KEY MESSAGES OF CHAPTER 3

- With GHG emissions along livestock supply chains estimated at 7.1 gigatonnes CO_2-eq per annum, representing 14.5 percent of all human-induced emissions, the livestock sector plays an important role in climate change.

- Feed production and processing and enteric fermentation from ruminants are the two main sources of emissions, representing 45 and 39 percent of sector emissions. Manure storage and processing represent 10 percent. The remainder is attributable to the processing and transportation of animal products.

- Included in feed production, land-use change – the expansion of pasture and feed crops into forests – accounts for about 9 percent of sector emissions.

- Cutting across categories, the consumption of fossil fuels along the sector supply chains accounts for about 20 percent of emissions.

- The animal commodities contributing most of the sector's GHG emissions are beef and cattle milk, contributing 41 and 20 percent of the sector's emissions respectively. Methane from rumination plays an important role.

- Pig meat and poultry meat and eggs contribute respectively 9 percent and 8 percent to the sector's emissions.

THE AGGREGATE PICTURE

3.1 OVERALL EMISSIONS

Important contribution to total human-induced emissions

Total GHG emissions from livestock supply chains are estimated at 7.1 gigatonnes CO_2-eq per annum for the 2005 reference period. They represent 14.5 percent of all human-induced emissions using the most recent IPCC estimates for total anthropogenic emissions (49 gigatonnes CO_2-eq for the year 2004; IPCC, 2007).

This absolute figure is in line with FAO's previous assessment, *Livestock's long shadow*, published in 2006 (FAO, 2006), although it is based on a much more detailed analysis involving major methodological refinements and improved data sets (Chapter 2). Relative contributions cannot be compared because reference periods differ. The 2006 assessment compared its estimate (based on a 2001 to 2004 reference period) with the total CH_4, N_2O and CO_2 anthropogenic emissions estimate provided by the World Resource Institute (WRI) for the year 2000.

Methane: the most emitted gas

About 44 percent of the sector's emissions are in the form of CH_4. The remaining part is almost equally shared between N_2O (29 percent) and CO_2 (27 percent). Livestock supply chains emit:[9]

- 2 gigatonnes CO_2-eq of CO_2 per annum, or 5 percent of anthropogenic CO_2 emissions (IPCC, 2007)
- 3.1 gigatonnes CO_2-eq of CH_4 per annum, or 44 percent of anthropogenic CH_4 emissions (IPCC, 2007)
- 2 gigatonnes CO_2-eq of N_2O per annum, or 53 percent of anthropogenic N_2O emissions (IPCC, 2007)

Emissions of hydrofluorocarbons (HFCs) are marginal on a global scale.

3.2 EMISSIONS BY SPECIES AND COMMODITIES

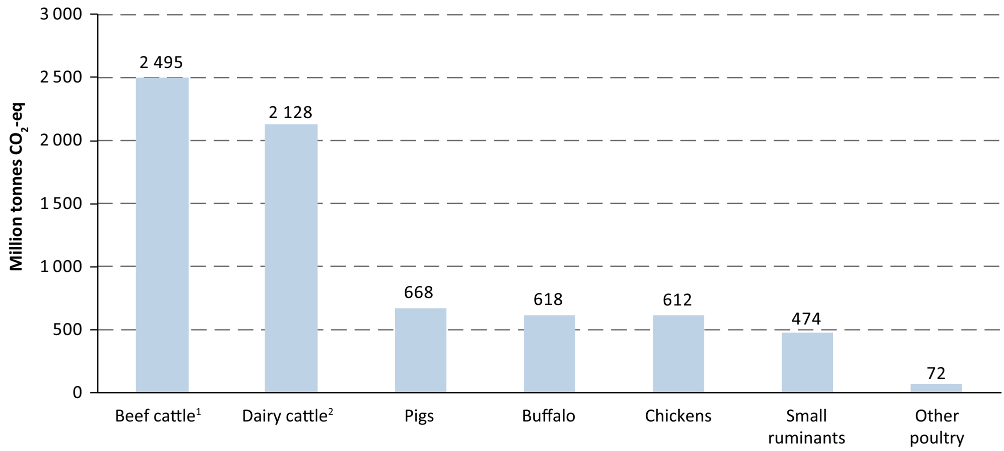
Cattle contribute most to emissions

Cattle are the main contributor to the sector's emissions with about 4.6 gigatonnes CO_2-eq, representing 65 percent of sector emissions. Beef cattle (producing meat and non-edible outputs) and dairy cattle (producing both meat and milk, in addition to non-edible outputs) generate similar amounts of GHG emissions.

Pigs, poultry, buffaloes and small ruminants have much lower emission levels, with each representing between 7 and 10 percent of sector emissions (see Figure 2).

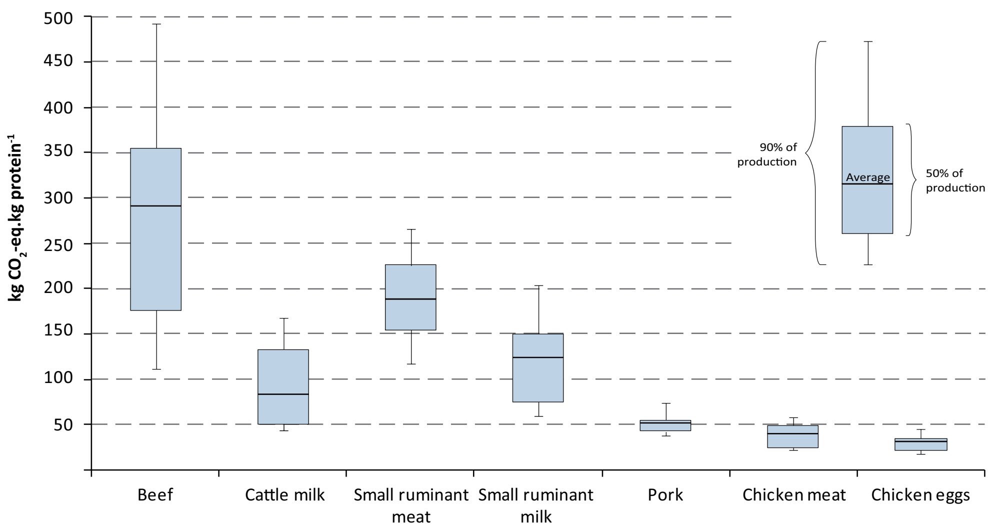
[9] GHG emission values are computed in GLEAM for 2005, while IPCC estimates of total anthropogenic emissions are for 2004.

FIGURE 2. Global estimates of emissions by species*



*Includes emissions attributed to edible products and to other goods and services, such as draught power and wool.
[1] Producing meat and non-edible outputs.
[2] Producing milk and meat as well as non-edible outputs.
Source: GLEAM.

FIGURE 3. Global emission intensities by commodity



Source: GLEAM.

Beef: commodity with highest total emissions and emission intensities

Beef contribute 2.9 gigatonnes CO_2-eq, or 41 percent, and cattle milk 1.4 gigatonnes CO_2-eq, or 20 percent, of total sector emissions. They are followed by pig meat, with 0.7 gigatonnes CO_2-eq, or 9 percent of emissions, buffalo milk and meat (8 percent), chicken meat and eggs (8 percent), and small ruminant milk and meat (6 percent). The rest are emissions from other poultry species and non-edible products.

When emissions are expressed on a per protein basis, beef is the commodity with the highest emission intensity (amount of GHGs emitted per unit of output produced), with an average of over 300 kg CO_2-eq per kg of protein; followed by meat and milk from small ruminants, with averages of 165 and 112 kg CO_2-eq per kg of protein, respectively. Cow milk,[10] chicken products and pork have lower global average emission intensities, all below 100 kg CO_2-eq per kg of edible protein (Figure 3).

Large differences in emission intensity between producers

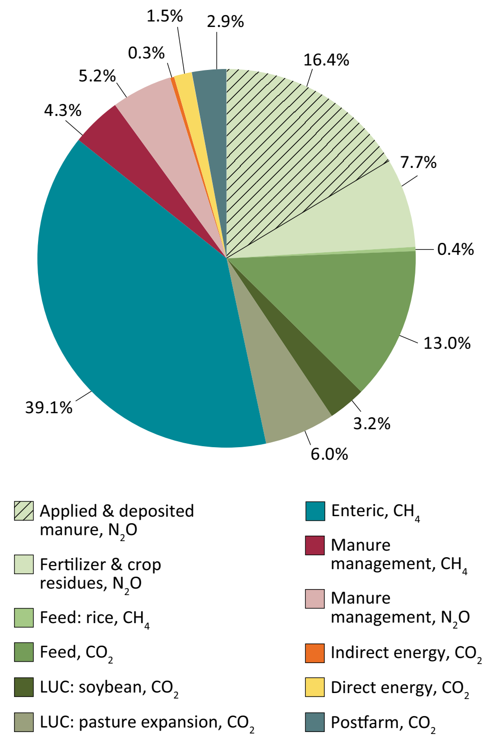
For ruminant products especially, but also for pork and chicken meat and eggs, emission intensities vary greatly among producers (Figure 3). Different agro-ecological conditions, farming practices and supply chain management explain this heterogeneity, observed both within and across production systems. It is within this variability – or gap between producers with highest emission intensity and those with lowest emission intensity – that many mitigation options can be found (Chapter 5 contains a detailed discussion).

3.3 MAIN SOURCES OF EMISSIONS

Emissions from the production, processing and transport of feed account for about 45 percent of sector emissions. The fertilization of feed crops and deposition of manure on pastures generate substantial amounts of N_2O emissions, representing together about half of feed emissions (i.e. one-quarter of the sector's overall emissions). About one-quarter of feed emissions (less than 10 percent of sector emissions) are related to land-use change (Figure 4).

Among feed materials, grass and other fresh roughages account for about half of the emissions, mostly from manure deposition on pasture and land-use change. Crops produced for feed account for an additional quarter of emissions, and all other feed materials (crop by-products, crop residues, fish meal and supplements) for the remaining quarter (Figure 4).

FIGURE 4. Global emissions from livestock supply chains by category of emissions



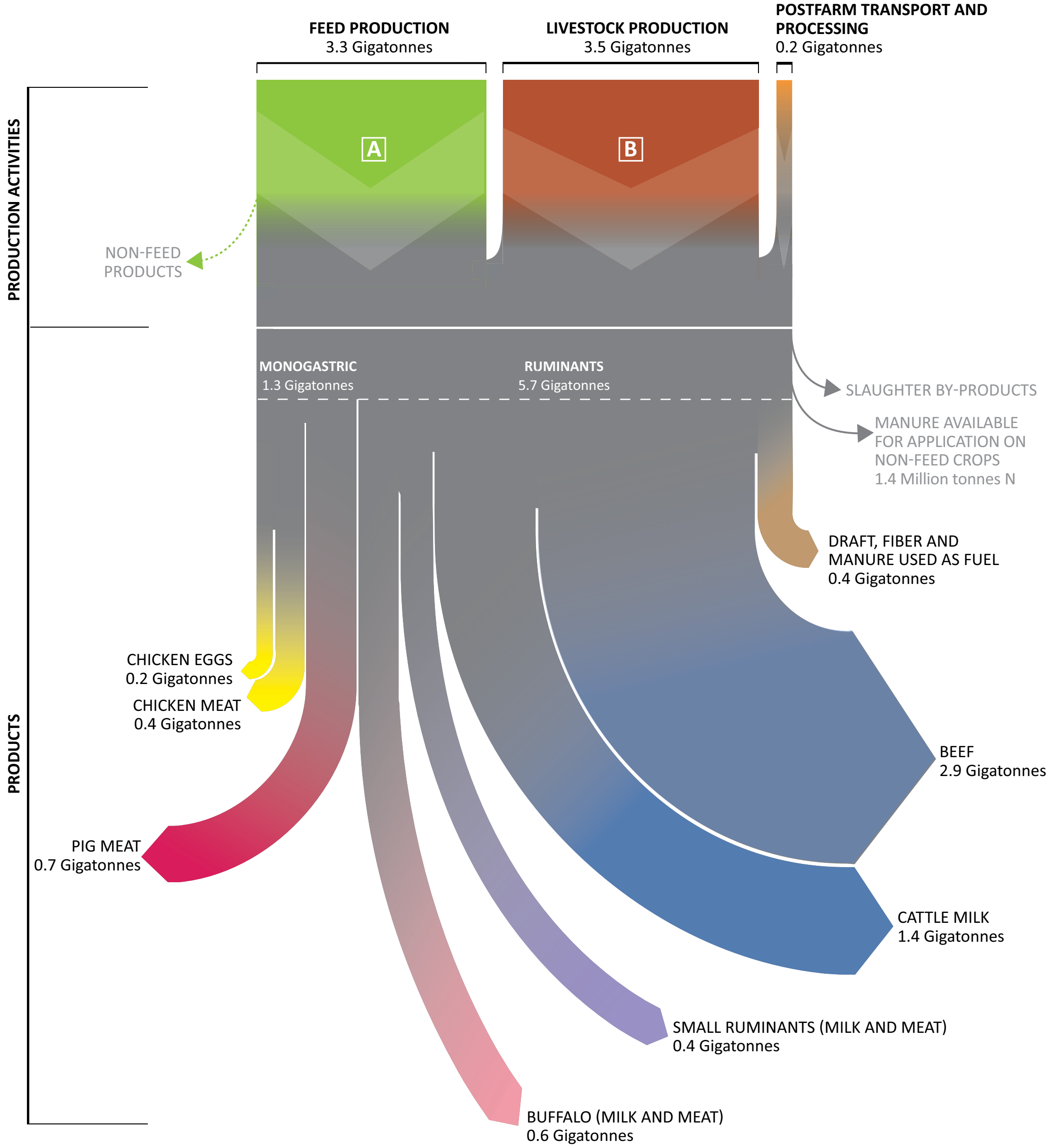
Enteric fermentation is the second largest source of emissions, contributing about 40 percent to total emissions. Cattle emit most of the enteric CH_4 (77 percent), followed by buffalos (13 percent) and small ruminants (10 percent).

Methane and N_2O emissions from manure storage and processing (application and deposition excluded) represent about 10 percent of the sector's emissions.

Emissions associated with energy consumption (directly or indirectly related to fossil fuel) are mostly related to feed production, and fertilizer manufacturing, in particular. When added up along the chains, energy use contributes about 20 percent of total sector emissions.

[10] Throughout this document, milk units are corrected for fat and protein content – see FPCM in Glossary.

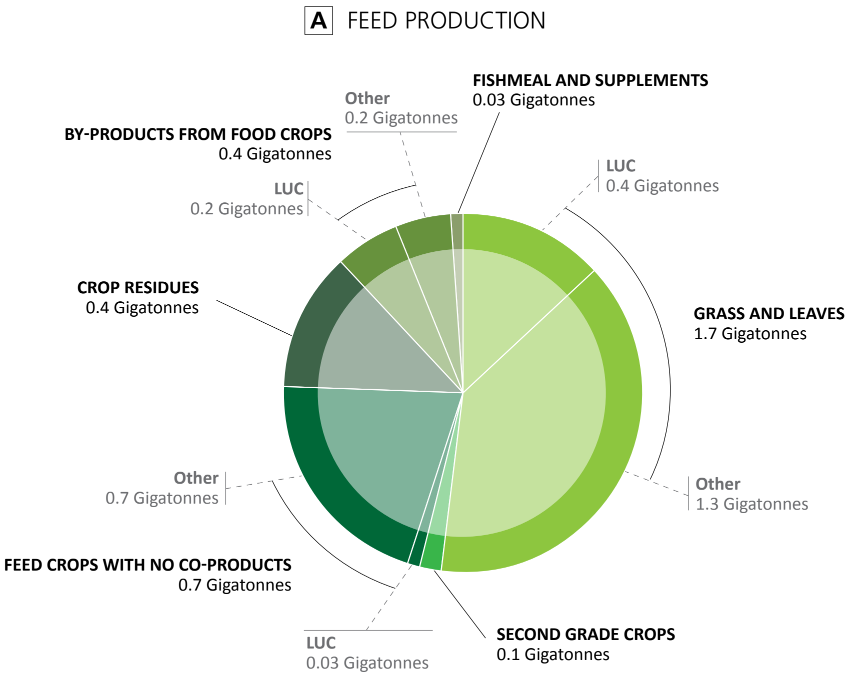
FIGURE 5. GHG emissions from global livestock supply chains, by production activities and products

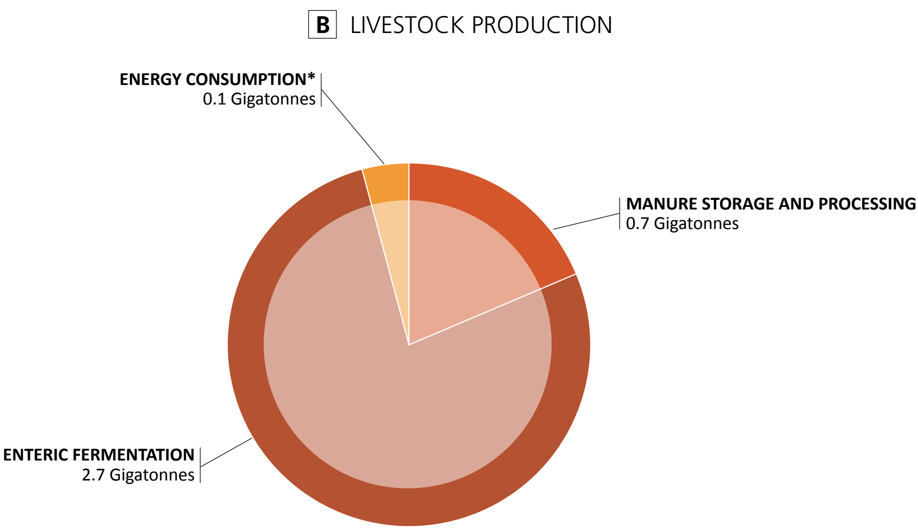


GHG EMISSIONS FROM GLOBAL LIVESTOCK SUPPLY CHAINS, BY PRODUCTION ACTIVITIES AND PRODUCTS

Different types of feed crops are identified: second grade crops (food crops that do not match quality standards for human consumption and that are fed to livestock), feed crops with no co-products (crops cultivated as feed, e.g. maize, barley), crop residues (residues from food of feed crops, e.g. maize stover, straw), and by-products from food crops (by-products from food production and processing, e.g. soybean cakes, bran). The arrow "non-feed products" reminds, that the emissions from the production of feed are shared with other sectors. For example, household food waste used to feed pigs in backyard systems are estimated to have an emission intensity of zero because emissions are entirely attributed to household food. In the same way, emissions related to crop residues (e.g. maize stover) are low because most of the emissions are attributed to the main product (maize grain).

No emissions could be allocated to slaughterhouse by-products (e.g. offal, skins, blood). Case studies show that by-products can add about 5 to 10 percent to the total revenue at slaughterhouse gate, for example for beef and pork in the Organisation for Economic Co-operation and Development (OECD) countries (FAO, 2013a and 2013b). Poultry other than chicken are not included in the graph.





*Embedded energy related to manufacture of on-farm building and equipment is included in this category.
Source: GLEAM.

BOX 1. MAIN EMISSION PATHWAYS

The bulk of GHG emissions originate from four main categories of processes: enteric fermentation, manure management, feed production and energy consumption.

Methane emissions from enteric fermentation. Ruminant animals (cattle, buffalo, sheep and goat) produce CH_4 as part of their digestive process. In their rumen (stomach), microbial fermentation breaks down carbohydrates into simple molecules that can be digested by the animals. Methane is a by-product of this process. Poorly digestible (i.e. fibrous) rations cause higher CH_4 emissions per unit of ingested energy. Non-ruminant species, such as pigs, also produce CH_4 but amounts are much lower by comparison. Enteric fermentation from cattle, buffalo, small ruminants and pigs, but not from poultry, is included in this assessment.

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

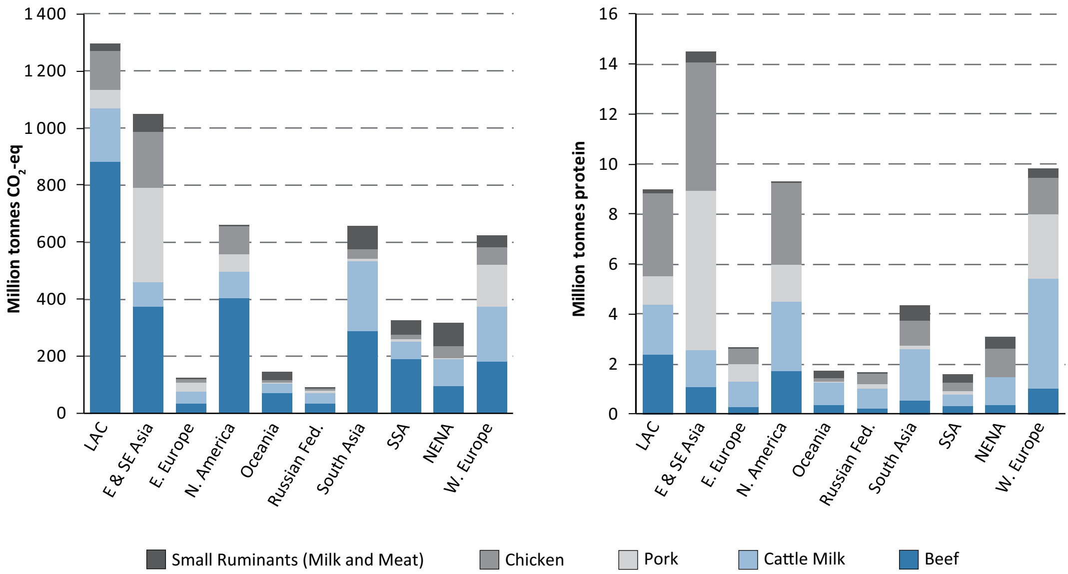
Carbon dioxide and N_2O emissions from feed production, processing and transport. Carbon dioxide emissions originate from the expansion of feed crops and pasture into natural habitats, which causes the oxidation of C in soil and vegetation. They also originate from the use of fossil fuel to manufacture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

Carbon dioxide emissions from energy consumption. Energy consumption occurs along the entire livestock supply chains producing CO_2 emissions. At feed production level, energy consumption mostly relates to the production of fertilizers and to the use of machinery for crop management, harvesting, processing and transportation. Energy is also consumed on the animal production site, either directly through mechanized operations, or indirectly for the construction of buildings and of equipment. Finally, processing and transportation of animal commodities involve further energy use.

Throughout the report, emissions categories are indicated in the following ways in the legend accompanying Figures:

- Feed, N_2O including:
  - Fertilizer & crop residues, N_2O – emissions from fertilizer applied to feed crops and from the decomposition of crop residues;
  - Applied & deposited manure, N_2O – emissions from manure applied to feed crops and pasture or directly deposited on pastures by animals.
- Feed, CO_2 – emissions from the production, processing and transport of feed;
- LUC: soybean, CO_2 – emissions from the expansion of cropland for feed production;
- LUC: pasture expansion, CO_2 – emissions from the expansion of pasture;
- Feed: rice, CH_4 – emissions from rice cultivation for feed purposes;
- Enteric, CH_4 – emissions from enteric fermentation;
- Manure management, CH_4 – emissions from manure storage and processing (application and deposition excluded);
- Manure management, N_2O - emissions from manure storage and processing (application and deposition excluded);
- Direct energy, CO_2 – emissions from energy use on animal production unit (heating, ventilation, etc.);
- Indirect energy, CO_2 – emissions related to the construction of the animal production buildings and equipment;
- Postfarm, CO_2 – emissions related to the processing and transportation of livestock product between the production and retail point.

FIGURE 6. Global livestock production and GHG emissions from livestock, by commodity and regions



Source: GLEAM.

3.4 EMISSIONS BY REGIONS

Regional emissions and production profiles vary widely (Figure 6). Differences are explained by the respective shares of ruminants or monogastrics in total livestock production, and by differences in emission intensities for each product, between regions.

Latin America and the Caribbean have the highest level of emissions (almost 1.3 gigatonnes CO_2-eq), driven by an important production of specialized beef. Although at reduced pace in recent years, ongoing land-use change contributes to high CO_2 emissions in the region, due to the expansion of both pasture and cropland for feed production.

With the highest livestock production and relatively high emission intensities for its beef and pork, East Asia has the second highest level of emissions (more than 1 gigatonnes CO_2-eq).

North America and Western Europe have similar GHG emission totals (over 0.6 gigatonnes CO_2-eq) and also fairly similar levels of protein output. However, emission patterns are different. In North America, almost two-thirds of emissions originate from beef production which has high emission intensities. In contrast, beef in Western Europe mainly comes from dairy herds with much lower emission intensities (Section 4). In North America, emission intensities for chicken, pork and milk are lower than in Western Europe because the region generally relies on feed with lower emission intensity.

South Asia's total sector emissions are at the same level as North America and Western Europe but its protein production is half what is produced in those areas. Ruminants contribute a large share due to their high emission intensity. For the same reason, emissions in sub-Saharan Africa are large, despite a low protein output.