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Livestock Greenhouse Gas Emissions in Ethiopia by Region: A Graphic Summary

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A Graphic Summary

Technical Report

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

This report is based on the Inventory of GHG emissions from cattle, sheep, and goats in Ethiopia (1994-2018) calculated using the IPCC Tier 2 approach approved by the Ministry of Agriculture (Wilkes et al., 2020). That national inventory report presented in detail the data sources, methods and results for GHG emissions from cattle, sheep and goats at national level. This report summarizes the main results for each region in Ethiopia.

Keywords
Ethiopia; livestock production; greenhouse gases.

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Introduction

Livestock GHG emissions and why they matter

Livestock production accounts for about 33% of the global agriculture gross domestic product, making significant contributions to food security, income and employment worldwide. Livestock also contribute about 15% of global greenhouse gas (GHG) emissions, which are the major cause of global warming and climate change (Gerber et al. 2013). For most countries in Sub-Saharan Africa, agriculture is the largest source of GHG emissions, and in many countries livestock account for more than half of total agriculture GHG emissions. This is also the case in Ethiopia where the agriculture sector accounts for about 74% of total national GHG emissions, with over 60% of coming from livestock (MEF 2015).

Ethiopia is one of the most advanced countries in Africa in its commitments to tackle climate change. The Climate Resilient Green Economy (CRGE) Strategy issued in 2011 aimed to reduce national GHG emissions by 64% compared to a business-as-usual strategy. The CRGE was mainstreamed into the Growth and Transformation Plan II (2016-2020), and included measures to reduce GHG emissions from livestock. The CRGE also formed the basis for Ethiopia's First Nationally Determined Contribution (NDC) which set out the country's commitments to the international community under the United Nations Framework Convention on Climate Change (UNFCCC). In 2020, Ethiopia updated its NDC, integrating its plans for adaptation to climate change and mitigation of GHG emissions with the new Ten Year Development Plan (10YDP). The updated NDC aims to reduce livestock GHG emissions by 1% in 2030 using the country's own resources and by a further 14.7% with international support (FDRE 2020).

Identifying measures to reduce livestock GHG emissions and tracking progress towards national goals requires an inventory of GHG emissions from livestock. Furthermore, there is also a growing interest in estimating GHG emissions and emission reductions at regional level within Ethiopia because of their roles in delivering on the national GHG mitigation strategy and the potential to leverage climate finance if the effects of mitigation actions can be tracked. In 2020, the Ministry of Agriculture produced a new inventory of GHG emissions from cattle, sheep and goats using the internationally recognized Tier 2 method (Wilkes et al. 2020). This inventory uses advanced methods to estimate GHG emissions from livestock at both national and regional levels. This report, therefore, summarizes the main results for each of Ethiopia's regions to support regional governments and other stakeholders to identify the main sources of livestock GHG emission, and to consider effective ways to reduce GHG emissions while developing rural economies and adapting to the effects of climate change.

About this report

This report is based on the *Inventory of GHG emissions from cattle, sheep, and goats in Ethiopia (1994-2018) calculated using the IPCC Tier 2 approach* approved by the Ministry of Agriculture (Wilkes et al., 2020). That national inventory report presented in detail the data sources, methods and results for GHG emissions from cattle, sheep and goats at national level. This report summarizes the main results for each region in Ethiopia.

GHG emissions were estimated using the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines. The GHG emission sources estimated include emissions from five sources:

- Enteric fermentation [CH_4] (category 3A1)
- Manure management [CH_4, N_2O] (category 3A2)
- Direct N_2O emissions from managed soils, dung and urine deposited on pasture (category 3C4)
- Indirect N_2O emissions from managed soils, dung and urine deposited on pasture (category 3C5)
- Indirect N_2O emissions from manure management (category 3C6)

In this report, the five emission sources have been summarized into three categories: (i) enteric fermentation (category 3A1); (ii) manure management (i.e., categories 3A2 and 3C6); and (iii) manure deposited on pasture (categories 3C4 and 3C5).

GHG emissions were quantified for cattle (including both dairy and dual-purpose cattle), sheep and goats. Emissions were quantified separately for livestock in four production systems: commercial dairy, smallholder dairy, mixed crop-livestock, and pastoral/agro-pastoral systems. The main source of data on livestock populations was the Central Statistics Agency annual sample survey reports. Emission factors (i.e., GHG emissions per head of livestock) were estimated using methods described in the national inventory report (Wilkes et al. 2020). Methane (CH_4) and nitrous oxide (N_2O) are the main GHGs emitted by livestock. CH_4 was converted to carbon dioxide equivalents (CO_2e) using a global warming potential of 25 and N_2O was converted using a value of 298. The unit used to report CO_2e values is million tonnes (Mt).

About the numbers in this book

Why are some numbers here different from livestock populations reported by CSA or regional governments? Cattle populations in the GHG inventory include cattle in the commercial dairy sector, which are not yet reported by CSA. CSA data for pastoral/agro-pastoral systems only cover some zones in Afar and Somali Region, but the GHG inventory used various assumptions to estimate the numbers not counted by CSA. For more details, see the full inventory report.

How do livestock produce GHG emissions?

Enteric fermentation: Cattle, sheep and goats are ruminants. Ruminants have a 'fore-stomach' (called the rumen) in which coarse plant materials (e.g., cellulose, fibre, starch etc.) are broken down to provide nutrients and energy to the animal (Figure 1). The plant materials are broken down by fermentation by microbes. CH_4 is a by-product of fermentation in the rumen and alongside other gases like carbon dioxide, they are removed belching. Simply put, the amount of CH_4 produced depends on the quantity and quality of the feed consumed. Coarse roughages (e.g., straw, hay) are not easily digested resulting in more CH_4 being produced per kg of feed consumed by animals whose diet mainly consist of.

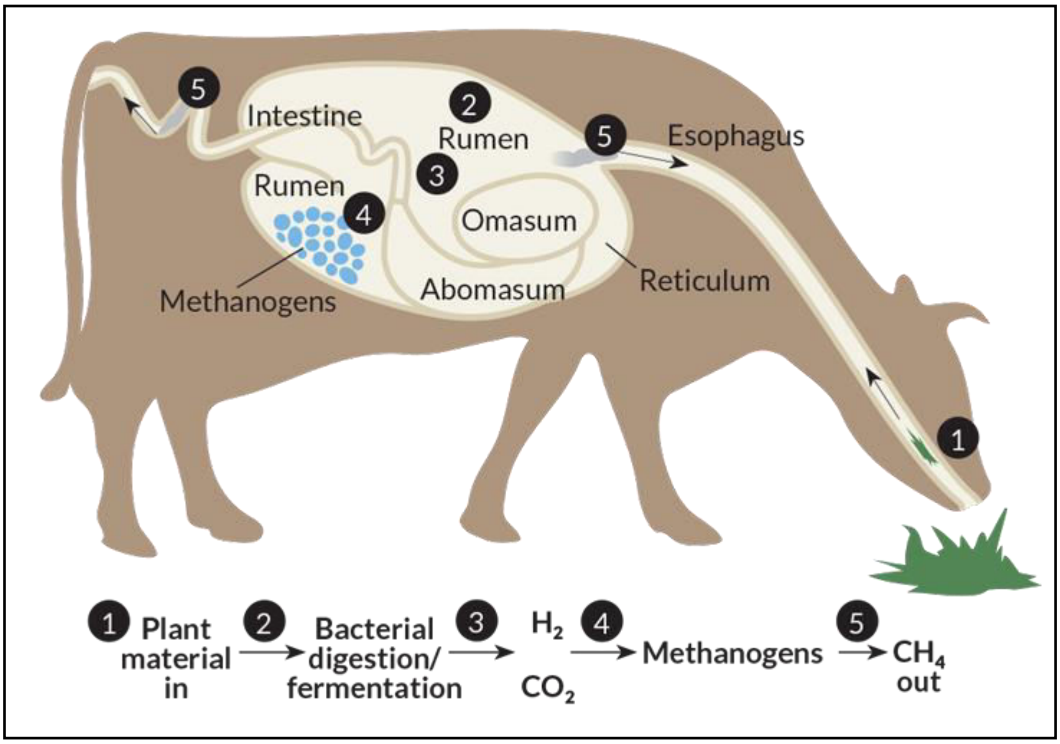


Figure 1. Simplified representation of methane production from a cow roughages

Source (https://water.unl.edu/article/manure-nutrient-management/reducing-carbon-footprint-cattle-operations-through-diet)

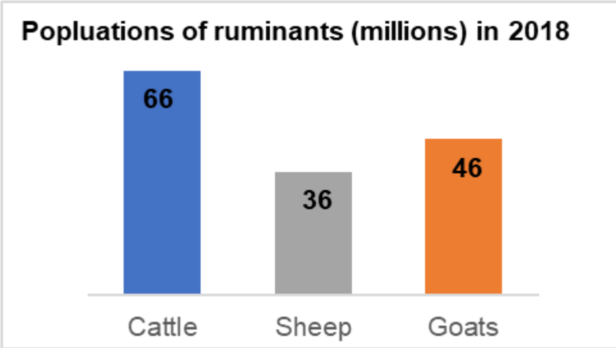
Methane from manure management: Manure is dung and urine excreted by animals. Decomposition of manure by bacteria produces methane, particularly under anaerobic conditions (i.e., in the absence of oxygen). Anaerobic conditions are more likely to happen when manure collects together from large numbers of animals, and when manure is stored in pits or in liquid form. So different methods for storage and management (Figure 2) of manure affect how much methane is produced. Temperature also affects the amount of methane produced.

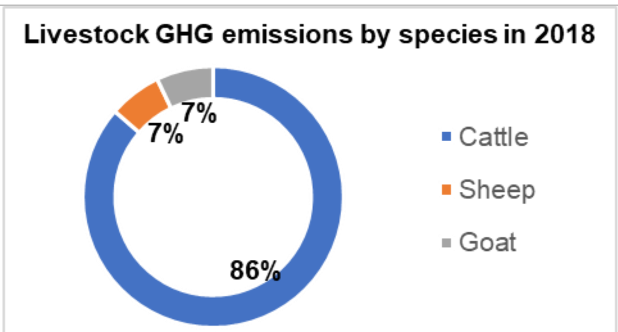
Figure 2. Different manure management system in Ethiopia dung cake (left) and dry lot (right).

Nitrous oxide from manure management: Manure contains nitrogen. If there is sufficient oxygen, nitrous oxide (N_2O) can be emitted as a direct N_2O emission due to processes called nitrification and denitrification. The nitrogen content of manure and methods for manure storage and management have big impacts on the rate of N_2O emission. Indirect emissions of N_2O can also be caused by a portion of manure organic nitrogen converting to ammonia nitrogen, and by leaching or runoff when rainfall or water used for cleaning cattle yards carries nitrogen into water ways.

National GHG emissions from cattle, sheep and goats

The main ruminant livestock species include cattle, sheep and goats. With a national population of about 147.5 million head in 2018, GHG emissions from cattle, sheep, and goats totalled 107 Mt CO_2e, which represents about 51% of the total agriculture GHG emissions in Ethiopia.[1]





Although the combined sheep and goat population was larger than the cattle population, cattle emitted over 85% (i.e., ~ 92.4 Mt CO_2e) of GHG emissions from the main ruminant livestock species in 2018. Most cattle emissions came from the mixed crop-livestock system in which over 67% of ruminant livestock are kept.

The largest source of livestock GHG emissions in 2018 was enteric fermentation (i.e., ~ 91.8 Mt CO_2e). Manure management on-farm accounted for about 11%, while GHG emissions from manure deposited on pasture contributed only 3% (i.e., ~ 3.6 Mt CO_2e).

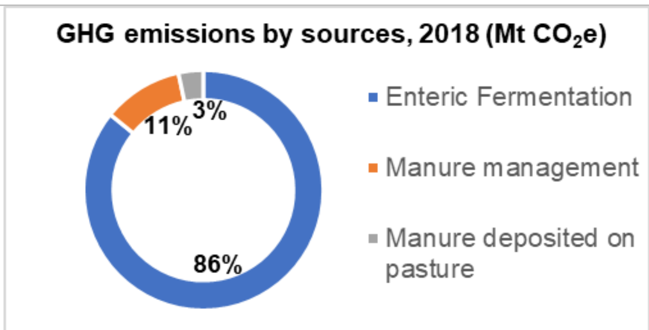


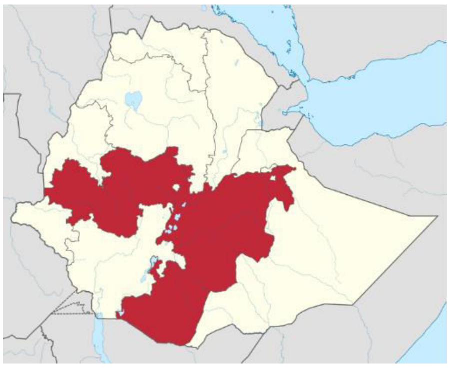
Table 1 Emissions (Mt CO_2e) by species in 2018

Emission source	Cattle	Sheep	Goats
Enteric Fermentation	78.6	6.4	6.8
Manure management	10.9	0.3	0.4
Manure on pasture	2.9	0.3	0.4

For each category of GHG emission, cattle are the main source, and enteric fermentation is the biggest source of cattle emissions. Therefore, reducing emissions from cattle, especially enteric fermentation, would have the biggest contribution to mitigating livestock GHG emissions.

[1] http://www.fao.org/faostat/en/#country/238

Oromia Region



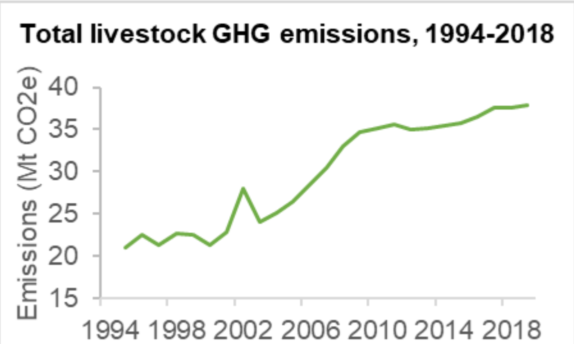
Livestock populations: In 2018, Oromia Region had 24.8 million cattle (Table 2), representing about 38% of the national cattle herd. The region also had 9.7 sheep and 9.1 million goats.

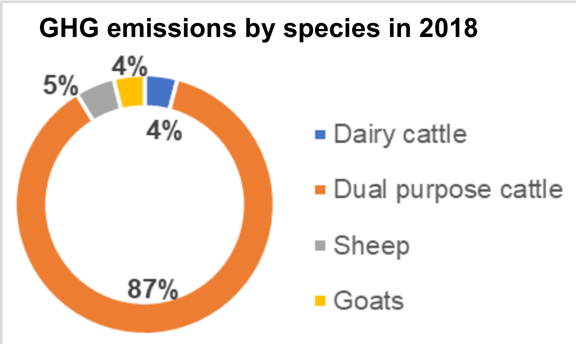
Production systems: 92% of cattle were kept in the mixed crop-livestock system in highland areas. 4% were in pastoral/agro-pastoral systems in the lowland areas. Oromia Region had 253,228 dairy cattle in commercial systems, and 521,999 dairy cattle in smallholder dairy systems. Together, dairy cattle in Oromia accounted for 41% of the national dairy herd. 93% of sheep and 89% of goats were in the mixed crop-livestock system in the region.

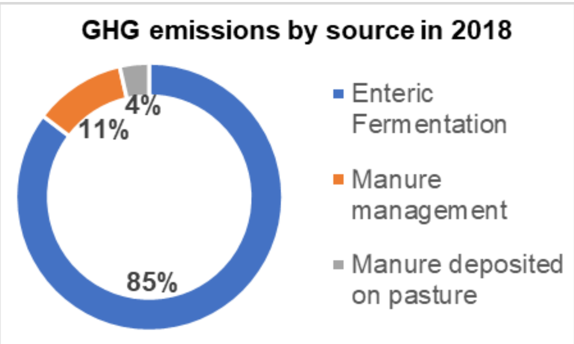
Table 2 Livestock populations in different production systems in Oromia Region

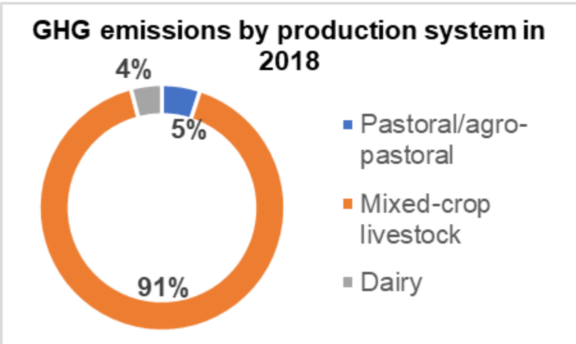
Production system	Livestock populations		
	Cattle	Sheep	Goats
Commercial dairy	253,228	-	-
Smallholder dairy	521,999	-	-
Mixed crop livestock	22,933,130	9,159,711	8,062,043
Pastoral / agro-pastoral	1,091,964	616,747	1,020,703
Total	**24,800,321**	**9,776,458**	**9,082,746**

GHG emissions: In 2018, livestock in Oromia Region emitted 38 Mt CO_2e, accounting for 35% of national livestock GHG emissions. 91% of emissions were from cattle, and most were from enteric fermentation. 2018 emissions were 106% greater than in 2010. 50% of the increase was due to cattle in the mixed crop livestock system and 25% due to smallholder dairy cattle. Sheep and goats in the mixed crop-livestock system contributed about 14% of the increase.









Amhara Region

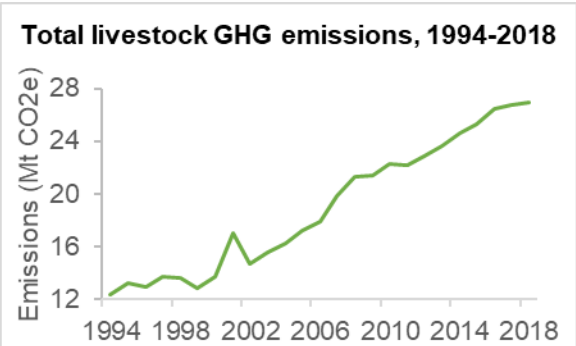
Livestock populations: In 2018, Amhara Region had 16.6 million cattle (Table 3), representing about 25% of the national cattle herd. The region also had 9.6 million sheep and 6.8 million goats.

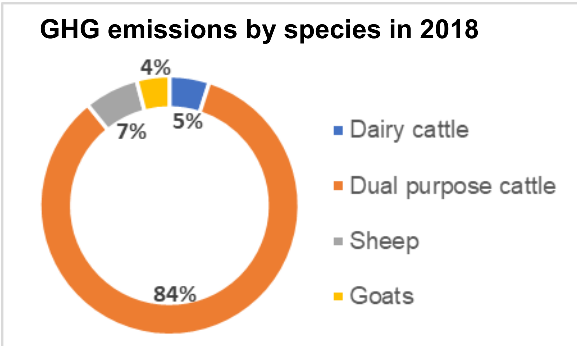
Production systems: 95% of cattle were kept in the mixed crop-livestock system in highland areas. Amhara Region had 211,395 dairy cattle in commercial systems, and 461,997 dairy cattle in the smallholder dairy systems. Together, these accounted for 35% of the national dairy herd. All sheep and goats in this area were kept in the mixed crop-livestock system.

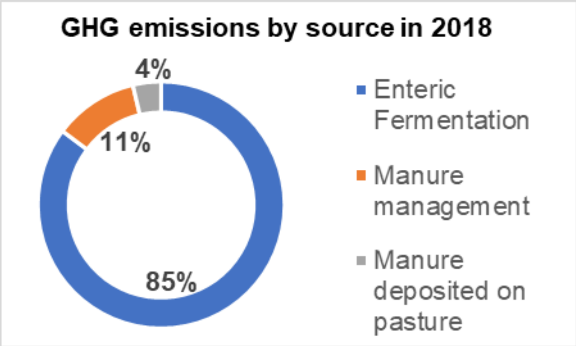
Table 3 Livestock populations in different production systems in Amhara Region

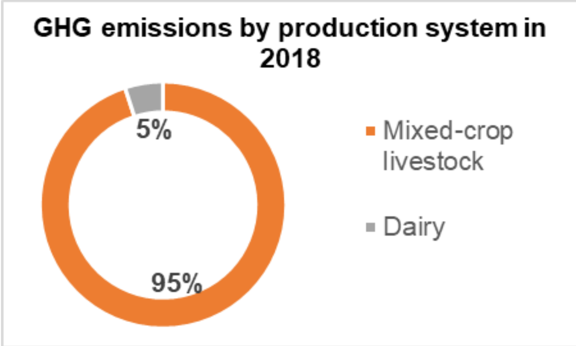
Production system	Livestock populations		
	Cattle	Sheep	Goats
Commercial dairy	211,395	-	-
Smallholder dairy	461,997	-	-
Mixed crop livestock	15,950,735	9,650,635	6,805,724
Pastoral / agro-pastoral	-	-	-
Total	**16,624,127**	**9,650,635**	**6,805,724**

GHG emissions: In 2018, livestock in the Amhara Region emitted 27 Mt CO_2e, accounting for 25% of national livestock GHG emissions. 89% of emissions were from cattle. Most livestock GHG emissions were from enteric fermentation. 2018 emissions were about 121% greater than in 2010. 71% of the increase was due to cattle in the mixed crop-livestock system and 17% due to cattle in the smallholder dairy system. Sheep and goats contributed about 9% of the increase.









Tigray Region

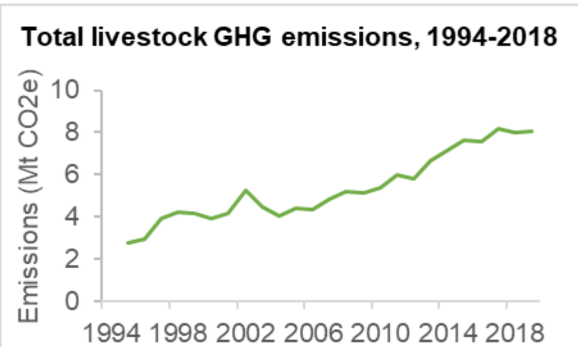
Livestock populations: In 2018, the Tigray Region had 4.8 million cattle (Table 4), representing about 7% of the national cattle herd. The region also had 2.2 million sheep and 4.2 million goats.

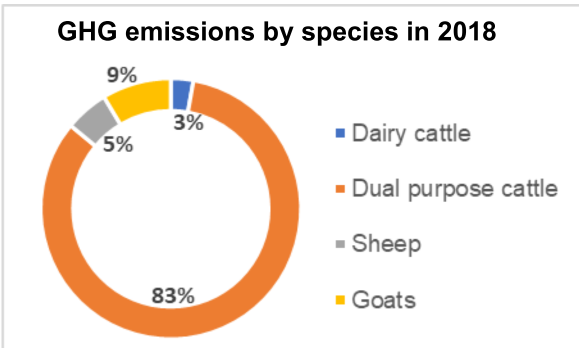
Production systems: 79% of cattle were kept in the mixed crop-livestock system and 19% in the pastoral/agro-pastoral system. Tigray Region had 2,046 dairy cattle in commercial systems, and 107,684 dairy cattle in smallholder dairy systems. Together, these accounted for 6% of the national dairy herd. Most sheep and goats were in the mixed crop-livestock system.

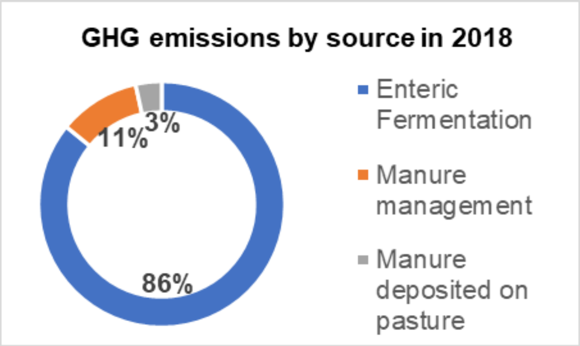
Table 4 Livestock populations in different production systems in Tigray Region

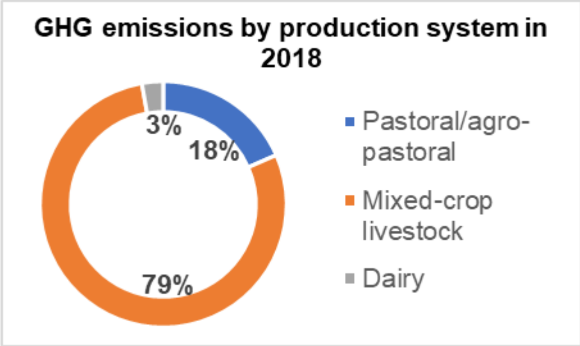
Production system	Livestock populations		
	Cattle	**Sheep**	**Goats**
Commercial dairy	2,046	-	-
Smallholder dairy	107,684	-	-
Mixed crop livestock	3,833,031	2,156,468	3,448,957
Pastoral / agro-pastoral	915,210	126,279	783,723
Total	**4,857,971**	**2,282,747**	**4,232,680**

GHG emissions: In 2018, livestock in Tigray Region emitted 8 Mt CO_2e, accounting for 8% of national livestock GHG emissions. 86% of emissions were from cattle. Most livestock GHG emissions were from enteric fermentation. 2018 emissions were about 134% greater than in 2010. 65% of the increase was due to cattle in the mixed crop-livestock system and 16% due to sheep and goats in the mixed crop-livestock system.









Afar Region

Livestock populations: In 2018, Afar Region had 4.5 million cattle (Table 5), representing about 7% of the national cattle herd. The region had 6.4 million and 14.2 million goats.

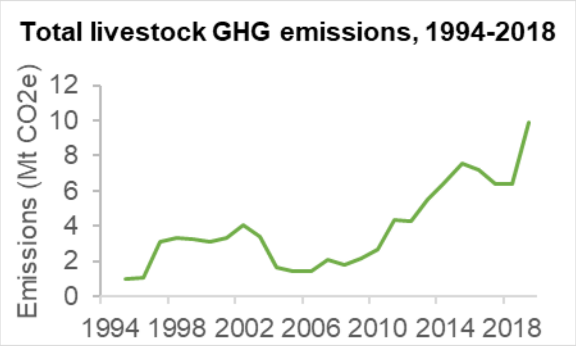
Production systems: All cattle, sheep and goats in this region were kept in the pastoral/agro-pastoral system. Afar Region had no specialised dairy cattle production systems.

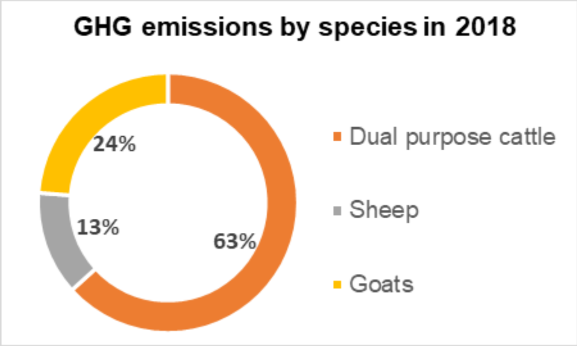
Table 5 Livestock populations in different production systems in Afar Region*

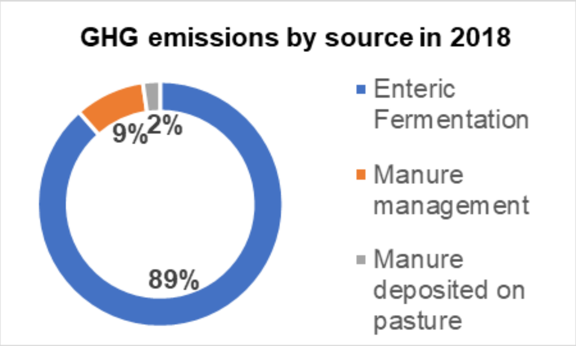
Production system	Livestock populations		
	Cattle	Sheep	Goats
Commercial dairy	-	-	-
Smallholder dairy	-	-	-
Mixed crop livestock	-	-	-
Pastoral / agro-pastoral	4,546,586	6,411,604	14,292,446
Total	**4,546,586**	**6,411,604**	**14,292,446**

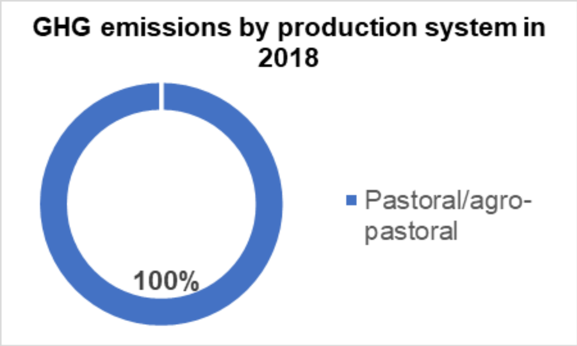
** Populations include animals not enumerated in CSA annual sample surveys, estimated using assumptions described in the national inventory report.*

GHG emissions: In 2018, livestock in Afar Region emitted 10 Mt CO_2e, accounting for 9% of national livestock GHG emissions. 63% of emissions were from cattle. Most livestock GHG emissions were from enteric fermentation. 2018 emissions were about 228% greater than in 2010. 54% of the increase was due to cattle, 31% to goats and 15% to sheep in the pastoral/agro-pastoral system.









Somali Region

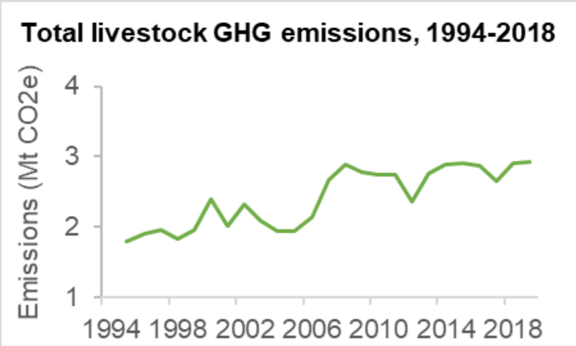
Livestock populations: In 2018, Somali Region had 1.2 million cattle (Table 6), representing about 2% of the national cattle herd. The region also had 2.0 million sheep and 4.1 million goats.

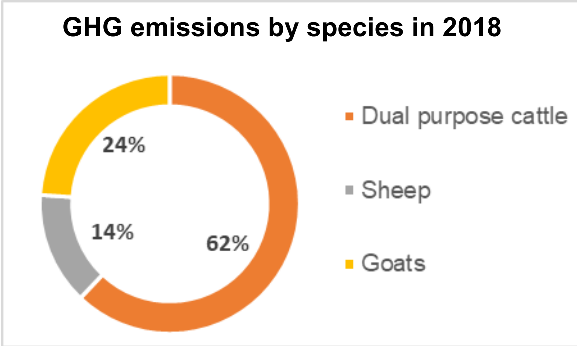
Production systems: All cattle, sheep and goats in this region were kept in pastoral/agro-pastoral systems. The Somali Region had no specialised dairy cattle production systems.

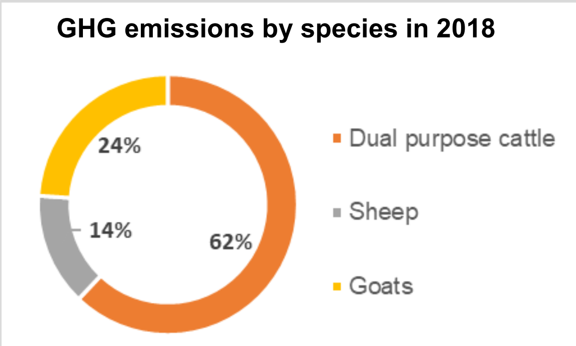
Table 6 Livestock populations in different production systems in Somali Region

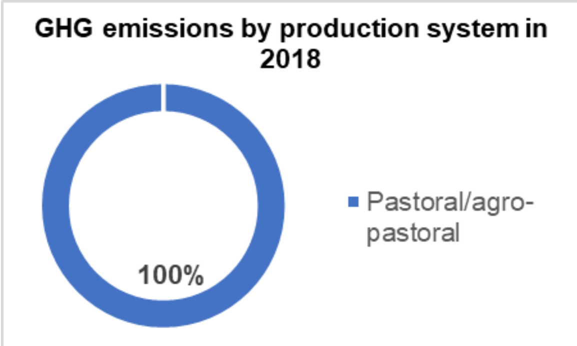
Production system	Livestock populations		
	Cattle	Sheep	Goats
Commercial dairy	-	-	-
Smallholder dairy	-	-	-
Mixed crop livestock	-	-	-
Pastoral / agro-pastoral	1,288,974	2,015,352	4,186,250
Total	**1,288,974**	**2,015,352**	**4,186,250**

GHG emissions: In 2018, livestock in Somali Region emitted 3 Mt CO_2e, accounting for 3% of national livestock GHG emissions. 62% of emissions were from cattle. Most livestock GHG emissions are from enteric fermentation. 2018 emissions were about 107% greater than in 2010. Most of the increase was due to goats in the pastoral/agro-pastoral system.









Benishangul-Gumuz Region

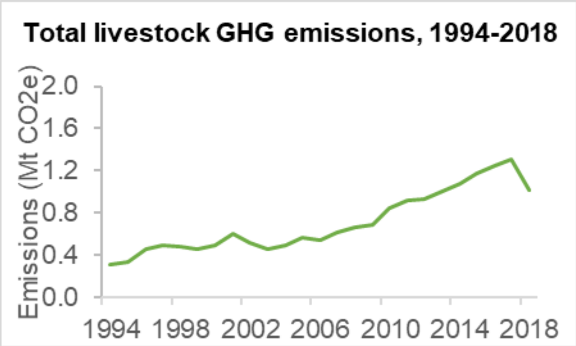
Livestock populations: In 2018, Benishangul-Gumuz Region had 0.6 million cattle (Table 7), representing about 1% of the national cattle herd. The region also had 0.1 million sheep and 0.5 million goats.

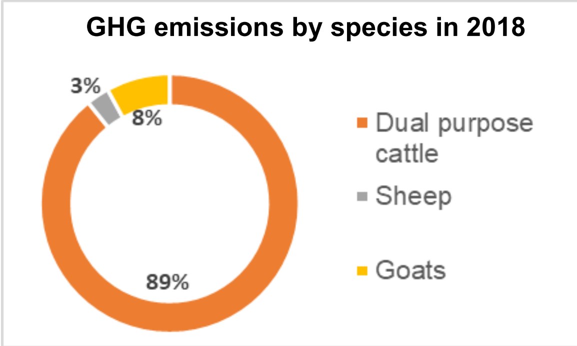
Production systems: 72% of cattle were kept in pastoral/agro-pastoral systems and the rest in mixed crop-livestock systems. Benishangul-Gumuz Region had no specialised dairy cattle production systems. Sheep and goats are almost equally distributed in mixed crop-livestock and pastoral/agro-pastoral systems.

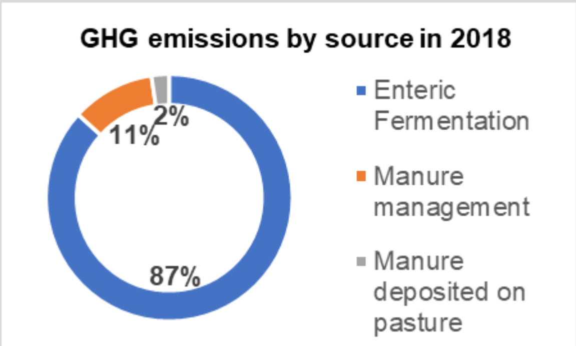
Table 7 Livestock populations in different production systems in Benishangul-Gumuz Region

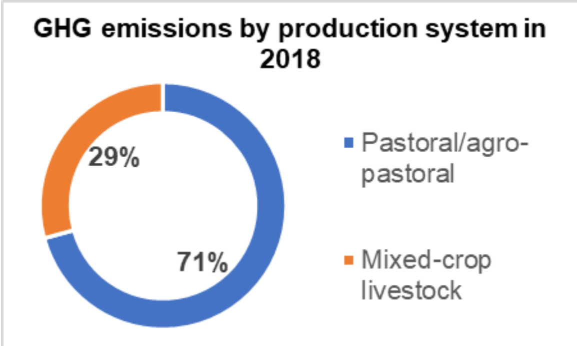
Production system	Livestock populations		
	Cattle	**Sheep**	**Goats**
Commercial dairy	-	-	-
Smallholder dairy	-	-	-
Mixed crop livestock	173,472	73,638	252,468
Pastoral / agro-pastoral	452,871	70,026	271,847
Total	**626,343**	**143,664**	**524,315**

GHG emissions: In 2018, livestock in Benishangul-Gumuz Region emitted 1 Mt CO_2e, accounting for 1% of national livestock GHG emissions. 89% of emissions were from cattle. Most livestock GHG emissions are from enteric fermentation. 2018 emissions were about 120% greater than in 2010. 55% of the increase was due to cattle in the mixed crop-livestock system and 34% due to cattle in the pastoral/agro-pastoral system. Sheep and goats contributed about 11% of the increase.









SNNPR Region

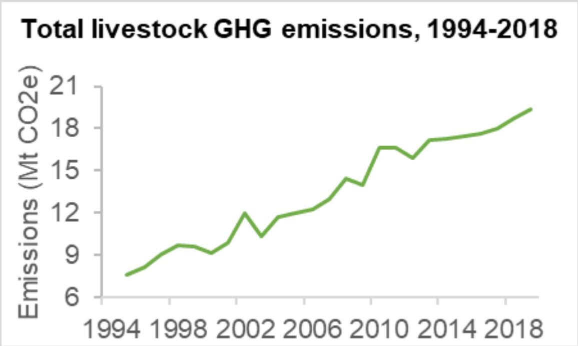
Livestock populations: In 2018, SNNPR Region had 12.5 million cattle (Table 8), representing about 19% of the national cattle herd. The region also had 5.7 million sheep and 6.0 million goats.

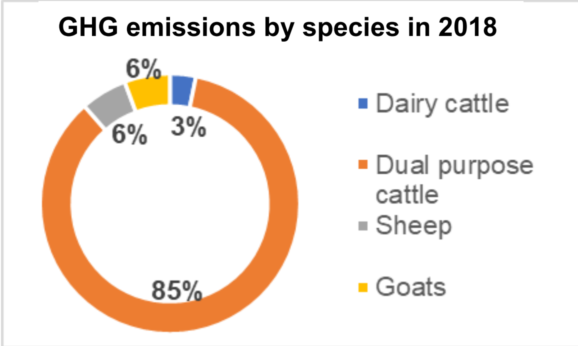
Production systems: 83% of cattle were in the mixed crop-livestock system and 14% in the pastoral/agro-pastoral system. SNNPR Region had 139,639 commercial dairy cattle and 176,123 smallholder dairy cattle. Together, these accounted for 17% of the national dairy herd. 68% of sheep were in the mixed crop-livestock system and 58% of goats in the pastoral/agro-pastoral system.

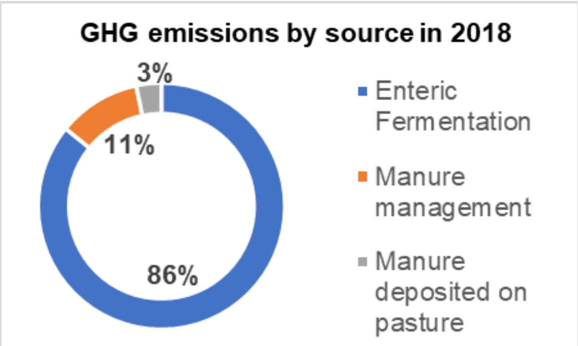
Table 8 Livestock populations in different production systems in SNNPR Region

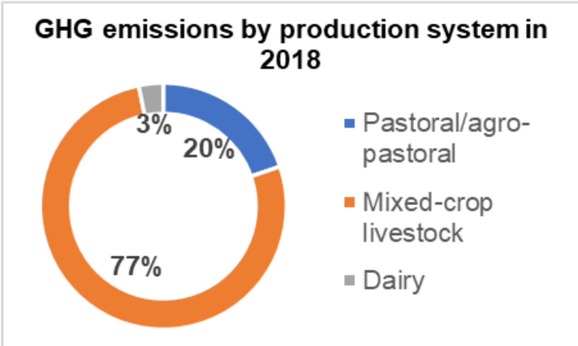
Production system	Livestock populations		
	Cattle	Sheep	Goats
Commercial dairy	139,639	-	-
Smallholder dairy	176,123	-	-
Mixed crop livestock	10,372,859	3,918,520	2,520,782
Pastoral / agro-pastoral	1,781,270	1,858,506	3,565,900
Total	**12,469,891**	**5,777,026**	**6,086,681**

GHG emissions: In 2018, livestock in the SNNPR Region emitted 19 Mt CO_2e, accounting for 18% of national livestock GHG emissions. 88% of emissions were from cattle. Most livestock GHG emissions were from enteric fermentation. 2018 emissions were about 116% greater than in 2010. 50% of the increase was due to cattle in the pastoral/agro-pastoral system and 28% due to sheep and goats in the pastoral/agro-pastoral system.









Gambela Region

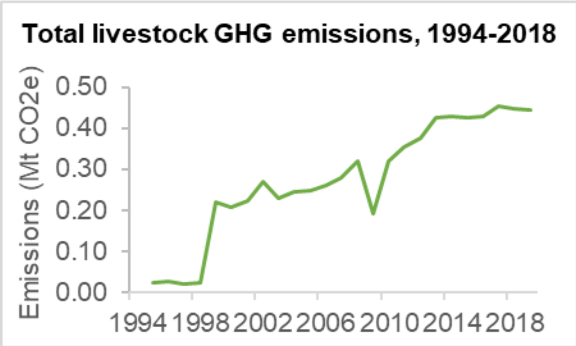
Livestock populations: In 2018, Gambela Region had 0.2 million cattle (Table 9), representing about 0.4% of the national cattle herd. The region had 41,026 sheep and 81,127 goats.

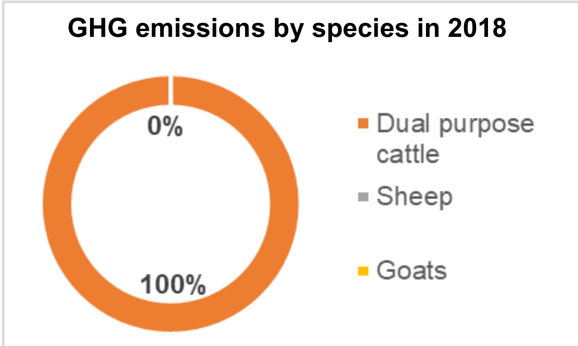
Production systems: All cattle, sheep and goats in this region were in pastoral/agro-pastoral systems. Gambela Region had no specialised dairy cattle production system.

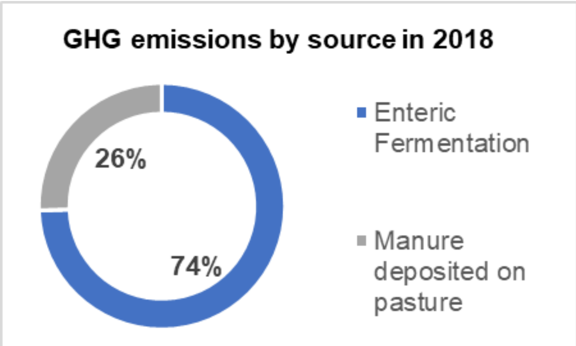
Table 9 Livestock populations in different production systems in Gambela Region

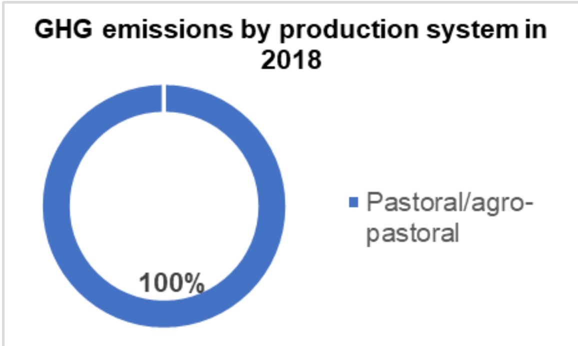
Production system	Livestock populations		
	Cattle	Sheep	Goats
Commercial dairy	-	-	-
Smallholder dairy	-	-	-
Mixed crop livestock	-	-	-
Pastoral / agro-pastoral	290,616	41,026	81,127
Total	**290,616**	**41,026**	**81,127**

GHG emissions: In 2018, livestock in Gambela Region emitted 0.4 Mt CO_2e, accounting for 0.4% of national livestock GHG emissions. 99% of emissions were from cattle. Most livestock GHG emissions were from enteric fermentation. 2018 emissions were about 125% greater than in 2010. 91% of the increase was due to cattle and the remainder to goats in the pastoral/agro-pastoral system.









Harari Region

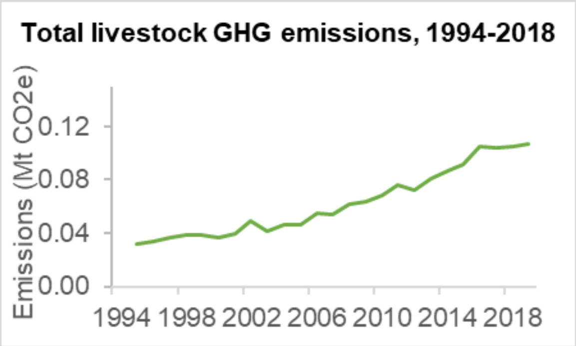
Livestock populations: In 2018, Harari Region had 63,933 cattle (Table 10), representing less than 0.5% of the national cattle herd. The region had 5,661 sheep and 81,466 goats.

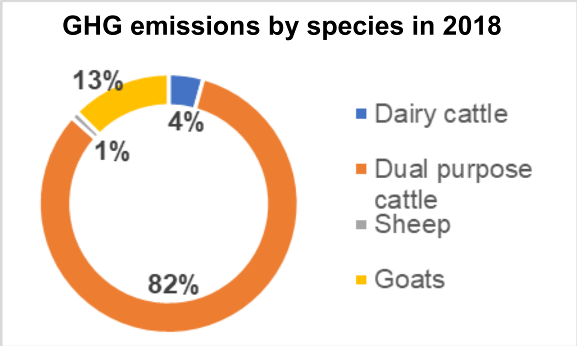
Production systems: 98% of cattle were in the mixed crop-livestock system and none in the pastoral/agro-pastoral system. Harari Region had 2,260 dairy cattle in smallholder dairy systems, accounting for about 0.1% of the national dairy herd population. All sheep and goats were kept in the mixed crop-livestock systems.

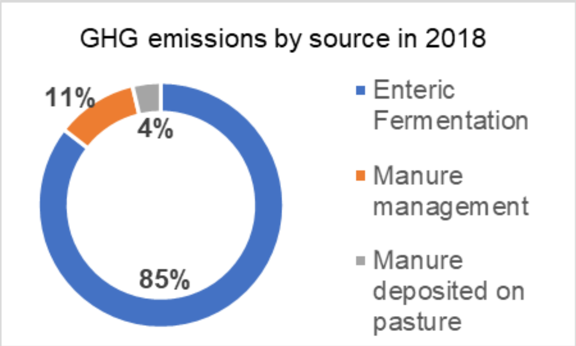
Table 10 Livestock populations in different production systems in Harari Region

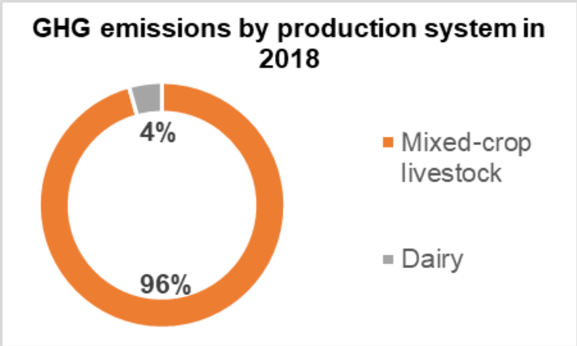
Production system	Livestock populations		
	Cattle	Sheep	Goats
Commercial dairy	-	-	-
Smallholder dairy	2,260	-	-
Mixed crop livestock	67,673	5,661	81,466
Pastoral / agro-pastoral	-	-	-
Total	**69,933**	**5,661**	**81,466**

GHG emissions: In 2018, livestock in the Harari Region emitted 0.1 Mt CO_2e, accounting for 0.1% of national livestock GHG emissions. 87% of emissions were from cattle. Most livestock GHG emissions were from enteric fermentation. 2018 emissions were about 140% greater than in 2010. 69% of the increase was due to cattle and 19% due to goats in the mixed crop-livestock system, and 12% due to smallholder dairy cattle.









Dire Dawa City Administration

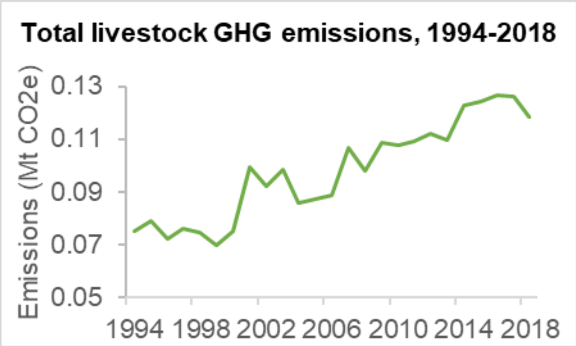
Livestock populations: In 2018, Dire Dawa city had 51,783 cattle (Table 11), representing about 0.1% of the national cattle herd. The city also had 70,408 sheep and 186,001 goats.

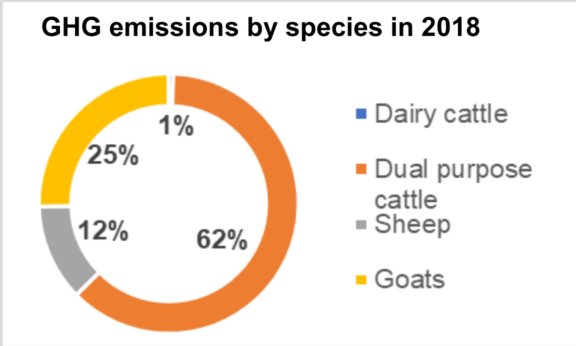
Production systems: 99% of cattle were in the pastoral/agro-pastoral system. There were also 361 dairy cattle in commercial systems, which accounted for about 0.02% of the national dairy herd. All sheep and goats were kept in the pastoral/agro-pastoral system.

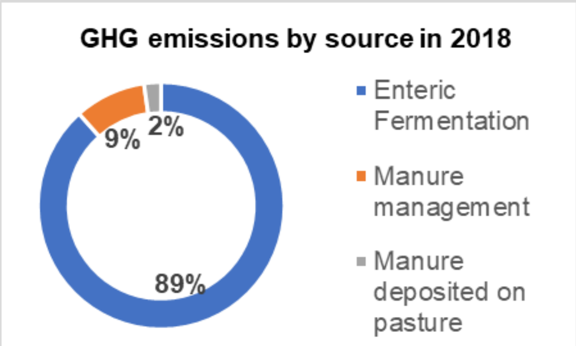
Table 11 Livestock populations in different production systems in Dire Dawa City

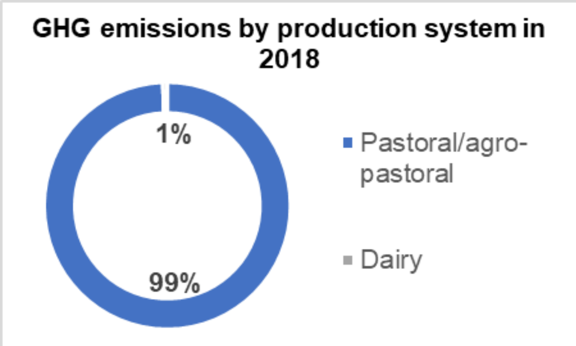
Production system	Livestock populations		
	Cattle	Sheep	Goats
Commercial dairy	361	-	-
Smallholder dairy	-	-	-
Mixed crop livestock	-	-	-
Pastoral / agro-pastoral	51,422	70,408	186,001
Total	**51,783**	**70,408**	**186,001**

GHG emissions: In 2018, livestock in Dire Dawa emitted 0.12 Mt CO_2e, accounting for 0.1% of national livestock GHG emissions. 62% of emissions were from cattle. Most livestock GHG emissions were from enteric fermentation. 2018 emissions were about 110% greater than in 2010. 80% of the increase was due to cattle and 18% due to sheep and goats in the pastoral/agro-pastoral system.









Addis Ababa City Administration

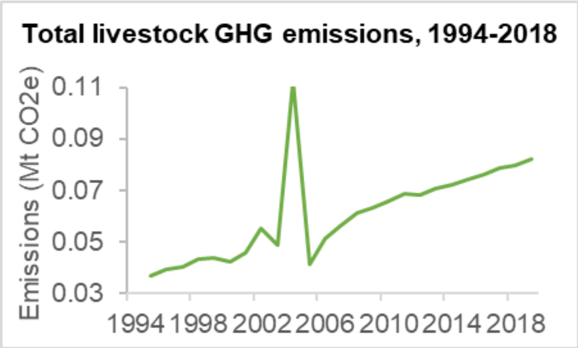
Livestock populations: In 2018, Addis Ababa city had 51,935 cattle (Table 12), representing about 0.08% of the national cattle herd. The city also had 1,926 sheep and 431 goats.

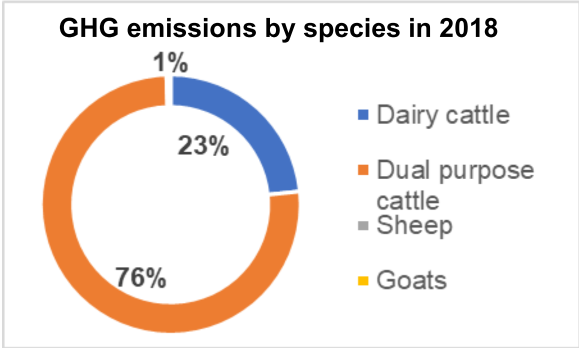
Production systems: 80% of cattle were kept in mixed crop-livestock systems. Addis Ababa had 10,167 dairy cattle kept in commercial systems, accounting for 0.5% of the national dairy herd. All sheep and goats were kept in mixed crop-livestock systems.

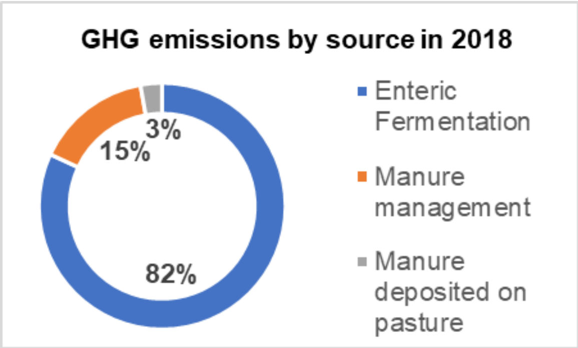
Table 12 Livestock populations in different production systems in Addis Ababa City

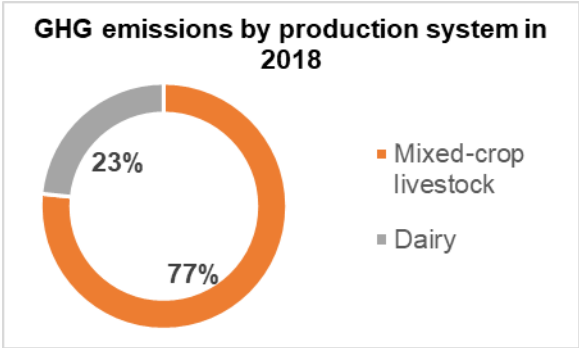
Production system	Livestock populations		
	Cattle	Sheep	Goats
Commercial dairy	10,167	-	-
Smallholder dairy	-	-	-
Mixed crop livestock	41,768	1,926	431
Pastoral / agro-pastoral	-	-	-
Total	**51,935**	**1,926**	**431**

GHG emissions: In 2018, livestock in Addis Ababa City emitted 0.08 Mt CO_2e, accounting for less than 0.1% of national livestock GHG emissions. 99% of emissions were from cattle. Most livestock GHG emissions were from enteric fermentation. 2018 emissions were about 120% greater than in 2010. 55% of the increase was due to cattle in the mixed crop-livestock system and 45% due to commercial dairy cattle.









Mitigation of livestock GHG emissions

Ethiopia's updated NDC (2020) addresses both adaptation to climate change and GHG mitigation (Table 13). In addition, the Ten-Year Development Plan sets goals for the development of livestock sector:

- reduce the total number of milk cows and raise the proportion of improved breeds;
- raise the total quantity of milk production from cows, goats and camels;
- increase the average daily milk yield per cow for indigenous, cross-bred and exotic breeds;
- increase the total quantity of meat from cattle, goats, sheep, and camels; and
- increase the egg and chicken meat production.

Table 13: Adaptation and mitigation actions in Ethiopia's updated NDC

Adaptation to climate change	Mitigation of GHG emissions
• Diversify livestock and animal mix, including promotion of poultry and small ruminants • Improve animal breeds for enhanced climate resilience • Strengthen and expand animal health	• Intervention packages for smallholder and commercial dairy development to increase productivity • Intervention packages for red meat through improved breeds and feedlots • Intervention packages for poultry to

services for enhanced climate resilience in livestock • Prevent and control the spread of climate-driven vector-borne diseases and macro parasites • Improve rangeland and pasture management, including selection of drought-resistant animal breeds	increase poultry numbers and productivity • Manure management • Mechanization to reduce oxen numbers increase of share of poultry

Developing the farm economy and adapting to the risks of climate change are priorities for farmers. However, many livestock development and adaptation measures may also have benefits for GHG mitigation. There are three general strategies to consider:

1. **Reducing GHG emissions:** Some measures to develop livestock production can **reduce** the total amount of GHGs emitted:
   - **Improved feed quality:** Better quality feed increases productivity and also reduces GHG emissions per unit of feed consumed.
   - **Composting manure and using manure to produce biogas:** Composting and using biogas made from manure reduce methane emissions. Compost and biogas slurry are also very good fertilizers to boost crop production.
   - **Early off-take of cattle, sheep or goats:** Early off-take, for example selling animals at a younger age to fatten in feedlots, can reduce GHG emissions because animals are alive for fewer days in the year.
   - **Replacing oxen with farm machines:** Fewer oxen will reduce more GHG emissions than any increase in GHG emissions from tractor fuel use.
   - **Replacing less productive cattle with better breeds and reducing total cattle numbers:** If low-productivity animals are replaced with more productive animals and farmers reduce the total number of animals on farm so that each animal is better fed and managed, total GHG emissions will reduce.
2. **Carbon sequestration:** In addition to these measures that reduce GHG emissions, some measures can remove carbon from the atmosphere:
   - **Rangeland management:** Better management of rangelands and pasture can improve livestock production, improve the capacity of livestock to cope during droughts, and may also remove carbon from the atmosphere and store it in rangeland soils, shrubs and trees.
   - **Planting fodder trees:** The leaves of some trees provide good quality fodder and can also increase soil fertility in fields. Trees store carbon in their wood, which is removed from carbon dioxide in the atmosphere through photosynthesis.

3. **Reducing the GHG intensity of livestock production: '**GHG intensity' means GHG emissions per unit of milk, meat or protein produced. Some measures may increase total GHG emissions but reduce GHG emissions per unit of milk, meat or protein produced:
   - **Adopting more productive breeds:** More productive breeds need to consume more energy to grow faster or produce more milk, but the increase in production is greater than the increase in enteric fermentation emissions, so GHG emissions per unit output may decrease.
   - **Improved animal health:** Pests and disease make animals less productive and increase deaths resulting in unproductive GHG emissions. Improving animal health may increase total GHG emissions but also increase the amount of livestock products obtained and marketed.
   - **Promoting poultry and small ruminants:** Poultry, sheep and goats emit fewer GHGs per unit of meat or protein than cattle. If the total national demand is fixed, then a shift in species mix towards lower-emitting animals would reduce total GHG emissions. If consumer demand is growing, then increasing the share of protein marketed from sheep, goats or poultry could reduce GHG emissions per unit of protein marketed.

Climate change will put pressure on land, feed, water and other natural resources. Measures that increase the efficiency of resource use may also reduce GHG emission intensity. So this strategy can be one way to balance livestock and rural development with GHG mitigation objectives. Yet, for many farmers, adopting these measures will require support with access to finance, farming inputs and markets, and technical advice.

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