Options for improved livestock activity data collection and management to support measurement, reporting and verification (MRV) in Ethiopia

Working Paper No. 368

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and the Global Alliance for Research on Agricultural Greenhouse Gases (GRA)

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Abstract

To complement an ongoing CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) project ‘Enhancing capacities for MRV of sustainable livestock action in East Africa (Kenya and Ethiopia)’, which is implemented by UNIQUE forestry and land use, the Australian Centre for International Agricultural Research (ACIAR) supported CCAFS to implement a Small Research Activity (SRA) entitled ‘Building capacities for an integrated livestock MRV system in Ethiopia’. The objective of the SRA was to support Ethiopian stakeholders to improve the methods and procedures used to produce and manage the livestock activity data required for measurement, reporting and verification (MRV) of greenhouse gases (GHG) in Ethiopia.

This report summarizes the main results of the project’s activities and the activity data collection and data management methods recommended for use in Ethiopia. These findings may be relevant to livestock MRV in other countries in East Africa and elsewhere.

Section 1 explains the focus of the research activities on livestock activity data in Ethiopia. Ethiopia has identified livestock as a key subsector for GHG mitigation. An advanced livestock GHG inventory has been compiled using the Tier 2 method. However, some gaps remain in terms of data availability and data quality. The pilot activities were designed to fill those gaps, and thus enable Ethiopia to better quantify livestock GHG emissions and emission reductions in line with its national commitments on climate change.

Section 2 describes the data collection tools and data management methods tested and the results. The data collection tools focused on collecting improved data on diet composition, milk yield and manure management activity data. A further pilot involved the Ethiopian Institute for Agricultural Research (EIAR) in analyses and communication of data.

Section 3 highlights key recommendations for the adoption of the tools and data management activities evaluated by stakeholders. It also provides some reflections on the piloting process from the project team, which may provide some guidance for future piloting of MRV innovations elsewhere in East Africa.

Section 4 presents the manual's purpose for each production system to guide data collection procedures. It extends to guidance and pilots' lessons learned on sampling, selection of participants, preliminary analysis, and other practical implementation issues. These enable scaling up of the use of the piloted tools to regional and national levels.

Keywords

Livestock; MRV; GHG inventory; feed digestibility, manure management system; milk yield, liveweight.

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Table of contents

Acronyms

ACIAR	Australian Centre for International Agricultural Research
BAU	Business-as-usual
BUR	Biennial Update Report
CCAFS	Climate Change Agriculture and Food Security program of the CGIAR
CRGE	Climate Resilient Green Economy
CSA	Central Statistical Agency
DE	Digestible energy
EFCCC	Environment, Forestry and Climate Change Commission
ECCD	Environment and Climate Change Directorate (Ministry of Agriculture)
GHG	greenhouse gas
GTP	Growth Transformation Plan
LMP	Livestock master plan
MCF	Methane correction factor
ME	Metabolizable energy
MMS	manure management system
MRV	measurement, reporting and verification
Mt	Million metric tonnes
NC	National communication
NDC	Nationally Determined Contribution
SRA	Small Research Activity
UNFCCC	United Nations Framework Convention on Climate Change

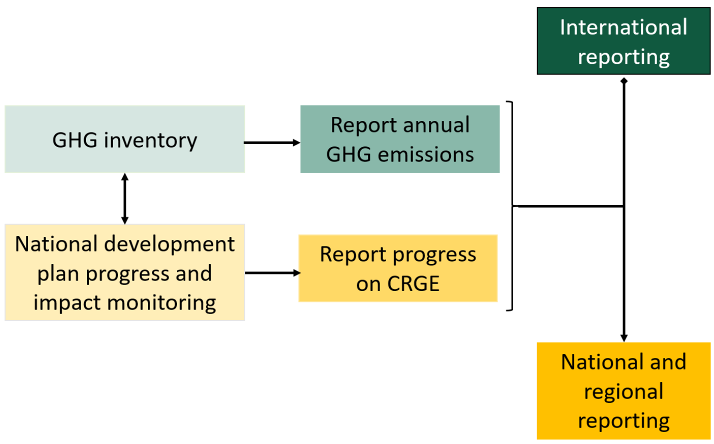
Introduction

1 Livestock activity data improvement needs in Ethiopia

1.1 Ethiopia's climate commitments in the livestock sector

Ethiopia is a party to the UN Framework Convention on Climate Change (UNFCCC) and ratified the Paris Agreement in 2017. Parties to the UNFCCC, including Ethiopia, have agreed general requirements for measurement, reporting and verification (MRV) of greenhouse gas (GHG) emissions. Under the Paris Agreement, parties have agreed a new reporting system applicable to both developed and developing countries, to be implemented from 2024.[1] The core of this MRV system is a Biennial Transparency Report, which is to be submitted every two years by each country, with flexibility for least developed countries, such as Ethiopia. This report should include a national GHG inventory, and a report of progress made in implementing and achieving the nationally determined contributions (NDC). Ethiopia's initial NDC (2015), was based on the country's Climate Resilience Green Economy (CRGE) Strategy.[2] The CRGE was mainstreamed into the national development plan, the Growth and Transformation Plan (GTP-II, 2016-2020). Ethiopia communicated an updated NDC to the UNFCCC in December 2020.[3] This updated NDC is in line with the measures set out in the CRGE but enhances the level of ambition and further elaborated measures for GHG mitigation in the livestock sector. The updated NDC is also in line with the country's new Ten-Year Development Plan. In summary, Ethiopia needs to be able to regularly compile and submit a national GHG inventory and to regularly report on the effects of mitigation actions, and these needs reflect both its national and international commitments (Figure 1).

Figure 1: Schematic overview of Ethiopia's MRV needs



Source: This study.

[1] https://unfccc.int/sites/default/files/resource/CMA2018_03a02E.pdf#page=18
[2] https://www.undp.org/content/dam/ethiopia/docs/Ethiopia%20CRGE.pdf
[3] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Ethiopia%20First/Ethiopia's%20NDC%20update%20summary%202020.pdf

Table 1 Livestock sector intervention areas in Ethiopia's Climate Resilient Green Economy (CRGE)

Intervention areas	General description	Likely effects on livestock
Improve cattle value chain efficiency	Increase productivity per head through improved breeding, feeding, health, marketing etc.	Change in breed Increased liveweight Increased milk yield Change in feed
Increase share of poultry and other low-emitting animals	Increase meat supply from poultry and other low-emitting animals	More chickens, sheep and goats Change in breed Increased productivity
Promote mechanization	Introduce tractors through small-scale mechanization programs	Fewer oxen Fewer work hours per ox
Improve rangeland management	Increase productivity of pasture and improve rangeland management	Improved feed availability and quality

Source: Compiled for this study based on the CRGE Strategy.

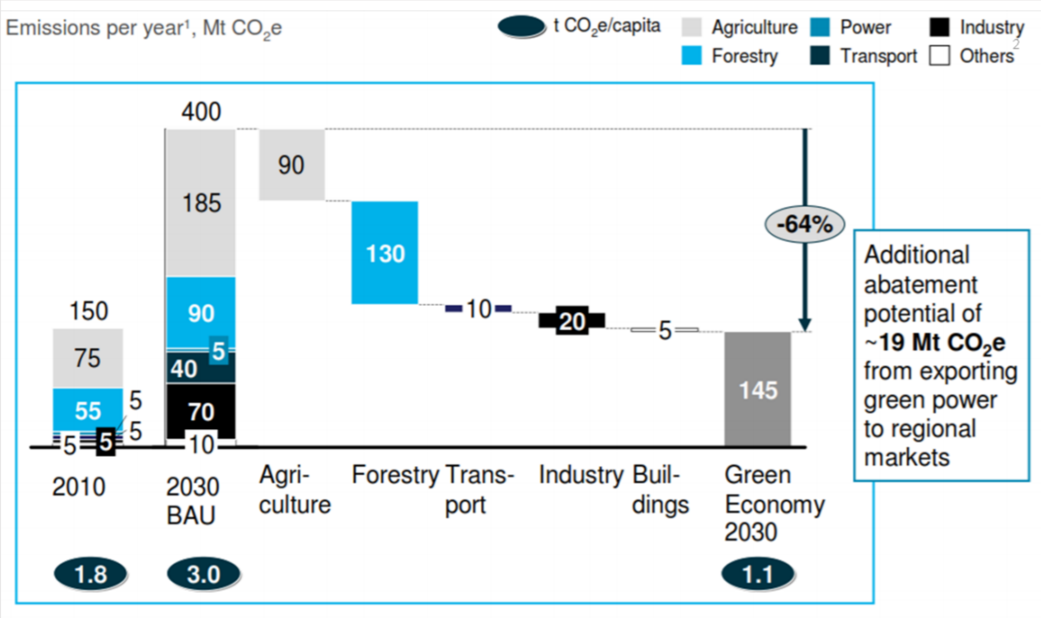
Mitigation actions: The livestock sector has been identified as one of the priority sectors in the CRGE.[4] Within the livestock sector, four main intervention areas were identified in the CRGE (see Table 1 and Box 1). The CRGE Strategy was mainstreamed into the national development plan, the Growth and Transformation Plan (2016-2020, [GTP II]), and will most likely be integrated with the upcoming ten-year Perspective Development Plan (10YDP). Building a climate-resilient green economy is one pillar of the GTP II. The monitoring matrix for GTP II included indicators to monitor progress in implementing and achieving the CRGE targets.[5] The CRGE indicators related to the livestock sector intervention areas were:

- Emissions of CO_2e per litre of milk produced
- Estimated annual reduction in CO_2e emissions due to improved productivity of livestock
- Estimated reduction of CO_2e due to shift to rearing of low carbon emitting animal species
- Estimated reduction in CO_2 emissions due to improved grazing (total, communal and private) land management.

[4] The priority sectors are agriculture, forestry, energy and transport.
[5] https://www.cmpethiopia.org/media/gtp_ii_policy_matrix_english_final_august_2016_2

Box 1: Ethiopia's CRGE and the livestock sector

Business-as-Usual (BAU) projections: Analysis supporting the CRGE strategy suggests that Ethiopia's total GHG emissions would increase from 150 Mt CO_2e in 2010 to 400 Mt CO_2e in 2030, an increase of 167%. Agriculture emissions would increase from 75 Mt CO_2e in 2010 to 185 Mt CO_2e in 2030, which is based on the assumption that the total cattle population doubles over this period. Of the 2010 agricultural emissions, 65 Mt CO_2e (i.e. 87%) are from livestock and BAU projections in 2030 for livestock are 124 Mt CO_2e. Of the livestock emissions, 84% are from cattle. Ethiopia's first NDC is based on the same BAU projections.



Source: Ethiopia's first NDC.

Mitigation options and potential: The CRGE Strategy identifies a mitigation potential of 90 Mt CO_2e to 2030, of which 48 Mt CO_2e is due to livestock sector interventions. The livestock sector interventions analysed were:

- value chain efficiency (40.1 Mt CO_2e): increasing productivity per head of cattle and off-take rate, led by better health and marketing, assuming 19.5 million pastoralist and farmer households are reached through dairy development and feedlot expansion;[6]
- increased supply and consumption of lower-emitting animal species (17.7 Mt CO2e), assuming that poultry account for 30% of animal source protein supply in 2030;[7]
- substituting draft oxen with mechanized ploughing and tillage (11.2 Mt CO2e), assuming 13.2 million households reached; and
- rangeland carbon sequestration (3 Mt CO2e), assuming 5 million ha improved.

Source: CRGE Strategy.

[6] Note that although sheep and goat fattening also occurs, they were not included in the CRGE scenario analysis.
[7] Note that although sheep and goats are also sometimes referred to as lower-emitting species, they were not included in the CRGE scenario analysis.

Updated NDC commitments:

The updated NDC is in line with the measures set out in the CRGE but enhances the level of ambition and further elaborates measures for GHG mitigation in the livestock sector. The new estimate of current and projected heads of livestock in the country as well as other key parameters (e.g. revised emission factors) significantly elevate BAU emissions (194.8 Mt CO_2e) of the livestock sector compared to the first NDC (124 Mt CO_2e). The updated NDC indicates that the emission reductions in the livestock sector are to be achieved through packages of policy interventions combining mitigation, efficiency gains and output growth in the sector, with interventions that are in line with sector-specific strategies and national development plans, including the livestock master plan (LMP), the 10YDP, and the CRGE strategy. According to the updated NDC, livestock policy interventions will reduce the emission level from 194.8 to 180 Mt CO2e (7.6%) and from 194.8 to 193 Mt CO2e (0.92%) by 2030 in the conditional pathway and in the unconditional pathway, respectively. Table 2 indicates the envisioned policies of the sector in the coming years emanating from these policy documents.

Table 2. Policy interventions in the livestock sector

Policy intervention	Indicator (unit)	Lead institution
Dairy, red meat and poultry intervention packages - Enhancing efficiency and productivity in livestock subsectors	Number of improved cows (owned by women/men) GHG intensity of agricultural GDP	Ministry of Agriculture
Agricultural mechanization - Replacing cattle/oxen with tractors for farmers and smallholders	Number of heads of livestock reduced (received by women/men) Number of tractors distributed	Ministry of Agriculture
Increase in the share of poultry -Replacing non-dairy cattle stock with chickens (supply side) and inducing a demand shift from beef to chicken	Number of non-dairy cattle replaced (owned by women/ men)	Ministry of Agriculture
Oilseed feeding -Improved feeding to reduce emissions from enteric fermentation	Improved feeding deployed (tonnes)	Ministry of Agriculture

Source: FDRE. 2021. *Updated Nationally Determined Contribution.* Addis Ababa

1.2 MRV systems in Ethiopia's livestock sector

1.1.1 National GHG inventory

In December 2020, Ethiopia's Ministry of Agriculture adopted an inventory of livestock GHG emissions compiled using the Tier 2 method of the Intergovernmental Panel on Climate Change (IPCC).[8] The inventory estimates GHG emissions from cattle, sheep and goats from 1994 to 2018.

1.1.2 MRV of mitigation actions

To date, an MRV system for the livestock sector has not been operational due to lack of a clear methodology and available data for GHG accounting. However, such a system could be created on the basis of the Tier 2 inventory with additional data sources. Our research demonstrated that the GHG emission intensity accounting method could be implemented to track the NDC mitigation actions using data available in the Tier 2 GHG inventory together with supplementary data from the annual Central Statistical Agency (CSA) livestock sample surveys. Emission intensity is a measure of GHG emissions per unit of livestock product output. For dairy cattle, a measure of emission intensity is $kgCO_2e/kg$ milk while for beef cattle a measure of emission intensity is $kgCO_2e/kg$ meat. Because livestock have multiple outputs and to enable calculation across different livestock products and species (e.g. combining milk, meat, and eggs together), another measure of emission intensity is $kgCO_2e/kg$ protein. GHG emission intensity is increasingly used worldwide to estimate emission reductions in the livestock sector. It can be applied into two steps: i) calculate total GHG emissions from the target livestock species in all production systems in Ethiopia (i.e. commercial and smallholder, mixed crop-livestock and pastoral / agropastoral systems). This method can use the same data sources as the Tier 2 GHG inventory for livestock; ii) calculate the total amount of livestock products produced. For milk, this can be calculated from the Tier 2 inventory (excluding milk suckled by calves), and for meat, this can be calculated using data from CSA on numbers of cattle sold and slaughtered. Furthermore, large-scale regional and national projects (e.g. LFSDP[9] and OFLP[10]) proposed to use a GHG emission intensity accounting approach. Aligning national NDC and CRGE MRV accounting methodologies with those used at regional and project level would increase the simplicity and efficiency of national MRV system as well as provide the methodological basis for a unified MRV system across regional and federal levels in the livestock sector.

1.3 Data needs and data gaps for livestock MRV

1.3.1 GHG inventory data needs

Based on the Tier 2 inventory, the data gaps (i.e. missing data) listed in Table 3 were identified, and the parameters listed in Table 4 were identified as being based on very limited or poor-quality data. The initial GHG inventory was completed using proxy data (e.g. live animal and meat export data as a proxy for commercial feedlot cattle populations), or the best available national data, or international default values where national data quality was limited. Future improvements in data availability would then provide

[8] https://cgspace.cgiar.org/bitstream/handle/10568/110982/Ethiopia%20Tier%202%20Inventory%20Final%20Version.pdf
[9] Livestock and Fishery Sector Development Project
[10] Oromia Forested Landscape Project

new, improved data and the GHG inventory could be revised accordingly, as stipulated in the IPCC (2006) guidelines.[11]

Table 3. Parameters with missing data in the draft GHG inventory for Ethiopia

Population data
▪ Cattle, sheep and goats in pastoral zones of Afar and Somali regions ▪ Dairy cattle population in commercial, urban and peri-urban systems ▪ Commercial feedlot cattle population data
Animal performance data
▪ Commercial dairy cattle milk yields annual time series

Table 4. Parameters with poor quality data in the draft GHG inventory

Animal performance data
▪ Available data on diet composition is not specific to livestock species or cattle subcategory ▪ Cattle liveweight, weight gain, mature weight are estimated based on available small-scale studies ▪ Data on manure management practices is very limited

1.3.2 Data needs for MRV of mitigation actions

Based on the analysis of national MRV needs, it follows that Ethiopia has policy needs to monitor progress in implementing the CRGE strategy in the livestock sector and to account for the resulting emission reductions. The data sources and methodologies used for MRV of the CRGE strategy should as far as possible be consistent and comparable with those used in the national GHG inventory, and the GHG inventory should, to the greatest extent possible, be capable of reflecting the changes targeted by CRGE interventions.

Table 5. Key parameters for estimation of CRGE livestock core indicators

Dairy value chain efficiency
▪ Population of indigenous, hybrid and exotic cattle ▪ Productivity (meat and milk) per animal, indigenous, hybrid and exotic ▪ Emission factors for indigenous, hybrid and exotic animals
Feedlot value chain efficiency
▪ Population of fattened and non-fattened cattle (dairy and pastoral) ▪ Productivity (meat and milk) per animal, fattened and non-fattened (dairy and pastoral) ▪ Emission factors for fattened and non-fattened animals (dairy and pastoral)
Increased share of poultry meat in meat supply
▪ Population numbers for poultry and high-emitting species ▪ Average liveweight and dressing percentage for poultry and high-emitting species ▪ Manure management emission factors for poultry

[11] See IPCC (2006) Vol 1 Chapter 5 on recalculations due to methodological revisions or refinements.

Box 2: Data needs for GHG inventory and CRGE's livestock sector

National GHG inventory analysis conducted for this project revealed several gaps in the data collected (feed digestibility, milk yield, manure management system, liveweight) in the different production system in Ethiopia (Tables 3 and 4). Assessment of indicators for CRGE interventions for livestock sector also suggested that those data presented in Table 5 are among the key information used in monitoring, reporting and verifying of GHG emission in livestock production systems.

It is notable that for both enteric fermentation and manure management, the majority of the most influential variables can be improved with better activity data, especially on feed digestibility and liveweight of different cattle subcategories. Accordingly, the following data needs were prioritized for pilots:

- Population and herd structure: for commercial dairy and feedlot farms, urban and peri-urban dairy farms (Pilot 1).
- Feed digestibility: feed type, percentage of each feed for commercial dairy and feedlot farms, urban and peri-urban dairy farms, mixed crop-livestock system (Pilot 1)
- Manure management system: fraction of manure managed in each manure management system: for commercial dairy and feedlot farms, urban and peri-urban dairy farms, and mixed crop-livestock farms (Pilot 2)
- Milk yield: for commercial dairy farm, urban and peri-urban dairy farms (Pilot 2)
- Liveweight: for commercial dairy and feedlot farms, urban and peri-urban dairy farms, and mixed crop-livestock farms (Pilot 2)

1.4 Livestock activity data pilots

Pilot 1

Herd composition

The national GHG inventory indicates that the CSA annual sample survey does not report separately the herd structure of indigenous cattle and cross-bred dairy cattle in the mixed crop livestock system. Moreover, the GHG inventory reported that cattle population and herd structure is missing for urban and peri-urban, commercial dairy and feedlot cattle production systems because these systems are not reported in CSA annual sample survey reports. Therefore, the first objective of Pilot 1 was to develop and test cattle population and herd composition data collection tools for cross-bred cattle in the mixed crop livestock system, urban and peri-urban system, and large commercial dairy and feedlot farms.

Farmers are asked for the number of cattle of each animal type owned currently. The data collection tool is the same as the existing CSA survey tool, but this question was asked separately for indigenous and cross-bred dairy cattle in mixed crop livestock, urban and peri-urban, and commercial production systems. The purpose of this innovation is to obtain data on the herd structure disaggregated by breed type.

Diet composition (feed energy digestibility)

The national GHG inventory indicated that DE (%) of feed for animal subcategories in different production systems has a significant influence on both enteric fermentation and manure management methane emissions. The CSA annual livestock survey collects data on diet composition by asking farmers to directly estimate the percentage of intake from six different categories of forage, fodder and feed. The categories of feed are:

- green fodder obtained by grazing
- crop residue: harvested by-products (straw and chaff of cereals and pulses, etc.)
- improved feed (e.g. oat or alfalfa)
- hay (including any type of grass, clover etc.) cut and dried as fodder; and
- industrial by-products or oil cakes (e.g. noug cake, sunflower cake, etc.), bran, and brewery residue.
- Others (non-conventional feedstuffs).

This data collection method is consistent with the standard feed use indicator data collection method recommended in existing guidelines for conduct of agricultural surveys (GSARS 2018: FAO 2020). However, the current CSA tool is inadequate for accurate representation of diets because the CSA tool: i) does not report feed utilization separately for indigenous and dairy cattle; ii) does not capture seasonal differences in diet; iii) does not record specific feed types within each feed category; and iv) does not report feed utilization separately for different animal subcategories (i.e. lactating cow, oxen, calves etc.). Therefore, the aim of Pilot 1 was to compare the existing diet composition data collection tool to alternative data collection tools (Table 6). Tool 1, Tool 2, Tool 3, and Tool 4 were tested for mixed crop-livestock farms, while Tool 3, Tool 4, Tool 5, and Tool 6 were tested for urban and peri-urban dairy farms. Tool 2 and Tool 7 were tested for both commercial dairy and feedlot farms.
The DE (%) value of each feed component as a percentage of gross energy values of each feedstuff was estimated using metabolizable energy content of feedstuffs as recorded in the Tier 2 livestock GHG inventory (Wilkes et al., 2020).

Pilot 2

The national GHG inventory also identified a lack of data on manure management system (MMS), milk yield and liveweight as important sources of uncertainty. Currently there is no established data management system (whether surveys or administrative data) that can provide a representative annual time series of data on milk yield or liveweight from commercial dairy farms and urban and peri-urban dairy farms. Furthermore, no official data sources collect data on MMS. Therefore, Pilot 2 aimed to test data collection tools for MMS, milk yield, and liveweight activity data.

Statistical tests were carried out to compare means of feed digestibility data estimated from each feed component using different data collection tools. For variables with large samples and normally distributed data, a paired samples t-test was used. For samples that were not normally distributed, a median sign test was used. Furthermore, the results of pilot tests were evaluated against set criteria.

The following criteria were used for stakeholder evaluation of pilot results:

- Data collection, and management procedures' suitability for filling data gaps.
- Extent to which pilots' procedures have the potential to improve existing information management systems, address the breed difference, analysis, and communication.
- Likelihood of scaling up piloted procedures to regional and national levels.
- Need for additional finance and human resource for implementation.
- Cost of new procedures vs existing news, including cost synergies.

Evaluation was given for subtotal score (excellent= 5, very good=4, satisfactory/Good=3, poor= =2 and unsatisfactory//very poor=1).

Box 3: Rationale and goals for tools tested in the pilots

The rationale for the design of a set of pilot activities is based on

- The need for action to improve data for GHG inventory and an enhanced the CRGE MRV system.
- Engagement with stakeholders on their needs and activities surrounding livestock data, and particularly its quantity and quality.

The specific objectives of the pilot program were to:

- trial ways of filling data gaps,
- trial ways of improving data quality,
- orient selected data collection, analysis, and dissemination activities toward MRV, and
- foster multi-stakeholder approaches to improved collection, analysis, and dissemination of livestock data.

Table 6. Types of data collection tools for GHG and CRGE-MRV system data needs

Data needs	Data collection tools
Herd composition	**Tool 1:** Farmers are asked to report the cattle population for each animal of subcategory for both indigenous cattle and for cross-bred cattle.
Diet composition	**Tool 1: Annual diet composition:** Farmers are asked to estimate the percent of each main feed category in the diet for the herd. This is the same as the CSA survey tool, but one adjustment to the CSA method was that this question was asked separately for indigenous and dairy cattle.
	Tool 2: Diet by season: Farmers are first asked to define the months that are in the dry and wet seasons. Then they are asked to estimate the percent of each main feed category for the dry and wet seasons separately for the herd.
	Tool 3: Annual diet composition by animal subcategory: Farmers are asked to estimate the percent of each main feed category in the diet and to estimate the percent of diet contributed by each feed category for animal subcategories of different sex and age.
	Tool 4: Diet by animal subcategory: Farmers are asked to specify the percent of each specific feed type fed and to estimate for animal subcategories of different sex and age the percent of diet contributed by each feed type.
	Tool 5: Diet composition by season for main feed category and animal subcategory: Farmers are first asked to define the months in the dry season and in the wet season and then asked to estimate the percent of each feed category in the diet fed for animal subcategories of different sex and age.
	Tool 6: Diet composition by season for specific feed type and animal subcategory: Farmers are first asked to define the months in the dry season and in the wet season and farmers are asked to specify the percent of each specific feed type fed and then asked to estimate the percent of diet contributed by each feed category for animal subcategories of different sex and age.
	Tool 7: Diet composition by season for specific feed type: Farmers are first asked to define the months in the dry season and in the wet season and asked to estimate the percent of diet contributed by each feed category for the herd.

Manure management system	**Fraction (%) of manure:** Farmers are asked to estimate percentage of manure managed in different manure management systems.
	Further questions ask about manure residence time in different manure management systems and usage after the main storage system
Milk yield	**Farmer recall:** Farmers are asked to estimate average daily milk yield from lactating cows in the current or last lactation
	Measured milk yield: Enumerators monitored (measured) and recorded milk production from lactating cows twice per day (morning and evening) for two consecutive days at early, mid, and late lactation from individual cows to verify the farmer recall data.
Liveweight	**Liveweight:** Direct heart-girth measurements are used together with allometric equations

2 Main results

The project tested new tools and compared the results of existing (reference) and alternative data collection tools across several indicators, i.e. herd composition, feed digestibility, manure management, and milk yield methods on cattle in two pilots (Table 6). In some cases, it was not possible to use all tools, such as in cases where milk yield was not collected for mixed crop-livestock and large commercial dairy farm system.

2.1 Herd composition

Table 7 summarizes the herd composition data. Dairy cows accounted for 74.4%, 72.6% and 63.9% of cattle in large commercial dairy farms, urban and peri-urban dairy farms, and mixed crop-livestock farms, respectively. The existing and alternative tools for estimating the numbers of animals and herd structure all centred on farmer recall. In general, the alternative tool offered significant improvements in terms of disaggregation especially by livestock breed. The alternative questionnaire revealed the presence of all subcategories of cross-bred cattle breeds which the existing questionnaire would have reported as "total number of cross-bred cattle". This methodological improvement addressed data disaggregation by breed, which enables the data collected to meet the information needs of the GHG inventory and the CRGE MRV system.

Table 1. Proportion of cross-bred/pure exotic dairy cattle subcategory from total herd in each production system (%).

Subcategory	Crossbred dairy cattle in mixed crop-livestock farms	Urban peri-urban system	Large commercial dairy intensive system
Adult cross-bred and pure exotic dairy cows (3 -10 and above years)	63.88	74.38	72.58
Adult cross-bred and pure exotic males (3 and above years)	16.69	0.93	3.71
Crossbred and pure exotic calves (<6 months) male and female	4.64	4.28	5.27
Crossbred and pure exotic calves (6 m-< 1 yr.) male and female	4.64	4.28	5.27
Crossbred and pure exotic growing males (1-< 3 years)	3.91	5.11	3.49
Crossbred and pure exotic growing females (1-< 3 years)	6.25	11.02	9.68

2.2 Tools for collecting data on diet composition

The existing tool obtains information on the main type of feed (i.e. pasture, crop residue, hay, improved feed, and agro-industrial by-products and others) fed to cattle in the different production systems. The alternative tools sought information on the type of main feed category utilized disaggregated by breed, season, animal subcategory, and specific feed types (Table 8). Furthermore, different stakeholders were asked to evaluate on the scale from 1 (poor) to 5 (excellent) the existing and alternative tools against certain criteria, including suitability for filling data gaps, alignment, and potential for improving the existing CSA data collection tool, and cost-effectiveness.

Mixed crop-livestock production system

Four feed data collection tools were tested in the mixed crop-livestock system. The existing method (Tool 1) estimates the annual average diet composition utilized by the herd while the alternative tools estimate seasonal weighted (wet/dry season) average diet composition for the total herd (Tool 2), the annual average diet composition for specific animal subcategories (Tool 3), and the annual average diet composition using specific feed types for specific animal subcategories (Tool 4). When these diet compositions are converted to an estimate of DE for the whole diet using the GHG inventory feed digestibility default values, sign tests showed a significant difference in feed digestibility (%) for indigenous and cross-bred cattle when using all four tools (Table 8).

Table 8. Sign test results comparing mean feed digestibility (%) estimates for cross-bred and indigenous cattle breed using Tool 1 and Tool 2 (mean, standard deviation)

	Tool 1	Tool 2	Tool 3	Tool 4
Indigenous	54.84^{B} (1.06)	54.72^{B} (1.06)	54.58^{B} (1.28)	55.58^{B} (1.63)
Crossbred	56.98^{A} (1.63)	57.15^{A} (0.44)	58.04^{A} (1.09)	58.18^{A} (0.24)
Tool 1: Z-statistic =5.96, P= 0.0001 (significance. 2 tailed) Tool 2: Z- statistic =4.644, P= 0.0006 (significance. 2 tailed) Tool 3: Z-statistic =4.16, P= 0.005 (significance. 2 tailed) Tool 4: Z- statistic =4.55, P= 0.0015 (significance. 2 tailed)				

Different superscript letters in the same column indicate significant differences between cattle breeds ($P < 0.05$)

However, when we compared the feed digestibility (%) estimate using Tool 1, Tool 2 and Tool 3 and Tool 4, there no was significant difference among tools for either cross-bred nor indigenous cattle (Table 9).

Table 9. Comparison of feed digestibility (%) estimates of cross-bred and indigenous cattle using Tool 1, Tool 2, Tool 3 and Tool 4

	Tool 1	Tool 2	Tool 3	Tool 4
Crossbred cattle	56.98^{A}	57.15^{A}	58.04^{A}	58.18^{A}
Indigenous cattle	54.84^{A}	54.72^{A}	54.58^{A}	55.58^{A}
Crossbred cattle: Z statistic < 1.96, P > 0.05 (2 tailed) Indigenous cattle: Z statistic < 1.96, P > 0.05 (2 tailed)				

Different superscript letters in the same row indicate significant differences between Tools ($P < 0.05$)

This indicates that there may not be significant improvements by collecting detailed data on diet composition and using DE values specific to each feed type. On the other hand, it also highlights that default DE values per feed category can give significantly different results. Therefore, collecting more detailed data on diet composition can help to increase the representativeness of default main feed category feed digestibility (%) values used. Furthermore, the stakeholders then rated on each of these four tools on a subjective scale of 1–5. As a result, the existing tool (Tool 1) performed reasonably well against the different alternative tools in terms of addressing the breed differences and alignment and potential for improving the existing tools as well as offering savings on data collection costs.

Table 10. Descriptive results of cattle feed composition using Tool 1

Proportion of each feed category provided to cattle during last one year (%)				
Feed category	Indigenous cattle		Crossbred cattle	
	Mean	SD	Mean	SD
Grazing	33.97	17.51	23.86	15.05
Crop residue	38.71	17.73	30.57	19.73
Improved feed	1.82	5.93	2.29	7.11
Hay	4.48	9.1	17.77	14.44
Agro-industrial by-product	8.85	9.72	14.26	11.5
*Others	12.17	11.89	11.26	10.33

SD: Standard deviation, * others include non-conventional feedstuffs (i.e. banana leaves, local brewer's waste).

There are significant differences in diet composition between indigenous and cross-bred cattle. Because cross-bred cattle are mostly raised for dairy purposes, it can be expected that this dietary difference is common in Ethiopia. Estimated feed digestibility (%) using Tool 1 varied by 4% between indigenous and cross-bred cattle (Table 8). However, cross-bred cattle are only about 3% of the cattle enumerated in the CSA annual livestock sample survey. Therefore, the pilot innovation suggests collecting data on diet composition separately for indigenous and cross-bred cattle will increase the accuracy of the DE estimates, and thus improve GHG quantification

Urban and peri-urban dairy production system

Alternative tools (i.e. Tool 3 and Tool 4, Tool 5 and Tool 6) were compared in the urban and peri-urban dairy production systems, since there was no existing tool to collect data on diet composition in this production system. Tool 3 essentially estimates the annual average diet composition using main feed categories for specific animal subcategories, whereas Tool 4 estimates the annual average diet composition using specific feed types for specific animal subcategories. Tool 5 estimates the seasonal (wet/dry season) weighted average diet composition using main feed categories for each animal subcategory, while Tool 6 estimates the seasonal (wet/dry season) weighted average diet composition using specific feed types for animal subcategories in urban and per-urban dairy farms.

Table 11. Comparison of feed digestibility estimates for cross-bred dairy cattle in the urban and peri-urban system using Tool 3, Tool 4, Tool 5, and Tool 6

Tools	Mean, DE%	SD
Weighted Tool 3	56.57^{A}	0.968
Weighted Tool 4	57.19^{A}	1.107
Weighted Tool 5	50.60^{B}	0.398
Weighted Tool 6	53.00^{B}	1.106

Different superscript letters in the same column indicate significant differences between tools ($P < 0.05$)

When the diet composition data from Tool 3, Tool 4, Tool 5, and Tool 6 are converted to an estimate of DE% for the whole diet using the national GHG inventory default DE values, sign tests showed significance differences in feed digestibility (%) between Tool 3 and Tool 5 and between Tool 3 and Tool 6 (Table 11). Similarly, sign tests showed significant differences in feed digestibility (%) between Tool 4 and Tool 5 and between Tool 4 and Tool 6 (Table 11). However, there was no significant difference between Tool 3 and Tool 4 or between Tool 5 and Tool 6 (Table 11). This result suggests that collecting data on annual diet composition for each animal subcategory either using main feed categories and/or specific feed type have no effect on DE estimates. However, collecting diet composition data by season using Tool 5 and Tool 6 gave lower feed digestibility (%) estimates than when data is collected on an annual basis (Tool 3 and Tool 4). The lower feed digestibility (%) estimates based on Tool 5 and Tool 6 are not in line with what is being reported in the literature for dairy cattle in the urban and peri-urban production system in Ethiopia (Wilkes et al. 2020).

Table 12. Comparison of DE estimate between lactating cows and other cross-bred cattle in urban and peri- using Tool 3, Tool 4, Tool 5 and Tool 6

	Tool 3	Tool 4	Tool 5	Tool 6
Lactating cow	57.93^{A}	58.09^{A}	59.68^{A}	62.70^{A}
Other cattle	56.71^{B}	57.99^{A}	58.79^{A}	62.89^{A}
Z statistic	3.12	0.07	2.10	-0.12
P-value (2 tail sign)	0.0001	0.4681	0.091	0.46

Different superscript letters in the same column indicate significant differences between tools ($P < 0.05$)

There was some variation in diet composition for different animal subcategories and resulting estimates of feed digestibility (%) were significantly different for some subcategories when using default feed digestibility (%) values. For instance, there were differences in mean estimated feed digestibility (%) for lactating cows and other subcategories when using Tool 3 but not when using Tool 4, Tool 5 or Tool 6 (Table 12). This suggests that there might be a significant added value to changing the CSA tool to collect diet composition data specific to lactating cows, which made up about 70% of the herd in this pilot study (Table 7). However, data on diet composition for other subcategories that have only minor effects on overall inventory uncertainty could be collected at the herd level in the urban and peri-urban dairy production system. Furthermore, when stakeholders rated on each of these four tools (Tool 3, Tool 4, Tool 5 and Tool 6) on a subjective scale of 1–5, the alternative tool (Tool 3) performed reasonably well against the other tools in terms of its suitability for filling data gaps on the level of feed characterization as well as offering savings on data collection costs.

Large commercial dairy and feedlot production systems

The alternative tools (i.e. Tool 2 and Tool 7) were tested in the large commercial dairy and commercial feedlot production systems, since no official data is being collected on diet composition in these production systems. Tool 2 estimates seasonal weighted average diet composition using main feed categories for the total herd, while Tool 7 estimates seasonal weighted average diet composition using specific feed types for the total cattle herd in commercial dairy and feedlot farms. When the diet components in Tool 2 and Tool 7 were converted to an estimate of feed digestibility (%) for the whole diet using the national GHG inventory default feed digestibility (%) values, sign tests indicated no significant difference in feed digestibility between Tool 2 and Tool 7 (Table 13). Furthermore, stakeholders assessed that Tool 2 performed reasonably well against the more detailed alternative tool in terms of data on seasonal diet composition differences, level of feed characterization as well as offering savings on data collection costs. Therefore, it might be worthwhile for CSA to adapt its existing tool to separately capture dry and wet season diet composition for commercial dairy and feedlot production system (Tool 2). However, it is necessary to better quantify typical diets and diet components within main feed categories.

Table 13. Comparison of feed energy digestibility estimate for commercial dairy cattle using Tool 2 and Tool 7

	Tool	Mean	SD
Commercial dairy system	Tool 2	64.79^{A}	0.28
	Tool 7	62.12^{A}	1.30
Commercial feedlot system	Tool 2	65.54^{A}	0.59
	Tool 7	62.79^{A}	3.25
Large commercial dairy farms: Z statistics= 1.4, P=0.0808 (2 tail sign) Large commercial feedlot farms: Z-statistic=1.498, P= 0.0681 (sign 2 tail)			

Different superscript letters in the same column indicate significant differences between Tools (P < 0.05)

Box 4: Diet composition for indigenous and cross-bred cattle

There are significant differences in diet composition between indigenous and cross-bred cattle. Because cross-bred cattle are mostly raised for dairy purposes, it can be expected that this dietary difference is common in Ethiopia. Estimated feed digestibility using Tool 1, Tool 2 Tool 3 and Tool 4 varied by 4-6% between indigenous and cross-bred cattle. However, cross-bred cattle are only about 3% of the cattle enumerated in the CSA annual livestock sample survey. Therefore, separate CSA data on diet composition for indigenous and cross-bred cattle is critical for improve the accuracy of feed DE (%) estimate thus, improve GHG quantification in Ethiopia.

2.3 **Tools for collecting data on manure management practices**

Data on the proportion of manure managed in different MMS (%) in Ethiopia is extremely very limited (Wilkes et al. 2020, Annex 5). Neither CSA nor other institutes regularly collect data on MMS in Ethiopia. Manure management methods may vary with farm characteristics (e.g. feeding system, herd size, housing, and infrastructure). A survey tool was designed to estimate the percentage of manure managed in different MMS (aligned with IPCC manure management system definitions), and to test whether supplementary questions on residence time in the selected MMS improve manure management estimates.

Table 14 summarizes the MMS in the different livestock production systems. The results indicate that deposit of dung and urine on pasture, solid storage and burned for fuel are the most common MMS in the mixed crop-livestock system, accounting for about 58% of manure management. Stored in a pit, stored in piles, and collected fresh manure and dried the most common MMS in the urban/peri-urban and large commercial dairy farms are, accounting for about 67%, and 79% of manure management, respectively. Daily spread, stored in a pit, and collected fresh manure and dried are the most common MMS in large commercial feedlot farms, accounting for about 90% of manure management.

Table 14. Percentage of seasonally weighted manure managed in different manure management systems.

		Mixed system	Urban/peri-urban dairy system	Large commercial dairy system	Large commercial feedlot farms
1	Deposit of dung and urine on pasture	22.7%	2.0%	5.9%	0.0%
2	Daily spread	14.2%	5.5%	2.6%	23.3%
3	Dry lot	1.4%	3.3%	0.6%	18.9%
4	Pit storage	13.5%	15.5%	16.5%	16.7%
5	Solid storage	17.5%	29.4%	38.9%	25.8%
6	Composting	4.2%	4.7%	4.1%	2.3%
7	Liquid storage	0.2%	2.6%	2.8%	2.7%
8	Anaerobic digestion	0.0%	3.3%	1.8%	0.3%
9	Collected fresh manure dried and sold or burned for fuel	17.3%	22.0%	23.9%	5.4%
10	Collected dried manure and burned for fuel	9.0%	11.6%	2.8%	4.6%
	Total	100.0%	100.0%	100.0%	100.0%

Do supplementary questions on management practices and residence time improve manure management estimates?

Supplementary questions (residence time) were only asked if the farmer reported using dry lot, solid storage, composting or liquid storage systems. Then, we programmed the national GHG inventory software with the manure management system activity data from Table 14 and the default values for other parameters in the inventory for both cross-bred and indigenous cows in the mixed crop-livestock, urban and peri-urban dairy, large commercial dairy, and commercial feedlot farms. Next, residence time was adjusted in each manure management system using data from the survey to re-calculate the methane conversion factor. The results indicate that as a result of these MMS adjustments, the manure management methane emission factor decreased by 35% (from 14.85 to 9.66 kg CH_4 head^{-1} year^{-1}), 32% (from 20.01 to 13.49 kg CH_4 head^{-1} year^{-1}), from 70% (34.28 to 10.27 kg CH_4 head^{-1} year^{-1}), and 75% from 10.67 to 2.65 kg CH_4 head^{-1} year^{-1}) in the mixed crop-livestock, urban and peri-urban dairy, large commercial dairy farms, and commercial feedlot farms, respectively (Table 15). This decrease was mainly due to accounting for the duration of manure in the dry lot, solid storage, composting, and liquid manure management systems. Therefore, supplementary questions to identify the duration of residence in the selected manure management practices can improve the ability of activity data to represent actual manure management practices and can improve emission factor estimates from manure management systems.

Table 15. Emission factor (kg CH_4 head^{-1} year^{-1}) for methane emission from manure management

Production system	MMS						
	Original	Adjust dry lot	Adjust solid storage MCF	Liquid storage (6 month)	Adjusted composting	All 4 adjustments	% decrease
Mixed crop-livestock system	14.85	14.84	14.32	10.30	3.93	9.66	35.0%
Urban/peri-urban dairy system	20.01	19.97	18.98	14.72	5.78	13.49	32.6%
Large commercial dairy system	34.28	18.56	17.18	11.74	5.33	10.27	70.1%
Large commercial feedlot system	10.67	10.47	10.34	3.81	2.92	2.65	75.2%

Box 5: Supplementary questions on management practices and residence time of manure improve manure management estimates

Supplementary questions (residence time) were only asked if the farmer reported either dry lot, solid storage, composting or liquid storage system. The results indicate that as a result of the four manure management systems adjustments, the emission factor decreased by 35%, 33%, 70% and 75% in the mixed crop-livestock system, urban/peri-urban dairy, large commercial dairy farms, and large commercial feedlot farms, respectively. This show that supplementary questions to identify the duration of residence in the selected manure management practices can improve the ability of activity data to represent actual manure management practices and can improve emission factor estimates from manure management systems.

2.4 Tools for collecting data on milk yield

A survey collecting farmer recall data on milk yield was administered to selected households in urban and peri-urban dairy farms, and then compared with the results of a physical measurement of milk off-take using graduated buckets over two consecutive days in the same households. The idea was to assess the accuracy of farmer-reported milk off-take at different stages over the lactating period. The resulting milk off-take data from farmer recall and measurement was converted to annual milk yield using weighted average milk yield, which was calculated using the number of households reporting at different lactation stages (early, mid, and late). Calf suckling before and after milking is a common practice in the urban and peri-urban dairy farm system, so annual milk off-take reported and measured from the pilot survey was corrected for milk suckled by calves using energy requirements of the calf (NRC 2001). The detailed methods and assumptions are described in Wilkes et al. (2020) in Annex 3. Cow milk yield was then calculated as the sum of milk off-take and estimated calf milk consumption. For measured milk yield the average estimate was 9.56 kg/day and for reported milk yield the average estimate was 8.34 kg/day.

Table 16. Comparison (t-test) of mean daily milk yield reported with weighted average mean milk yield measured

Group	Mean	SD
Milk yield reported by recall method	8.34^{A}	2.11
Milk yield measured weighted average	9.21^{A}	3.32
t-statistic= 0.938, P .t=0.38		

The resulting final daily milk yield (farmer recall vs. measured) estimates in urban and peri-urban system were compared using a two-sample t test for mean difference. The farmer recalled daily milk data was 13% lower than the daily milk yield value from direct measurement, but the difference was not significant (P > 0.05; Table 16). Therefore, data collection on milk yield using the recall method is sufficient for the GHG emission inventory.

2.5 Tools for collection data on liveweight

The national GHG inventory indicated that liveweight of animal subcategories in different production systems has a significant influence on both enteric fermentation and manure management methane emissions. As there was no alternative and/or existing method for measuring liveweight in the mixed crop-livestock, urban and peri-urban dairy, large commercial dairy, and feedlot production systems, it was not possible to make a comparison. The project focused on using proxy measures such as heart girth and body length measurements which require neither expensive equipment nor extensive training of enumerators and can be carried out and compiled by the households themselves. The detailed methods and procedures are described in Annex 1, section 3 of this report).

3. Recommendations and reflections

3.1 Recommendations

Herd composition: While the CSA annual livestock survey is able to provide a consistent time series of data on the indigenous cattle population disaggregated by sex, age, and purpose in the rural mixed crop-livestock system, there are some data gaps. In particular, there is no disaggregated data on cross-bred cattle, and no sampling is conducted in commercial dairy farms or urban / peri-urban areas which are critical for the GHG inventory and CRGE MRV system. This pilot survey tested an alternative tool for estimating the numbers of cattle and herd structure of cross-bred cattle in the mixed crop-livestock system, urban and peri-urban and large commercial dairy production system based on farmer recall. The alternative questionnaire revealed the presence of all subcategories of cross-bred cattle breeds which the existing tool would have reported as "total number of cross-bred cattle". In general, the alternative tool offers significant improvements in terms of disaggregation especially by livestock breed. Therefore, to improve data on commercial dairy and urban and peri-urban dairy populations, CSA should conduct surveys of both commercial farms and urban/peri-urban farms. Since the inventory is structured on the basis of existing CSA livestock categories, there are no recommendations to change existing livestock categories in the CSA survey tools or reports.

Diet composition: Mixed crop-livestock production system: There are significant differences in diet composition and estimated feed digestibility (%) between indigenous and cross-bred cattle in the mixed crop-livestock production system when using Tool 1. Therefore, the pilot innovation suggests that collecting data on diet composition using Tool 1 separately for indigenous and cross-bred cattle will increase the accuracy of the DE estimates, and thus improve GHG quantification in the mixed crop-livestock production system.

Urban and peri-urban dairy production system: There was some variation in diet composition for different animal subcategories and the resulting estimates of feed digestibility (%) were significantly different between lactating cows and other subcategories when using Tool 3 but not when using Tool 4, Tool 5 or Tool 6. This suggests that there might be a significant added value by using Tool 3 to collect diet composition data specific to lactating cows which make up about 70% of the herd. On the other hand, data on diet composition for other subcategories that have only minor effects on overall inventory uncertainty could be collected at the herd level in the urban and peri-urban dairy production system.

Large commercial dairy and feedlot production system: Although estimated feed digestibility (%) using Tool 2 and Tool 7 were not significantly different, it might be worthwhile for CSA to adapt its existing tool to separately capture dry and wet season diet composition for commercial dairy and feedlot production systems (Tool 2). Furthermore, based on the stakeholder's evaluation (scoring), the existing tool (Tool 1) in mixed crop-livestock, Tool 3 in the urban and peri-urban dairy, and Tool 2 in the large commercial dairy/feedlot farms performed reasonably well against the different alternative tools in terms of addressing the breed differences, herd structure, seasonal diet difference, alignment, and potential for improving the existing tools as well as offering savings on data collection costs.

Manure management: The survey tool piloted is a feasible method to collect manure management data that can be used to estimate emissions in all livestock production systems. Supplementary questions on the residence time in the selected manure management practices (dry lot, solid storage, composting, and liquid storage) are useful for improving emission estimates.

Milk yield: There was no significant difference in farmer recall and measured milk yield data. The milk yield data obtained through farmer recall (survey) requires less resources in terms of human resource, finance, material. Furthermore, the recall method had better synergy with existing CSA data collection system. Therefore, the recall data collection method is the best option for milk yield data in urban and peri-urban system.

Liveweight: There is no official annual source for liveweight data, but liveweight typically increases slowly, so annual values may not be required. Change is likely to be very slow, so a representative large-scale survey should be done using use direct heart-girth measurements together with allometric equations to estimate liveweight and to improve the uncertainty of GHG inventory.

Generally, the alternative tools addressed more variables and included more detailed questions than did the existing tools. There was strong agreement across involved institutes that the alternative tools data were more useful and more relevant than the existing questionnaire data. It was possible to obtain more detailed information from farmers than had previously been attempted. It was also agreed that caution is required when using farmer recall data on milk yield because overreliance on farmers recall data on milk yield will have a potential to result in inaccurate measurements of milk production, and therefore unreliable data.

Additional recommendations include:

3.2 Reflections

The process of piloting alternative livestock activity data collection tools illustrated three key lessons. First, GHG inventory improvement can be greatly supported by addressing limitations in statistical and administrative data, data that are collected for other reasons and by stakeholders not directly involved in GHG inventory compilation. The tools tested in this study were designed to complement the existing data collection procedures of CSA and the Ministry of Agriculture. CSA collects data to meet diverse needs of diverse stakeholders. This data is used for various purposes, such as sector planning. GHG inventory needs are a new and additional social demand on statistical systems, but rarely given sufficient importance to justify establishing stand-alone data collection systems. Long-term improvements in data availability for the GHG inventory and MRV can best be accomplished by integrating those data needs with existing data collection systems.

Second, more detailed data is not necessarily better data. Several examples in this study showed that the additional accuracy achieved by collecting more detailed data (e.g. diet characterization of specific animal subcategories) does not always justify the resources required to obtain it. Stakeholders rated the tools tested on their alignment with existing data collection systems, which indicates the ease and feasibility of adopting new tools, and the human, time and financial resources required to implement each data collection tool. A balance needs to be struck between accuracy and the cost-effective use of limited resources. In some cases, GHG inventory data needs can be adequately met using ‘second-best’ data collection tools.

Third, it was essential that the tools were piloted together with the stakeholders who might potentially adopt these tools. Researchers can pilot the tools independently but conducting the tests together with CSA and the Ministry of Agriculture gave additional insights into the practicality of each tool in the specific working context of the staff of these organizations. Furthermore, decisions by these agencies to formally adopt improved tools can be greatly facilitated by engagement them in the development, testing and evaluation of the tools.

Overall, the experience of this project, which focused on the links between GHG inventories and national data systems, provides a useful example to inform future efforts to improve livestock GHG inventories and MRV systems in Africa.

Box 6: Future outlook

Generally, the alternative tools addressed more variables and included more detailed questions than did the existing tools. However, a dedicated survey is required to characterise the specific feed types within each feed category in order to improve the default DE value applied to each main feed category in the inventory.

Further studies are also required to provide more reliable estimates of the metabolizable energy (ME) of natural pasture in different seasons.

Although estimating liveweight using the heart girth measurement method is highly practical, there is significant uncertainty in this estimation method. Further research specific to Ethiopia’s cattle breeds is needed to produce more accurate allometric equations and to validate them so that the uncertainty associated with use of heart girth measurements can be better estimated.

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Manual for improved animal data collection

The manual

This manual's purpose is to enable scaling up of the use of the piloted tools to regional and national level. It is presented here for each production system to guide data collection procedures. It extends to guidance and pilots' lessons learned on sampling, selection of participants, preliminary analysis, and other practical implementation issues. The manual addresses roles for stakeholders in livestock data collection, such as the Ministry of Agriculture of MOA and CSA in data collection.

The manual contains four parts, each of five sections:

Section 1. Collection of information on herd composition and number of cattle by breed type and age.

Section 2. Collection of information feed type used and the proportions of each feed type in the total diets of animals, by breed.

Section 3. Collection of data on heart girth and body length to enable estimation of animal liveweight.

Section 4. Collection of data on the proportion of manure managed in different manure management systems, and identification of manure management practices as they relate to GHG emissions.

Section 5. Collection of data on milk yield, lactation length, calving interval and calving rate. Correction of milk production data for calf suckling, and associated corrections to lactation length, calving rate, and calculation of annual milk yield.

General statements on livestock data collection

Sampling, and farm level and animal level data

Data addressed by this manual are present both at farm level (animal numbers, manure management, feed intake) and animal level (productivity).

Collection of farm level data targets data that characterizes the farm in a Tier 2 framework. This requires that the numbers and types of animals present, and key elements of their management, can be understood and applies to other farms within their system.

Collection of animal level data requires that information – generally recall information – can be generalized to apply to animals being farmed within this system and possibly in other systems.

Although selection of farms would mostly follow CSA sampling procedures, this manual provides guidance for selection of animals.

Ownership

The data collector must be aware of the potential for animals to be present which are owned by others, and for the farmer to own animals located elsewhere on the day of the data collection. In general, we refer to those animals present at the time of data collection as being "owned" by the farmer.

Farmer recall

The method entails use of farmers' recall of animal numbers, age, sex, status, and breed. Numbers are entered as the interview proceeds. Farmers may need prompting in order to recall all details, and this manual offers tools and procedures to assist farmers in this way. Interviews must include a review with the farmer to confirm the observations recorded.

Annex 1. Mixed crop livestock production system

Background to study design and purpose

Current data collection procedures do not provide detail on livestock in mixed production systems. In accordance with a Tier 2 method, this handbook provides methods for collection of data that is disaggregated by breed, herd structure, provides data on production and feeds' intakes, and manure production.

Sampling issues

The sampling procedure for farms, and selection of farms, follows standard CSA procedures. Farms would be selected based on CSA's sampling frame and randomized selection procedures. This allows for selection of farmers who for one reason or another have no livestock on the farm.

At farm level, selection of animals for measurement tasks falls outside CSA procedures. The sampling aim is to achieve a set of measurements which are indicative of the particular farm's production and management system. Selection of animals for measurement or assessment would ideally address animals that are representative of a particular class or type, amongst the classes or types for which data is being collected.

Data collection methods and roles

The most senior person available should be interviewed. In many cases this will not be the owner. Should the data collector believe that the person being interviewed is not able to provide correct information, data collection should be postponed until a more suitable person can be identified and interviewed.

Farms are ideally to be visited at a time when the person to be interviewed is available. As farm visits occur on a continuous basis throughout the day, contact with the best available person at the farm will need to be arranged ahead of time and with the assistance of local government authorities.

This manual provides detail of the questions to be asked, and tables into which the data are to be entered.

Additional sources of information

Region	Zone	Wereda	Kebele	Household ID

Note: A household identifying number will be given by the enumerator to each household

The date recorded should follow specify the system in use, and the time should specify a.m./p.m.

Household head name	
Respondent name	
Mobile number	
Interviewer name	
Date and time of interview	

Section 1. Herd composition

This section refers to data collection on the number of animals individual farmer owns.

The method entails use of farmers' recall of animal numbers, age, sex, status, and breed. Numbers are entered as the interview proceeds. Interviews must include a review with the farmer to confirm the observations recorded.

The questions below assist the enumerator in collecting data that is disaggregated by age, sex and other important variables. This includes calves pre-weaning and post weaning, heifers, steers, and mature animals (Table A1.1). Owing to breeds' different size, productivity and feeding requirements, separate column totals are compiled are pure bred or cross bred (exotic) animals and local (indigenous) animals.

Table A1.1 How many local and purebred and cross-bred cattle are kept and owned by the household?

	Animal type	**Head count**		**Total**
		1=PB/XB	2= Local	
	Bulls (>3 years)			
	Castrated adult males (oxen >3 years)			
	Growing males (1 < 3 years)			
	Cow (dry and lactating)			
	Female calves (between 6 months and <1 year)			
	Male calves (between 6 months and <1year).			
	Heifers (female (1 ≥3 year)			
	Pre weaning females (<6 months)			
	Pre weaning males (<6 months)			

PB/XB= pure exotic bred or cross-bred

Section 2. Feeding practice in the last 12 months

This section refers to data collection on feed provided to animals.

The method entails use of farmers' recall of feeding practices and volumes. The data collector must be aware that numbers of animals fluctuate during the year. Further, feeds differ in their volume, quality, availability and price during the year. It is therefore important to check with the farmer at the end of the interview to confirm the data entered.

The farmer is asked to list the main feed categories in a "feed basket" (Table A1.2).

Table A1.2 The "feed basket"

Feed basket component	**Examples and explanatory notes**
Green fodder or grazing	Any green feed animal from grazing land, or green feed harvested from grazing land, fallow land or back yard. Includes feed provided to the animal by cut and carry systems.
Improved forage	Products from crops planted specifically for animals' consumption including fodder crops (standing or cut alfalfa, roots crops, and some foliage from tree crops).
Hay	Preserved improved whole stems and heads from grass or crop species, legumes or their mixtures, produced by allocated land or backyard Includes mixed grasses, Rhodes grass hay, *Setaria*, *Pennisetum*, *Brachiaria spp*, oats, vetch, alfalfa, clover and various mixtures.
Crop residues	Any products left behind from crop harvest and post-harvest (such as threshing).

	Includes straw from Teff, wheat and barley; discarded tops from root crops.
Agro-industrial by-products	Feeds derived from the agricultural and food industry such as molasses, brewery wastes, wheat bran, wheat middling, Linseed cake, noug seed cake, sunflower cake, cottonseed meal and Bean hulls.
Other feeds	These include household wastes, leftovers from household food and beverage processing (Areke Atela and Tela Atela) and various items including Enset leaves, sweet potato leaves, banana leaves.
Mineral supplements and salt	Purchased inputs for feed and supplementation purposes.

The period addressed the previous one year from the date of the interview, and the farmer is asked to estimate the proportion of each feed category in the diet of the classes of animal, disaggregated by breed (Table A1.3). Note that these sum to 100% for each breed.

Table A1.3 What types of feed were provided to your cattle during the last year?

	Type of livestock feed	**Utilized Yes=1, No=2**	**Percent of total feed utilized**
1	Feed type provided to **indigenous cattle**		
	Green fodder/grazing		
	Crop residue		
	Improved feed (grass and Legume)		
	Hay		
	Agro-industrial by-products		
	Others		
		Total	**100%**
2	Feed type provided to **cross-bred cattle**		
	Green fodder/grazing		
	Crop residue		
	Improved feed (grass and Legume)		
	Hay		
	Agro-industrial by-products		
	Others		
		Total	**100%**

A tool to assist farmers in estimating the proportion used of each feed is “proportional piling”, where 100 small items (grains or beans) are piled to represent proportional use.

After the feed basket data are assembled, the next step is to process the diet composition (DC, or proportion of each feed category) into diet digestibility (DE%) information content using inventory DE value for each feed category (see Annex 5). This entails multiplying DC value by (DE (%)/100) and summing up for all feed category:

Average Digestibility of the diet =

*DC of grazing *(DE of grazing/100)*
*+ DC of Crop residue * (DE of crop residue/100)*
+ DC hay (DE of Hay/100)*
*+ DC of Agro-industrial by-products * (DE of Agro-industrial by-products)*
*+ DC other feed * (DE other feed/100)*

For DE of main feed category/diet composition, please refer to Annex 5)

Section 3. Liveweight

This section refers to data collection on animals' liveweight.

The method entails measurement of proxies for liveweight: heart girth and/or body length (see figure 1). The circumference or heart girth (C) is measured from a point slightly behind the shoulder blade, down the fore-ribs and under the body behind the elbow all the way around.

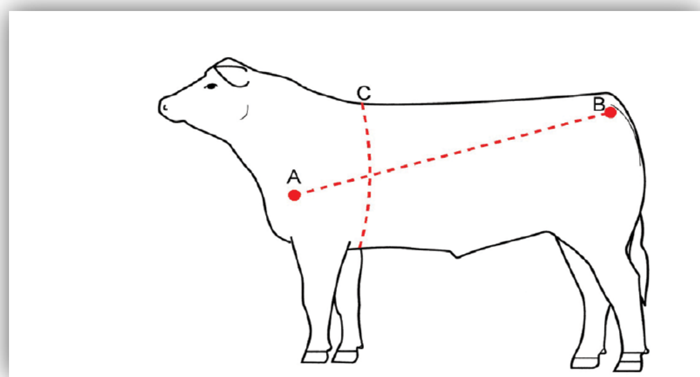

Figure 1. Scheme of body measurements for hearth girth (C) and body length (A-B) in cattle

Because data collection targets individual animals, a sampling procedure is needed. The recommended sample is that if the number of animals on a farm of a particular type is less than 10, then all will be measured (Table A1.4). If the number is over 10 then measure ten randomly selected animals (possibly every second or every third animal until 10 have been measured).

Table A1.4. Sampling for measurements as proxies for liveweight

		Animal type	
	All if > 10	10 randomly selected	
	if < 10	All	Bulls (> 3 years)
	if < 10	All	Castrated adult males (oxen>3 years)
	if < 10	All	Growing males (< 3 years)
	if < 10	All	Dry and lactating cow
	if < 10	All	Female calves (between 6 months and <1 year)
	if < 10	All	Male calves (between 6 months and<1year)
	if < 10	All	Heifers (female < 3 year)
	if < 10	All	Pre weaning females (< 6 months)
	if < 10	All	Pre weaning males (< 6 months)

Table A1.5 Measurements for liveweight in indigenous cattle

	1	2	3	4	5	6	7	8	9	10
	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm
	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth

Table A1.6 Measurements for liveweight in XB/PB cattle

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm
	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth

Once the measurement done, the liveweight can be calculated using the method described in Goopy et al. 2017 http://dx.doi.org/10.1071/AN16577):

For cross-bred/purebred and indigenous cattle

Step 1: Measure the circumference or heart girth (C) as shown in figure 1.

Step 2: Liveweight (kg) can be estimated using the following BOX COX linear regression equation:
$LW^{0.3595} = 0.02451 + 0.04894 * HG$
Where LW is liveweight of individual animal and HG is heart girth measurement (cm)

Section 4. Manure management system

This section refers to data collection on manure management carried out on the farm.

The method entails observation and recording of practices (uses) by the data collector, as well as questioning of the farmer about practices during other periods not observed by the data collector. Practices during the wet and dry seasons are to be recorded (Table A1.8). Manure management includes several steps of removal, storage and use as farm facilities are cleaned. This means that supplementary questions are required.

Before questioning the farmer about the proportion of manure managed in various ways, the data collector reads their definition (Table A1.7). Date entry refers to the codes shown in Table A1.8.

Table A1.7 Definitions used to describe manure management systems

MMs	
Left where deposited on pasture	Cattle drop manure in grazing land or pasture while grazing
Collected and spread on pasture or crops the same day	Farmers collect manure after dropped by animal spread on crop land or pasture the same day
Left in the area where cows are kept	Where the manure left in the animal barn/yard for some times
Stored in a pit	• Pit is below the animal shed, which means that both dung and urine are collected, but no or little water is added. • The manure is collected and stored in pit found in the smallholder farms, If the stored manure in a pit stays dry then the month it is dry would-be **solid storage.** • if the manure pit floods in the rainy season, then the months it is wet would-be l**iquid storage**
Collected and stored in piles for several months before use (Solid storage)	Farmers collect manure and stored in piles several months without turning and mixing
Composted	Farmers collected and stored manure in pile with turning and mixing the manure
Stored as a liquid or slurry	Where farm uses water to clean yard or house flooring and the discharge from the farm is liquid, or where the manure is dumped into a river or other water body.
Biodigester	Farmer collect manure and treat it for Biogas production
Collected, dried and sold or burned for fuel	Farmers collect manure dried it and use for fuel or sold it

Definition of solid storage vs composting

Solid storage involves piling the manure with or without organic additives (e.g. bedding, straw etc.). It can be covered/uncovered or compacted/not compacted, but there is no aeration or turning.

Composting requires oxygen, therefore, if the manure pile is turned, mixed or aerated with a fan. Turning or mixing is more common in Ethiopian conditions.

Questions to distinguish between solid storage and compost:

1. Is the manure collected and stored in piles for some several months? (either solid storage or composting)
2. After collecting into a pile, do you turn or mix the manure? (yes = composting, no=solid storage)
3. If yes: Do you turn or mix the manure every day? (yes= intensive windrow composting, no= passive windrow composting)

Definition of liquid storage vs pit storage

Liquid storage is seen where the farm uses water to clean the yard and the discharge from the farm is liquid. It may also be seen where the manure is dumped into a river or other water body.

Pit storage is seen where the pit is below the animal shed, which means that both dung and urine are collected, but no or little water is added.

Questions to distinguish between liquid and solid storage may be required. Smallholder farms' storage in a pit where the pit stays dry, is solid storage. If water is added, or if the pit floods in the rainy season, then in those months it is liquid storage. Clarifying supplementary questions include:

If the answer in the table is 'pit storage', then:

1. Is the pit underneath where the animals are kept? (yes=pit storage, no = go to question 2)
2. do you add water when the manure is stored in the pit, or does the pit get flooded in the rainy season? (no = solid storage, yes = go to question 3)
3. how many months of the year is it wet or flooded? (Months wet = months of liquid storage, the remaining months = solid storage).

Table A1.8 What % of cattle manure is used in different ways in the dry and wet seasons?

Manure management practice / use of manure	Dry season (enter % for each use)	Wet season (enter % for each use)
Left where deposited on pasture		
Collected and spread on pasture or crops the same day		
Left in the area where cows are kept		
Stored in a pit		
Collected and stored in piles for several months before use (after collecting no turning or mix manure)		
Composted (piles with turn and mixing)		
Stored as a liquid or slurry		
Biodigester		
Collected fresh manure dried and sold or burned for fuel		
Collected dried manure and burned for fuel		
	Total 100%	Total 100%

Supplementary questions are used to further identify the manure management practices used. These refer to the same codes listed in Table A1.9.

5. If the manure is left in the area where cows are kept

5a. How many days is it left there before removal? ------------------------days

5b. How is it stored or used after removal? Code C -------------------------------------

6. If stored in piles,

6a. How many days is it left before storing in a pile? ---------------------------------days

6b. Is the pile covered or uncovered? (Covered =1, uncovered =2)---------------------

6c. How many months is it stored in the pile? -----------------------------------months

6d. How is it stored or used after it has been in the pile? Code C ----------------------------

7. If composted,

7a. Is the compost turned over or aerated? (Yes=1, no=2)----------------

7b. How many months is the manure composted for? -------------------------months

7c. How is it stored or used after it has composted? Code C --

8. If stored as a liquid or slurry,

8a. How many months is it stored as a liquid? ---------------------------------months

8b. Does a crust form on the top of the liquid? Yes=1, no=2-------------------

8c. How is it stored or used after that? Code C --------------------------

Table A1.9 Codes used for manure management practice: uses

Code	Use or practice
1	spread on pasture or crops
2	stored in piles for several months before use
3	Stored in a pit
4	Composted
5	Biodigester
6	Burnt for fuel
7	Sold

Once data on proportion of manure managed in each manure management system are obtained for the dry and wet seasons, the next step is to calculate annual weighted MMS values.

Weighted average annual MMS value =

Proportion of manure managed in MMS-X during dry season * (number of months in dry season/12)

+ Proportion of manure managed in MMS-X during wet season * (number of months in wet season/12)

Section 5. Milk yield

This section refers to data collection on milk production.

The farmer is asked if he has milking cows during the last one year. He is then asked to estimate, using recall, average milk yield per day from each nominated lactating cow, that cow's lactation period (number of days between start milk off take and date of dry off), and its calving interval (number of days between previous calving data and next calving date).

The sampling strategy is to record information about all cows if the farmer has less than 5 lactating cows, and 5 cows per household if cow numbers are larger.

This question will be asked for indigenous and cross-bred cattle separately.

Table A1.10 Recall estimate of milk yield data for lactating cow

Tag Nr.	Number of currently lactating cows or recently dry off cows	In current or last lactation,		Number of days in milk/ lactation length	If this is not the first calving, number of months dry between last lactation and calving date	If this is not the first calving, calving interval before last calving (in months) (calving interval)
		Maximum yield (peak yield after calving)	Minimum yield since calving			

To provide indicative data for the farm, mean milk yield needs to be adjusted for calf suckling or milk consumed by calves. Further, lactation length, calving interval and the proportion of cows giving birth (calving rate) allow calculation of farm level milk production on an annual basis.
The proportion of cows giving birth (Calving rate) can be calculated from number of calves born and cows in milk (see the equation below).
Calf milk consumption will be estimated based on methods and assumptions described by NRC (2001), and the estimated energy requirements of the calf are based on metabolizable energy for maintenance and growth:

1. *Metabolizable energy (Mcal)*

2. $= (0.1*(LW^{0.75})) + (((0.84*(LW^{0.355}))* (LWG^{1.2})))$

where LW is average liveweight of a calf between birth and weaning, and LWG is liveweight gain of the calf before weaning (kg/day).
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 estimated volume of milk consumed by the calf per day is converted to an annual average daily milk yield (i.e. average over 365 days) by assuming that calves are weaned at 90 days, entailing a calculation of the

kg milk consumption by calves multiplied by (90/365) and then multiplied by calving rate to consider all cows in the herd (lactating and dry cows).

Milk consumed by the calf is then added to milk yield reported by farm.

The proportion of cows giving birth (calving rate)

*= [total number of calves (dead + reported)/number of cows in milk] * 100*

An alternative method for calculation of calving rate is

Calving rate

*= 365 * (100/calving interval in days)*

Annex 2. Urban and peri-urban dairy farms

Background to study design and purpose

Urban and peri-urban dairy farms are currently not subject to CSA sampling and are not represented in national statistics. In accordance with a Tier 2 method, this handbook provides methods for collection of data from this production system that is disaggregated by animal type, provides data on production and feeds' intakes, and manure production.

Sampling issues

The sampling procedure for farms will draw on local authorities' knowledge of farms, and of their owners and staff. All such farms will be selected.

At farm level, selection of animals for measurement aims to achieve a set of measurements which are indicative of the particular farm's production and management system. Selection of animals for measurement or assessment would ideally address animals that are representative of a particular class or type, amongst the classes or types for which data is being collected.

Data collection methods and roles

The most senior person available should be interviewed. In many cases this will not be the owner. Should the data collector believe that the person being interviewed is not able to provide correct information, data collection should be postponed until a more suitable person can be identified and interviewed.

Farms are ideally to be visited at a time when the person to be interviewed is available. As farm visits occur on a continuous basis throughout the day, contact with the best available person at the farm will need to be arranged ahead of time and with the assistance of local government authorities.

This manual provides detail of the questions to be asked, and tables into which the data are to be entered.

Region	**Zone**	**Wereda**	**Kebele**	**Household ID**

Note: A household identifying number will be given by the enumerator to each household

The date recorded should follow specify the system in use, and the time should specify a.m./p.m.

Household head name	
Respondent name	
Mobile number	
Interviewer name	
Date and time of interview	

Section 1. Herd composition

This section refers to data collection on the number of animals individual farmer owns.

The method entails use of farmers' recall of animal numbers, age, sex, status, and breed. Numbers are entered as the interview proceeds. Interviews must include a review with the farmer to confirm the observations recorded.

The questions below assist the enumerator in collecting data that is disaggregated by age, sex and other important variables. This includes calves pre-weaning and post weaning, heifers, steers, and mature animals (Table A2.1).

Owing to breeds' different size, productivity and feeding requirements, separate column totals are compiled are pure bred or cross bred (exotic) animals and local (indigenous) animals.

Table A2.1 How many local and purebred and cross-bred cattle are kept and owned by the household?

	Animal type	Head Count		Total
		1=PB/XB	2= Local	
	Bulls (>3 years)			
	Castrated adult males (oxen > 3 years)			
	growing males (1 < 3 years)			
	Dry and lactating cow			
	Female calves (between 6 months and < 1 year)			
	Male calves (between 6 months and < 1 year)			
	Heifers (female (1 ≥ 3 year)			
	Pre weaning females (< 6 months)			
	Pre weaning males (< 6 months)			

PB/XB= pure exotic bred or cross-bred

Section 2. Feeding practice in the last 12 months

This section refers to data collection on feed provided to animals.

The method entails use of farmers' recall of feeding practices and volumes. The data collector must be aware that numbers of animals fluctuate during the year. Further, feeds differ in their volume, quality, availability and price during the year. It is therefore important to check with the farmer at the end of the interview to confirm the data entered.

The farmer is asked to list the main feed categories in a "feed basket" (Table A2.2).

Table A2.2 The "feed basket"

Feed basket component	Examples and explanatory notes
Green fodder or grazing	Any green feed animal from grazing land, or green feed harvested from grazing land, fallow land or back yard. Includes feed provided to the animal by cut and carry systems.
Improved forage	Products from crops planted specifically for animals' consumption including fodder crops (standing or cut alfalfa, roots crops, and some foliage from tree crops).
Concentrate supplements	Feeds produced from grains and other high energy sources
Hay	Preserved improved whole stems and heads from grass or crop species, legumes or their mixtures, produced by allocated land or backyard Includes mixed grasses, Rhodes grass hay, Seteria, Pennisetum, Brachiaria spp, oats, vetch, alfalfa, clover and various mixtures.
Crop residues	Any products left behind from crop harvest and post-harvest (such as threshing). Includes straw and stover from Teff, wheat and barley, maize; and discarded tops from root crops.
Agro-industrial by-products	Feeds derived from the agricultural and food industry such as molasses, brewery wastes, wheat bran, wheat middling, Linseed cake, noug seed cake, sunflower cake, cottonseed meal and Bean hulls.

Other feeds	These include household wastes, leftovers from household food and beverage processing (Areke Atela and Tela Atela) and various items including Enset leaves, sweet potato leaves, banana leaves.
Mineral supplements and salt	Purchased inputs for feed and supplementation purposes.

The period addressed the previous one year from the date of the interview, and the farmer is asked to estimate the proportion of each feed category in the diet of the classes of animal, disaggregated by breed (Table A2.3). Note that these sum to 100% for each breed.

Table A2.3 What types of feed were provided to your cattle during the last year?

	Lactating cows		Other adult cattle	
Feed type	% of total diet		% of total diet	
	XB/PB	Local	XB/PB	Local
Natural grazing				
Grass hay				
Crop residue				
Improved forage				
Concentrate supplement				
Agro-industrial by prod				
Others				
Mineral supplement or salt				
Total	100%	100%	100%	100%

A tool to assist farmers in estimating the proportion used of each feed is "proportional piling", where 100 small items (grains or beans) are piled to represent proportional use. Prompts might be given to refer to seasonal uses (draft power) and status (pregnancy or sale) of animals.

After the feed basket data are assembled, the next step is to process the diet composition (DC, or proportion of each feed category) into diet digestibility (DE%) information content using inventory DE value for each feed category (see annex 5). This entails multiplying DC value by (DE/100) and summing up for all feed category:

Average Digestibility of the diet =

*DC of grazing *(DE of grazing/100)*
*+ DC of Crop residue * (DE of crop residue/100)*
+ DC hay (DE of Hay/100)*
*+ DC of Agro-industrial by-products * (DE of Agro-industrial by-products)*
*+ DC other feed * (DE other feed/100)*

For DE of main feed category/diet composition, please refer annex 5)

Section 3. Liveweight

This section refers to data collection on animals' liveweight.

The method entails measurement of proxies for liveweight: heart girth and/or body length (see figure 1). The circumference or heart girth (C) is measured from a point slightly behind the shoulder blade, down the fore-ribs and under the body behind the elbow all the way around.

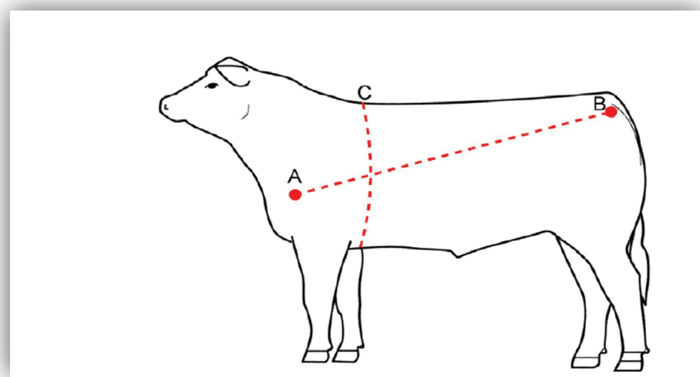

Figure 1. Scheme of body measurements for hearth girth (C) and body length (A-B) in Cattle.

Because data collection targets individual animals, a sampling procedure is needed. The recommended sample is that if the number of animals on a farm of a particular type is less than 10, then all will be measured. If the number is over 10 then measure ten randomly selected animals (possibly every second or every third animal until 10 have been measured) (see Table A2.5 and Table A2.6).

Table A2.4 Sampling for measurements as proxies for liveweight

			Animal type
	All if > 10	10 randomly selected	
	All if < 10	All	Bulls (> 3 years)
	All if < 10	All	Castrated adult males (oxen > 3 years)
	All if < 10	All	Growing males (< 3 years)
	All if < 10	All	Dry and Lactating cow
	All if < 10	All	Female calves (between 6 months and <1 year)
	All if < 10	All	Male calves (between 6 months and<1year)
	All if < 10	All	Heifers (female < 3 year)
	All if < 10	All	Pre weaning females (<6 months)
	All if < 10	All	Pre weaning males (<6 months)

Table A2.5 Measurements for liveweight in indigenous cattle

	1	2	3	4	5	6	7	8	9	10
	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm
	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth

Table A2.6 Measurements for liveweight in XB/PB cattle

	1	2	3	4	5	6	7	8	9	10
	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm
	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth

Once the measurement done, the liveweight can be calculated using the method described in Goopy et al. 2017 http://dx.doi.org/10.1071/AN16577):

For cross-bred/purebred and indigenous cattle

Step 1: Measure the circumference or heart girth in centimeter (C) as shown in figure 1.

Step 2: Liveweight (kg) can be estimated using the following BOX COX linear regression equation:

$LW^{0.3595} = 0.02451 + 0.04894 * HG$

Where LW is liveweight of individual animal and HG is heart girth measurement (cm).

Section 4. Manure management system

This section refers to data collection on manure management carried out on the farm.

The method entails observation and recording of practices (uses) by the data collector, as well as questioning of the farmer about practices during other periods not observed by the data collector. Practices during the wet and dry seasons are to be recorded (Table A2.8). Manure management includes several steps of removal, storage and use as farm facilities are cleaned. This means that supplementary questions are required.

Before questioning the farmer about the proportion of manure managed in various ways, the data collector reads their definition (table A2.7). Date entry refers to the codes shown in Table A2.8.

Table A2.7 Definitions used to describe manure management systems

MMs	
Left where deposited on pasture	Cattle drop manure in grazing land or pasture while grazing
Collected and spread on pasture or crops the same day	Farmers collect manure after dropped by animal spread on crop land or pasture the same day
Left in the area where cows are kept	Where the manure left in the animal barn/yard for some times
Stored in a pit	• Pit is below the animal shed, which means that both dung and urine are collected, but no or little water is added. • The manure is collected and stored in pit found in the smallholder farms, If the stored manure in a pit stays dry then the month it is dry would-be **solid storage.** • if the manure pit floods in the rainy season, then the months it is wet would-be l**iquid storage**
Collected and stored in piles for several months before use (Solid storage)	Farmers collect manure and stored in piles several months without turning and mixing
Composted	Farmers collected and stored manure in pile with turning and mixing the manure
Stored as a liquid or slurry	Where farm uses water to clean yard or house flooring and the discharge from the farm is liquid, or where the manure is dumped into a river or other water body.
Biodigester	Farmer collect manure and treat it for Biogas production
Collected, dried and sold or burned for fuel	Farmers collect manure dried it and use for fuel or sold it

Definition of solid storage vs composting

Solid storage involves piling the manure with or without organic additives (e.g. bedding, straw etc.). It can be covered/uncovered or compacted/not compacted, but there is no aeration or turning.

Composting requires oxygen, therefore, if the manure pile is turned, mixed or aerated with a fan.

Turning or mixing is more common in Ethiopian conditions.

Questions to distinguish between solid storage and compost:

4. Is the manure collected and stored in piles for some several months? (either solid storage or composting)
5. After collecting into a pile, do you turn or mix the manure? (yes = composting, no=solid storage)
6. If yes: Do you turn or mix the manure every day? (yes= intensive windrow composting, no= passive windrow composting)

Definition of liquid storage vs pit storage

Liquid storage is seen where the farm uses water to clean the yard and the discharge from the farm is liquid. It may also be seen where the manure is dumped into a river or other water body.

Pit storage is seen where the pit is below the animal shed, which means that both dung and urine are collected, but no or little water is added.

Questions to distinguish between liquid and solid storage may be required. Smallholder farms' storage in a pit where the pit stays dry, is solid storage. If water is added, or if the pit floods in the rainy season, then in those months it is liquid storage. Clarifying supplementary questions include:

If the answer in the table is 'pit storage', then:

4. Is the pit underneath where the animals are kept? (yes=pit storage, no = go to question 2)
5. do you add water when the manure is stored in the pit, or does the pit get flooded in the rainy season? (no = solid storage, yes = go to question 3)
6. how many months of the year is it wet or flooded? (months wet = months of liquid storage, the remaining months = solid storage).

Table A2.8 What % of cattle manure is used in different ways in the dry and wet seasons?

Manure management practice / use of manure	Dry season (enter % for each use)	Wet season (enter % for each use)
Left where deposited on pasture		
Collected and spread on pasture or crops the same day		
Left in the area where cows are kept		
Stored in a pit		
Collected and stored in piles for several months before use (after collecting no turning or mix manure)		
Composted (piles with turn and mixing)		
Stored as a liquid or slurry		
Biodigester		

Collected fresh manure dried and sold or burned for fuel		
Collected, dried manure and burned for fuel		
	Total 100%	Total 100%

Supplementary questions are used to further identify the manure management practices used. These refer to the same codes listed in Table A2.9.

If the manure is left in the area where cows are kept

a. How many days is it left there before removal? -----------------------days

b. How is it stored or used after removal? Code C -----------------------------------

If stored in piles,

a. How many days is it left before storing in a pile? --------------------------------days

b. Is the pile covered or uncovered? (Covered =1, uncovered =2)--------------------

c. How many months is it stored in the pile? ----------------------------------months

d. How is it stored or used after it has been in the pile? Code C ---------------------------

If composted,

a. Is the compost turned over or aerated? (Yes=1, no=2)---------------

b. How many months is the manure composted for? ------------------------months

c. How is it stored or used after it has composted? Code C --

If stored as a liquid or slurry,

a. How many months is it stored as a liquid? --------------------------------months

b. Does a crust form on the top of the liquid? Yes=1, no=2------------------

c. How is it stored or used after that? Code C -------------------------

Table A2.9 Codes used for manure management practice: uses

Code	Use or practice
1	spread on pasture or crops
2	stored in piles for several months before use
3	Stored in a pit
4	Composted
5	Biodigester
6	Burnt for fuel
7	Sold

Once data on proportion of manure managed in each manure management system are obtained for the dry and wet seasons, the next step is to calculate annual weighted MMS values.

Weighted average annual MMS value =

Proportion of manure managed in MMS-X during dry season * (number of months in dry season/12)

+ Proportion of manure managed in MMS-X during wet season * (number of months in wet season/12)

Section 5. Milk yield

This section refers to data collection on milk production.

The farmer is asked if he has milking cows during the last one year. He is then asked to estimate, using recall, average milk yield per day from each nominated lactating cow, that cow's lactation period (number of days between start milk off take and date of dry off), and its calving interval (number of days between previous calving data and next calving date).

The sampling strategy is to record information about all cows if the farmer has less than 5 lactating cows, and 5 cows per household if cow numbers are larger.

This question will be asked for indigenous and cross-bred cattle separately.

Table A2.10 Recall estimate of milk yield data for lactating cow

Tag Nr.	Number of currently lactating cows or recently dry off cows	In current or last lactation,		Number of days in milk/ lactation length	If this is not the first calving, number of months dry between last lactation and calving date	If this is not the first calving, calving interval before last calving (in months) (calving interval)
		Maximum yield (peak yield after calving)	Minimum yield since calving			

To provide indicative data for the farm, mean milk yield needs to be adjusted for calf suckling or milk consumed by calves. Further, lactation length, calving interval and the proportion of cows giving birth (calving rate) allow calculation of farm level milk production on an annual basis.

The proportion of cows giving birth (Calving rate) can be calculated from number of calves born and cows in milk (see the equation below).

Calf milk consumption will be estimated based on methods and assumptions described by NRC (2001), and the estimated energy requirements of the calf are based on metabolizable energy for maintenance and growth:

3. Metabolizable energy (Mcal)

4. $= (0.1*(LW^{0.75})) + (((0.84*(LW^{0.355}))*(LWG^{1.2})))$

where LW is average liveweight of a calf between birth and weaning, and LWG is liveweight gain of the calf before weaning (kg/day).

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 estimated volume of milk consumed by the calf per day is converted to an annual average daily milk yield (i.e. average over 365 days) by assuming that calves are weaned at 90 days, entailing a calculation of the kg milk consumption by calves multiplied by (90/365) and then multiplied by calving rate to consider all cows in the herd (lactating and dry cows). Milk consumed by the calf is then added to milk yield reported by farm.

The proportion of cows giving birth (calving rate)

*= [total number of calves (dead + reported)/number of cows in milk] * 100*

An alternative method for calculation of calving rate is

Calving rate

*= 365 * (100/calving interval in days)*

Annex 3. Large commercial dairy farms

Background to study design and purpose

Large commercial dairy farms are currently not subject to CSA sampling and are not represented in national statistics. In accordance with a Tier 2 method, this handbook provides methods for collection of data from this production system that is disaggregated by animal type, provides data on production and feeds' intakes, and manure production.

Sampling issues

The sampling procedure for farms will draw on local authorities' knowledge of farms, and of their owners and staff. All such farms will be selected.

At farm level, selection of animals for measurement aims to achieve a set of measurements which are indicative of the particular farm's production and management system. Selection of animals for measurement or assessment would ideally address animals that are representative of a particular class or type, amongst the classes or types for which data is being collected.

Data collection methods and roles

The most senior person available should be interviewed. In many cases this will not be the owner. Should the data collector believe that the person being interviewed is not able to provide correct information, data collection should be postponed until a more suitable person can be identified and interviewed.

Farms are ideally to be visited at a time when the person to be interviewed is available. As farm visits occur on a continuous basis throughout the day, contact with the best available person at the farm will need to be arranged ahead of time and with the assistance of local government authorities.

This manual provides detail of the questions to be asked, and tables into which the data are to be entered

Region	Zone	Wereda	Kebele	Household ID

Note: Area Identification number given by enumerator unique code; Household Id to be given by enumerator for each household it will be Unique number

Household head name	
Respondent name	
Mobile number	
Interviewer name	
Date and time of interview	

Section 1. Herd composition:

This section is designed to collect data on number of animals individual farmer owns currently. The questions below assist enumerator to collect data on animal types by age, sex, etc. including calves pre-weaning and post weaning, heifers, steers, and mature animals, male and female (Table A3.1). At the end the interview, it is also important take some time and ask the farmers again about his responses on the number and type of cattle he owns.

Table A3.1 How many cross-bred/exotic cattle are kept and owned by the household?

	Animal type	**Number of animals**
		PB/XB
	Bulls (>3 years)	
	Castrated adult males (oxen>3 years)	
	growing males (1 < 3 years)	
	Dry and lactating cow	
	Female calves (between 6 months and <1 year)	
	Male calves (between 6 months and <1year)	
	Heifers (female (1 ≥ 3 year)	
	Pre weaning females (< 6 months)	
	Pre weaning males (< 6 months)	

PB/XB= pure exotic bred or cross-bred

Section 2. Feeding practice in the last 12 months

In this section farmers will be asked to list main feed categories (Crop residues, Hay, Improved forage, Agro-industrial by-products, concentrate, other feeds and mineral or salt) fed for his herd during dry and wet season in the last one year and to estimate the proportion of each feed category listed in the diet of the animal. Crop residue means any by-products left from crop threshing such as Teff straw, wheat straw, barely etc. Improved feed consists of grass, legume or their mixture that farmers fed his animal such as Oat, Vetch, Oat vetch mixture, Alfalfa, clover etc), Hay is a type of feed produced from natural grass and or legume harvested and conserved through drying. Agro-industrial by-products is feed type obtained by-products from Agricultural industry like molasses, brewery, wheat bran etc.

Concentrate defined as any commercially prepared feed or home mixed feed. Other feed type means, example such as household left over, Brewery waste, by-products from local beverage (Areke Atela and Tela Atela), Enset leaves, sweet potato leaves, banana leaves, crop standing thinning etc.

To assist farmers to be able to give you proportion of each feed category it is better to use some assistance tools so that he can easily estimate proportion of each feed category from total diet, for example give farmers about 10 grains so that he can distribute the grains to the feed categories he listed inform frames to use his own criteria but give guidance to consider the value of feed in terms giving high milk yield, calves growth, ox for power, seasonal availability, price etc. Make sure that total or the sum of each category's proportion should add to 100%.

Table A3.2 The "feed basket"

Feed basket component	Examples and explanatory notes
Green fodder or grazing	Any green feed animal from grazing land, or green feed harvested from grazing land, fallow land or back yard. Includes feed provided to the animal by cut and carry systems.
Improved forage	Products from crops planted specifically for animals' consumption including fodder crops (standing or cut alfalfa, roots crops, and some foliage from tree crops).
Concentrate supplements	Feeds produced from grains and other high energy sources
Hay	Preserved improved whole stems and heads from grass or crop species, legumes or their mixtures, produced by allocated land or backyard Includes mixed grasses, Rhodes grass hay, Seteria, Pennisetum, Brachiaria spp, oats, vetch, alfalfa, clover and various mixtures.
Crop residues	Any products left behind from crop harvest and post-harvest (such as threshing). Includes straw and stover from Teff, wheat and barley, maize; and discarded tops from root crops.
Agro-industrial by-products	Feeds derived from the agricultural and food industry such as molasses, brewery wastes, wheat bran, wheat middling, Linseed cake, noug seed cake, sunflower cake, cottonseed meal and Bean hulls.
Other feeds	These include household wastes, leftovers from household food and beverage processing (Areke Atela and Tela Atela) and various items including Enset leaves, sweet potato leaves, banana leaves.
Mineral supplements and salt	Purchased inputs for feed and supplementation purposes.

Table A3.3 Feed types provided to different animal subcategories

	Dry season		Wet season	
Feed type	**Utilized (Yes=1, No=2)**	**% of total diet**	**Utilized (Yes=1, No=2)**	**% of total diet**
Natural grazing				
Grass hay				
Crop residue				
Improved forage				
Concentrate supplement				
Agro-industrial by prod				
Others				
Mineral supplement or salt				
Total		100%		100%

Once the feed composition data are collected using Table A3. 3, the next step is to convert diet composition (DC) or proportion of each feed category and feed type into DE% content using pilot or inventory DE value for each feed category by multiplying DC value by (DE/100) and summed up for all feed category as follows:

Average Digestibility of the diet = DC of grazing *(DE of grazing/100)

+ DC of Crop residue * (DE of crop residue/100)

+ DC hay* (DE of Hay/100)

+ DC of Agro-industrial by-products * (DE of Agro-industrial by-products)

+ DC other feed * (DE other feed/100).

For DE of main feed category/diet composition, please refer annex 5)

Section 3. Liveweight

This section will assist enumerator to collect data on heart girth measurement and or body length measurement for cross-bred and indigenous cattle liveweight estimates. If number of animals by type owned by individual farmers is less than 6 then measure all but if greater than 6 take 10 animals randomly and measure them (please refer Table 3.1).

For cross-bred/ pure exotic dairy cattle:

Step 1 Measure the circumference or heart girth © as shown in figure 1. Measure from a point slightly behind the shoulder blade, down the fore-ribs and under the body behind the elbow all the way around., as shown in distance C in the figure 1. Make sure to measure girth in relation to the location of the animal's heart.

Step 2. Read and record the weight of animal in kg from measurement tape.

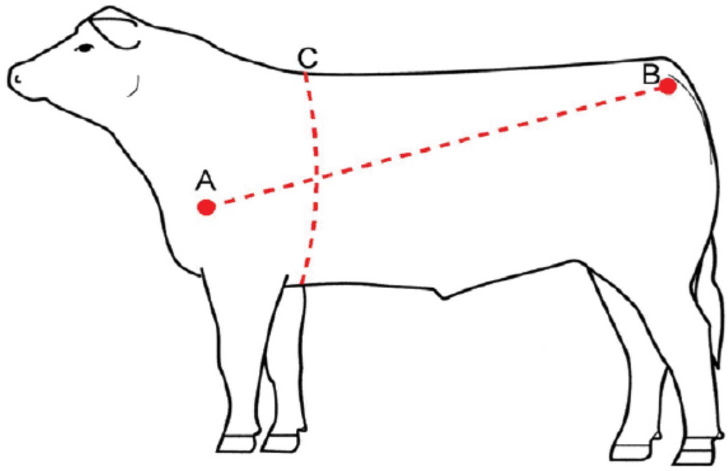

Figure 1. Scheme of body measurements for hearth girth © and body length (A-B) in cattle.

Because data collection targets individual animals, a sampling procedure is needed. The recommended sample is that if the number of animals on a farm of a particular type is less than 6, then all will be measured. If the number 6-10? If the number is over 10 then measure ten randomly selected animals (possibly every second or every third animal until 10 have been measured) (see table 3.1).

Table A3.4 Sampling for measurements as proxies for liveweight

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm
	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth	Girth

Table A3.5 Measurements for liveweight in XB/PB cattle

Code		**Animal type**	
	if > 10	10 randomly selected	
	if < 10	All	Bulls (> 3 years)
	if < 10	All	Castrated adult males (oxen > 3 years)
	if < 10	All	Growing males (< 3 years)
	if < 10	All	Dry and Lactating cow
	if < 10	All	Female calves (between 6 months and < 1 year)
	if < 10	All	Male calves (between 6 months and < 1 year)
	if < 10	All	Heifers (female < 3 year)
	if < 10	All	Pre weaning females (< 6 months)
	if < 10	All	Pre weaning males (< 6 months)

Once the measurement done, the liveweight can be calculated using the method described in Goopy et al. 2017 http://dx.doi.org/10.1071/AN16577):

For cross-bred/purebred and indigenous cattle

Step 1: Measure the circumference or heart girth in centimeter (C) as shown in figure 1.

Step 2: Liveweight (kg) can be estimated using the following BOX COX linear regression equation:

$LW^{0.3595} = 0.02451 + 0.04894 * HG$

Where LW is liveweight of individual animal and HG is heart girth measurement (cm).

Section 4. Manure management system

This section refers to data collection on manure management carried out on the farm.

The method entails observation and recording of practices (uses) by the data collector, as well as questioning of the farmer about practices during other periods not observed by the data collector. Practices during the wet and dry seasons are to be recorded (Table 4). Manure management includes several steps of removal, storage and use as farm facilities are cleaned. This means that supplementary questions are required.

Before questioning the farmer about the proportion of manure managed in various ways, the data collector reads their definition (Table A3.6). Date entry refers to the codes shown in Table A3.7.

Table A3.6 Definitions used to describe manure management systems

MMs	
Left where deposited on pasture	Cattle drop manure in grazing land or pasture while grazing
Collected and spread on pasture or crops the same day	Farmers collect manure after dropped by animal spread on crop land or pasture the same day
Left in the area where cows are kept	Where the manure left in the animal barn/yard for some times
Stored in a pit	• Pit is below the animal shed, which means that both dung and urine are collected, but no or little water is added. • The manure is collected and stored in pit found in the smallholder farms, If the stored manure in a pit stays dry then the month it is dry would-be **solid storage.** • if the manure pit floods in the rainy season, then the months it is wet would-be l**iquid storage**
Collected and stored in piles for several months before use (Solid storage)	Farmers collect manure and stored in piles several months without turning and mixing
Composted	Farmers collected and stored manure in pile with turning and mixing the manure

Stored as a liquid or slurry	Where farm uses water to clean yard or house flooring and the discharge from the farm is liquid, or where the manure is dumped into a river or other water body.
Biodigester	Farmer collect manure and treat it for Biogas production
Collected, dried and sold or burned for fuel	Farmers collect manure dried it and use for fuel or sold it

Definition (Solid storage Vs composting)

1. Solid storage involves piling the manure with or without organic additives (e.g. bedding, straw etc.). It can be covered/uncovered or compacted/not compacted, but there is no aeration or turning.
2. **Composting** requires oxygen, therefore, if the manure pile is turned, mixed or aerated with a fan. Turning or mixing is more common in Ethiopian conditions.

Therefore, if we ask the right questions, we can distinguish between solid storage and compost, e.g.

a. Is the manure collected and stored in piles for some several months? (Answer is either solid storage or composting)
b. After collecting into a pile, do you turn or mix the manure? (yes = composting, no=solid storage)
c. If yes: Do you turn or mix the manure every day? (yes= intensive windrow composting, no= passive windrow composting)

Definition (Liquid storage Vs Pit storage)

Liquid storage would be where the farm uses water to clean the yard and the discharge from the farm is liquid, or where the manure is dumped into a river or other water body. For discharge or dumping solids into a water body, it is easier to identify.

For pit storage, the IPCC definition is that the pit is below the animal shed, which means that both dung and urine are collected, but no or little water is added. Large-scale, intensive, commercial farms in Ethiopia may use this system.

In the smallholder farms, they may store manure in a pit. If the manure in the pit stays dry, I would say that this is solid storage. If water is added, or if the pit floods in the rainy season, then the months it is dry would-be solid storage and the months it is wet would-be liquid storage. Again, we may need some detailed questions to identify these:

If the answer in the table is ‘pit storage’, then:

a. is the pit underneath where the animals are kept? (yes=pit storage, no = go to question b)
b. do you add water when the manure is stored in the pit, or does the pit get flooded in the rainy season? (no = solid storage, yes = go to question c)

c. how many months of the year is it wet or flooded? (= months of liquid storage, the remaining months = solid storage).

Once data on proportion of manure managed in each manure management system are obtained for dry and wet season the next step is to calculated annual weighted as follows;

Weighted average annual MMS value =

(Proportion of manure managed in MMS-X during dry season * (number of months in dry season/12)

+

(Proportion of manure managed in MMS-X during wet season * (number of months in wet season/12)

Table A3.7 Can you tell me what % of cattle manure is used in different ways in the dry and wet seasons?

MMs	**Dry season (enter % for each use)**	**Wet season (enter % for each use)**
Left where deposited on pasture		
Collected and spread on pasture or crops the same day		
Left in the area where cows are kept		
Stored in a pit		
Collected and stored in piles for several months before use (after collecting no tun or mix manure)		
Composted (piles with turn and mixing)		
Stored as a liquid or slurry		
Biodigester		
Collected fresh manure dried and sold or burned for fuel		
Collected dried manure and burned for fuel		
	Total should be 100%	**Total should be 100%**

Supplementary question

To fill the question on how the manure is used or stored after main storage system? Use the code number in Code C in Table A3.8.

If the manure left in the area where cows are kept,

a. How many days is it left before cleaning? ------------------------days

5b. how is it stored or used after cleaning? Code C -------------------------------------

If stored in piles,

a. how many days is it left before storing in a pile? ---------------------------------days

b. is the pile covered or uncovered? (Covered =1, uncovered =2)---------------------

c. How many months is it stored in the pile? ----------------------------------months

d. How is it stored or used after it has been in the pile? Code C ----------------------------

If composted,

a. Do you turn over or aerate the compost? (Yes=1, no=2)----------------

b. How many months is the manure composted for? -------------------------months

c. How is it stored or used after it has composted? Code C ---

If stored as a liquid or slurry,

a. how many months is it stored as a liquid? ---------------------------------months

b. does a crust form on the top of the liquid? Yes=1, no=2-------------------

c. How is it stored or used after that? Code C -------------------------

Table A3.8 Codes used for manure management practice: Uses

Code C	
1	Spread on pasture or crops
2	Stored in piles for several months before use
3	Stored in a pit
4	Composted
5	Biodigester
6	Burned for fuel
7	Sold

Section 5. Milk yield

Milk yield data required for cross-bred dairy cattle. Farmers will be asked if he has milking cows for last one year and to estimate average milk yield per day from one lactating cows, lactation period (number of days between start milk off take and date of dry off), and calving interval (number of days between previous calving data and next calving date). This question will be asked for indigenous and cross-bred cattle separately (if the farmer has less than 5 lactating cows report all animals, if greater 5 lactating cows report at least 5 cows per household).

Table A3.9 Recall estimate of milk yield data for lactating cow

Tag Nr.	Currently lactating cows or recently dry off cows	In current or last lactation,		Number of days in milk/ lactation length	If this is not the first calving, number of months dry between last lactation and calving date	If this is not the first calving, calving interval before last calving (in months) (Calving interval)
		Maximum yield (e.g. peak yield after calving)	Minimum yield since calving			

Annex 4. Commercial feedlot farm

Background to study design and purpose

Large commercial feedlot farms are currently not subject to CSA sampling and are not represented in national statistics. In accordance with a Tier 2 method, this handbook provides methods for collection of data from this production system that is disaggregated by animal type, provides data on production and feeds' intakes, and manure production.

Sampling issues

The sampling procedure for farms will draw on local authorities' knowledge of farms, and of their owners and staff. All such farms will be selected.

At farm level, selection of animals for measurement aims to achieve a set of measurements which are indicative of the particular farm's production and management system. Selection of animals for measurement or assessment would ideally address animals that are representative of a particular class or type, amongst the classes or types for which data is being collected

Data collection methods and roles

The most senior person available should be interviewed. In many cases this will not be the owner. Should the data collector believe that the person being interviewed is not able to provide correct information, data collection should be postponed until a more suitable person can be identified and interviewed.

Farms are ideally to be visited at a time when the person to be interviewed is available. As farm visits occur on a continuous basis throughout the day, contact with the best available person at the farm will need to be arranged ahead of time and with the assistance of local government authorities.

This manual provides detail of the questions to be asked, and tables into which the data are to be entered.

Region	Zone	Wereda	Kebele	Household ID

Note: Area identification number given by enumerator unique code; Household Id to be given by enumerator for each household it will be a unique number

Household head name	
Respondent name	
Mobile number	
Interviewer name	
Date and time of interview	

Section 1. Herd composition

This section is designed to collect data on number of animals under feedlot program (growing males 1 to 3 years age) number of cycles per year used to fatten cattle and number of animals per cycle. The questions bellow assists you to collect data on number of animals per year and or per fattening cycle. it is important to ask farmers separately for indigenous cattle and cross-bred cattle.

Average time in feedlot means the number of days or months from starting animals in feedlot till the animal sold. Number of cycles per year is the number of times the farm used to fatten cattle starting from purchase to finishing the fattening per year. Typical weight at purchase means weight of animal at the time of purchasing while desire weight means targeted weight at finishing or liveweight of animals at the end of fattening period.

Table A4.1 Animal number

Type	Head Count		Total
	1=PB/XB	2= Local	
Growing males 1-3 years			

Table A4.2 Animal numbers per cycle

	Measuring unit	Recall
Average time in feedlot (cycle length)	Day	
Number of cycles per year	Cycle	
Typical weight at purchase	Kg	
Desired weight at slaughter	Kg	

Section 2. Feeding practice in the last 12 months

In this section farmers will be asked to list main feed categories (Crop residues, Hay, Improved forage, Agro-industrial by-products, concentrate, other feeds and mineral or salt) fed for his herd during the wet and dry season for the last one year and to estimate the proportion of each feed category listed in the diet of the animal. Crop residue means any by-products left from crop threshing such as Teff straw, wheat straw, barely etc. Improved feed consists of grass, legume or their mixture that farmers fed his animal such as oat, vetch, oat-vetch mixture, alfalfa, clover etc.), Hay is a type of feed produced from natural grass and or legume harvested and conserved through drying. Agro-industrial by-products is feed type obtained by-products from Agricultural industry like molasses, brewery, wheat bran etc. Concentrate defined as any commercially prepared feed or home mixed feed. Other feed type means, example such as household left over, Brewery waste, by-products from local beverage (Areke Atela and Tela Atela), enset leaves, sweet potato leaves, banana leaves, crop standing thinning etc.

To assist farmers to be able to give you proportion of each feed category it is better to use some assistance tools so that he can easily estimate proportion of each feed category from total diet, for example give farmers about 10 grains so that he can distribute the grains to the feed categories he listed inform frames to use his own criteria but give guidance to consider the value of feed in terms giving high milk yield, calves growth, ox for power, seasonal availability, price etc. Make sure that total or the sum of each category's proportion should add to 100%.

Table A4.3 Feed types provided to different animal subcategories

	Dry season		**Wet season**	
Feed type	**Utilized (Yes=1, No=2)**	**% of total diet**	**Utilized (Yes=1, No=2)**	**% of total diet**
Natural grazing				
Grass hay				
Crop residue				
Improved forage				
Concentrate supplement				
Agro-industrial by-products				
Others				
Mineral supplement or salt				
Total		100%		100%

Once the feed composition data are collected the next step is to convert diet composition (DC) or proportion of each feed category and feed type into DE% content using pilot or inventory DE value for each feed category by multiplying DC value by (DE/100) and summed up for all feed category as follows;

Average Digestibility of the diet = DC of grazing *(DE of grazing/100)

+ DC of Crop residue * (DE of crop residue/100)

+ DC hay* (DE of Hay/100)

+ DC of Agro-industrial by-products * (DE of Agro-industrial by-products)

+ DC other feed * (DE other feed/100).

For DE of main feed category/diet composition, please refer annex 5)

Section 3. Liveweight

This section will assist enumerator to collect data on heart girth measurement and or body length measurement for cross-bred and indigenous cattle liveweight estimates. Take LW measurement for all animals if < 20, otherwise only 20, weigh every second animal until reach 20 (please refer Table 3.1).

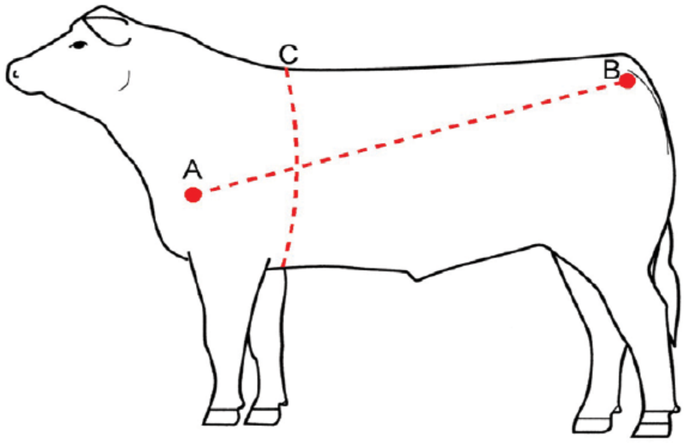

Figure 1. Scheme of body measurements for hearth girth (C) and body length (A-B) in Cattle.

A4.4 Measurements for liveweight in PB/XB cattle girth measurement

	Tag No.	Days in feedlot	Girth (cm)	1=PB/XB or 2=local
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Once the measurement done, the liveweight can be calculated using the method described in Goopy et al. 2017 http://dx.doi.org/10.1071/AN16577):

For cross-bred/purebred and indigenous cattle

Step 1: Measure the circumference or heart girth in centimeter (C) as shown in figure 1.

Step 2: Liveweight (kg) can be estimated using the following BOX COX linear regression equation:

$LW^{0.3595} = 0.02451 + 0.04894 * HG$

Where LW is liveweight of individual animal and HG is heart girth measurement (cm).

Section 4. Manure management system

Questionnaire prepared for this section assist you to collect data on animal manure management practices in dry and wet season. The question will be asked for each household head or responsible person for management of cattle).

Before filling proportion of manured managed in different manure management practice reads the definition of manure management practices at the end of this section (Table A4.5). Date entry refers to the codes shown in Table A4.6.

Table A4.5 definition Manure management system

MMs	
Left where deposited on pasture	Cattle drop manure in grazing land or pasture while grazing
Collected and spread on pasture or crops the same day	Farmers collect manure after dropped by animal spread on crop land or pasture the same day
Left in the area where cows are kept	Where the manure left in the animal barn/yard for some times
Stored in a pit	pit is below the animal shed, which means that both dung and urine are collected, but no or little water is added. The manure is collected and stored in pit found in the smallholder farms, If the stored manure in a pit stays dry then the month it is dry would-be **solid storage.** if the manure pit floods in the rainy season, then the months it is wet would-be l**iquid storage**
Collected and stored in piles for several months before use (Solid storage)	Farmers collect manure and stored in piles several months without turning and mixing
Composted	Farmers collect and stored manure in pile with turning and mixing the manure
Stored as a liquid or slurry	Where farm uses water to clean yard or house flooring and the discharge from the farm is liquid, or where the manure is dumped into a river or other water body.

Biodigester	Farmer collect manure and treat it for Biogas production
Collected, dried and sold or burned for fuel	Farmers collect manure dried it and use for fuel or sold it

Definition (Solid storage vs composting)

3. Solid storage involves piling the manure with or without organic additives (e.g. bedding, straw etc.). It can be covered/uncovered or compacted/not compacted, but there is no aeration or turning.
4. **Composting** requires oxygen, therefore, if the manure pile is turned, mixed or aerated with a fan. Turning or mixing is more common in Ethiopian conditions.

Therefore, if we ask the right questions, we can distinguish between solid storage and compost, e.g.

d. Is the manure collected and stored in piles for some several months? (Answer is either solid storage or composting)

e. After collecting into a pile, do you turn or mix the manure? (yes = composting, no=solid storage)

f. If yes: Do you turn or mix the manure every day? (yes= intensive windrow composting, no= passive windrow composting)

Definition (Liquid storage vs pit storage)

Liquid storage would be where the farm uses water to clean the yard and the discharge from the farm is liquid, or where the manure is dumped into a river or other water body. For discharge or dumping solids into a water body, it is easier to identify.

For pit storage, the IPCC definition is that the pit is below the animal shed, which means that both dung and urine are collected, but no or little water is added. Large-scale, intensive, commercial farms in Ethiopia may use this system.

In the smallholder farms, they may store manure in a pit. If the manure in the pit stays dry, I would say that this is solid storage. If water is added, or if the pit floods in the rainy season, then the months it is dry would-be solid storage and the months it is wet would-be liquid storage. Again, we may need some detailed questions to identify these:

If the answer in the table is “pit storage”, then:

d. is the pit underneath where the animals are kept? (yes=pit storage, no = go to question b)

e. do you add water when the manure is stored in the pit, or does the pit get flooded in the rainy season? (no = solid storage, yes = go to question c)

f. how many months of the year is it wet or flooded? (= months of liquid storage, the remaining months = solid storage).

Table A4.6 Can you tell me what % of cattle manure is used in different ways in the dry and wet seasons?

MMs	Dry season (enter % for each use)	Wet season (enter % for each use)
Left where deposited on pasture		
Collected and spread on pasture or crops the same day		
Left in the area where cows are kept		
Stored in a pit		
Collected and stored in piles for several months before use (after collecting no tun or mix manure)		
Composted (piles with turn and mixing)		
Stored as a liquid or slurry		
Biodigester		
Collected fresh manure dried and sold or burned for fuel		
Collected dried manure and burned for fuel		
	Total should be 100%	**Total should be 100%**

Supplementary question

To fill the question on how the manure is used or stored after main storage system? Use the code number in Code C at the end of the questions.

5. If the manure left in the area where cows are kept,

5a. How many days is it left before cleaning? ------------------------days

5b. how is it stored or used after cleaning? Code C -------------------------------------

6. If stored in piles,

6a. how many days is it left before storing in a pile? ---------------------------------days

6b. is the pile covered or uncovered? (Covered =1, uncovered =2)---------------------

6c. How many months is it stored in the pile? -----------------------------------months

6d. How is it stored or used after it has been in the pile? Code C ----------------------------

7. If composted,

7a. Do you turn over or aerate the compost? (Yes=1, no=2)----------------

7b. How many months is the manure composted for? -------------------------months

7c. How is it stored or used after it has composted? Code C ---

8. If stored as a liquid or slurry,

8a. how many months is it stored as a liquid? ---------------------------------months

8b. does a crust form on the top of the liquid? Yes=1, no=2-------------------

8c.How is it stored or used after that? Code C --------------------------

Table A4.7 Codes used for manure management practice: Uses

Code C	
1	Spread on pasture or crops
2	Stored in piles for several months before use
3	Stored in a pit
4	Composted
5	Biodigester
6	Burned for fuel
7	Sold

Once data on proportion of manure managed in each manure management system are obtained for dry and wet season the next step is to calculated annual weighted as follows:

Weighted average annual MMS value =

(Proportion of manure managed in MMS-X during dry season * (number of months in dry season/12) +

(Proportion of manure managed in MMS-X during wet season * (number of months in wet season/12)

Annex 5. Inventory DE value for each main feed category

Feed Type	DM (%)	CP (%, DM)	NDF (g/kg DM)	ADF (g/kg DM)	ME (MJ/kg DM)	OMD	DE (MJ)	DE (%)
Natural grazing								
	91.3	7.7	68.1	44.6	8.3	47.1	10.2	55.69
Hay								
Rhodes grass hay	92.57	15.49	74.32	28.93	9.3		11.5	62.40
Setaria spp		11.3	52.7	38.9	7.8		9.6	52.33
Pennisetum spp		8.1	71.6	42.5	8.6		10.6	57.70
Brachiaria spp					8.0		9.9	53.68
Oat hay	89.2	9.1	61.7	38.1	8.3		10.2	55.69
								56.36
Crop residue								
Teff straw	92.7	5.2	75.2	45.8	8.0	53.1	9.9	53.677
Wheat straw	93.1	4.8	75.5	49.5	7.5	50.0	9.3	50.322
Barley straw	93.0	6.0	72.9	45.7	6.8	48.0	8.3	45.290
Maize Stover	92.1	3.7	78.2	53.9	6.9	40.9	8.5	46.296
Oat	91.8	6.7	72.8	48.5	6.7	44.4	8.3	44.954
Finger millet	92.1	6.6	60.6	33.0	9.4	62.4	11.6	62.847
Sorghum stover	93.0	3.7	76.6	48.2	7.3	53.0	9.0	48.980
Other straw					7.5		9.3	50.338
								50.34
Improved forage								
Grass-legume mix	43.8	22.70	51.9	39.0	8.6	57.1	10.6	57.70
Napier grass/desho	93.5	5.45	67.3	38.1	8.22		10.1	55.15
Alfalfa	34.9	25.9		33.9	9.2	61.4	11.4	61.73
Vetch	89.25	22.43	42.96	31.01	10.43	66.6	12.9	69.98
Oat	55.15	5.48	70.8	57.29	9.32		11.5	62.53
Concentrate								61.42
Commercial	89.2	18.7	44	15.6	10.1	67	12.5	67.77
Home-made	90.6	21.7			11		13.6	73.81
Agro-industrial by-products								70.79
Noug seed cakes	92.1	28.5	35.8	29.8	9.6	63.8	11.9	64.41
Wheat bran	88.6	15.8	47.1	14.7	10.7	71.2	13.2	71.79
Wheat middling	88.5	16.7	40.3	14	11.1	73.4	13.7	74.48
Linseed cake	91.6	28.6	36.2	28.4	10.9	72.1	13.5	73.13
Bean hulls	93.3	6.8	52	32.1	5.1	33.6	6.3	34.22
Molasses	69.9	3.3			10.8		13.3	72.46
Mixed grains screenings	90.8	9.5	6.2	4	12.4	82.9	15.3	83.20
Mixed pulses screenings	92.7	30.1	39.4	33.4	12.5	83.4	15.4	83.87
								69.70
Others								

Brewer's waste	95.6	23.8	63.4	29.3	8.8	58.8	10.9	59.0
Enset leaves	94.7	4.8	73.1	53.0	7.2	48.5	8.9	48.3
Banana leave	92.5	14.7	60.0	37.7	5.9	39.4	7.3	39.6
Sweet potato leaves	91.8	26.5	25.8	15.2	8.8		10.9	59.0
Crop stand thinning					8.5		10.5	57.0
By-products from (Atela,								
Areki Atela	96.7	18.2	54.2	22.0	10.1	67.4	12.5	67.8
Tela Atela	95.4	21.2	55.8	22.0	9.2	61.4	11.4	61.7
Household left-over					6.5		8.0	43.6
								54.5

*DE (%) = Digestible energy (DE, MJ)/18.4, and DE (MJ) = Metabolizable energy (ME MJ)/0.81.

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