table 26: Average time manure stored in liquid slurry storage system

	Number of months the manure stored as a liquid (slurry or pit)		
Production system	N	Mean (months)	SE
MCL	70	2.6	0.309
Smallholder dairy	26	9.15	4.68
Large commercial dairy	25	13.00	5.80
Large commercial feed lot	17	7.8	5.147

5.3.8 How manure is stored or used after it has been in the original storage system.

Use of manure left in area animals are kept after cleaning

The majority of MCL HHs and large commercial feedlot farms use manure that has been stored in a dry lot or that has been left in an area where animals are kept after being cleaned. They then spread the manure on pastures or crop land which acts as a fertilizer. Alternatively, smallholder dairy and medium-large commercial dairy farmers utilized/sold dry lot stored manure for producing fuel and for fertilizer (Table 27),

Table 27: Use of manure left in area animals are kept after cleaning

Manure use after storage	MCL		Smallholder dairy		Large commercial dairy		Commercial feedlot	
	N	%	N	%	N	%	N	%
Spread on pasture or crops	149	65.9	1	7.69	5	35.71	33	94.3
Stored in piles for several months before use	74	32.7	2	15.38	3	21.43	9	25.7
Stored in a pit	49	21.7	4	30.77	5	35.71	8	22.9

Manure use after storage	MCL		Smallholder dairy		Large commercial dairy		Commercial feedlot	
	N	%	N	%	N	%	N	%
Composted	56	24.8	4	30.77	3	21.43	4	11.4
Biodigester	4	1.8	1	7.69		0.00		
Collect dried/sold for fuel	705	46.50	7	53.85	7	50.00	12	34.3
Sold	-	-	-	-	2	14.29	9	25.7

Utilization of pile stored manure after storage time

Manure stored in pile systems in MCL, small dairy and large commercial dairy farms used manure mainly for fuel and for other differently. Large commercial feedlot farms were mostly sold manure for fuel (67%), spread on pastures or crop land (47%), or stored in a pile for several month before use (24%). (Table 28).

Table 28: Types of use and proportion of HHS that use pile stored

	How manure is used after pile storage							
	MCL		Smallholder dairy		Large commercial		Feedlot	
Manure use after pile	N	%	N	%	N	% o	N	%
Spread on pasture or crops	192	63.0	12	17.91	21	46.67	19	63.3
Stored in piles for several months before use	46	15.1	5	7.46	11	24.44	8	26.7
Composted	99	32.5	14	20.90	22	48.89	2	6.7
Biodigester	8	2.6	2	2.99	7	15.56		
Dried/ sold for fuel making	194	63.6	37	55.22	30	66.67	12	40

Use of composted manure after storage time

The majority of composted manure in all production systems (except PAP) were used as fertilizer to spread on crop land or composted for a long time before used and sold. Manure composted in MCL systems and large commercial dairy farms was used/sold for fertilizer or stored in pile and

sold. While smallholder urban per-urban dairy farms used composted manure more for fertilizer and compost, large commercial feedlot farmers use/sold composted manure for fertilizer or stored it in pile after cleaning the compost (Table 30)

Table 29: proportion of HHs that utilize composted manure

Use of compost manure	How composted manure store or used after cleaning							
	MCL		Small		Large		Feedlot	
	N	%	N	%	N	%	N	%
Spread on pasture or crops	145	76.7	19	79.17	28	77.78	10	76.9
Pile	35	18.5	3	12.50	6	16.67	7	53.8
Composted	72	38.1	6	25.00	17	47.22	3	23.1
Sold	20	10.6	2	8.33	3	8.33		

Use of manure stored in liquid slurry or pit system

The majority of liquid slurry manure in MCL, large commercial dairy and commercial feedlot systems used/sold slurry manure for fertilizer/spread on crop land or composted it after collecting from slurry. More of slurry manure was used/ sold for fuel making, spread on crop land or stored in pit by smallholder dairy farmers (Table 30). A small proportion of slurry manure was used for biogas making in all production systems.

Table 30: Use of manure stored in liquid slurry or pit system

Use of manure	How manure stored in slurry or pit system used after storage							
	MCL		Small		Large		Feedlot	
	N	% of HHs	N	% of HHs	N	% of HHs	N	% of HHs
Spread on pasture or crops land/sold for fertilizer	43	61.4	10	38.46	12	48.00	16	94.1
Stored in piles for several months before use	10	14.3	5	19.23	5	20.00	6	35.3
Stored in a pit	22	31.4	5	19.23	4	16.00	9	52.9
Composted	30	42.9	2	7.69	5	20.00	2	11.8
Biodigester	5	7.1	0	0.00	1	4.00	1	5.9

Use of manure	How manure stored in slurry or pit system used after storage							
	MCL		Small		Large		Feedlot	
	N	% of HHs	N	% of HHs	N	% of HHs	N	% of HHs
Collect, dried/sold for fuel	32	45.7	21	80.77	9	36.00	2	5.9

Other manure characteristics in storage place

The proportion of HHs that did not cover their pile manure was higher than the proportion of HHs that cover their pile manure in all four production systems (Table 31). This difference had implications on GHG emission from MMS.

Table 31: Proportion of manure covered and uncovered during pile storage

Production system	Covered		Un covered	
	N	% of HHS	N	% of HHS
MCL	70	23.0	235	77.0
Smallholder dairy	20	36	35	64
Large commercial dairy	16	31	36	69
Feedlot	3	10.0	27	90.0

The proportion of HHs that turned or aerated their composted manure was higher in smallholder and in large commercial dairy farms, while the proportion of HHs that turned/aerated their compost was similar in MCL. More of HHs in large commercial feedlot farms did not turn/aerate compost (Table 32).

Table 32: Percentage of HHs that used to turn/aerate or not to turn composted manure

Production system	Turn over or aerate the compost		No turnover or aerate the compost	
	N	% of HH	N	% of HH
MCL	93	49.2	96	50.8
smallholder dairy	17	77.3	5	22.7
Large commercial dairy	26	73.0	10	27.0
Large commercial feed lot	4	30.8	9	69.2

In most production systems, the formation of a crust on top of the slurries was not reported as opposed to farmers having reported that there was the formation of a crust on top of the slurry (Table 33).

Table 33: Proportion of HHs that experienced or not formation of crust on top of slurry

Production system	Is crust form on the top of the liquid			
	Crust formed		Crust not formed	
	N	% of HHs	N	% of HHs
MCL	23	32.9	47	67.1
Smallholder dairy	9	35	17	65
Large commercial dairy	17	68	8	32
Large commercial feed lot	5	29.4	12	70.6

5.4. AVERAGE DAILY MILK YIELD

The average daily milk yield was estimated for indigenous and crossbred cows in MCL, smallholder farms in urban & peri-urban and medium-large commercial dairy farms. The average milk yield per cow per day (Lt/head/day) was estimated from daily maximum and minimum milk yield data on the current or last lactation period. Since the data is not normally distributed, Median value was taken.

Consequently, daily milk yield/offtake of indigenous cattle and cross bred dairy cows in MCL was found to be 1.50 and 9 liters/day/head. The median daily milk yield of cross bred/pure exotic dairy cows in smallholder and medium-large commercial dairy farms were 9.5 and 12.5 liters per day, respectively (Table 34).

For indigenous cattle in MCL calving rate was estimated as number of lactating cows divided by number of dry and lactating cows. Due to lack of or incomplete information on number of lactating cows of crossbred/pure exotic dairy cattle in MCV, smallholder and medium-large commercial, calving rate was calculated using information on number of calves < 1 years age divided by total number of dry and lactating cows. Table 35 indicated the average calving rate for indigenous breed in MCL, crossbred cows in MCL, smallholder dairy cows and medium-large commercial dairy cows were 73, 71, 70 and 46 percent, respectively.

Table 34: Maximum, Minimum and Median Average Daily Milk yield

	Maximum (liters/day)			**Minimum (liters/day)**			**Daily yield (liters/day)**		**Calving rate (%)**
	No of lactating cows	**median**	**SE**	**No of cows**	**median**	**SE**	**median**	**SE**	
Crossbreed in MCL	358	12.00	0.30	358	6	0.18	9	0.22	71
Indigenous breed in MCL	440	2.0	0.032	440	1.0	0.021	1.5	0.024	73
Smallholder dairy in urban and peri-urban	331	12	**0.33**	331	6.00	0.20	9.50	0.23	69.70
Medium-large Commercial dairy	445	17.00	**0.33**	445	8.0	0.20	12.50	0.23	46

Average lactation length of 210 for local breed and 325 days for crossbred/pure exotic dairy cattle were used to calculate average daily milk yield adjusted for number of days in a year (365) (UNIQUE 2018). The average adjusted milk yield for lactation length and calving rate was indicated in Table 35. Conversion rate from litter to kg milk was done by multiplying litters with 1.031 kg.

Table 35: Average milk offtake adjusted for Lactation length and calving rate

	Indigenous cattle in MCL	Crossbred in MCL	Small commercial	Large commercial
Average daily milk yield in litter/head/day	1.50	9	9.50	12.50
Average Lactation Length in days	210	325	325	325
Average calving rate	0.73	0.71	0.6967	0.4619
Milk offtake adjusted for Lactation and calving rate kg/day	0.649	5.88	6.076	5.300

5.4.1 Indigenous cattle breed milk yield adjusted for calf milk suckling

The average daily milk yield that was reported by the farmers for the indigenous cattle breeds in MCL was not included the amount of milk consumed by the calf. Therefore, the amount of milk suckled by the calf's was estimated and included in the report (Table 37). The amount of milk suckled by the calf was estimated based on methods and assumptions described by NRC (2001), and the energy requirements of the calf's growth are based on the metabolizable energy for maintenance and growth: The following equation was used to estimate the amount of milk suckled by the calf:

Metabolizable energy (Mcal)= (0.1*(LW^0.75)) + (((0.84*(LW^0.355))* (LWG^1.2)))

Where LW is average liveweight of a calf between birth and weaning (49 kg/day from survey work and LWG is liveweight gain of the calf before weaning (0.125 kg/day). The estimated milk consumption by the calf in Mega calories (Mcal), is converted into kg/day on the basis of assumed metabolizable energy 5.37 Mcal per kg dry matter content of milk (DM) using a dry matter (12.5%) content of milk (NRC 2001).

The calculated volume of milk consumed by the calf per day is converted to an annual average daily milk yield (average over 365 days) by assuming that calves are weaned at 90 days old, involving a calculation of the milk consumed by calves multiplied by (90/365) and then multiplied by the calving rate to include all cows in the herd (lactating and dry cows). Average lactation length in Oromia region was estimated to be 7 months (210 days; CSA 2022). The proportion of cows giving birth (calving rate=0.73). The estimated daily off-take of indigenous cattle breed was converted to an annual average daily off-take (i.e. average lactation length of 210/365 days) and then multiplied by the calving rate of 0.73 for the average cow (i.e. including lactating and non-lactating). Milk yield in litters was converted to kg using a standard conversion of 1.031 kg per liter. Milk consumed by the calf is then added to the milk yield reported by farmer (Table 36).

Table 36: Calf milk suckling and total milk yield of indigenous cows in MCL

Average calf weight at 90 days, kg/head	49	Male and female calves average live weight at 90 days from survey data

Preweaning calf growth rate	0.125	Male and female calves average daily growth rate between 0 age and 3 months age from survey data
Calf milk consumption Mcal	2.13	NRC 2001, Unique 2018
ME content of milk Mcal/kg DM	5.37	NRC 2001, Unique 2018
DM content of milk,	0.13	NRC 2001, Unique 2018
calf Milk consumption in kg DM base	3.17	NRC 2001, Unique 2018
90 days milk consumption in kg adjusted for 365 days	0.78	
calf milk consumption adjusted for calving rate, kg/day/head	0.57	
Total milk yield of indigenous cows (milk offtake+ calf consumed) kg/day/head	1.22	

5.5. DIET COMPOSITION

Data on feed basket/type for animals was collected from mixed crop-livestock, pastoral& agro-pastoral, and commercial feed lot systems. Livestock feed utilization data was obtained by asking each farmer to list the types of feed provided to each animal and to estimate the proportions of different feed types of the total feed utilized. Farmers were directly asked (a) whether specific feed staff (list in the protocol) and (b) to estimate the percentage of each feed type in total feed utilized and percentage of specific feed types . This question was asked separately for indigenous and cross-bred dairy cattle in mixed crop livestock systems and pastoral, agro-pastoral, smallholder dairy in urban-peri urban and medium- large commercial dairy, commercial feedlot systems.

Data on nutritive value (DM content, CP%, ME, etc.) of each feed in each feed basket was collected from the literature during the desk review. This data was used to estimate digestible energy (DE %) of feed type required for GHG emission calculations.

The DE (%) value of each feed type for each sub-category in mixed crop-livestock production and pastoral systems smallholder and commercial feedlot systems using the following formula:

Feed DE (MJ) = Metabolizable energy (MJ)/0.81

Feed digestibility (DE, %) = Digestible energy (MJ)/18.4

Average DM content of the diet = average of diet composition (DC) of feed type 1*(DM of feed type 1/100) + average DC of feed type 2 * (DM of feed type 2/100) + average DC of type 3 * (DM of feed type 3/100) + average DC of feed type X * (DM of feed type X/100)

Average Digestibility of the diet = average of DM of feed type 1* (DE of feed type 1/100) + average DM of feed type 2 * (DE of feed type 2/100) + average DM of feed type 3 * (DE of feed type 3/100) + average DM of feed type X * (DE of feed type X/100)

Statistical analysis: Data on diet composition from each household by animal sub-category was entered into an Excel spreadsheet, edited, segregated and transposed into SPSS software. Then, analysis was conducted using a descriptive statistic. Data quality was checked for normality. When the data was normally distributed, average, standard error were calculated for each sub-category.

Table 37: Nutrient composition of feed types from literature

Specific feed types	ME (MJ)	CP (%)	DM (%)	Remark	Reference
Alfalfa	9.2	25.9	34.9		Seyoum et al. 2007
Areki Atela	10.1	18.2	96.7		Feyissa et al 2015
Atela+oat (nifash) husk	10.05	14.85	96	Average of Atela and Oat)	Seyoum et al. 2007
Avocadoo leave	13.6	14.7	92.5	Avocado peel	https://www.sciencedirect.com/ science/article/abs/pii/S0377840109002946
Banana leave	5.9	14.7	92.5		wassie et al. 2021
Barley straw	6.8	6	93		Seyoum et al. 2007
Bean	14	23.7	91.1	grain sun cured	Seyoum et al. 2007
Bean hulls	5.1	6.8	93.3		wassie et al. 2021
Brachiaria spp hay	8	10.99	90.885	other hay value (DM & CP)	wassie et al. 2021
Bread	12.9	20.8	90.6	wheat grain sun cured	Seyoum et al. 2007
Brewer's waste	8.8	23.8	95.6		wassie et al. 2021
By products from fruit and vegetables	7.68	17.5	93	Average of banana, sweet potato, etc. leave (other feed 1)	wassie et al. 2021
Clover	8.6	22.7	43.8	Value of native legume	Seyoum et al. 2007
Commercial concentrate	10.1	18.7	89.2		wassie et al. 2021
Commercial concentrate	11.1	31.4	89.2	Dairy ration	Seyoum et al. 2007
Corn cane	14.5	11.4	90.5	maize; zea mays	Seyoum et al. 2007
Cottonseed meal	8.9	26.9	92.5		Seyoum et al. 2007
Crop stand thinning	8.5	17.5	93.7	Average of other feeds	wassie et al. 2021
Crushed maize seed	14.5	11.4	90.5	Zea Maize grain	Seyoum et al. 2007
Cut and carry natural harass and elephant grass	8.3	7.7	91.3	natural grazing value	wassie et al. 2021
Cut and carry natural grass	8.3	7.7	91.3	natural grazing value	wassie et al. 2021
Elephant grass	8.22	5.45	93.5		wassie et al. 2021
Emmoo/browse species	8.6	22.7	43.8	browse species, fresh	Seyoum et al. 2007
Enset leaves	7.2	4.8	94.7		wassie et al. 2021
Finger millet straw	9.4	6.6	92.1		wassie et al. 2021
Grass-legume mix	8.6	22.7	43.8		wassie et al. 2021
Hen faeces	8.6	13.8	61.2		PESTI et al.
Home-made concentrate	11	21.7	90.6		wassie et al. 2021

Specific feed types	ME (MJ)	CP (%)	DM (%)	Remark	Reference
Household left-over	6.5	17.7	96.05	Average of other feeds	wassie et al. 2021
Linseed cake	10.9	28.6	91.6		Feyissa et al 2015
Local brewery waste	10.1	19.7	96.7	Average of Areke and Tela Atela	Feyissa et al 2015
Maize grain	14.5	11.4	90.5	Zea Maize grain	Seyoum et al. 2007
Maize Stover	6.9	3.7	92.1		wassie et al. 2021
Maize Stover	7.2	1.8	92.1		Seyoum et al. 2007
Maize, bean, lentil	12.97	19.4	91	Average of maize, Lentile & Bean	Seyoum et al. 2007
Maize, lentil	12.45	17.25	90.95	Average of maize and Lentile	Seyoum et al. 2007
Mango leave	5.9	14.7	92.5	Value of banana leave	Seyoum et al. 2007
Milled crops/Mixed food flour	12.4	9.5	90.8	Mixed grains screenings	Feyissa et al 2015
Milled maize	14.5	11.4	90.5	Value of maize grain	Seyoum et al. 2007
Mixed food flour	12.4	9.5	90.8	Mixed grains screenings	
Molasses	10.8	3.3	69.9		Feyissa et al 2015
Napier grass/desho	8.22	5.45	93.5		wassie et al. 2021
Natural grazing	8.3	7.7	91.3	Mixed grains screenings	Feyissa et al 2015
Nifash/Mixed grains screenings	12.4	9.5	90.8	Mixed grains screenings	Feyissa et al 2015
Noug seed cakes	9.6	28.5	92.1		wassie et al. 2021
Oat and vetch improved feed	9.88	13.96	72.2	average of oat and Vetch was taken	Feedipedia
Oat and vetch hay	8.3	9.1	89.2	Value of oat hay	Feedipedia
Oat green feed	9.32	5.48	55.15	Improved feed	wassie et al. 2021
Oat hay	8.3	9.1	89.2		Feedipedia/wassie et al. 2021
Oat straw	6.7	6.7	91.8		wassie et al. 2021
Other straw	7.5	5.2	92.5		wassie et al. 2021
Pennisetum spp hay	8.6	8.1	90.885		Feedipedia/Seyoum et al. 2007,
Porridge	6.5	18.2	96.05	Average of other feeds	wassie et al. 2021
Poultry waste	8.6	13.8	61.2		PESTI et al.
Pea straw	8.8	7.9	91.8	peas: straw, sun cured cut post ripe	Seyoum et al. 2007
Rhodes grass hay/ Elephant grass	8.76	10.47	93.04	Average of Rhodes grssa and Eleohant grass	Unique 2021;Seyoum et al. 2007,

Specific feed types	ME (MJ)	CP (%)	DM (%)	Remark	Reference
Rice hull/straw	5.25	4.3	90	Rice straw	Drake et al. 2015
Seteria spp hay	7.8	11.3	90.9		wassie et al. 2021
Silage	11.5	8	30.5	Maize silage	Feedpedia/AYANO ABERA
Sorghum Stover	7.3	3.7	93.0		wassie et al. 2021
Soya bean straw	7.5	5.2	92.5	Brewery waste	Seyoum et al. 2007
Spaint grain	8.8	23.8	95.6	Brewery waste	wassie et al. 2021
spaint grain	11.3	20	92	brewery grain; malted	Seyoum et al. 2007
Sugarcane leaves	9	4.9	91		Seyoum et al. 2007
Sunflower cake	9.6	29	93.5	Value of noug seed cake	Seyoum et al. 2007
Sweet potato leaves	8.8	26.5	91.8		Feedipedia
Teff straw	8	5.2	92.7		Feyissa et al 2015
Tela Atela	9.2	21.2	95.4		Feyissa et al 2015
Traditional brewery product	9.65	19.7	96.05	Average of Areke Tela Atela	Feyissa et al 2015
Tree leave	8.6	22.7	43.8	browse, fresh	Seyoum et al. 2007
Vetch	10.4	22.4	89.3		wassie et al. 2021
Wadeesaa/Browse sp.	8.6	22.7	43.8	browse, fresh	Seyoum et al. 2007
Wheat bran	13	18.9	88.8		wassie et al. 2021
Wheat middling	11.9	19.3	88.5		wassie et al. 2021
Wheat straw	7.5	4.8	93.1		wassie et al. 2021
Wood bark/ browse sp.	8.6	22.7	43.8	browse, fresh	Seyoum et al. 2007
Yuddoo/browse sp.	8.6	22.7	43.8	browse species, fresh	Seyoum et al. 2007

5.5.2 Diet composition of indigenous cattle breed in MCL

Natural grazing, wheat straw and barely straw were the major feed type provided for indigenous cattle in dry season. Natural grazing contributed to a higher proportion of wheat straw (32%, 25% & 33%), barely straw (16, 13, 29%), Rhodes grass hay (7, 9 & 9%) of total diet for lactating cows, Ox and Other cattle, respectively. During the wet season natural grazing was the major feed type that was contributing to 49%, 48% and 53% of the total diet of lactating cows, Ox and other cattle, respectively. (Table 39).

Table 38: Diet composition of indigenous cattle breed in MCL

	Dry season Dc, % of total feed									Wet season Dc, % of total feed								
	Lactating cow			Ox			Other			Lactating cow			Ox			Other		
Specific feed	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Alfalfa				118	25.5	1.98	273	33.1	1.63	325	49.3	1.53	188	48.4	1.98	372	53.1	1.53
Areki Atela	1	0.1	0.11	30	3.8	0.74	83	4.8	0.57	84	4.7	0.54	28	2.7	0.59	85	4.5	0.51
Avocado leave	1	0.0	0.01							1	0.0	0.04	1	0.0	0.05	1	0.0	0.02
Banana leave	32	0.7	0.16							1	0.0	0.02	0	0.0	0.00	0	0.0	0.00
Barley straw	86	6.7	0.82	1	0.0	0.02		0.0	0.00	3	0.1	0.06	0	0.0	0.00	1	0.0	0.02
Bean	1	0.0	0.01	12	1.8	0.63	13	1.0	0.34	17	1.3	0.38	20	2.5	0.69	22	1.4	0.36
Bean hulls	10	0.1	0.04	87	12.0	1.23	94	5.8	0.64	77	4.2	0.51	68	7.6	0.89	62	3.1	0.44
Bread	1	0.0	0.02	122	23.4	1.80	202	19.0	1.20	133	9.9	0.84	110	15.0	1.27	154	10.7	0.86
Brewer's waste	10	0.5	0.18	50	9.2	1.35	121	9.3	0.93	49	2.9	0.45	32	3.4	0.59	67	3.7	0.50
By products from fruit and vegetables	35	0.8	0.16	38	4.0	0.80	126	6.3	0.64	121	5.9	0.58	57	4.3	0.66	120	5.0	0.53
Clover	3	0.3	0.18															
Commercial concentrate	66	4.9	0.63	1	0.0	0.05		0.0	0.00	2	0.0	0.01	1	0.0	0.01	1	0.0	0.01
Corn cane				2	0.7	0.48	26	4.1	0.87	11	0.9	0.33	0	0.0	0.00	12	0.9	0.31
Cottonseed meal	17	0.9	0.21	15	0.9	0.25	23	0.7	0.15	18	0.5	0.13	13	0.7	0.21	19	0.5	0.13
Crop stand thinning	7	0.2	0.12	7	0.3	0.10	17	0.5	0.13	29	1.6	0.33	8	0.6	0.24	33	1.6	0.32
Crushed maize seed	2	0.0	0.04							1	0.1	0.06	0	0.0	0.00	1	0.0	0.02
Emmoo/ Browse sp.	1	0.0	0.01	1	0.1	0.10	1	0.0	0.01	3	0.2	0.10	5	0.6	0.27	4	0.2	0.12
Enset leaves	33	0.8	0.17							2	0.1	0.09	3	0.4	0.22	1	0.0	0.04
Finger millet straw	1	0.0	0.01	4	0.5	0.26	17	1.0	0.26	28	1.5	0.34	32	2.6	0.58	44	1.7	0.29
Grass-legume mix	1	0.0	0.03	46	5.2	0.77	65	3.7	0.49	43	2.4	0.39	26	2.1	0.47	30	1.1	0.25

	Dry season Dc, % of total feed									Wet season Dc, % of total feed								
	Lactating cow			Ox			Other			Lactating cow			Ox			Other		
Specific feed	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Home-made concentrate	24	0.9	0.23	7	0.3	0.13	22	0.5	0.17	15	0.3	0.09	4	0.1	0.07	9	0.1	0.05
Household left-over	30	0.8	0.20	5	0.5	0.22	1	0.0	0.01	2	0.0	0.02	1	0.0	0.02	0	0.0	0.00
Linseed cake	13	0.2	0.06	57	5.1	0.65	82	3.2	0.36	59	2.9	0.38	41	3.5	0.55	53	2.3	0.37
Maize	3	0.1	0.04	11	0.9	0.32	13	0.3	0.12	7	0.2	0.07	8	0.4	0.18	7	0.2	0.10
Maize Stover	124	7.2	0.71	4	0.2	0.13	1	0.0	0.01	8	0.1	0.04	2	0.0	0.03	1	0.0	0.01
Mango leave	1	0.0	0.01	0	0.0	0.00		0.0	0.00									
Mineral Supplement/salt (It can not be greater than 1%)	361	1.0	0.00	8	0.2	0.11	7	0.1	0.03	9	0.2	0.06	8	0.3	0.11	9	0.2	0.06
Mixed food flour	6	0.1	0.07	3	0.1	0.07	4	0.1	0.07	2	0.1	0.06	2	0.1	0.07	4	0.1	0.09
Molasses	1	0.1	0.05	208	1.0	0.00	407	1.0	0.00	362	1.0	0.00	209	1.0	0.00	408	1.0	0.00
Napier grass/desho	17	0.8	0.31	3	0.2	0.14	9	0.4	0.16	3	0.2	0.10	2	0.1	0.11	2	0.1	0.07
Natural grazing	261	32.9	1.56	11	0.2	0.08	29	0.6	0.16	6	0.1	0.05	2	0.1	0.06	7	0.1	0.06
Nifash/milling screening	2	0.1	0.07	9	0.4	0.17	30	0.6	0.15	11	0.2	0.06	2	0.1	0.05	11	0.1	0.04
Noug seed cakes	5	0.2	0.09	0	0.0	0.00		0.0	0.00									
Oat green feed	7	0.3	0.12	0	0.0	0.00		0.0	0.00									
Oat and vetch				1	0.0	0.05	5	0.2	0.09	3	0.1	0.07	1	0.1	0.11	3	0.1	0.06
Oat hay	10	0.8	0.33							63	5.3	0.78	8	0.8	0.33	64	4.8	0.71
Oat straw				1	0.1	0.14	1	0.1	0.10	1	0.1	0.11	1	0.2	0.19	1	0.1	0.10
Oat Vetch	0	0.0	0.00	7	0.4	0.17	14	0.4	0.15	7	0.3	0.13	5	0.3	0.16	8	0.3	0.13
Other straw	22	0.6	0.16	14	0.6	0.20	36	0.9	0.28	31	0.6	0.18	11	0.3	0.10	32	0.7	0.17

	Dry season Dc, % of total feed									Wet season Dc, % of total feed								
	Lactating cow			Ox			Other			Lactating cow			Ox			Other		
Specific feed	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Pennisetum spp hay	2	0.0	0.03	0	0.0	0.00		0.0	0.00									
Porridge	6	0.1	0.07	0	0.0	0.00	3	0.3	0.16	7	0.4	0.20	0	0.0	0.00	7	0.4	0.18
Rhodes grass hay	71	4.4	0.54	17	1.4	0.32	18	0.8	0.18	16	0.7	0.19	16	1.2	0.29	17	0.6	0.16
Rhodes grass hay Elephant grass				2	0.1	0.11	6	0.1	0.06									
Seteria spp hay				1	0.0	0.01	3	0.0	0.01	7	0.1	0.05	1	0.0	0.00	5	0.0	0.02
Silage	0	0.0	0.00	2	0.1	0.06	2	0.0	0.03	1	0.0	0.02	2	0.1	0.06	1	0.0	0.02
Sorghum Stover	28	5.0	1.00	0	0.0	0.00	1	0.0	0.01									
Sugar cane leaf	1	0.1	0.08	0	0.0	0.00		0.0	0.00	1	0.0	0.01	0	0.0	0.00	0	0.0	0.00
Sweet potato leaves	5	0.2	0.11	0	0.0	0.00	2	0.1	0.05	2	0.1	0.10	0	0.0	0.00	1	0.0	0.05
Teff straw	103	6.3	0.66	1	0.0	0.02	3	0.1	0.05	2	0.0	0.03	0	0.0	0.00		0.0	0.00
Tela Atela	14	0.5	0.15	0	0.0	0.00		0.0	0.00	1	0.0	0.01	0	0.0	0.00	1	0.0	0.02
Traditional brewery product	3	0.1	0.05	0	0.0	0.00	1	0.0	0.01	2	0.0	0.04	0	0.0	0.00	1	0.0	0.01
Tree leave	3	0.2	0.21	0	0.0	0.00	1	0.2	0.18									
Wheat bran	88	4.2	0.46	2	0.0	0.03	3	0.0	0.03	5	0.5	0.26	0	0.0	0.00	5	0.5	0.26
Wheat middling	11	0.4	0.14	0	0.0	0.00	1	0.0	0.02									
Wheat straw	173	16.2	1.13	0	0.0	0.00	1	0.0	0.05									
Wood bark	5	0.1	0.09							5	0.1	0.05	0	0.0	0.00	1	0.0	0.02
Yuddoo/ Browse	2	0.1	0.04	13	0.6	0.19	22	0.5	0.13	18	0.4	0.10	6	0.2	0.10	9	0.1	0.05
Total DC		100.0			100.0			100.0			100.0			100			100.0	

5.5.3 Feed types of crossbred dairy cattle in MCL

Natural grazing, wheat straw and barely straw were the major feed types provided for crossbred cattle in the dry season. Concentrate feed contributed to 20%, 13% and 11% 10%, 10% and 11% of the total diet of lactating cows, dry cows, heifers, bulls, ox, calves and other crossbreed dairy cattle, respectively in the dry season. Natural grazing contributed to about 10%, 9%, 14%, 16%, 11% and 14 % of the diet of lactating cows, dry cows, heifers, bulls, ox, calves and other crossbreed dairy cattle, respectively in the dry season. Wheat bran contained about 7%, 5%, 6%, 4%, 4%, 5% and 5% of the diet of lactating cows, dry cows, heifers, bulls, ox, calves and other crossbreed dairy cattle, respectively in the dry season. Table 39 depicted the reported values

Table 39: Dry season DC for crossbred dairy cattle in MCL, % of total feed

Specific feed	Lactating cow			Dry cow			Helfer			Bull			Ox			Calf			Other		
	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE
Alfalfa																					
Barley straw	84	11.7	1.29	59	14.1	1.89	63	12.1	1.58	33	12.7	2.06	27	14.7	2.67	46	8.7	1.34	45	19.8	2.78
Bean hulls	7	0.2	0.07	2	0.1	0.07	6	0.3	0.13		0.0	0.00	1	0.1	0.06	7	0.4	0.15	7	0.4	0.19
Brach aria spp hay	1	0.1	0.11		0.0	0.00	1	0.1	0.14	1	0.2	0.17	1	0.1	0.13	1	0.1	0.06	1	0.1	0.13
Brewer's waste	12	1.0	0.29	9	1.1	0.39	6	0.6	0.25	5	1.3	0.56	2	0.8	0.63	6	0.6	0.27		0.0	0.00
By products from fruit and vegetables	3	0.2	0.11		0.0	0.00	4	0.2	0.09	1	0.3	0.29		0.0	0.00	4	0.3	0.19	4	0.4	0.26
Commercial concentrate	145	20.1	1.29	70	13.4	1.44	79	11.2	1.13	41	9.6	1.30	28	9.5	1.74	95	17.7	1.59	47	11.3	1.50
Cottonseed meal	16	1.3	0.32	6	0.7	0.30	12	1.2	0.36		0.0	0.00		0.4	0.29	13	1.7	0.46	9	1.6	0.51
Crop stand thinning	2	0.1	0.05	1	0.1	0.07		0.0	0.00		0.0	0.00	2	0.0	0.00		0.0	0.00		0.0	0.00
Enset leaves	3	0.2	0.14	2	0.2	0.12	2	0.1	0.10	2	0.4	0.31		0.0	0.00	2	0.2	0.18	2	0.2	0.23
Grazing	82	9.8	1.11	40	8.9	1.38	68	13.7	1.56	39	13.9	2.05	27	16.3	2.97	52	10.8	1.63	31	14.2	2.54
Home-made	9	0.5	0.18	4	0.3	0.15	6	0.6	0.29	2	0.5	0.36	4	0.8	0.44	7	0.9	0.36	6	0.8	0.32
Household left-over	10	0.4	0.15	4	0.4	0.19	7	0.6	0.24	1	0.1	0.10	1	0.1	0.14	7	0.5	0.20	5	0.5	0.21
Linseed cake	15	0.5	0.17	3	0.3	0.21	6	0.3	0.14	3	0.5	0.32	3	0.5	0.31	8	0.6	0.23	3	0.3	0.19
Maize Stover	16	1.3	0.39	8	1.6	0.67	13	1.7	0.57		0.0	0.00	1	0.1	0.14	6	0.9	0.39	5	0.8	0.41
Mineral Supplement/salt	238	1.0	0.00	144	1.0	0.00	173	1.0	0.00	87	1.0	0.00	71	1.0	0.00	147	1.0	0.00	108	1.0	0.01
Molasses	5	0.1	0.07	2	0.1	0.07	1	0.0	0.01	1	0.0	0.02	4	0.4	0.29	1	0.1	0.07	1	0.0	0.05
Napier grass/desho	7	0.6	0.24	7	0.7	0.28	4	0.3	0.16	3	0.3	0.16		0.0	0.00	1	0.1	0.06		0.0	0.00
Nifash/milling screening	4	0.2	0.11	3	0.3	0.20	2	0.2	0.12	2	0.3	0.24		0.0	0.00	2	0.2	0.14	1	0.0	0.01
Noug seed cakes	9	0.6	0.24	5	0.8	0.37	7	0.7	0.28	3	0.7	0.41	3	0.8	0.49	3	0.5	0.30		0.0	0.00
Oat improved feed (green)	13	1.4	0.43	11	1.5	0.51	8	0.8	0.30	5	1.5	0.72	6	1.5	0.64	3	0.3	0.20	5	1.0	0.56
Oat hay	19	2.2	0.53	9	2.0	0.73	11	1.7	0.56	5	1.1	0.53	7	2.0	0.78	14	2.9	0.81	10	2.3	0.82
Oat Vetch hay	3	0.3	0.20	1	0.1	0.07	2	0.2	0.18	1	0.3	0.34	2	0.5	0.38	3	0.5	0.32	1	0.2	0.23

Specific feed	Lactating cow			Dry cow			Helfer			Bull			Ox			Calf			Other		
	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE
Other straw	11	0.5	0.19	4	0.4	0.21	9	0.9	0.32	2	0.4	0.28	4	0.8	0.42	8	0.8	0.28	9	1.3	0.44
Pennisetum spp hay		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00	1	0.1	0.08
Rhodes grass hay	72	8.5	0.94	55	11.6	1.44	58	10.2	1.24	34	12.1	1.85	19	8.1	1.77	51	11.7	1.58	24	6.8	1.60
Silage	4	0.2	0.14	2	0.1	0.08	4	0.2	0.12	2	0.2	0.13	1	0.1	0.07	3	0.2	0.10	2	0.1	0.10
Sorghum Stover	11	2.2	0.74	7	2.6	1.05	8	2.1	0.80		0.0	0.00	1	0.3	0.28	4	1.4	0.71	3	1.2	0.73
Sweet potato leaves	1	0.1	0.08		0.0	0.00	1	0.1	0.12		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00
Teff straw	72	7.5	0.95	36	5.9	1.09	57	8.4	1.12	19	5.7	1.48	20	7.0	1.84	49	9.0	1.32	30	7.6	1.45
Tela Atela	15	0.8	0.21	11	0.9	0.28	12	1.0	0.31	9	1.5	0.50	5	1.2	0.58	12	1.3	0.42	1	0.1	0.06
Wadeesaa		0.0	0.00		0.0	0.00	1	0.1	0.14		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00
Wheat bran	69	6.4	0.76	44	5.5	0.82	45	5.8	0.81	17	4.0	0.97	14	4.5	1.12	35	5.2	0.81	23	4.6	1.01
Wheat middling	10	0.7	0.23	6	0.6	0.25	8	0.7	0.28	3	0.8	0.46	5	1.3	0.64	6	0.7	0.31	4	0.3	0.17
Wheat straw	150	19.2	1.25	97	24.7	2.01	108	22.8	1.83	65	30.7	2.82	46	26.9	3.12	89	20.8	1.89	57	22.3	2.54
		100.0			100.0			100.0			100.0			100.0			100.0			99.6	

Natural grazing, wheat straw and barely straw were the major feed types provided for crossbred in MCL in wet season (Table 41). Natural grazing and concentrate feed were the major feed Natural grazing contributed to about 32% of the diet of lactating cows, dry cows, heifers, bulls, ox, calves and other crossbreed dairy cattle, respectively in the dry season. Wheat bran contain 6.44%, 5.48%, 5.77%, 4.03%, 4.49%, 5.20% and 4.62% of the diet of lactating cows, dry cows, heifers, bulls, ox, calves and other crossbreed dairy cattle, respectively in the wet season. Table 40 depicted the reported values.

Table 40: Wet season DC of crossbred in MCL

Specific feed	Lactating cow			Dry cow			Helfer			Bull			Ox			Calf			Other		
	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE
Alfalfa	1	0.0	0.02		0.0	0.00	1	0.0	0.03		0.0	0.00		0.0	0.00	1	0.1	0.07	1	0.0	0.05
Barley straw	59	5.2	0.69	40	5.2	0.85	43	4.9	0.76	22	5.2	1.08	18	5.1	1.18	32	3.9	0.72	18	4.7	1.28
Bean hulls	10	0.2	0.07	4	0.1	0.08	7	0.2	0.10		0.0	0.00	2	0.1	0.09	8	0.3	0.12	8	0.4	0.17
Brach aria spp hay	1	0.1	0.12		0.0	0.00	1	0.1	0.05		0.0	0.00	1	0.2	0.20	1	0.0	0.03	1	0.2	0.18
Brewer's waste	10	0.7	0.23	9	1.2	0.40	5	0.6	0.25	5	1.1	0.50	2	0.8	0.63	7	0.8	0.35	1	0.1	0.10
By products from fruit and vegetables	4	0.1	0.06	1	0.0	0.03	4	0.1	0.06	1	0.2	0.23		0.0	0.00	5	0.3	0.16	5	0.4	0.22
Commercial concentrate	114	12.7	1.00	43	6.9	1.05	54	5.9	0.81	19	3.3	0.76	18	4.9	1.26	62	8.8	1.05	13	2.0	0.60
Cottonseed meal	16	1.2	0.31	6	0.8	0.34	11	1.3	0.37		0.0	0.00	2	0.5	0.39	14	1.8	0.48	10	1.9	0.57
Crop stand thinning	12	1.9	0.62	9	2.9	1.08	7	1.8	0.77		0.0	0.00		0.0	0.00	3	0.9	0.54	3	1.3	0.77
Enset leaves	5	0.2	0.11	3	0.2	0.15	4	0.2	0.12	2	0.3	0.23	1	0.2	0.24	3	0.1	0.08		0.0	0.00
Grass-legume mix	1	0.0	0.02		0.0	0.00	1	0.0	0.02		0.0	0.00	1	0.1	0.06		0.0	0.00	1	0.0	0.04
Grazing	174	30.3	1.71	102	32.9	2.44	132	35.3	2.24	78	42.0	2.80	62	47.0	3.43	109	30.2	2.44	91	50.6	3.18
Home-made	5	0.1	0.06	2	0.1	0.10	4	0.2	0.09		0.0	0.00	4	0.4	0.21	6	0.3	0.14	4	0.3	0.17
Household left-over	4	0.2	0.09	3	0.1	0.09	3	0.1	0.06	2	0.2	0.18	1	0.1	0.07	4	0.2	0.09	2	0.1	0.05
Linseed cake	16	0.4	0.10	2	0.1	0.10	5	0.2	0.10	3	0.4	0.25	2	0.3	0.22	8	0.4	0.15	2	0.1	0.06
Maize Stover	30	2.2	0.45	19	1.8	0.42	27	2.3	0.49	13	1.6	0.43	9	1.4	0.48	16	1.8	0.51	9	0.9	0.34
Mineral Supplement/salt	235	1.0	0.01	142	1.0	0.01	172	1.0	0.01	85	1.0	0.02	69	1.0	0.02	147	1.0	0.01	104	1.0	0.01
Molasses	4	0.2	0.11	4	0.2	0.13	2	0.1	0.12	1	0.1	0.06	1	0.2	0.20	2	0.1	0.07	2	0.1	0.08
Napier grass/desho	10	0.9	0.33	7	0.9	0.40	6	0.6	0.27	3	0.6	0.37	1	0.1	0.14	3	0.2	0.10	3	0.3	0.18
Nifash/milling screen	4	0.2	0.09	3	0.3	0.20	3	0.3	0.19	3	0.5	0.32	1	0.3	0.27	3	0.4	0.27		0.0	0.00
Noug seed cakes	5	0.1	0.05	2	0.1	0.09	2	0.1	0.04	2	0.1	0.07	1	0.1	0.06	1	0.0	0.03		0.0	0.00
Oat improved feed (green)	51	4.7	0.67	39	5.1	0.80	35	3.6	0.62	25	4.0	0.81	19	3.7	0.82	33	6.7	1.33	26	3.8	0.77
Oat and vetch green	2	0.2	0.17	3	0.3	0.20	4	0.4	0.22	1	0.2	0.17	1	0.3	0.28	3	0.3	0.18	2	0.2	0.17

Specific feed	Lactating cow			Dry cow			Helfer			Bull			Ox			Calf			Other		
	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE
Oat hay	28	2.7	0.51	14	2.0	0.58	19	2.2	0.54	11	2.7	0.86	9	2.6	0.87	19	3.2	0.80	19	3.9	0.96
Oat Vetch hay	5	0.6	0.28	1	0.2	0.24	3	0.3	0.18	2	0.6	0.44	3	0.9	0.51	2	0.4	0.26	2	0.6	0.40
Other straw	11	0.3	0.11	2	0.1	0.10	9	0.5	0.19	2	0.3	0.25	4	0.5	0.26	10	0.7	0.21	8	0.9	0.31
Pennisetum spp hay		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00	1	0.2	0.18
Rhodes grass hay	58	6.7	0.90	45	9.9	1.43	52	8.8	1.21	28	9.1	1.72	16	5.7	1.40	47	10.6	1.52	21	5.6	1.43
Sorghum Stover	10	1.3	0.46	6	0.9	0.39	7	1.3	0.58		0.0	0.00		0.0	0.00	4	0.8	0.42	2	0.6	0.42
Sugarcane leaves	1	0.1	0.06		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00
Sweet potato leaves	1	0.1	0.10		0.0	0.00	1	0.1	0.14		0.0	0.00		0.0	0.00		0.0	0.00		0.0	0.00
Teff straw	63	5.5	0.74	29	4.4	0.94	50	6.7	0.96	15	4.3	1.35	16	5.5	1.67	43	6.8	1.14	25	5.4	1.20
Tela Atela	13	0.5	0.15	12	0.9	0.30	11	0.7	0.24	9	1.7	0.56	4	0.9	0.48	11	1.2	0.43	2	0.3	0.26
Wheat bran	56	4.3	0.58	32	3.5	0.66	32	3.3	0.61	10	1.7	0.56	10	2.0	0.65	28	3.6	0.67	13	2.5	0.68
Wheat middling	7	0.3	0.11	5	0.4	0.18	6	0.4	0.16	2	0.2	0.16	2	0.2	0.15	6	0.4	0.18	2	0.1	0.08
Wheat straw	149	14.6	0.96	92	16.9	1.34	112	16.3	1.18	65	18.6	1.55	47	14.8	1.80	90	13.6	1.17	55	11.3	1.37
Sum		100.0			100.0			100.0			100.0			100			100			100	

5.5.4 Diet composition of commercial feedlot

All interviewees estimated that the dry season has 8 months and the wet season as 4 months.

The average (percent) of the different specific feed types estimated are indicated in Table 41. While, Wheat bran, Cotton seed meal, Wheat straw and Teff straw were the major feed types to be used for fattening male animals ages 1-3 years old in both the dry season and the wet season - but with different proportions.

Table 41: Diet composition of commercial feedlot males (% of total feed)

	Dry season DC			Wet season DC			Annual weighted average
Specific feed	N	Mean	SE	N	Mean	SE	Mean
Banana leave	2	0.3	0.2	1	0.1	0.1	0.23
Barley straw	17	3.4	1.3	15	3.2	1.2	3.35
Bean	2	0.5	0.4	1	0.1	0.1	0.37
Bean hulls	35	3.4	0.6	33	3.3	0.6	3.36
Brewer's waste	4	1.4	0.7	4	1.7	0.9	1.50
Commercial concentrate	32	17.9	2.7	29	16.6	2.7	17.48
Cottonseed meal	40	11.6	1.3	40	11.7	1.3	11.60
Enset leaves	3	0.4	0.2	2	0.3	0.2	0.34
Grazing	7	2.5	1.3	18	10.1	2.8	5.01
Hen feces	1	0.1	0.1	1	0.1	0.1	0.07
Home-made	5	2.4	1.2	5	1.7	1.0	2.20
Household left-over	3	0.5	0.3	4	0.4	0.2	0.48
Lentil straw, rice straw, Maize flour	1			1	0.3	0.3	0.09
Linseed cake	19	1.9	0.4	19	1.9	0.4	1.88
Maize	2	0.3	0.2	2	0.3	0.2	0.29
Maize grain	1	0.1	0.1	1	0.1	0.1	0.13
Maize Stover	6	1.3	0.6	6	1.4	0.7	1.36
Maize, bean, lentil	1	0.4	0.4	1	0.4	0.4	0.42
Maize, lentil					0.4	0.4	0.14
Mineral Supplement/salt	68	1.0	0.0	69	1.0	0.0	0.99
Mixed food flour	1	0.3	0.3	1			0.18
Molasses	5	0.4	0.4	5			0.28
Napier grass/desho	3	0.7	0.4	3	0.7	0.3	0.71
Noug seed cakes	7	1.0	0.7	9	1.6	0.9	1.21
Oat green	4	0.9	0.3	4	1.1	0.4	0.98

Oat and vetch green	7	0.6	0.3	8	0.7	0.4	0.60
Oat hay	4	1.0	0.4	5	1.0	0.4	1.03
Oat Vetch hay	3	0.7	0.4	1	0.6	0.3	0.63
Other straw	7	0.4	0.2	6	0.1	0.1	0.29
Pea		1.3	0.5	1	1.0	0.4	1.17
Poultry waste	1			1	0.4	0.4	0.12
Poultry litter	6	0.0	0.0	6	0.0	0.0	0.03
Rhodes grass hay	10	1.7	0.7	7	1.7	0.7	1.74
Rice hull	11	6.3	2.2	11	1.9	0.8	4.83
Sorghum Stover	3	0.6	0.2	3	0.6	0.2	0.64
Spain grain	1	0.7	0.5	1	0.7	0.5	0.65
Sugarcane	3	0.2	0.2	3	0.2	0.1	0.22
Teff straw	57	15.8	1.2	55	15.0	1.1	15.54
Wheat bran	33	12.6	1.8	32	12.7	1.8	12.63
Wheat middling	4	1.4	0.8	3	1.0	0.6	1.26
Wheat straw	22	3.9	0.7	24	4.0	0.7	3.92
Total		100.0			100.0		100.0

5.5.5 Feed type and diet composition of PAP

The major feed types in the dry season of PAP production system are concentrate, natural grazing, natural grass hay and maize Stover. While during the wet season natural grazing, natural grass hay and Rhodes grass hay were the major feel types. The percent of these different specific feed types estimated are indicated in Table 42.

Table 42: Diet composition of PAP cattle (specific feed type)

	Dry season DC, % of total									Wet season DC, % of total								
	Lactating cow			Ox			Other			Lactating cow			Ox			Other		
Specific feed	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Natural pasture grazing	15	12.8	2.7	4	10.0	4.1	20	15.0	2.3	23	70.0	4.9	10	90.0	3.7	27	56.1	6.2
Natural grass hay	11	8.2	2.2	4	8.5	3.6	15	12.3	2.6	20	30.0	4.9	5	10.0	3.7	20	43.2	6.3
Rhodes grass hay											0.0	0.0		0.0	0.0	1	0.7	0.7
Teff straw	25	34.8	2.3	10	30.5	4.5	30	32.7	2.9									
Maize Stover	10	9.2	2.5	8	18.0	3.9	13	10.2	2.5									
Other straw	1	0.4	0.4	1	1.0	1.0	1	0.7	0.7									

	Dry season DC, % of total									Wet season DC, % of total								
	Lactating cow			Ox			Other			Lactating cow			Ox			Other		
Specific feed	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Commercial Concentrate	25	32.2	2.6	10	30.0	4.5	30	25.8	2.6									
Wheat bran	1	0.8	0.8	1	2.0	2.0	1	0.7	0.7									
Olive Leaf	1	0.4	0.4		0.0	0.0	2	1.7	1.2									
Mineral/salt	1	1.2	1.2		0.0	0.0	1	1.0	1.0									
Total DC		100.0			100.0			100.0			100.0			100.0			100.0	

5.5.6 Smallholder dairy Diet composition (DC)

A total of more than 30 specific feed types in smallholder dairy in urban and peri-urban farms of Oromia region were identified. The average, standard error, t-test and 95% significant level were analyzed and reported (Table 43 and table 44). The major feed for lactating cows were commercial concentrate, Grass hay, wheat bran, wheat straw and Brewery waste (listed according to importance respectively).

Table 43: Dry season DC of smallholder dairy cattle

Specific feed	Lactating cow			Dry cows			Heifers			Ox			Growing _male			Bulls			Calf		
	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE
Alfalfa	3	0.2	0.1		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	1	0.0	0.0
Atela+oat (nifash) husk	1	0.1	0.1		0.0	0.0	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0	1	0.3	0.1
Banana leave	8	0.8	0.3	2	0.6	0.4	5	1.1	0.5		0.0	0.0	3	1.1	0.9	1	1.6	1.6	7	1.0	
Barley straw	65	16.4	2.0	36	10.3	1.9	30	11.9	2.4	1	5.0	5.0	16	13.8	3.7	4	18.4	10.6	46	14.6	2.3
Bean hulls	8	0.5	0.2	5	1.1	0.6	3	0.5	0.3		0.0	0.0	2	1.3	0.9		0.0	0.0	7	1.0	0.4
Brewer's waste	27	3.8	0.9	21	3.9	1.0	18	4.4	1.1	1	5.0	5.0	8	3.6	1.4	3	9.7	5.2	23	4.2	0.8
By products from fruit and vegetables	2	0.2	0.2	1	0.1	0.1	1	0.4	0.4		0.0	0.0	1	0.1	0.1		0.0	0.0	2	0.2	0.0
Commercial concentrate	71	13.0	1.3	43	11.2	1.4	30	8.7	1.5		0.0	0.0	16	7.8	1.7	6	11.4	4.4	53	11.5	1.5
Corn cane	1	0.1	0.1	1	0.2	0.2		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.7
Cottonseed meal	18	2.6	0.6	14	3.2	0.8	7	1.8	0.7		0.0	0.0	3	1.1	0.6		0.0	0.0	15	2.9	0.0
Crop stand thinning	2	0.1	0.1		0.0	0.0	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0	3	0.3	
Cut and carry natural grass and elephant grass	1	0.0	0.0	1	0.1	0.1	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Cut and carry natural grass	1	0.1	0.1	1	0.2	0.2	1	0.2	0.2		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Enset leaves	15	1.8	0.5	11	2.1	0.7	11	2.5	1.0		0.0	0.0	5	1.4	0.7	3	4.3	2.3	11	1.9	0.5
Finger millet	1	0.0	0.0		0.0	0.0	1	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	1	0.0	0.1
Finger millet straw																					
Grass-legume mix	5	1.1	0.5	3	1.0	0.6	3	0.9	0.5		0.0	0.0	1	0.9	0.9		0.0	0.0	1	0.2	0.2
Home-made concentrate	8	1.4	0.5	7	1.5	0.6	3	0.9	0.6		0.0	0.0	4	3.0	1.7		0.0	0.0	9	2.6	1.0
Household left-over	2	0.3	0.2		0.0	0.0	1	0.3	0.3		0.0	0.0	1	0.2	0.2		0.0	0.0	2	0.2	0.3

Specific feed	Lactating cow			Dry cows			Heifers			Ox			Growing _male			Bulls			Calf		
	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE
Linseed cake	14	1.3	0.4	4	0.9	0.5	6	1.0	0.5		0.0	0.0	1	0.1	0.1		0.0	0.0	4	0.7	0.3
Local brewery waste	3	0.3	0.2	1	0.3	0.3	2	0.2	0.1		0.0	0.0	1	0.6	0.6		0.0	0.0	1	0.1	0.0
Local beverages waste		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Maize grain	4	0.4	0.3		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Maize Stover	12	1.4	0.5	13	2.7	0.9	11	2.1	0.8		0.0	0.0	6	2.2	1.0		0.0	0.0	11	1.8	0.6
Milled crops		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Mineral Supplement/salt	127	1.0	0.0	78	1.0	0.0	67	1.0	0.0	2	1.0	0.0	33	1.0	0.0	9	1.0	0.0	88	1.0	0.1
Mixed food flour	2	0.2	0.2	1	0.1	0.1	1	0.4	0.4		0.0	0.0	1	0.3	0.3		0.0	0.0	1	0.1	0.0
Molasses	6	0.4	0.2	5	0.4	0.3	3	0.2	0.2		0.0	0.0	2	0.3	0.3	1	0.6	0.6	6	0.5	0.3
Napier grass/Desho	4	0.5	0.3	3	0.4	0.3	3	1.0	0.6		0.0	0.0	4	2.2	1.3		0.0	0.0	3	0.7	0.4
Natural grazing	31	6.2	1.2	17	5.4	1.8	19	9.9	2.6	1	25.0	25.0	11	10.4	3.3	1	8.9	8.9	19	5.8	1.7
Noug seed cakes	4	0.3	0.2	4	0.6	0.3	3	0.5	0.3		0.0	0.0		0.0	0.0		0.0	0.0	4	0.6	0.3
Oat		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Oat hay	1	0.2	0.2		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Other straw	3	0.6	0.4	18	8.6	2.1	18	11.2	2.6	2	44.5	4.5	11	9.8	3.0	5	14.1	5.9	20	6.7	1.6
Pennisetum spp hay		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Rhodes grass hay	24	6.1	1.3	4	1.2	0.6	2	0.8	0.7		0.0	0.0	1	1.2	1.2	2	10.6	7.0	4	1.4	1.0
Silage		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Sorghum Stover	1	0.3	0.3	1	0.5	0.5	1	0.6	0.6		0.0	0.0		0.0	0.0	1	4.7	4.7	1	0.5	0.5
Spaint grain		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.5
Sugarcane	12	1.1	0.4	4	0.7	0.3	4	0.9	0.5		0.0	0.0	4	2.2	1.1		0.0	0.0	12	1.6	0.0
Sunflower cake		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Sweet potato leaves																					0.2
Teff straw	49	8.9	1.2	34	10.6	1.7	25	9.1	1.8		0.0	0.0	13	7.5	2.1	1	4.4	4.4	42	9.9	1.4

Specific feed	Lactating cow			Dry cows			Heifers			Ox			Growing _male			Bulls			Calf		
	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE	N	Mean, %	SE
Tela Atela	7	0.7	0.3	4	0.5	0.2	5	0.8	0.4		0.0			0.0	0.0	1	1.5	1.5	8	1.1	0.1
Vetch	1	0.1	0.1	1	0.2	0.2	1	0.2	0.2		0.0	0.0		0.0	0.0	1	1.7	1.7	1	0.2	0.2
Wheat bran	57	10.1	1.2	32	9.8	1.6	27	8.0	1.4	1	9.5	9.5	8	4.9	1.9	1	1.1	1.1	37	8.5	1.3
Wheat middling	20	2.0	0.4	10	1.5	0.5	10	1.8	0.6		0.0	0.0	6	2.7	1.4	1	0.4	0.4	8	2.0	0.9
Wheat straw	70	15.3	1.6	50	19.4	2.3	36	16.3	2.3	1	10.0	10.0	20	20.3	3.8	2	5.4	4.3	55	16.1	1.9
Milled maize	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	
Sum		100			100			100			100.0			100.0			100			100	

Table 44: smallholder dairy wet season DC, % of total feed

Specific feed	Lactating cow			Dry cows			Heifers			Ox			Growing_ male			Bulls			Calf		
	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Alfalfa	3	0.4	0.3	1	0.3	0.3	1	0.4	0.4		0.0	0.0	1	0.4	0.4		0.0	0.0	3	0.4	0.2
Areki Atela		0.2	0.2		0.2	0.2		0.2	0.1		0.0	0.0		0.7	0.6		0.0	0.0		0.0	0.0
Atela+oat (nifash) husk	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	1	0.1	0.1
Banana leave	10	1.1	0.4	3	0.5	0.3	5	0.9	0.5		0.0	0.0		0.0	0.0	1	4.4	4.4	6	0.8	0.3
Barley straw	60	11.1	1.4	32	8.9	1.6	28	9.5	2.0	2	10.0	0.0	17	11.7	3.1	4	19.1	8.8	41	11.6	1.9
Bean hulls	8	0.4	0.2	6	0.8	0.4	4	0.5	0.3		0.0	0.0	2	0.7	0.6		0.0	0.0	10	0.8	0.3
Brachiaria spp hay		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Brewer's waste	28	3.7	0.8	15	2.8	0.9	16	3.9	1.1	1	5.0	5.0	11	5.7	1.9	1	0.8	0.8	23	3.9	1.0
By products from fruit and vegetables	1	0.1	0.1	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	1	0.1	0.1
Commercial concentrate	67	11.5	1.3	36	8.9	1.4	28	8.6	1.6		0.0	0.0	12	7.2	2.3	6	14.4	6.3	54	10.2	1.3
Corn cane	1	0.0	0.0	2	0.2	0.1	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0	2	0.1	0.1
Cottonseed meal	17	2.4	0.6	11	2.7	0.8	9	2.4	0.8		0.0	0.0	3	1.4	0.8		0.0	0.0	18	3.4	0.7
Crop stand thinning	1	0.1	0.1		0.0	0.0	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0	1	0.1	0.1
Cut and carry natural grass and elephant grass	1	0.2	0.2	1	0.3	0.3	1	0.3	0.3		0.0	0.0		0.7	0.7		0.0	0.0	1	0.3	0.3
Cut and carry natural grass	1	0.2	0.2	1	0.3	0.3	1	0.3	0.3		0.0	0.0	1	0.0	0.0		0.0	0.0		0.0	0.0
Elephant grass	1	0.1	0.1	1	0.1	0.1	1	0.1	0.1		0.0	0.0	1	0.5	0.5		0.0	0.0	1	0.2	0.2
Enset leaves	10	0.9	0.3	7	1.0	0.4	6	0.8	0.4		0.0	0.0	2	0.8	0.6	3	2.2	1.3	8	0.8	0.3
Grass-legume mix	2	0.2	0.1	1	0.3	0.3	1	0.2	0.2		0.0	0.0	1	1.1	1.1		0.0	0.0	1	0.5	0.5
Home-made concentrate	10	2.6	0.9	9	2.9	1.0	3	1.3	0.7		0.0	0.0	6	4.9	2.1		0.0	0.0	10	2.9	1.0
Household left-over	4	0.3	0.2	2	0.4	0.3	2	0.4	0.3		0.0	0.0	2	0.5	0.4		0.0	0.0	2	0.3	0.2
Linseed cake	14	1.2	0.4	4	0.7	0.4	6	0.8	0.4		0.0	0.0	1	0.1	0.1		0.0	0.0	5	0.8	0.4
Local brewery waste	3	0.0	0.0	1	0.0	0.0	2	0.0	0.0		0.0	0.0	2	0.0	0.0		0.0	0.0	1	0.0	0.0

Specific feed	Lactating cow			Dry cows			Heifers			Ox			Growing_ male			Bulls			Calf		
	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Maize grain	4	0.3	0.2		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Maize Stover	14	1.8	0.5	18	3.8	1.0	12	2.6	0.8		0.0	0.0	6	3.4	1.5	1	1.1	1.1	14	2.2	0.7
Milled crops		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Mineral Supplement/salt	127	1.1	0.1	76	1.0	0.0	70	1.0	0.0	2	1.0	0.0	34	1.0	0.0	9	1.0	0.0	92	1.1	0.1
Mixed food flour	1	0.1	0.1	1	0.1	0.1		0.0	0.0		0.0	0.0	1	0.2	0.2		0.0	0.0	1	0.1	0.1
Molasses	5	0.3	0.1	4	0.2	0.1	2	0.2	0.2		0.0	0.0	1	0.1	0.1	1	0.6	0.6	4	0.3	0.2
Napier grass		2.0	0.8		0.0	0.0		2.0	1.0		0.0	0.0		2.7	1.4		0.0	0.0		2.1	1.0
Napier grass & desho grass	7	0.0	0.0	4	1.5	0.8	4	0.0	0.0		0.0	0.0	4	0.0	0.0		0.0	0.0	5	0.0	0.0
Natural grazing	59	18.0	2.3	30	15.3	2.9	33	19.9	3.5	2	40.0	30.0	15	15.1	4.1	3	13.9	7.7	42	13.3	2.1
Noug seed cakes	3	0.2	0.1	3	0.5	0.3	2	0.4	0.3		0.0	0.0		0.0	0.0		0.0	0.0	3	0.4	0.2
Oat		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Oat hay		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Other straw	3	0.6	0.4	12	3.7	1.2	9	3.2	1.2	1	20.0	20.0	9	6.2	2.3	3	11.6	6.2	12	3.3	1.2
Pennisetum spp hay		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Rhodes grass hay	34	5.9	1.0	16	4.6	1.2	16	5.3	1.3		0.0	0.0	4	2.0	1.0	3	13.9	7.1	16	3.4	0.9
Silage		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Soya bean straw		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Spant grain	2	0.00	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	
Sugarcane	13	1.2	0.4	3	0.2	0.1	7	1.5	0.6		0.0	0.0	5	1.9	1.0		0.0	0.0	13	1.5	0.0
Sunflower cake		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.5
Teff straw	46	7.8	1.1	33	11.2	1.8	28	9.3	1.7	1	4.5	4.5	13	7.0	1.7	1	1.1	1.1	45	10.4	1.5
Tela Atela	8	0.8	0.3	5	0.5	0.2	7	1.0	0.4		0.0	0.0	1	0.3	0.3	2	2.7	2.1	9	1.6	0.7
Vetch		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Wheat bran	48	8.2	1.2	31	9.1	1.6	25	6.8	1.4	1	9.5	9.5	8	5.3	1.9	1	5.6	5.6	36	7.5	1.3
Wheat middling	18	2.0	0.5	8	1.7	0.6	10	2.0	0.7	2	0.0	0.0	2	0.6	0.5		0.0	0.0	4	0.3	0.2

Specific feed	Lactating cow			Dry cows			Heifers			Ox			Growing_ male			Bulls			Calf		
	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Wheat straw	70	12.7	1.4	48	15.0	1.9	38	13.9	2.0		10.0	0.0	22	17.7	3.2	3	7.7	4.6	61	15.2	1.6
Milled maize	1	0.0	0.0		0.0	0.0	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0	1	0.0	0.0
Sum		100			100						100.0			100			100.0			100	

5.5.7 Large commercial dairy DC

The major specific feed for dairy cattle in the dry season for medium-large commercial dairy farms were commercial concentrate, grass hay, wheat bran, wheat straw and brewery by product. Commercial concentrate contributed to about 22.63%, 14.64%, 12.77%, 15.90%, 13.90%, 11.41% and 17.58% of the diet of lactating cows, dry cows, heifers, Ox, growing male, bulls and calves, in the dry season. Wheat bran and brewery waste were among the specific feed types for all subcategories of medium-to large commercial dairy farms. Out of the roughage, green feed/natural grazing, grass hay, Teff straw and wheat straw were the major feed types used by all subcategories during the dry season (Table 45).

Table 45: Dry season diet composition of large commercial dairy

Specific feed	Lactating cow			Dry cows			Heifer			Ox			Growing male			Bull			Calf		
SP	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Alfalfa	2	0.1	0.1	2	0.2	0.1	2	0.2	0.1		0.0	0.0	1	0.2	0.2	1	0.4	0.4		0.0	0.0
Atela+oat husk		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Banana leave	6	0.5	0.2	5	0.7	0.4	4	0.4	0.2		0.0	0.0	1	0.7	0.7		0.0	0.0	3	0.6	0.4
Barley straw	13	3.2	1.0	13	2.8	0.8	11	2.9	0.9	3	6.6	3.7	6	2.5	1.0	3	2.0	1.2	10	2.8	0.9
Bean hulls	8	1.0	0.4	8	1.4	0.5	8	2.2	0.9		0.0	0	4	1.6	0.9	5	3.3	1.5	5	1.4	0.8
Brach aria spp hay	1	0.2	0.2	1	0.2	0.2	1	0.3	0.3		0.0	0.0		0.0	0.0		0.0	0.0	1	0.3	0.3
Brewer's waste	42	12.5	1.9	38	9.4	1.5	35	8.8	1.4		0.0	0.0	22	11.3	2.4	16	9.6	2.1	28	8.8	1.7
By products from fruit and vegetables	3	0.3	0.2	3	0.6	0.4	3	0.4	0.3		0.0	0.0	1	0.4	0.4		0.0	0.0	2	0.2	0.2
Commercial concentrate	68	23.1	1.9	55	14.9	1.5	44	13.5	1.7	8	15.9	3.9	27	14.3	2.3	13	10.3	2.5	50	17.8	1.9
Corn cane		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Cottonseed meal	1	0.1	0.1	1	0.1	0.1	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0	1	0.1	0.1
Crop stand thinning	1	0.1	0.1	1	0.1	0.1	1	0.2	0.2		0.0	0.0	1	0.4	0.4	1	0.7	0.7	1	0.3	0.3
Enset leaves	11	1.5	0.6	9	1.2	0.5	7	0.7	0.4	1	1.0	1.0	3	0.6	0.4	1	0.3	0.3	6	0.6	0.3
Grass-legume mix		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Home-made	2	0.2	0.1	2	0.6	0.5	2	0.3	0.2		0.0	0.0	1	0.3	0.3		0.0	0.0	1	0.1	0.1
Household left-over		0.0	0.0	1	0.0	0.0	1	0.1	0.1		0.0	0.0	1	0.1	0.1		0.0	0.0		0.0	0.0
Linseed cake	4	0.5	0.3	4	0.5	0.3	3	0.4	0.3	1	0.4	0.4	1	0.5	0.5		0.0	0.0	3	0.5	0.3
Local brewery waste		0.2	0.2		0.2	0.2		0.1	0.1		0.0	0.0		0.4	0.4		0.0	0.0		0.2	0.2
Maize grain	1	0.2	0.2		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Maize Stover	7	1.0	0.6	9	1.6	0.7	7	1.5	0.8		0.0	0.0	2	1.3	1.1	1	1.9	1.9	6	0.9	0.5
Milled crops	1	0.1	0.1	1	0.1	0.1	75	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Mineral Supplement/salt	89	1.0	0.0	90	1.0	0.0	12	1.0	0.0	10	1.0	0.0	44	1.0	0.0	27	1.0	0.0	76	1.0	0.0
Molasses	13	0.7	0.2	13	1.1	0.3	5	1.1	0.3	1	1.0	1.0	9	1.7	0.5	3	1.0	0.7	10	1.0	0.4
Napier grass/desho	7	1.4	0.7	6	0.8	0.4	25	1.0	0.5		0.0	0.0	4	1.9	1.1	2	1.4	1.1	4	1.2	0.7
Natural grazing	27	4.8	1.0	27	5.3	1.1	8	7.6	1.5	3	10.4	6.6	10	3.8	1.4	4	1.6	0.9	21	5.3	1.4
Noug seed cakes	8	0.9	0.4	8	0.8	0.4		1.1	0.5	1	3.0	3.0	5	1.2	0.8	3	0.3	0.2	7	1.1	0.6
Oat	1	0.2	0.2	1	0.2	0.2	1	0.3	0.3		0.0	0.0	1	0.5	0.5	2	0.0	0.0	1	0.3	0.3
Oat hay	4	0.6	0.4	4	1.2	0.8	2	0.5	0.4	1	2.5	2.5	2	0.8	0.6		3.2	2.6	3	1.2	1.0
Oat Vetch		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.00	0.00		0.00	0.00

Specific feed	Lactating cow			Dry cows			Heifer			Ox			Growing male			Bull			Calf		
SP	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Other straw		0.0	0.0	4	1.2	0.7	3	1.0	0.6		0.0	0.0		0.0	0.0		0.0	0.0	3	1.0	0.7
Pennisetum spp hay	1	0.1	0.1	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	1	0.1	0.1
Rhodes grass hay	63	18.4	1.9	58	24.2	2.5	50	25.7	2.7	5	17.4	7.3	29	26.0	3.5	24	37.1	3.7	51	24.8	2.9
Silage	1	0.3	0.3		0.2	0.2		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.2	0.2
Soya bean straw	1	0.3	0.3		0.3	0.3		0.5	0.5		0.0	0.0		0.7	0.7		1.4	1.4		0.4	0.4
Spaint grain		0.0	0.0	1	0.0	0.0	1	0.0	0.0		0.0	0.0	1	0.0	0.0	1	0.0	0.0	1	0.0	0.0
sugarcane		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Sunflower cake	1	0.1	0.1	1	0.1	0.1		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	1	0.1	0.1
Teff straw	26	4.1	0.9	28	5.8	1.1	23	6.0	1.2	1	3.0	3.0	16	7.8	1.9	6	4.8	2.0	22	5.0	1.0
Tela Atela		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Wheat bran	36	11.0	1.7	36	10.7	1.7	31	10.0	1.7	4	16.9	7.2	18	8.0	1.8	13	12.3	2.9	34	11.1	1.7
Wheat middling	14	2.9	1.0	14	2.7	0.8	11	2.9	1.0	1	1.0	1.0	2	1.3	1.1	2	2.7	2.1	8	2.7	1.1
Wheat straw	33	7.9	1.3	33	9.7	1.5	25	9.4	1.8	7	19.9	4.9	18	10.7	2.3	6	4.6	1.8	31	9.1	1.5
Total		100.0			100.0			100.0			100.0			100.0			100.0			100.0	

The major feed during the wet season for dairy cattle in medium-large commercial dairy farms were commercial concentrate contributing about 21.57%, 14.14%, 11.59%, 17.50%, 12.75%, 14.97% and 16.42% of the diet for lactating cows, dry cows, heifers, Ox, growing male, bulls and calves, respectively. Wheat bran and brewery waste were among the homemade concentrate that was used by all subcategories. Grass hay, wheat straw and Teff straw were among the major roughage used by all subcategories during the wet season (Table 46).

Table 46: Medium-Commercia dairy; Wet season DC, % of total feed

Specific feed	Lactating cow			Dry cows			Heifer			Ox			Growing male			Bull			Calf		
SP	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Alfalfa	2	0.13	0.11	2	0.16	0.11	2	0.15	0.12	1	0.64	0.64	1	0.23	0.23	1	0.31	0.31	2	0.00	0.00
Atela+oat (nifash) husk		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00
Banana leave	4	0.32	0.17	3	0.60	0.46	3	0.39	0.22		0.00	0.00		0.00	0.00		0.00	0.00	2	0.25	0.17
Barley straw	14	2.63	0.76	14	3.18	0.95	11	3.07	0.95	4	5.71	2.67	6	2.54	1.08	4	2.07	1.07	11	2.47	0.75
Bean hulls	7	0.87	0.34	7	1.13	0.47	7	1.64	0.78		0.00	0.00	4	1.79	0.96	5	2.55	1.28	4	0.91	0.64
Brach aria spp hay	2	0.50	0.35	2	0.49	0.35	2	0.45	0.35		0.00	0.00		0.00	0.00	1	0.66	0.66	2	0.56	0.39
Brewer's waste	42	10.16	1.48	38	9.81	1.53	35	10.47	1.64	3	2.71	1.55	19	12.36	2.72	16	10.28	2.75	29	8.90	1.65
By products from fruit and vegetables	3	0.46	0.31	3	0.34	0.24	3	0.55	0.37		0.00	0.00	1	0.23	0.23		0.00	0.00	2	0.36	0.27
Commercial concentrate	67	21.93	1.86	55	14.43	1.50	41	11.35	1.49	10	17.50	4.47	21	11.85	2.28	17	13.31	2.54	50	16.79	1.85
Corn cane		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00
Cottonseed meal	1	0.11	0.11	1	0.11	0.11	1	0.13	0.13		0.00	0.00		0.00	0.00		0.00	0.00	1	0.12	0.12
Crop stand thinning	1	0.04	0.04	1	0.04	0.04	1	0.13	0.13		0.00	0.00	1	0.10	0.10	1	0.31	0.31	1	0.01	0.01
Enset leaves	7	0.43	0.17	6	0.54	0.24	4	0.72	0.40	1	1.07	1.07	1	0.26	0.26	1	0.34	0.34	4	0.26	0.19
Grass-legume mix	5	0.94	0.49	5	0.91	0.42	5	1.09	0.51		0.00	0.00	2	1.13	0.90	3	2.10	1.32	4	1.32	0.72
Home-made	1	0.32	0.32	1	0.10	0.10		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	1	0.12	0.12
Household left-over	1	0.01	0.01	2	0.06	0.05	2	0.08	0.07		0.00	0.00	1	0.13	0.13		0.00	0.00		0.00	0.00
Linseed cake	3	0.38	0.25	3	0.38	0.25	2	0.29	0.22	1	0.29	0.29	1	0.51	0.51		0.00	0.00	2	0.33	0.26
Local brewery waste	2	0.09	0.06	2	0.11	0.08	2	0.12	0.08		0.00	0.00	1	0.10	0.10		0.00	0.00		0.00	0.00
Maize grain	1	0.22	0.22		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00
Maize Stover	7	1.37	0.59	9	1.14	0.42	7	1.25	0.51	1	0.71	0.71	4	0.87	0.43	3	1.34	0.77	6	1.10	0.50
Milled crops	1	0.11	0.11	1	0.06	0.06		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00
Mineral Supplement/salt	90	1.00	0.00	90	1.00	0.00	73	0.97	0.02	14	1.00	0.00	39	1.00	0.00	29	1.00	0.00	80	0.99	0.01
Mixed food flour		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00
Molasses	9	1.23	0.53	9	0.67	0.28	9	0.83	0.34	1	0.36	0.36	3	0.51	0.31	1	0.17	0.17	7	0.72	0.31
Napier grass/desho	9	2.49	1.05	8	2.10	0.90	8	2.80	1.14	1	0.29	0.29	5	3.69	2.02	4	4.31	2.55	5	2.21	1.09
Natural grazing	38	13.80	2.15	39	18.27	2.68	36	18.57	2.83	7	21.14	6.94	17	14.21	3.35	12	13.72	4.02	35	15.81	2.65
Noug seed cakes	7	0.91	0.42	7	0.92	0.43	5	0.45	0.23	2	2.50	2.15	3	1.03	0.59	3	0.86	0.56	5	1.21	0.60
Oat	2	0.72	0.52	2	0.44	0.31	2	0.67	0.48	1	1.79	1.79	1	0.77	0.77	1	1.69	1.69	1	0.49	0.49

Specific feed	Lactating cow			Dry cows			Heifer			Ox			Growing male			Bull			Calf		
SP	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Oat hay	6	0.80	0.34	5	0.66	0.29	4	0.61	0.33	2	4.21	3.52	3	1.28	0.73	1	0.38	0.38	5	0.68	0.33
Oat Vetch		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00
Other straw	3	0.88	0.51	7	2.27	0.89	5	1.87	0.86	1	2.14	2.14	2	1.00	0.80	1	1.03	1.03	7	2.27	0.87
Pennisetum spp hay	1	0.11	0.11	1	0.11	0.11		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	1	0.12	0.12
Rhodes grass hay	54	12.88	1.39	52	13.91	1.65	45	15.77	2.04	4	5.00	2.28	24	15.90	2.75	19	20.34	3.46	46	15.98	2.12
Silage	1	0.32	0.32	1	0.21	0.21		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	1	0.23	0.23
Soya bean straw	1	0.32	0.32	1	0.21	0.21	1	0.25	0.25		0.00	0.00	1	0.49	0.49	1	1.00	1.00	1	0.25	0.25
Sunflower cake	1	0.06	0.06	1	0.06	0.06		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	1	0.06	0.06
Teff straw	22	2.83	0.60	21	3.71	0.90	16	4.36	1.17	3	6.07	3.71	10	5.77	1.83	8	6.38	2.20	19	3.27	0.78
Tela Atela	2	0.26	0.22	2	0.26	0.22	2	0.32	0.26	1	1.36	1.36	1	0.49	0.49	1	0.17	0.17		0.30	0.24
Wheat bran	34	10.14	1.65	34	9.86	1.59	29	9.36	1.66	3	5.21	3.16	17	10.46	2.31	12	9.10	2.31	33	10.33	1.62
Wheat middling	14	2.37	0.77	13	2.59	0.82	12	2.77	0.91	1	0.71	0.71	4	2.13	1.10	2	1.72	1.22	8	2.53	0.99
Wheat straw	32	7.84	1.38	32	9.17	1.52	25	8.51	1.62	10	19.57	4.68	16	9.18	2.15	9	4.83	1.56	30	9.04	1.52
		100.0			100.0			100.0			100.0			100.0			100.0			100.0	

6. REFERENCES

Ayano abera gage, effect of feeding different levels of maize silage on Feed intake, live weight gain, carcass characteristics, and meat quality of harar cattle, may 2021. Haramaya university, haramaya;

Gołasa, P., Wysokiński, M., Bieńkowska-Gołasa, W., Gradziuk, P., Golonko, M., Gradziuk, B., Siedlecka, A. and Gromada, A., 2021. Sources of greenhouse gas emissions in agriculture, with particular emphasis on emissions from energy used. Energies, 14(13), p.3784.

CSA (Federal Democratic Republic of Ethiopia Central Statistics Authority). 2022. Agricultural Sample Survey II. Report on Livestock and Livestock Characteristics. Statistical Bulletin. Addis Ababa, Ethiopia.

ESMAP. 1996. Ethiopia Energy Assessment. World Bank, http://documents.worldbank.org/curated/en/602311468770964869/pdf/multi-page.pdf

Feedipedia. 2017. Animal Feed Resource Information System. https://www.feedipedia.org/
ILRI. 2011. Ethiopian Feed Composition Database. htpp//192.156.137.110/ethfeed/

Feyissa et al 2015 Ethiop. J. Agric. Sci. 26(1) 13-27

G. M. PESTI, L. O. FAUST, H. L. FULLER, and N. M. DALE, Nutritive Value of Poultry By-Product Meal. Metabolizable Energy Values as Influenced by Method of Determination and Level of Substitution, Department of Poultry Science, University of Georgia, Athens, Georgia 30602

National Research Council (NRC) 2001. Nutrient requirements of dairy cattle. National Academy Press, Washington D.C.

Rose, S., Khatri-Chhetri, A., Stier, M., Wiese-Rozanova, L.D., Shelton, S.W., Wollenberg, E.K. and Dittmer, K., 2021. Ambition for soil organic carbon sequestration in the new and updated nationally determined contributions 2020-2021: Analysis of agricultural sub-sectors in national climate change strategies.

Seyoum Bediye et al. 2007, Chemical composition and nutritive values of Ethiopian feeds, EIAR research report 73 Tadesse et al, 2017).

Wilkes, A., Wassie, S.E., Tadesse, M., Assefa, B., Abu, M., Ketema, A. and Solomon, D., 2020. Inventory of greenhouse gas emissions from cattle, sheep and goats in Ethiopia (1994-2018) calculated using the IPCC Tier 2 approach.

Gebre W, Alemayehu A, Demeke M, Bediye S, Tadesse A (2000) Status of dairy development. Smallholder Dairy Development Project (SDDP) dairy research in Ethiopia. In: The role of village dairy co-operatives in dairy development. Addis Ababa, Ethiopia.

Siegefreid D, Berhanu A (1991) Dairy marketing in Ethiopia: Markets of first sale and producers' marketing patterns. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Wassie, S.E., Tadesse, M., Wilkes, A., Baker, D., Solomon, D. 2021. Options for improved livestock activity data collection and management to support MRV in Ethiopia. CCAFS Working Paper no. 368 Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).
https://www.sciencedirect.com/topics/food-science/metabolizable-energy

https://www.sciencedirect.com/science/article/abs/pii/S0377840109002946

UNIQUE-ILRI 2020. Inventory of greenhouse gas emissions from cattle, sheep and goats in Ethiopia (1994-2018) calculated using the IPCC Tier 2 approach. Final report December 2020