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FAOSTAT ANALYTICAL BRIEF 14

Livestock and environment statistics: manure and greenhouse gas emissions

Global, regional and country trends

1990–2018

>> FAO Statistics Division

HIGHLIGHTS

→ **In 2018, world total livestock manure reached 125 million tonnes of nitrogen (N). Of this, 88 million tonnes N were left on pasture by grazing animals, 34 million tonnes N were treated in manure management systems, and 27 million tonnes N applied to soils for crop production.**

→ **N inputs from livestock manure to agricultural soils increased by 23 percent over 1990–2018, mostly due to increasing inputs from the manure left on pastures.**

→ **The global environmental impact of this manure in 2018 was nearly 60 million tonnes N, of which over 20 million tonnes N dispersed in the air, mostly as ammonia gas, and 35 million tonnes N leached in aquifers and water bodies.**

→ **Livestock-related greenhouse gas (GHG) emissions resulted from manure processes and enteric fermentation, amounting globally to 3.5 billion tonnes CO_2eq in 2018, 15 percent higher than in 1990. These livestock emissions represented two-thirds of all emissions from agriculture.**

→ **In 2018, Asia had the largest share of livestock manure and associated environmental impacts, followed by the Americas, while Africa had the fastest growth since 1990, nearly doubling manure production and associated GHG emissions.**

→ **China, Brazil, India, United States of America were among the top countries generating the most livestock manure and related emissions.**

FAOSTAT LIVESTOCK AND ENVIRONMENT

BACKGROUND

Livestock statistics made available in FAOSTAT provide valuable information to users worldwide. In particular, information on livestock numbers and production, provided by FAO by country and over a long time series, are used as inputs by the academic community to estimate relevant environmental statistics and indicators, including the availability and use of livestock manure and greenhouse gas (GHG) emissions. Such information is key to help designing and implementing sustainable agricultural practices (FAO, 2017; IPCC, 2019). FAOSTAT statistics on livestock type and number are used as input, directly or normalized as *Livestock standard units*, to estimate *Livestock Manure* nitrogen (N) availability, its management and application to agricultural soils. At the same time, these statistics describe N losses through leaching in aquifers and volatilization in the atmosphere. Emissions of GHG are also estimated, in relation to *Manure Management*, *Manure*

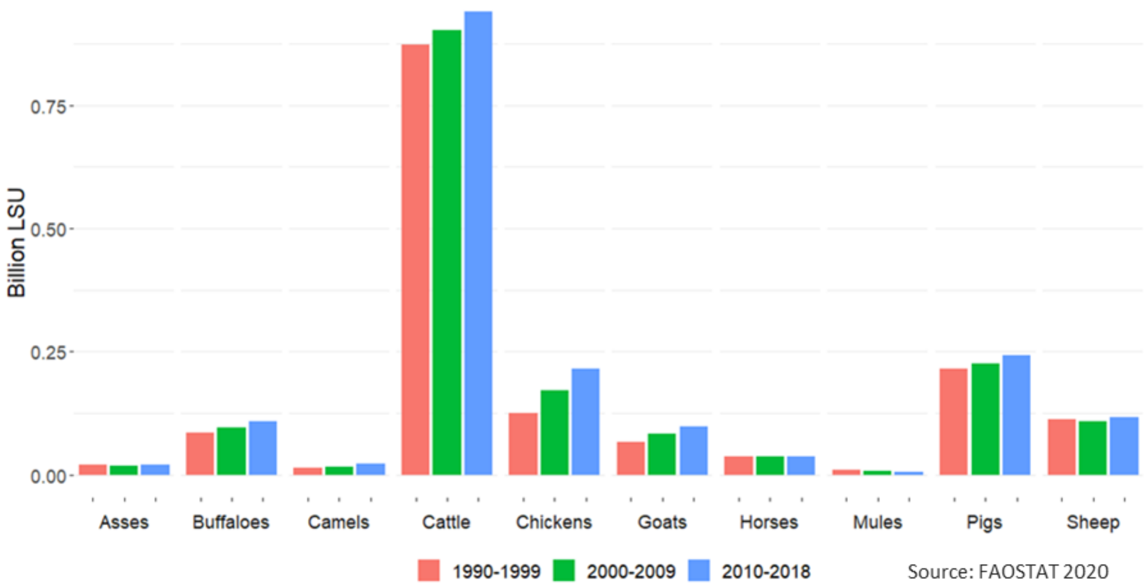
Left on Pasture and Manure applied to soils processes that mainly generate nitrous oxide (N_2O), as well as in relation to Enteric Fermentation processes in ruminant animals that generate methane (CH_4). The above FAOSTAT domains contain information over the time series 1961–2018. This analysis is limited to the period 1990–2018.

GLOBAL

Livestock standard units

In 2018 there were 1.9 billion livestock units (LSU) in total, specifically 965 million cattle; 242 million pigs; 237 million chickens; 226 million sheep and goats. Since 1990, LSU stocks of cattle, buffaloes, sheep and goats, swine had increased by 16 percent, while chicken numbers increased more than twofold (Figure 1).

Figure 1. Distribution of livestock types expressed in standard units (LSU), showing main types in FAOSTAT, over three recent periods, 1990–1999, 2000–2009, and 2010–2018.



Livestock manure

In 2018, world total production of livestock manure was 125 million tonnes N, a 23 percent increase since 1990, consistent with the increase in livestock expressed in LSU. Of this total, manure left on pasture was roughly 88 million tonnes N (+43 percent since 1990), manure treated in management systems was 34 million tonnes N, of which 7 million tonnes N were lost mainly as ammonia and 27 million tonnes N were applied to soils. A small amount, about 3 million tonnes N, was used for other purposes such as heating and construction (Figure 2). These manure management categories have not changed significantly over the 1990–2018 period.

The world total amount of livestock manure deposited in 2018 on agricultural land was therefore 116 million tonnes N, comparable to the amounts of synthetic fertilizers applied mostly on cropland. Over the period 1990–2018, the N inputs from manure treated and applied to soils increased by 4 percent only while the amount of N in manure directly left on pastures increased by 30 percent (Figure 3). This indicates a prevalence of extensive production systems worldwide. At the same time, it suggests that there are significant opportunities for further development of manure management systems.

Figure 2. The global cascade from excretion of nitrogen (N) in livestock manure to applications to agricultural land, including losses from manure management systems, volatilization and leaching (2018 values, in million tonnes).

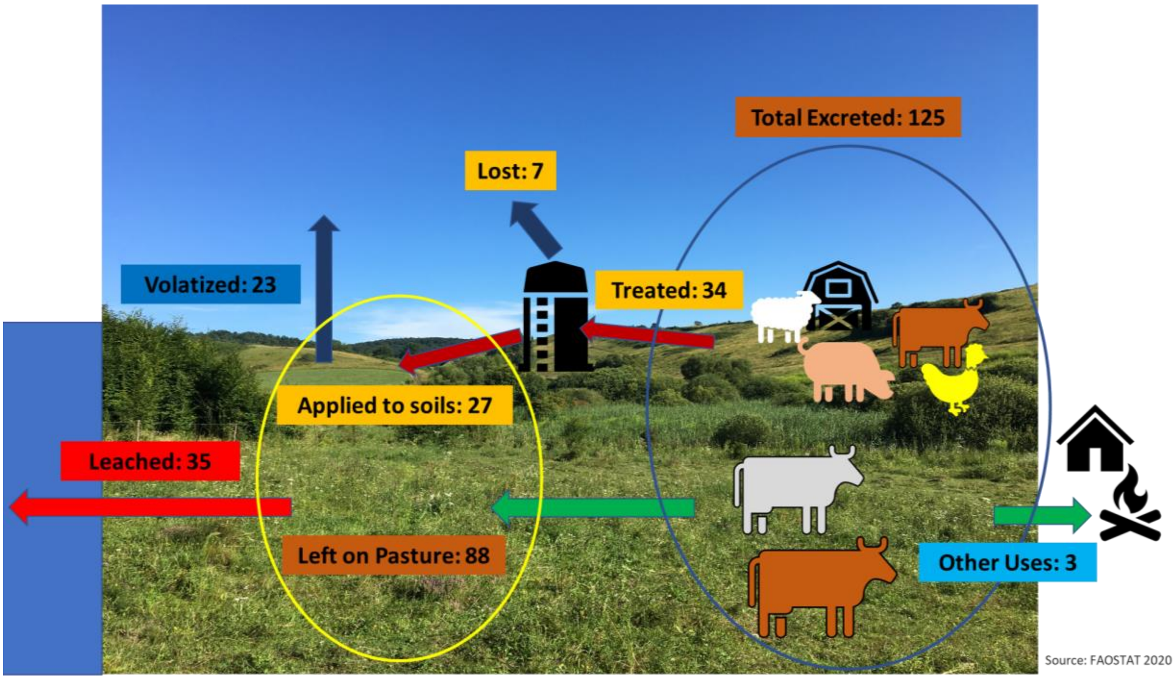
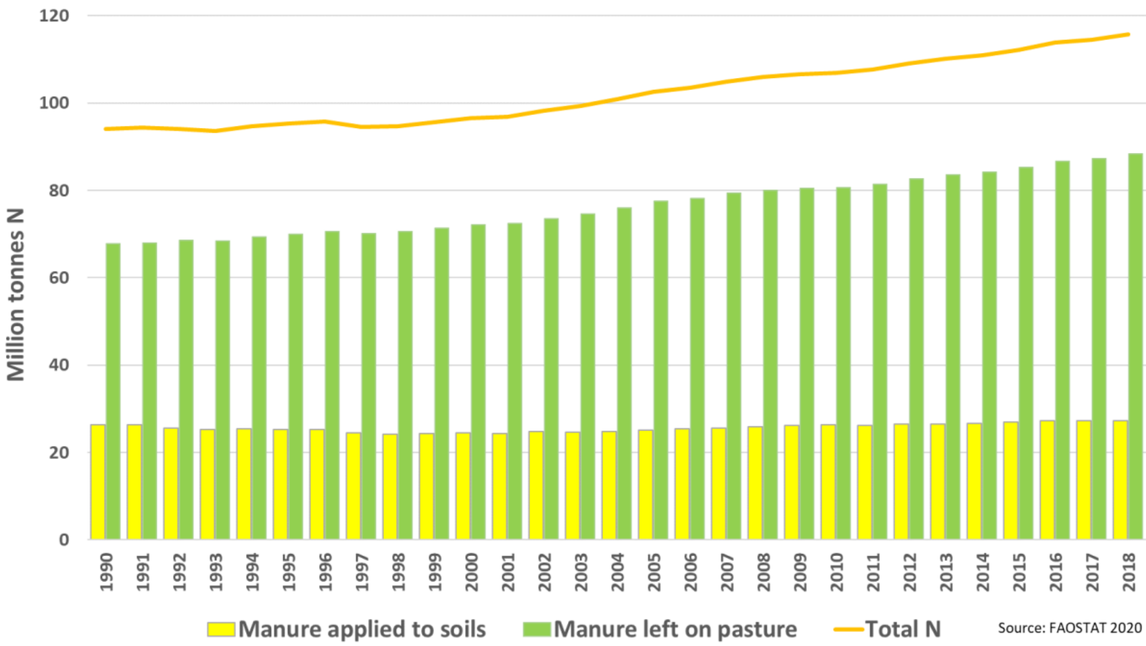


Figure 3. Global nitrogen (N) inputs to agricultural soils from livestock manure left on pastures and manure treated and applied to soils, 1990–2018.

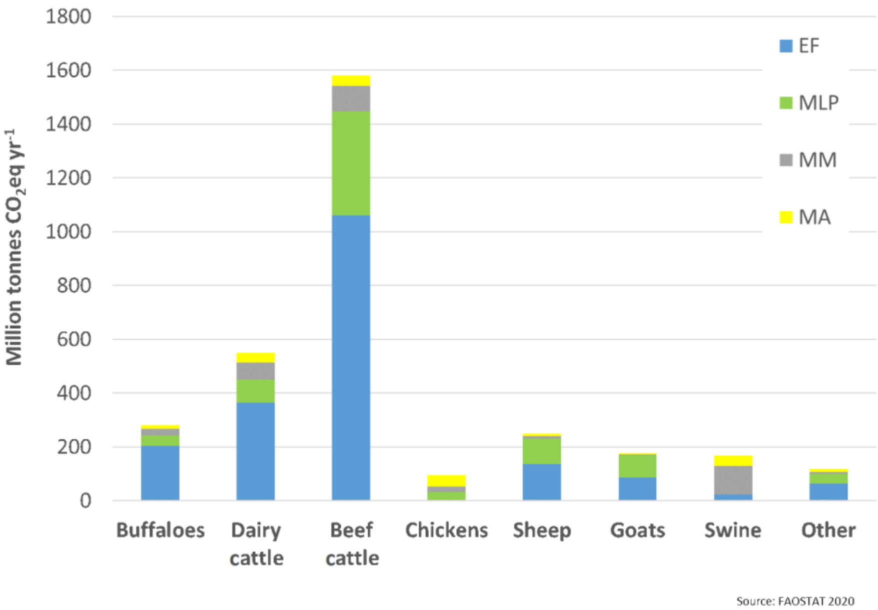


Environmental pollution: volatilization, leaching and GHG emissions

In 2018, the amount of manure N deposited on agricultural soils (i.e. on agricultural land) that volatized in the atmosphere, mostly as ammonia gas, was 23 million tonnes N, leading to negative pressures on local air quality. At the same time, about 35 million tonnes N were lost in soil water and runoff via leaching, leading to pollution of waterways and ultimately of coastal seas (Figure 2 above). In total, completing an environmental N cascade from production to losses, the world total environmental impact in terms of excess N in 2018 was 58 million tonnes N, or 50 percent of the total manure deposited on agricultural land.

In terms of climate impacts, in 2018 annual GHG emissions from livestock manure were more than 1.4 billion tonnes CO_2eq, specifically 875 million tonnes CO_2eq from manure left on pasture, 190 million tonnes CO_2eq from manure applied to soils, as N_2O gas, and 347 million tonnes CO_2eq as methane lost in manure management systems. In addition, annual GHG emissions from enteric fermentation were nearly double those generated from manure processes, with a world total in 2018 of 2.1 billion tonnes CO_2eq. Therefore in 2018 the total impact of livestock was about 3.5 billion tonnes CO_2eq, or about two-thirds of all GHG emissions produced from all production processes located within the farm gate. Livestock species that contributed the most to these emissions, with a focus on enteric fermentation as the dominant GHG source, were cattle (with larger contribution of the non-dairy), contributing annually more than 1.5 billion tonnes CO_2eq, followed by buffalo (240 million tonnes CO_2eq), sheep (140 million tonnes CO_2eq) and goat (110 million tonnes CO_2eq) (Figure 4). Pollution trends observed over the period 1990 to 2018 were the same discussed for the manure amounts, depending almost linearly—in the IPCC default methodology applied—on trends in livestock species composition and numbers.

Figure 4. Distribution of 2018 GHG livestock emissions by animal and pathway. The latter includes CH_4 Enteric Fermentation (EF); N_2O manure left on pastures (MLP); CH_4 and N_2O manure management systems (MM); and N_2O manure applied to soils (MA).



REGIONAL

Livestock standard units

In 2018, more than 40 percent of world livestock, expressed in LSU, was in Asia (770 million LSU), about 30 percent in the Americas (540 milion LSU), and 20 percent in Africa (330 million LSU). Over the period 1990 to 2018, the livestock population grew at an average annual rate of 2.3 percent in Africa, surpassing Asia (1.2 percent) and the Americas (0.8 percent). Conversely, Europe and Oceania had negative average annual growth rates (-1.7 and -0.5 percent, respectively). Because of decreases in agricultural area in these two regions however, the LSU per unit of agricultural land, an indicator of livestock pressure on land resources, kept increasing, at an average annual rate of about 0.3 percent.

Livestock manure

In 2018, livestock manure deposited annually on agricultural soils was largest in Asia (40 million tonnes N, up 50 percent since 1990), followed by the Americas (30 million tonnes N, up 20 percent) and Africa (also 30 million tonnes N, however it doubled since 1990). Conversely in Europe (11 million tonnes N) and Oceania (4.3 million tonnes N), livestock manure decreased since 1990 by nearly 46 and 34 percent, respectively. The decrease observed in Europe was consistent with EU-level regulation, passed at the end of the 1980s, that aimed to limit N pollution from agriculture. Interestingly, Europe was the only region where the amount of livestock manure applied to soils was greater than the amount left on pasture (i.e., on average over the study period, 8.3 vs. 4.8 million tonnes N). This is consistent with a preponderance, compared with other regions, of intensive livestock production with limited grazing.

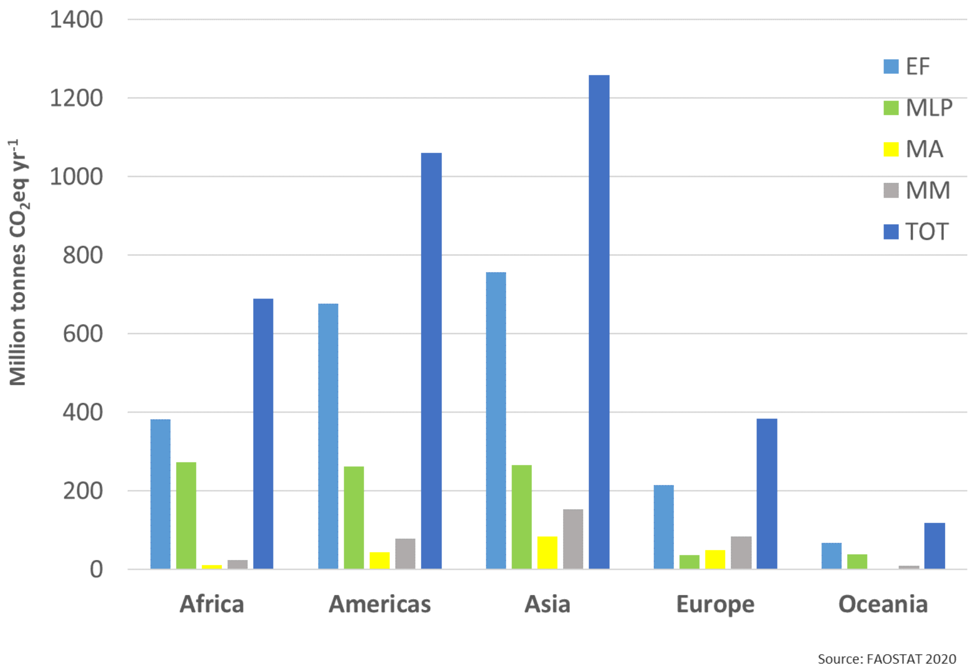
Environmental pollution: volatilization, leaching and GHG emissions

In 2018, N pollution in air and waters followed the same patterns found for livestock manure deposited on agricultural land, i.e., greatest in Asia, followed by the Americas and Africa, and representing roughly 50 percent of the manure N applied in each continent.

In terms of livestock-related GHG emissions, in 2018 Asia and the Americas were the dominant regions, each emitting annually more than 1 billion tonnes CO_2eq, through a combination of emissions from enteric fermentation and manure processes (Figure 5). In each region, in line with world total composition, the larger emission source was methane from enteric fermentation, followed by N_2O emissions from livestock manure left on pasture—where Africa (275 million tonnes CO_2eq) leads Asia (265 million tonnes CO_2eq) and the Americas (262 million tonnes CO_2eq). The exception was Europe, where the second largest GHG source after enteric fermentation was manure management (84 million tonnes CO_2eq), and where, in agreement with previous observations on manure applications, emissions from manure applied to soils were larger than those on pastures.

GHG emissions grew fastest in Africa over the period 1990–2018, at an average annual growth rate of 2.4 percent. They decreased instead in Europe and Oceania, respectively at average annual rates of -2.2 and -1.1 percent.

Figure 5. Regional distribution of 2018 GHG emissions from livestock processes, including enteric fermentation (EF), manure left on pasture (MLP), and manure applied to soils (MA), manure management (MM). Total emissions (TOT) also shown.



COUNTRY

Livestock standard units

In 2018 China had the largest population of livestock, expressed in standard units (270 million LSU), followed by India (180 million LSU) and Brazil (170 million LSU).

At the same time, livestock pressure on land, expressed in LSU per agricultural land area, was highest in countries with little agricultural land but relatively high livestock numbers. In 2018, these included Singapore (52 LSU/ha), Brunei Darussalam (12 LSU/ha) and China, Hong Kong SAR (11 LSU/ha). These high densities well capture food systems that are characterized by high intensive production with limited grazing, often in conjunction with high levels of feed imports.

Livestock manure

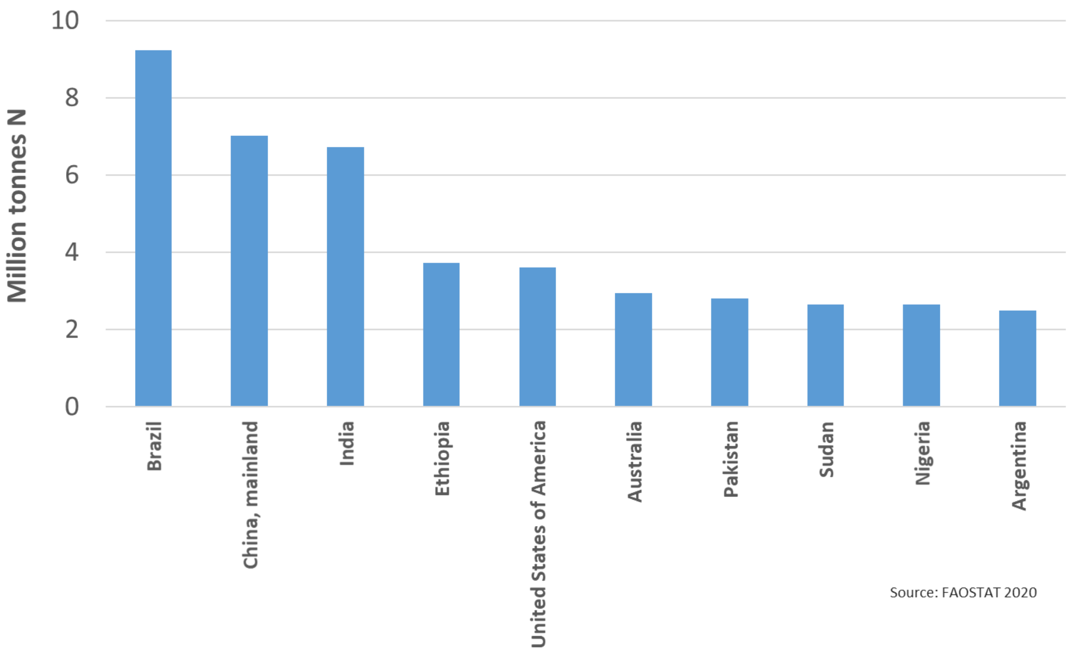
In 2018, Brazil, China, India, Ethiopia and the United States of America were the countries with the most livestock manure N left on pasture (mainly by cattle), with annual amounts ranging 3–9 million tonnes N (Figure 6).

In Brazil, the most substantial contribution (more than 80 percent) was from non-dairy cattle; conversely in China small ruminants, particularly goats, were the dominant source of livestock manure (nearly 30 percent).

In 2018, China also had the largest amount of livestock manure N applied to soils (4.7 million tonnes N). The United States of America and India followed with about 2.5 and 2.3 million tonnes N respectively.

Finally, in terms of manure treated by livestock type, in 2018 swine contributed 30 percent to the total manure treated and applied to soils in China, whereas in the United States of America the largest source was dairy cattle (23 percent).

Figure 6. Top ten countries in terms of 2018 amount of manure N left on pasture by grazing animals.



Source: FAOSTAT 2020

GHG emissions

The methane (CH_4) generated from enteric fermentation, mostly of ruminants, is the main contributor to world total livestock GHG emissions. In 2018, the country with the largest annual emissions from enteric fermentation, was India (292 million tonnes CO_2eq, mainly from its dairy cattle), followed by Brazil (265 million tonnes CO_2eq, mainly from beef cattle), China (140 million tonnes CO_2eq), the United States of America (127 million tonnes CO_2eq), and Pakistan (93 million tonnes CO_2eq) (Figure 7).

In terms of annual GHG emissions from livestock manure treated and applied to agricultural soils, in 2018 the top countries were China, the United States of America, India and Brazil, with emissions about one order of magnitude less than enteric fermentation, i.e., ranging 11–33 million tonnes CO_2eq. The contribution by type of animal was more varied, with swine and poultry contributing significantly in addition to cattle. Several European countries were among the top ten in 2018 in this category (Figure 8), as a consequence of the importance of this emission source in the region.

Figure 7. Top ten countries in terms of 2018 GHG emissions from enteric fermentation.

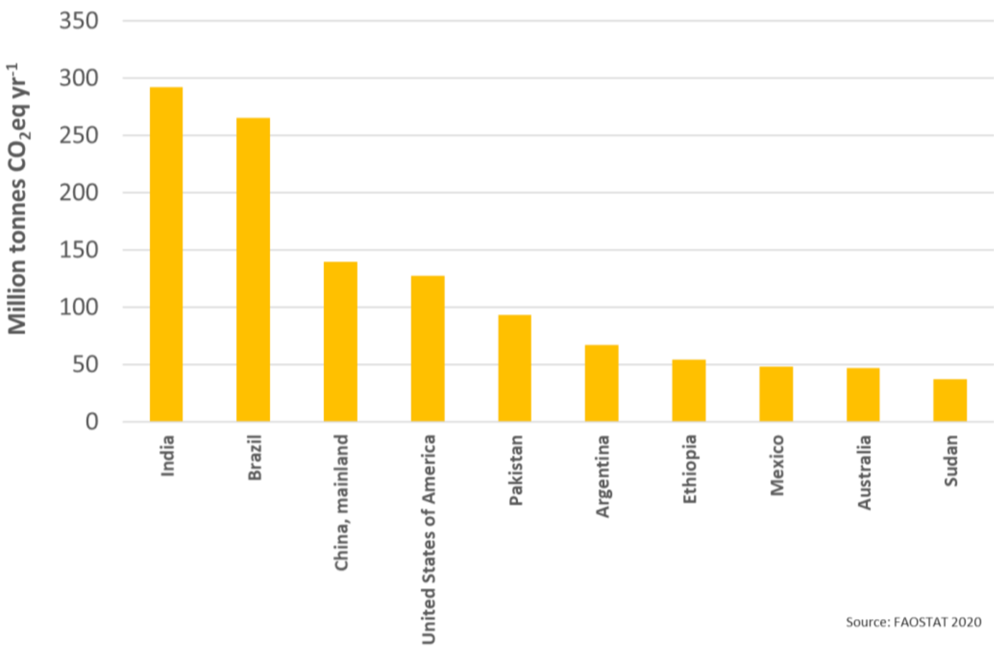
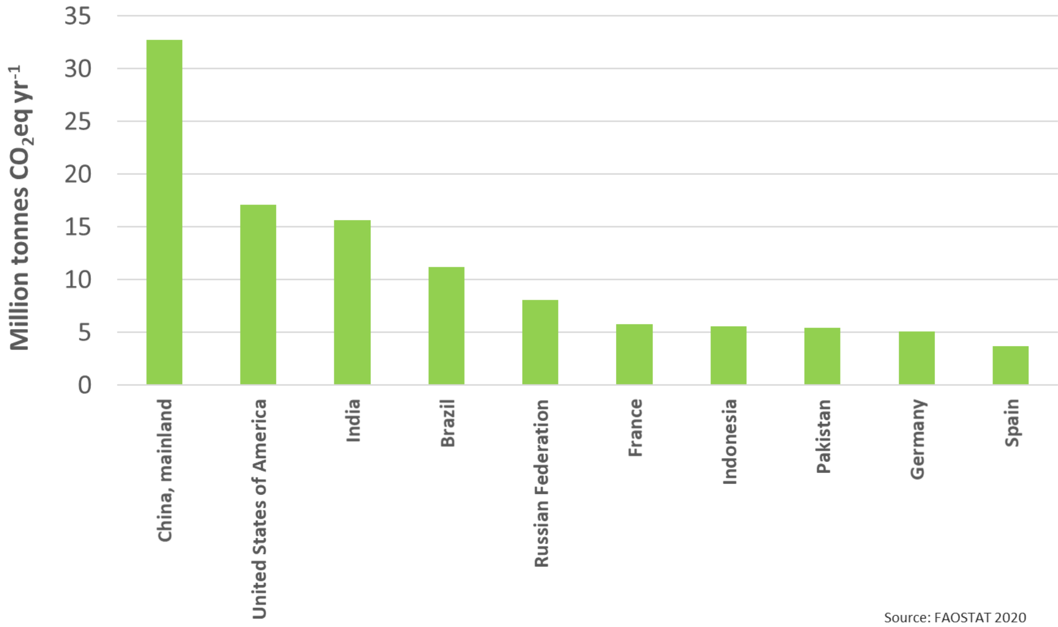
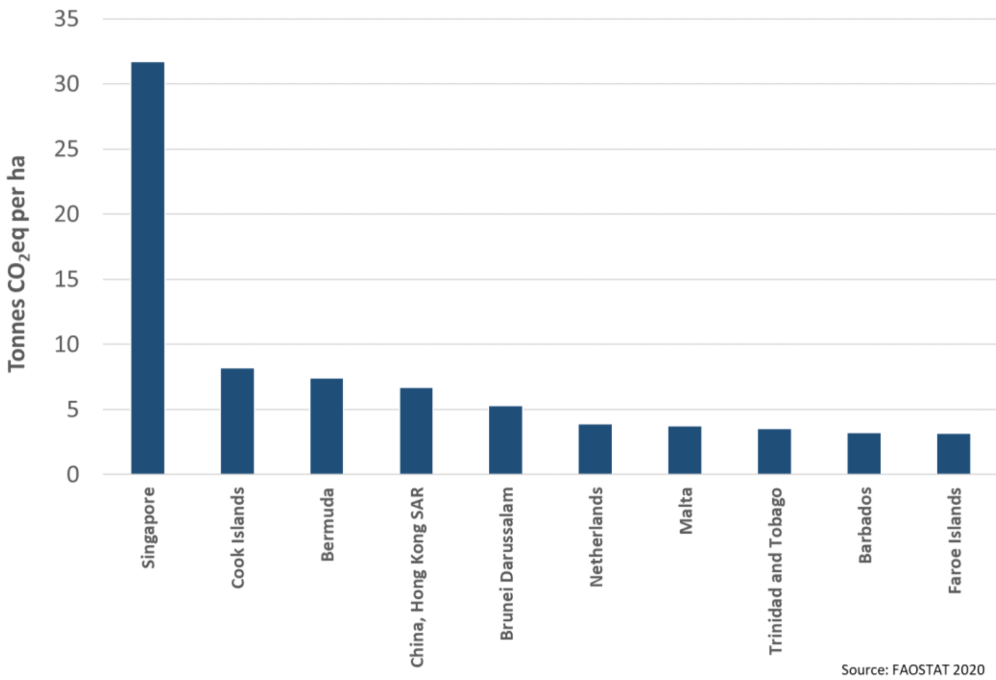


Figure 8. Top ten countries in terms of 2018 GHG emissions from manure applied to soils.



As found for manure, while the figures above reflect livestock numbers and are thus dominated by large countries with strong agricultural sectors, GHG emissions per hectare of agricultural land reflect the high environmental pressures of livestock in countries with limited land and high intensity of production. For instance, in 2018, total GHG per hectare of agricultural land was highest in Singapore (more than 30 tonnes CO_2eq per hectare), followed by a number of small island or city states with rates between 2.5–7.5 tonnes CO_2eq per hectare. The Netherlands were included in this particular list (Figure 9).

Figure 9. Top ten countries in terms of 2018 total livestock-related GHG emissions per hectare of agricultural land.



EXPLANATORY NOTES

- The estimates of livestock manure are computed and disseminated by livestock type, by country, and in regional aggregates, for the period 1961–2018. They use as input official FAOSTAT statistics of animal stocks and of producing animals and apply N excretion and other relevant coefficients as defined in the Tier 1 (default) approach of the 2006 Intergovernmental Panel on Climate Change Guidelines for National GHG Inventories (IPCC, 2006). The full method is described in the online metadata sheets of the FAOSTAT Livestock Manure domain, as well as in the FAO report on livestock manure statistics (FAO, 2017).
- The FAOSTAT emissions, including those from enteric fermentation and manure management and application processes, are computed from the manure statistics, also following Tier 1 IPCC 2006 Guidelines for National GHG Inventories, specifically vol. 4, ch. 10 and 11. GHG emissions are provided by country, regions and special groups, with global coverage, over the period 1961–2018, and with projections for the years 2030 and 2050. They are expressed in single component gases CH_4 and N_2O, as well as cumulatively in CO_2eq (using the IPCC Second Assessment Report global warming potentials), by livestock species (asses, buffaloes, camels, dairy and non-dairy cattle, goats, horses, llamas, mules, sheep, swine breeding and market swine) and by species aggregates (all animals, camels and llamas, cattle, mules and asses, sheep and goats, swine). Implied emissions factors for CH_4, N_2O and relevant activity data are also provided.
- The FAOSTAT statistics of livestock manure flows to agriculture and the environment, as well as of GHG emissions, are a unique knowledge product supporting research and applications of users around the world and as such are used as input in many international studies (e.g., IPCC, 2019). At the same time, there are known limitations to estimates made with the IPCC Tier 1 approach, notably a lack of important detail on key drivers such as differences in livestock managment systems, feeding regimes, etc., which would become inportant when analysing future mitigation options (see, e.g., FAO 2017).
- Estimates of livestock standard units, livestock manure and livestock emissions are made using as inputs stocks of the following animal categories: buffalo, sheep, goats, camels, llamas, horses, mules, asses, ducks, and turkeys, dairy and non-dairy cattle, chickens layers and broilers and market and breeding swine, taken from the relevant FAOSTAT production domains. A more detailed decription of data sources is available in FAOSTAT metadata sheets.
- In 2018, the databases covered 191 countries and 25 territories. The FAOSTAT domains Livestock Manure disseminates information on N inputs from livestock manure and their deposition on pasture, treatment in manure management systems, and availability for application to agricultural soils as organic fertilizer. Specific data on the N losses to air and water are also disseminated. Emissions from livestock are disseminated in the FAOSTAT Emissions-agriculture sub-domains “Manure Management”, “Manure left on pasture,” “Manure applied to soils” and ‘’Enteric Fermentation’’.

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