4. Results

4.1 CATTLE

This study estimates that in 2005, total emissions from cattle production amount to 4 623 million tonnes CO_2-eq. These emissions include emissions associated with the production of meat and milk, emissions related to land-use change, emissions associated with post farmgate activities, and emissions related to non-edible products and services, draught power and manure used for fuel.

The following sub-sections present the emissions associated with edible products (meat and milk) as well as a disaggregated overview of the contribution of production systems and regions to emissions.

4.1.1 Total production, absolute emissions and emission intensities

In 2005, the global cattle sector produced approximately 508.6 million tonnes of milk and 61.4 million tonnes of beef, of which 56 percent of beef was produced by the specialized beef sector and 44 percent by the dairy herd. Table 4 reports the volume of production, absolute emissions and average GHG emissions per kg of milk and meat for the dairy and beef subsectors.

Globally, about 4 255.9 million tonnes of CO_2-eq were emitted by the global cattle sector in 2005; of this 1 419.1 million tonnes were associated with milk production and 2 836.8 million tonnes with beef production.[5] This is equivalent to 2.8 kg CO_2-eq per kg of fat and protein corrected milk and 46.2 kg CO_2-eq per kg of carcass weight.[6]

Regarding beef production from the cattle sector, there is a distinct difference in emission intensity between beef produced by the dairy herd and the specialized beef herd; the carbon intensity of beef from the specialized beef herds is almost fourfold that produced from the dairy herd (67.8 vs. 18.4 kg CO_2-eq per kg CW) (Table 4). The low emission intensity for dairy meat is caused by the fact that both milk and meat are produced by the dairy herd. Because a large proportion of the

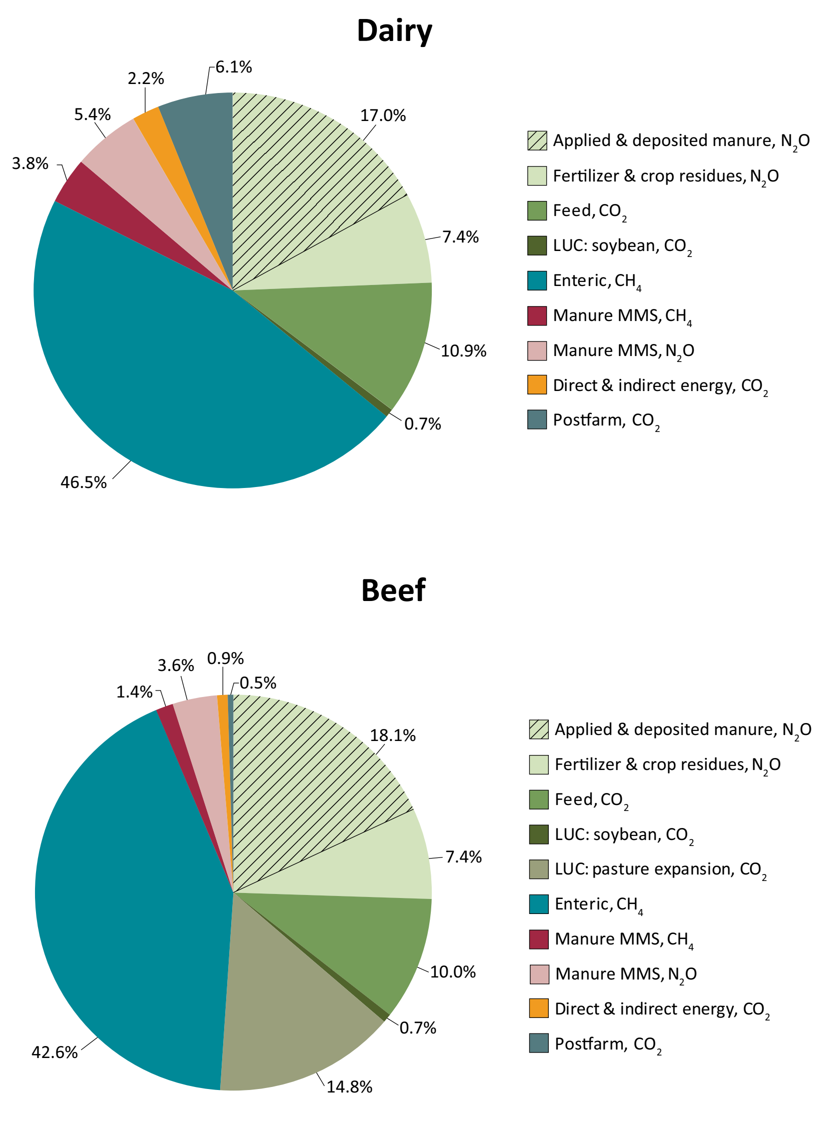
Table 4. Global production, absolute GHG emissions and emission intensities for milk and beef

Cattle herd	Production (million tonnes)		Absolute emissions[1] (million tonnes CO_2-eq)		Average emission intensity (kg CO_2-eq/kg product)	
	Milk[2]	**Meat[2]**	**Milk**	**Meat**	**Milk[2]**	**Meat[2]**
Dairy	508.6	26.8	1419.1	490.9	2.8	18.4
Beef	-	34.6	-	2345.9	-	67.8
Totals	**508.6**	**61.4**	**1419.1**	**2836.8**	**2.8**	**46.2**

[1] Absolute emissions include emissions from production, post farmgate processes and land-use change.
[2] Functional unit for milk and meat defined as fat and protein corrected milk and carcass weight.
Source: GLEAM.

[5] Unless otherwise stated, the term "beef" refers to meat from dairy and specialized beef herds.
[6] Does not include emissions associated to slaughter by-products. See Appendix F for discussion of effects on results.

Figure 5.
Relative contribution of different processes to total GHG emissions from the global cattle sector

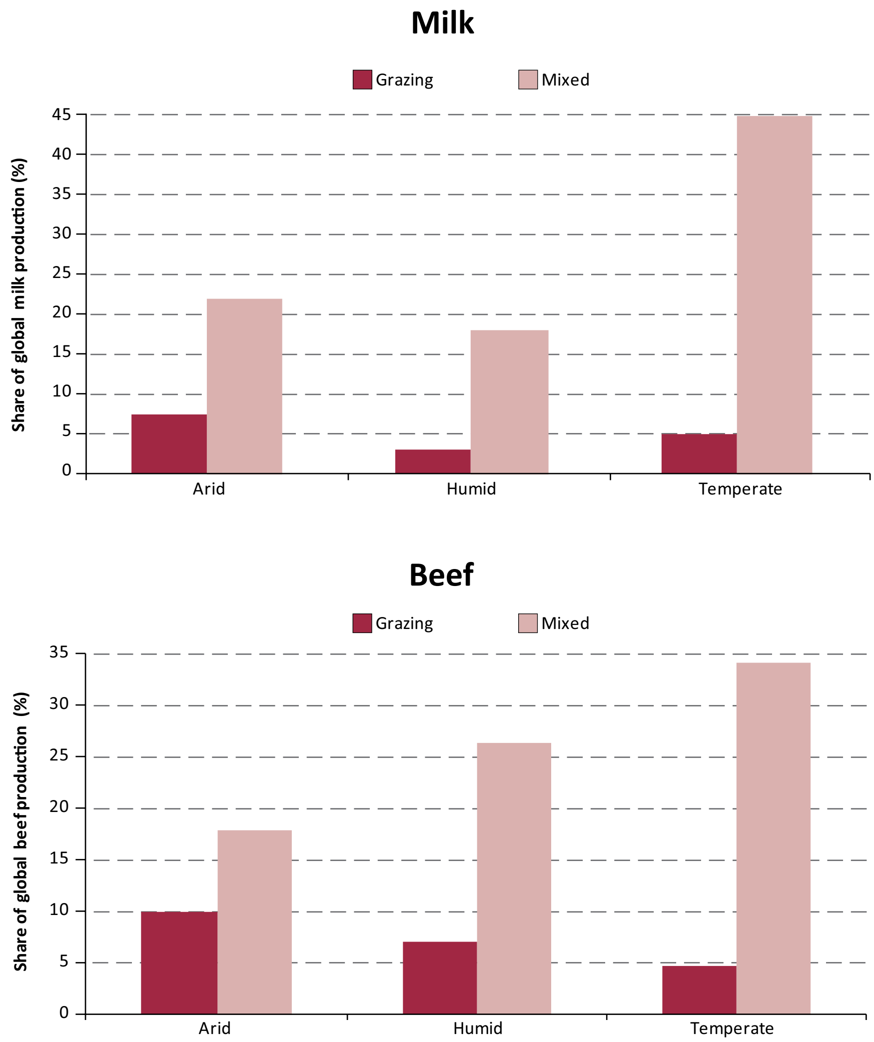


Source: GLEAM

total protein from the dairy herd originates from milk (see Map 6 in Appendix G), a greater proportion of the emissions from dairy herd is attributed to milk. Consequently, this reduces the GHG emissions attributed to meat from culled dairy cows and related meat production from surplus animals.

On the other hand, the specialized beef herd carries the entire burden of emissions because only one product is produced, while the reproductive overhead (cows, bulls and replacement animals) is almost the same. The overhead costs of the cow in dairy-based production systems are largely attributed to milk while in the specialized beef system the full costs are allocated to those animals destined for beef production.

Figure 6.
Contribution to total milk and beef production by production systems and agro-ecological zone[1]



[1] Excluding post farmgate and land-use change emissions (pasture expansion).
Source: GLEAM.

The relative contribution of production processes and gases to the emissions profile for milk and beef at global level is illustrated in Figure 5. A significant share of total GHG emissions is from CH_4 which accounts for 50 percent and 44 percent of the total emissions, with enteric fermentation contributing more than 92 percent and 97 percent of the total CH_4 emissions in dairy and beef production.

In both dairy and beef herds, N_2O emissions amounted to relatively similar proportions of the total carbon footprint – approximately 29 percent of the emissions. Main sources of N_2O emissions include N_2O from manure deposited during grazing and feed production.

On a global scale, CO_2 emissions represent 20 percent and 27 percent of the dairy and beef emission profiles, respectively. The difference in CO_2 emissions between dairy and beef herds is due to the CO_2 emissions from land-use change associated with the expansion of grassland into forest areas which accounts for 14.8 percent of the total emissions related to beef production and 55 percent of the CO_2 emission.

4.1.2 Emissions by production system and agro-ecological zone

Grass-based systems and mixed livestock production systems contribute 22 and 78 percent of global beef production, and 15 percent and 84 percent of global milk production, respectively (Figure 6).

Average emission intensities for milk and beef produced in grazing and mixed farming systems were estimated at 2.9 and 2.5 kg CO_2-eq/kg FPCM and 42.0 and 38.4 kg CO_2-eq/kg CW, respectively. The variation in emission intensity between the two systems is explained by several factors such as the generally higher slaughter weights, lower age at calving, reduced time to slaughter, and lower mortality rates and better feed quality in mixed farming systems.

Lowest emission intensity in milk and beef production corresponds to the temperate zones in both grassland-based and mixed farming systems (Figures 7 and 8), where productivity is rather high and CH_4 from enteric fermentation is low as a consequence of high digestibility of the feed in these zones. Concomitantly, temperate zones have slightly higher emissions associated with CO_2 feed compared with the humid and arid areas as a result of the high dependency on imported concentrate feed and synthetic fertilizer use in feed production. Lower emission intensity of beef produced in temperate zones is also related to the importance of dairy production in these areas; about 44 percent of the beef from the dairy sector is produced in temperate zones. Beef from the dairy sector as a consequence of the dairy system characteristics comes with discounted emissions because a large share of the emissions related to the meat from culled breeding animals is allocated to milk production.

Enteric CH_4 is the largest source of emissions in all systems; however it is highest in arid and humid zones of both grazing and mixed farming systems where feed, for the most part, is of low quality.

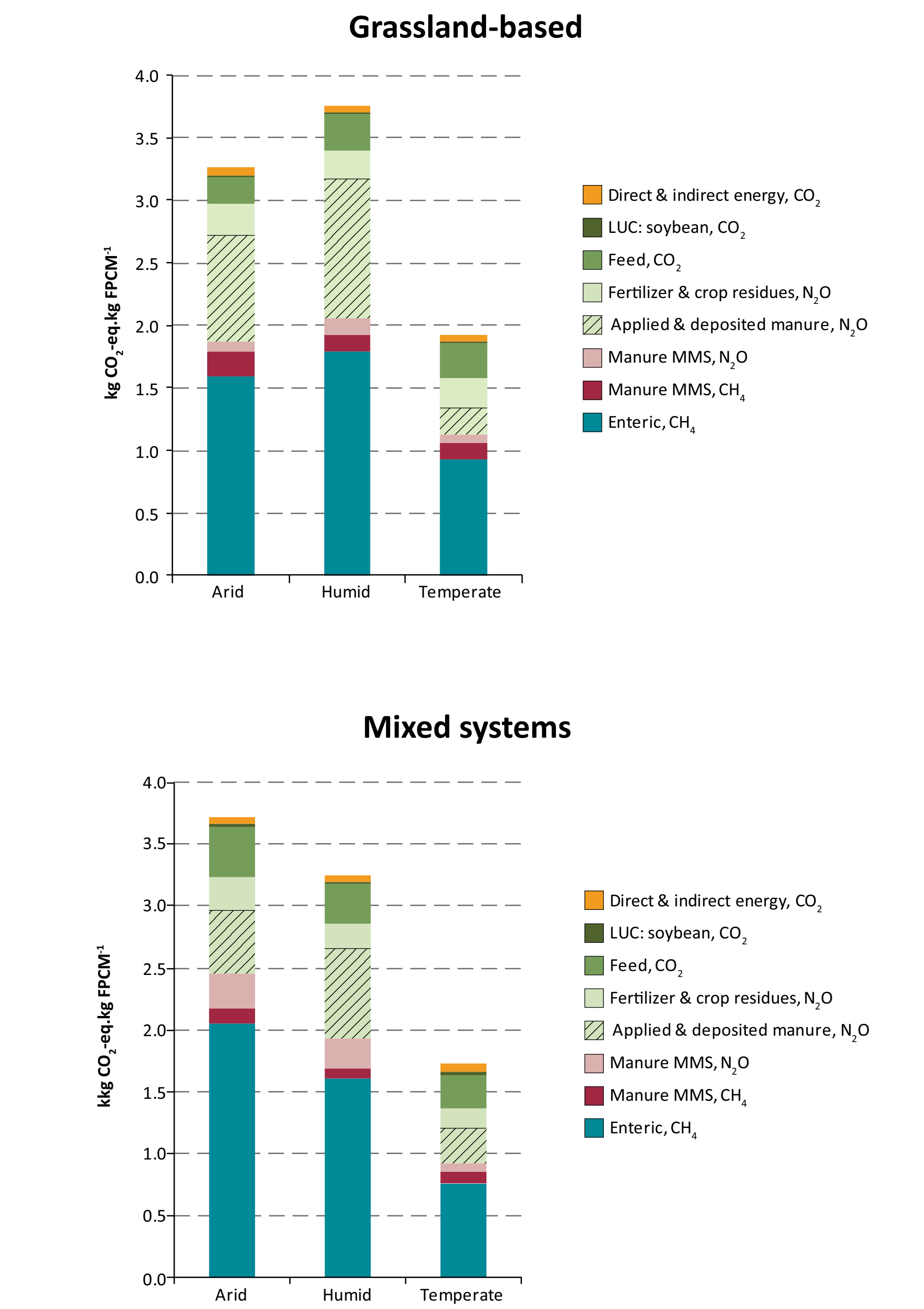
Nitrous oxide emissions from feed production are dominant in both grazing arid and humid zones resulting from manure deposited on pasture during grazing, while in the mixed systems high N_2O emissions are not only associated with manure deposition but also use of synthetic fertilizer in feed production (see Section 5.2).

On the other hand, CH_4 emissions from manure management in both systems are negligible and this is explained by the high proportion of manure that is managed in dry MMS such as drylots or solid systems. Nitrous oxide from manure management is generally low especially in grazing systems because animals are grazing most of the time and manure is mostly deposited on pasture.

4.1.3 Regional emissions, production and emission intensities

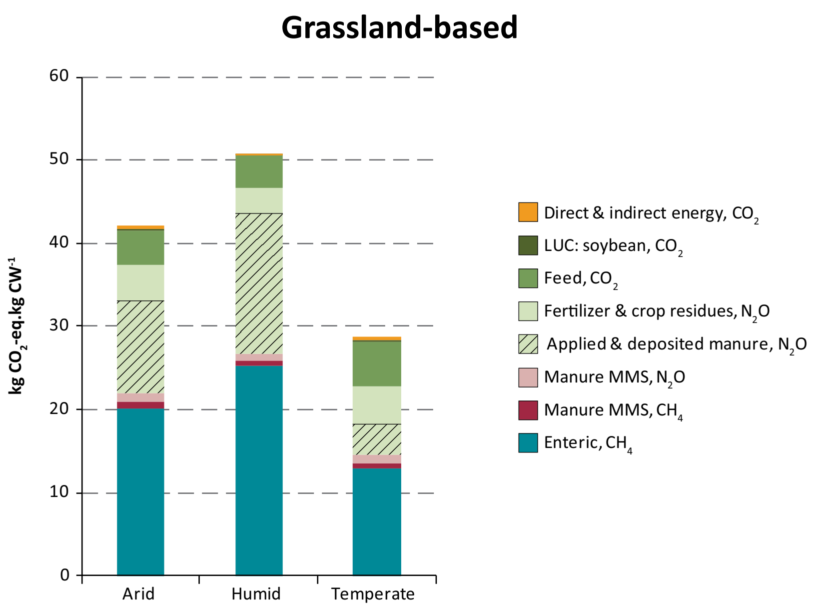
In terms of total production, approximately 67 percent of the total protein from the global cattle sector is from milk. However, this global estimate obscures variations at regional level, where large differences exist both in terms of production and emissions. With the exception of Latin America and the Caribbean, the contribution of milk protein to the total protein from the cattle sector on average ranges from 56 percent in sub-Saharan Africa to 81 percent in Western Europe (Figure 9; Map 6 in Appendix G). In Latin America, meat protein contributes about 54 percent of the

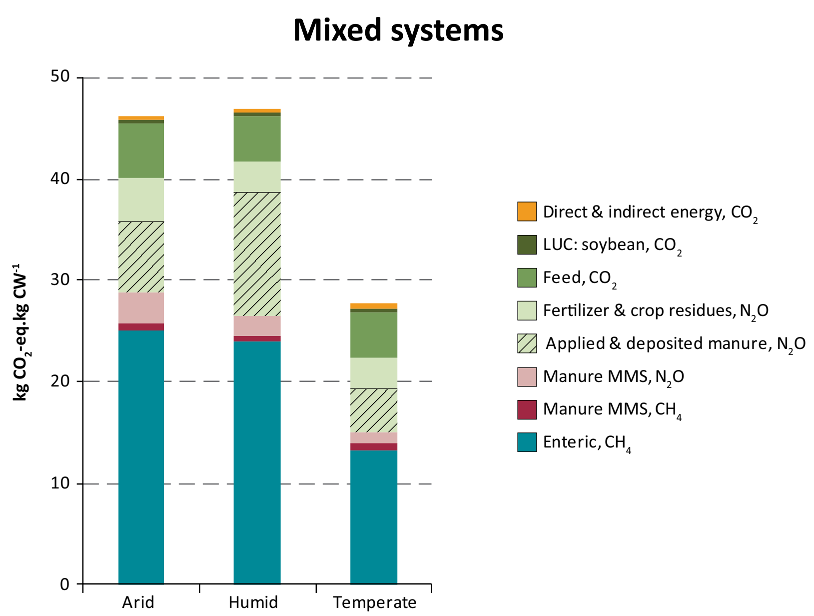
Figure 7.
Emission intensities for milk by production system and agro-ecological zone[1]



[1] Excluding post farmgate and land-use change emissions (pasture expansion).
Source: GLEAM.

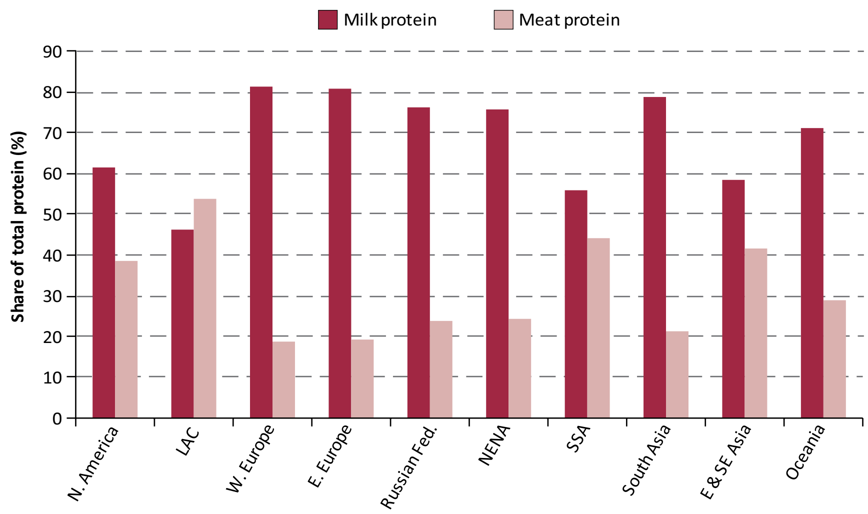
Figure 8.
Emission intensities for beef by production system and agro-ecological zone[1]





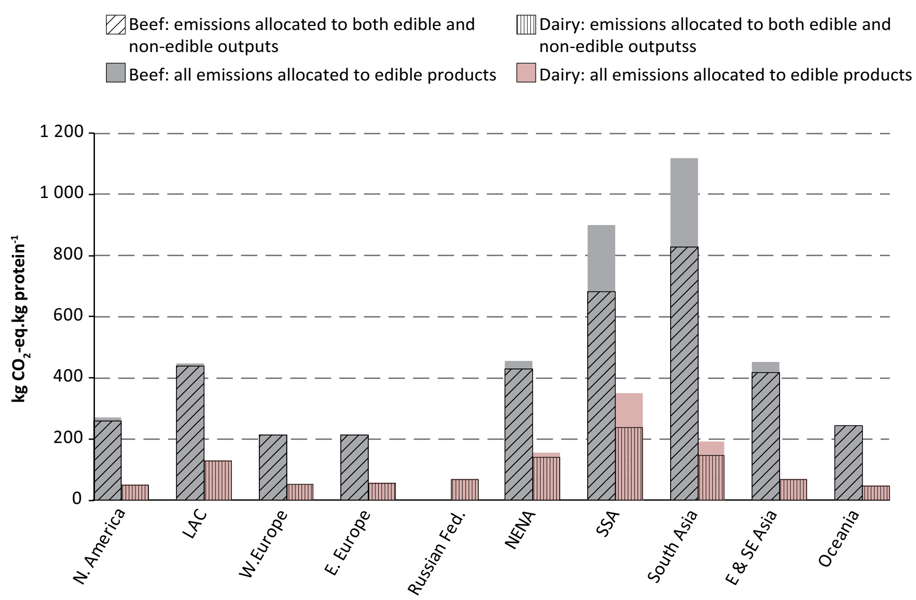
[1] Excluding post farmgate and land-use change emissions (pasture expansion).
Source: GLEAM.

Figure 9.
Regional contribution to milk and meat protein



Source: GLEAM.

Figure 10.
Emissions per kg meat and milk protein, comparing allocation of emissions to different outputs



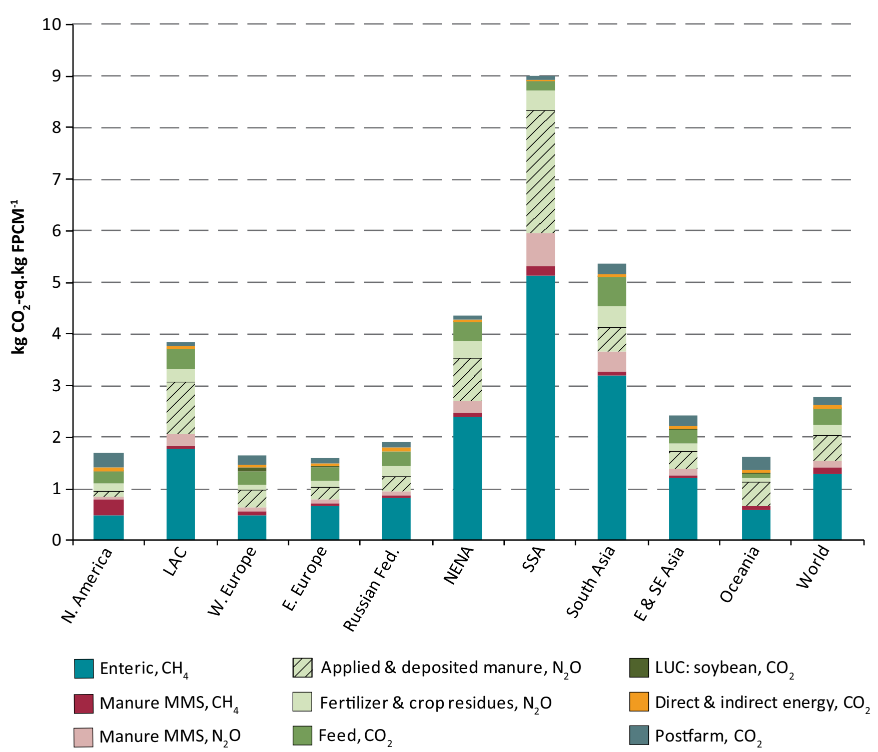
Source: GLEAM.

total protein from cattle, mainly because the emphasis is on beef production rather than dairy. In the other world regions, meat protein ranges between 18 percent in Europe to 44 percent in sub-Saharan Africa.

Figure 10 presents a regional comparison of emission intensities for two computation approaches where (i) all emissions from cattle production are allocated to the main edible outputs from the system, milk and meat; and (ii) emissions related to other functions and processes, e.g. draught power and those related to the use of manure as a source of fuel, are deducted from the overall system emissions.

Figure 10 illustrates the difference in carbon equivalent impact and the extent to which production is specialized, i.e. whether it is meant for milk and meat production or whether animals are kept for other purposes. The starkest difference in emission intensity is shown for sub-Saharan Africa and South Asia where cattle herds are multi-purpose, producing not only edible products but also non-edible products and services that are utilized in other production processes within or outside the livestock sector boundary. In these regions, use of draught power is important as well as the use of manure as a source of fuel, and allocation of emissions to these products and services significantly lowers the emission intensity of edible products in these regions. In contrast, in industrialized regions, production is more specialized with cattle being specifically reared to produce meat and milk products. In these regions, emission intensity is generally lower, because production is more

Figure 11a.
Regional variation in GHG emission intensities for cow milk



Source: GLEAM.

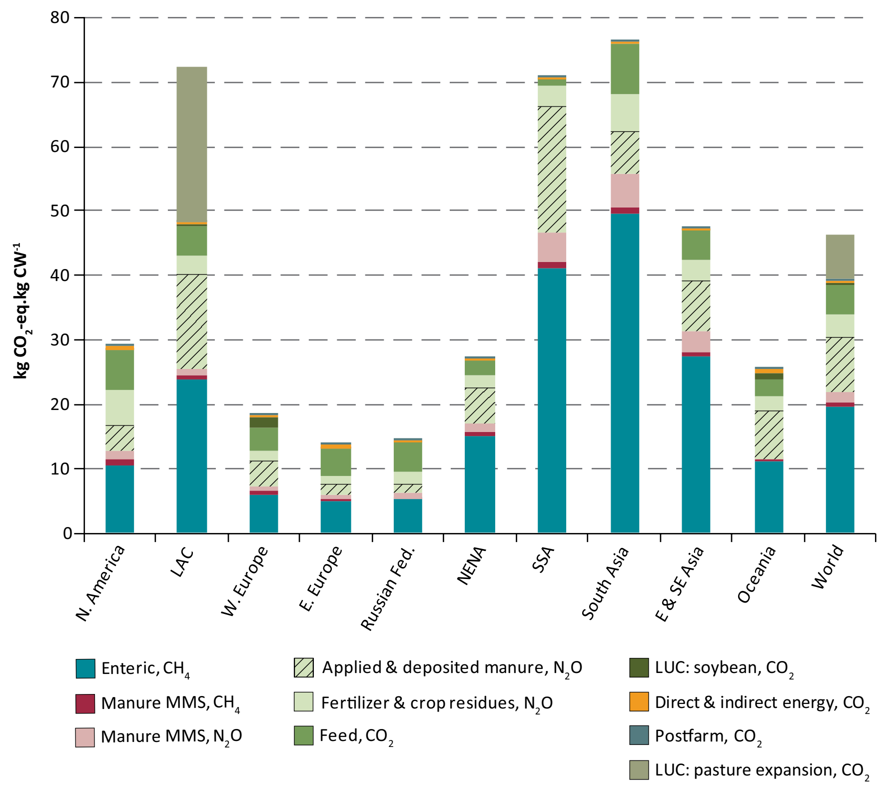
efficient, yields are higher, and animals are not kept for longer periods for other purposes such as draught power.

Figures 11a and 11b present regional variation in emission intensity for milk and meat (after allocation to draught and manure used for fuel) and the contribution of emission categories to the emission profile.

For milk, emission intensities vary from 1.6 kg CO_2-eq/kg FPCM in Eastern and Western Europe to 9 kg CO_2-eq/kg FPCM in sub-Saharan Africa (Figure 11a). Generally, industrialized regions of the world exhibit the lowest emission intensities per kg FPCM ranging between 1.6 and 1.7 kg CO_2-eq/kg FPCM, while in developing regions the range of emission intensity for milk is wider – 2.0 and 9.0 kg CO_2-eq/kg FPCM.

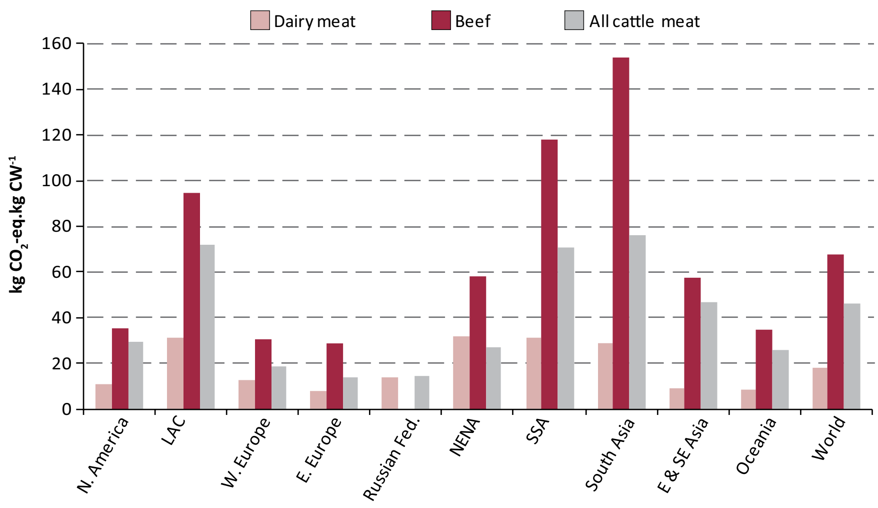
The main contribution to the GHG emission profile of milk in developing regions is enteric fermentation while in industrialized regions dominant emissions are largely related to feed production and processing. With regard to manure management, CH_4 emissions are highest in North America where on average 27 percent of manure from the dairy sector is managed in liquid systems that produce greater quantities of CH_4 emissions (see Section 5.3.1). In contrast, N_2O emissions from manure management are higher in developing regions as a result of the higher proportion of manure managed in dry systems.

Figure 11b.
Regional variation in GHG emission intensities for beef



Source: GLEAM.

Figure 12.
Regional comparison of emission intensity per kilogram of carcass



Source: GLEAM.

Regional variability in emission intensity for beef is presented in Figure 11b, with GHG emissions per kg carcass weight (CW) ranging from 14 kg CO_2-eq/kg CW in Eastern Europe and Russian Federation to 76 kg CO_2-eq/kg CW in South Asia. Highest emission intensities are found in developing regions: South Asia, sub-Saharan Africa, LAC and East and Southeast Asia. A key driver for the high emissions associated with beef is largely related to low feed digestibility, lower slaughter weights and higher age at slaughter. The carbon footprint of beef produced in Latin America comprises emissions related to land-use change from pasture expansion into forested areas. Consequently, land-use change is a major driver of emissions in the region, representing approximately one-third of the footprint (Figure 11b), equivalent to 24 kg CO_2-eq/kg CW. These LUC estimates are however associated with a high level of methodological uncertainty and do not capture recent deforestation trends (the period considered is 1990-2006).

The low emission intensities associated with beef in Europe (Western and Eastern Europe, and the Russian Federation) is explained by the large proportion of the beef produced from the dairy herd.[7] About 80 percent of the beef production in Europe is derived as a co-product from dairy production (from surplus calves and culled cows); in the Russian Federation, all beef is estimated to be produced by the dairy sector. The dairy sector therefore has a much higher impact on beef production in these regions and this is directly linked to the need for their dairy sectors to sustain milk production through production of calves in order to keep cows lactating. Figure 12 compares the regional emission intensity for beef produced by the dairy and beef herd and the average emission intensity of all beef produced by the cattle sector. The low emissions are also an artefact of the production characteristics of dairy herd (dual products) (see discussion on allocation techniques in Appendix A) and hence a large proportion of the emissions attribut-

[7] Table B22, Appendix B presents the contribution of dairy and beef herds to total beef production.

able to dairy cows is allocated to milk, resulting in a lower allocation to beef from the dairy herd.

The emission intensity for beef in Western Europe, North America and Oceania is lower than the global average mainly because these regions are key beef-producing regions characterized by high efficiency in production and high feed digestibility (Map 8 in Appendix G).

Table B13 in Appendix B illustrates average feed digestibility values for the average feed ration used in beef production in different regions. Highest feed digestility is found in industralized countries where feed rations are laregly composed of higher quality roughages and concentrates. The digestibility of average feed rations in developing regions is much lower, particulary in sub-Saharan Africa, South Asia and parts of East and Southeast Asia. Feed rations in this regions are laregly composed of roughages of low quality (grass, crop residues and leaves).

Regarding the contribution of different processes to the emission profile for beef, a distinct difference can be observed between the two broad regional groupings (developing and industrialized).

In developing regions, analogous to the dairy, the overall emission profile for beef is dominated by enteric CH_4 and N_2O emissions related to feed from manure deposited on pasture during grazing. The relatively higher N_2O emissions from manure management in sub-Saharan Africa, South Asia, and East and Southeast Asia reflects the higher share of manure managed in dry systems.

In contrast, enteric CH_4 emissions play a less important role in industrialized regions; however, this is compensated by high CO_2 and N_2O from feed emissions, reflecting a high dependence on feed imports, high fertilizer use in feed production and a higher level of mechanization (see Section 5.2).

4.2 BUFFALO

Milk and meat production from the global buffalo sector contributes an equivalent of 619 million tonnes CO_2-eq consisting of emissions from the production of meat and milk, emissions related to land-use change, emissions associated with post farmgate activities, and emission related to non-edible products and services, i.e. draught power and manure used for fuel.

4.2.1 Total production, absolute emissions, and emission intensities

In 2005, global buffalo milk and meat production amounted to 115.2 and 3.4 million tonnes, respectively, and associated with this, about 390 and 180.2 million tonnes CO_2-eq were emitted from the production of milk and meat from buffaloes, respectively (Table 5). On average, the emission intensity of buffalo milk and meat is estimated at 3.4 kg CO_2-eq/kg FPCM and 53.4 kg CO_2-eq/kg CW, respectively (Table 5). The emission intensity of meat produced by the dairy herd is significantly lower than that produced from the meat herd and the reasons are similar to those outlined in the previous sub-section on the cattle sector.

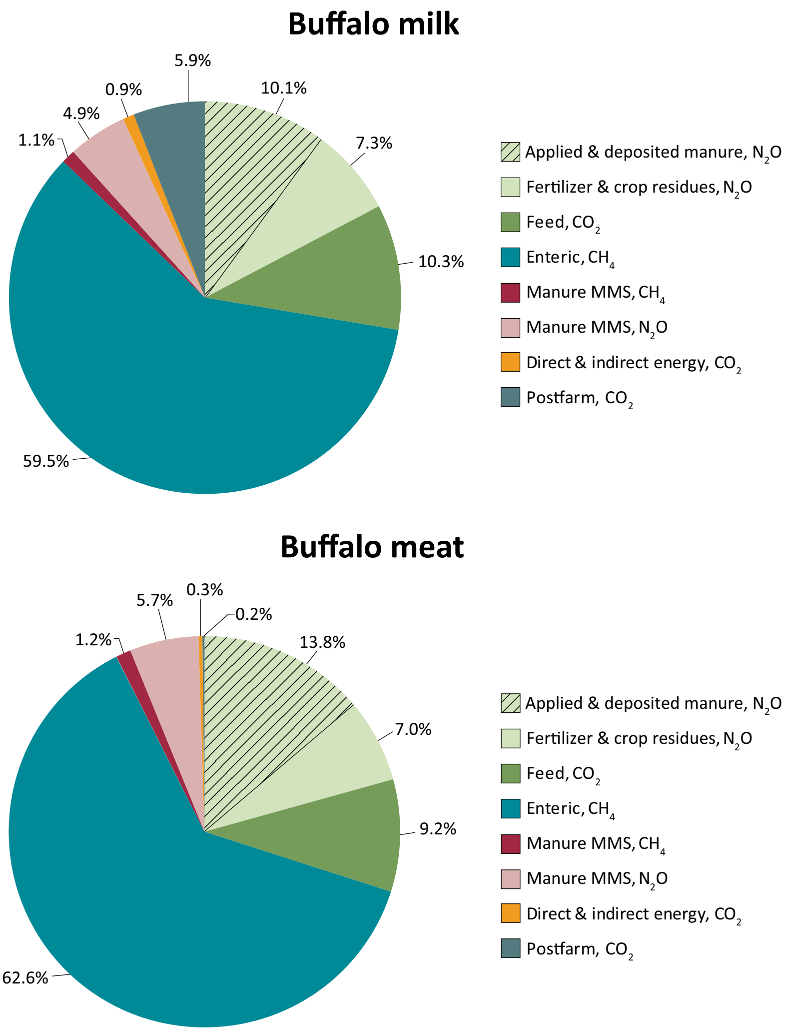
Enteric fermentation is by far the most important source of emissions, contributing over 60 percent of the emissions in both milk and meat production (Figure 13). Other important sources of emissions include emissions from feed production, particularly N_2O emissions from manure deposited largely determined by the long grazing period. Emissions from manure management (N_2O and CH_4 emissions) together contribute 6 percent and 7 percent of the total emissions from dairy and meat herds.

Table 5. Global production, emissions and emission intensity for buffalo milk and meat

Buffalo herd	Production (*million tonnes*)		Absolute emissions[1] (*million tonnes CO_2-eq*)		Average emission intensity (*kg CO_2-eq/kg product*)	
	Milk[2]	**Meat[2]**	**Milk**	**Meat**	**Milk[2]**	**Meat[2]**
Milk	115.2	2.4	389.9	40.4	3.4	16.6
Meat	-	0.95		139.9	-	143.9
Totals	**115.2**	**3.4**	**389.9**	**180.2**	**3.4**	**53.4**

[1] Absolute emissions include emissions from production and post farmgate emissions.
[2] Functional unit for milk and meat defined as fat and protein corrected milk and carcass weight.
Source: GLEAM.

Figure 13.
Relative contribution of different processes to GHG emission profile of buffalo milk and meat



Source: GLEAM.

4.2.2 Emissions by production system and agro-ecological zone

Average emission intensity of buffalo milk from grazing and mixed farming systems is estimated at 3.4 and 3.2 kg CO_2-eq/kg FPCM, respectively. On the other hand, the emission intensity of buffalo meat from grazing and mixed farming systems is 36.7 and 54.0 kg CO_2-eq/kg CW, respectively. About 82 percent and 67 percent of milk and meat production from buffalo is produced in the mixed arid zones. Production in the other ecological zones is unimportant.

Lowest emission intensities for milk are found in the grazing temperate and mixed arid production systems (Figure 14).

Lowest emission intensities for buffalo meat are found in the arid zones in both grazing and mixed systems (Figure 15), which contribute 70 percent of all buffalo meat, while humid zones in both systems have highest emission intensities. Important sources of emissions include: enteric fermentation, N_2O from feed production and grazing; and CO_2 emissions from feed production and processing. N_2O from manure and feed is an important source of emissions in the humid zones; these emissions are largely driven by the predominance of dry manure management systems and emissions from the deposition of manure on pasture. The remaining emissions are insignificant in terms of their contribution towards the carbon profile.

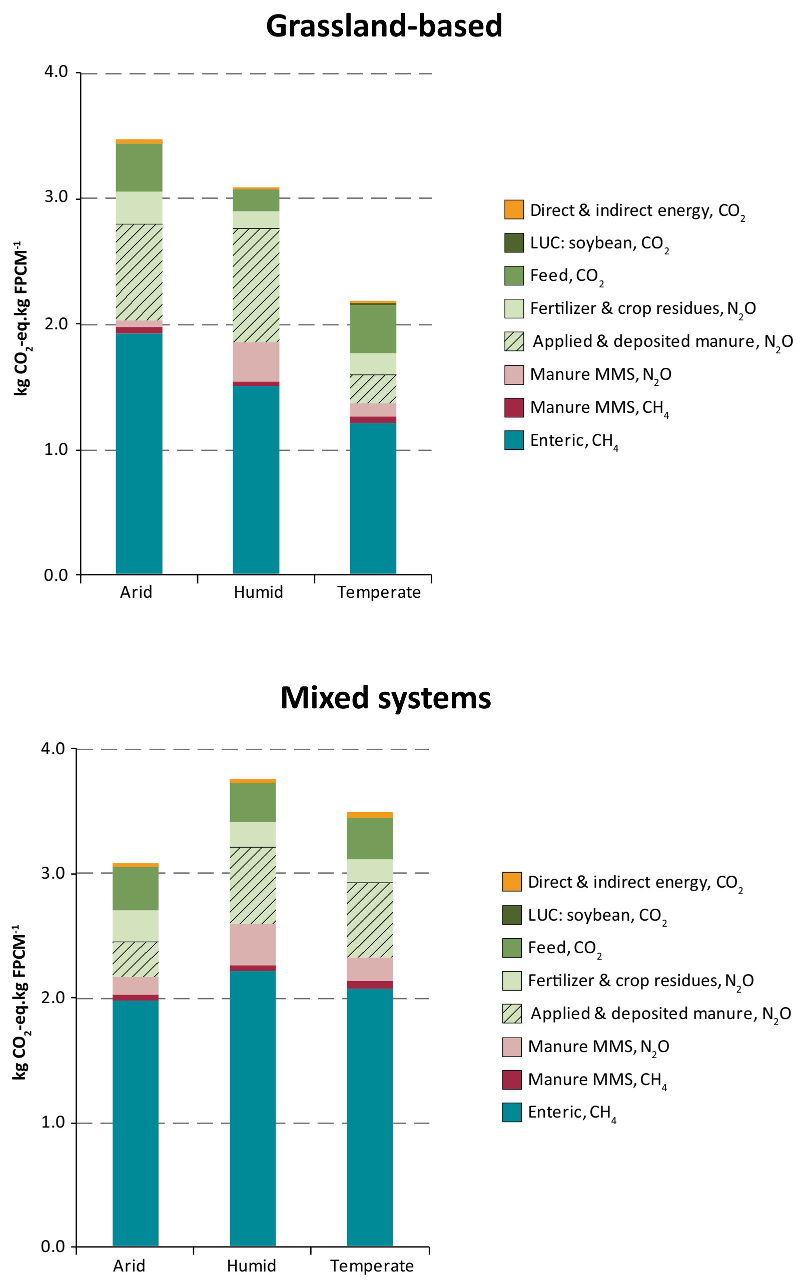
4.2.3 Regional production emissions and emission intensities

Global buffalo milk and meat production is important in three main world regions: South Asia, NENA and East & Southeast Asia; South Asia contributes 90 percent and 70 percent of the global buffalo milk and meat, respectively, and average milk emission intensity ranges from 3.2 to 4.8 kg CO_2-eq/kg FPCM (Figure 16a); milk produced in South Asia has the lowest emission intensity, explained by high yields. Emission intensity in South Asia is similar to the global average, explained by the fact that the bulk of buffalo milk (90 percent) is produced in the region.

On the other hand, the emission intensity of buffalo meat production at regional level ranges from 21 kg CO_2-eq/kg CW in NENA to 70.2 kg CO_2-eq/kg CW in East & Southeast Asia (Figure 16b). Key buffalo meat producing regions include South Asia (producing 70 percent of the global production), East & Southeast Asia (20 percent) and NENA (5 percent).

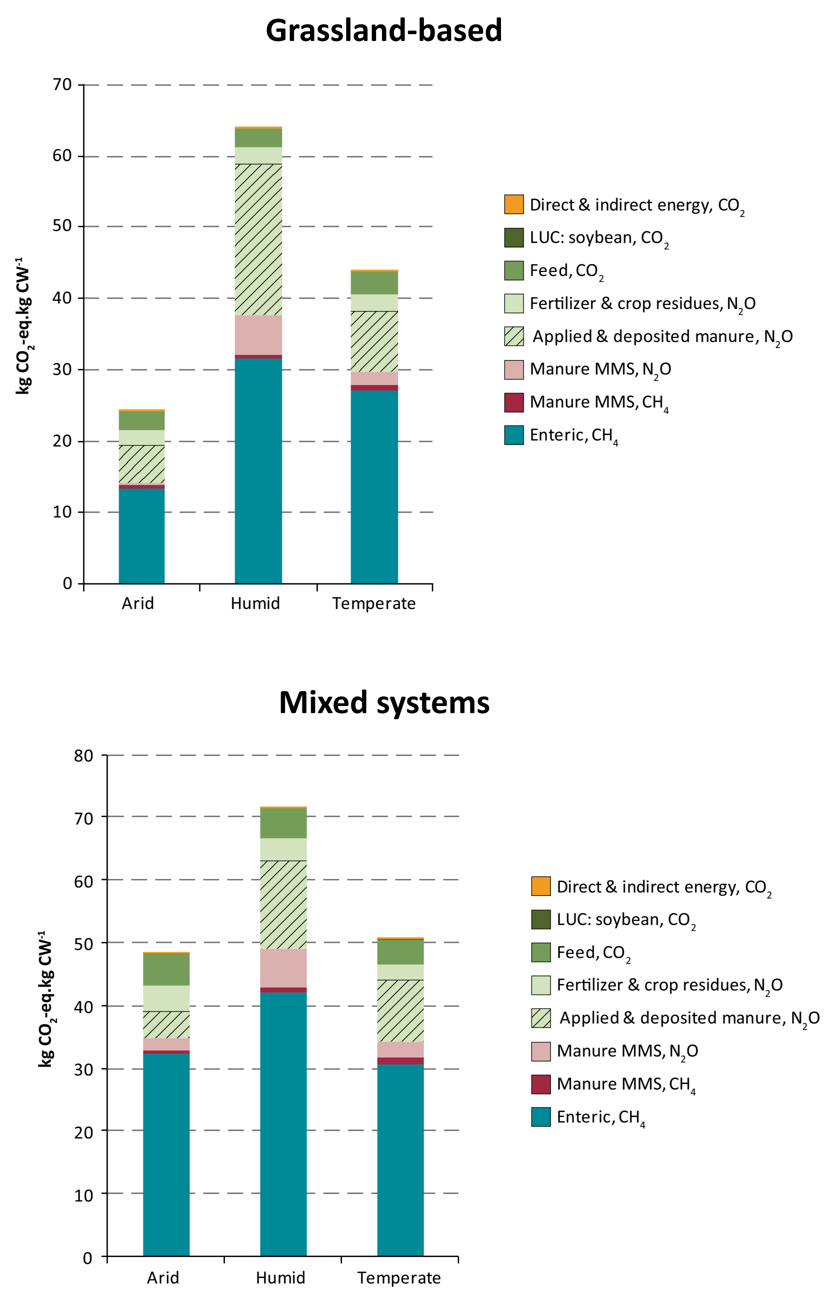
Enteric CH_4 and feed N_2O emissions associated with feed production are the dominant sources of emissions. Key sources of emissions in the buffalo carbon profile comprise CH_4 from enteric fermentation (contributing more than half of the carbon footprint), and CO_2 and N_2O emissions associated with feed production. Nitrous oxide emissions from manure management are significant in East & Southeast Asia, where manure is managed in dry and solid systems.

Figure 14.
Emission intensities for buffalo milk by production system and agro-ecological zone[1]



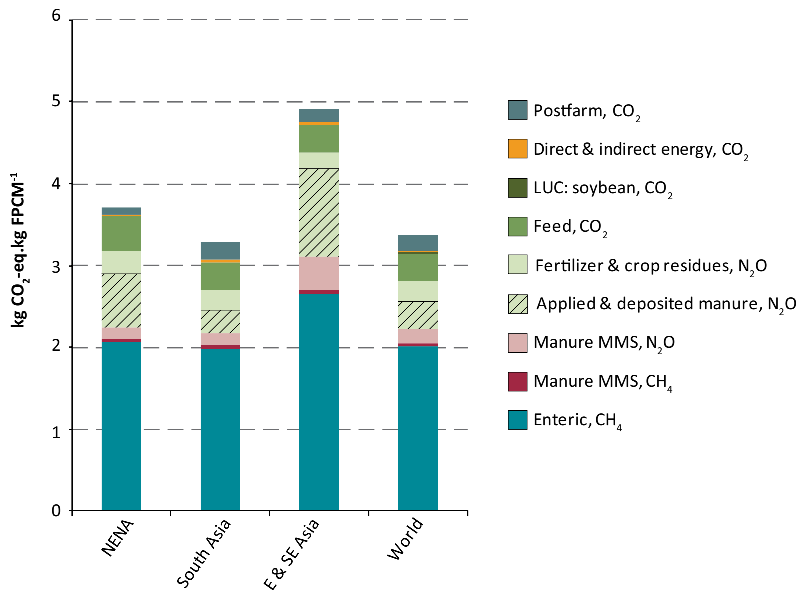
[1] Excluding post farmgate.
Source: GLEAM.

Figure 15.
Emission intensities for buffalo meat by production system and agro-ecological zone[1]



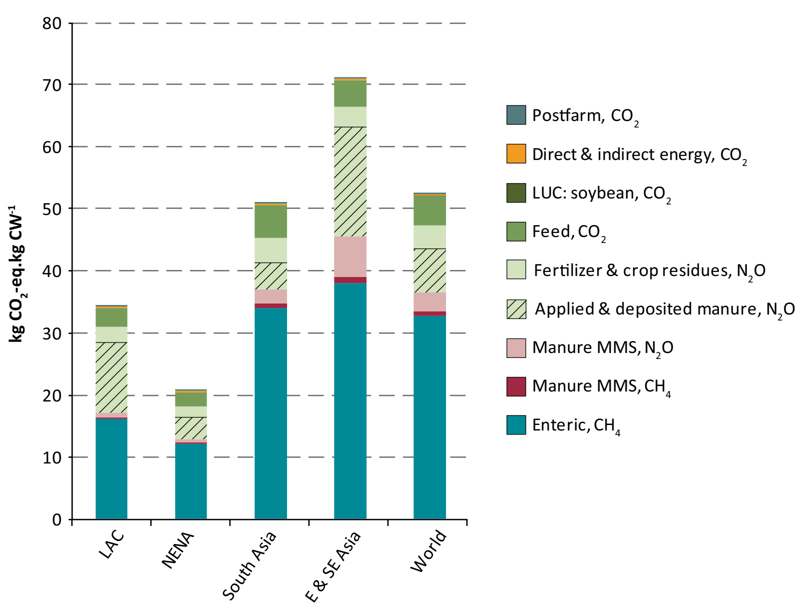
[1] Excluding post farmgate.
Source: GLEAM.

Figure 16a.
Regional variation in GHG emission intensities for buffalo milk[1]



[1] Excludes regions where contribution to global production is less than 2 percent.
Source: GLEAM.

Figure 16b.
Regional variation in GHG emission intensities for buffalo meat[1]



[1] Excludes regions where contribution to global production is less than 2 percent.
Source: GLEAM.