The significance of livestock as a contributor to global greenhouse gas emissions today and in the near future

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Abstract

Animal agriculture is responsible for 8% to 10.8% of total global greenhouse gas (GHG) emissions when assessed on the basis of IPCC accounting. When assessed on the basis of a lifecycle analysis, the contribution of livestock is up to 18% of total global emissions. Asia is the source of most enteric methane emissions with Latin America, Africa, Western Europe and North America being significant sources also. These emissions are dominated by emissions from the cattle herd. When emissions are related to food production, the top four most efficient regions are Eastern and Western Europe, North America, and the non-EU former Soviet Union (FSU) which together produced 46.3% of ruminant meat and milk energy and only 25.5% of enteric methane emissions in 2005. In comparison, the three least efficient producers (Asia, Africa and Latin America) produced an equivalent amount (47.1%) of ruminant meat and milk energy and almost three times (69%) as much enteric methane emissions in 2005. Livestock related emissions will increase as world population and food demand increases. For instance, enteric methane emissions are projected to grow by over 30% from 2000 to 2020. There are mitigation possibilities, but there is an imperative to develop new technologies, or ways to implement existing technologies in a more cost effective manner.

Keywords

Greenhouse gases, livestock, agriculture, food production, greenhouse gas mitigation

Introduction

Animal agriculture produces greenhouse gases (GHG) in the form of methane from enteric fermentation, nitrous oxide from the use of nitrogenous fertilisers, and methane and nitrous oxide from manure management and deposition of animal manures at pasture. Some CO_2 is also produced on animal farms from fossil fuel and energy usage.

This paper reviews several recent estimates of agriculture's contribution to global GHG emissions, and specifically the contribution of animal agriculture. The regional distribution of these emissions is examined, as is their relationship with food production in different regions. Likely trends in future emissions from animal agriculture are discussed and the possibilities for mitigation at a global level are examined.

Global emissions of greenhouse gas from agriculture and particularly animal agriculture

Several estimates of agriculture's contribution to global GHG emissions([1]) have been published recently, including some estimates that specifically relate to animal agriculture. Denman et al. (2007) estimated non CO_2 GHG emissions from agriculture to be 10% of total global emissions, while EPA (2006) estimated them to be 12%. These estimates do not consider CO_2 emissions or removals due to agriculture which are counted in the Intergovernmental Panel on Climate Change (IPCC) GHG inventory sector Land use, land-use change and forestry. FAO (2006a) estimated that animal agriculture contributes 18% of global emissions of GHG, while

[1] All references to greenhouse gas emissions in this paper refer to anthropogenic emissions.

FAO (2010) estimated that emissions from the global dairy sector were 4% of total emissions.

It is worth considering these reports in more detail to help reconcile the various estimates. Obviously the two Food and Agriculture Organisation (FAO) reports have a narrower focus than Denman et al. (2007) or EPA (2006), and in particular the 2010 report is only focused on the dairy sector. Yet FAO (2006a) has a much higher estimate for animal agriculture than the Denman et al. (2007) or EPA (2006) reports for the whole agriculture sector. This is because the two FAO reports take a Life Cycle Analysis approach, and include emissions from the production of inputs (such as feed and fertiliser), transport, processing, and land use change including deforestation to bring land into production for animal agriculture, whether as pastures or in the production of animal feed. On the other hand, the other two reports mentioned follow the sectoral approach of the IPCC which outlines five main sectors for GHG emissions reporting: (i) energy, (ii) industry, (iii) waste, (iv) land use, land use change and forestry (LULUCF) and (v) agriculture. This causes a significant difference between FAO (2006a) and the other estimates.

Table 1 shows the livestock related GHG emission estimates from FAO (2006a), and how these emissions would be counted by IPCC. Of the total livestock related emissions of 7.1 billion tonnes of CO_2 equivalent, 4.26 billion tonnes or 60% would be counted in the agriculture sector by IPCC. Most of the remainder is CO_2 emissions from soils, deforestation, transport, processing, fertilizer production and on-farm fossil fuel usage, with deforestation accounting for 85% of these emissions.

The livestock related emissions from FAO (2006a) that would be counted in the agriculture sector by IPCC equal 10.8% of global emissions. According to FAO (2006a), livestock constitute nearly 80% of agricultural emissions. Using this figure to calculate livestock's contribution to the other global agriculture emissions estimates gives estimates of 8% and 9.6% for Denman et al. (2007) and EPA (2006) respectively. Thus when these three global estimates are put on an equivalent basis (IPCC inventory system), the estimates of livestock's contribution to total global GHG emissions range from 8 to 10.8%.

It is worth noting that FAO (2006a) used a figure of 40 billion tonnes for total global GHG emissions, and livestock related emissions were 18% of this total. However, the data source used for total emissions (CAIT, 2010) now estimates global total emissions of 43.6 billion tonnes for 2005 (only CO_2, N_2O and CH_4 considered, and international bunkers included). The livestock emissions calculated in the FAO (2006a) report would be only 16% of this higher global total.

[Table 1 near here]

Regional emissions of livestock related greenhouse gases

Table 2 shows the regional distribution of the main ruminant farm animal species. Cattle are the most numerous, and given their greater size relative to the other two most populous species, sheep and goats, they are by far the greater contributor to global enteric methane emissions. Of the 1.35 billion cattle in the world, 29.1% are in Latin America, and 18.6% are in Africa. Asia has 28.6% of the world's cattle, with India and China having huge cattle populations. North America has 8.2% of the world's cattle population, while Western Europe has 6.8%, and Australia/New Zealand has 2.8%. The vast majority of the world's 175 million buffaloes are in Asia, with India and China having very large populations. Likewise, most of the world's 822 million goats are in Asia (52.9%), with Africa also having a very large proportion (33.3%). The world's 1.09 billion sheep are more widely distributed with most regions except North America and Eastern Europe having significant populations.

[Table 2 near here]

Greenhouse gas emissions from livestock can be expected to be closely related to ruminant numbers, and particularly cattle numbers. However, factors other than numbers will have an impact. The size and productivity of animals will affect their dietary intake and enteric methane emissions. The system of manure storage and handling (if any) will affect manure related emissions of methane and nitrous oxide. Other species such as pigs and poultry will also contribute significantly to manure related emissions. The extent of grazing, if any, will impact on the emissions of nitrous oxide from manure deposition on pasture.

Table 3 shows estimates of regional emissions of methane from enteric fermentation and manure management, and nitrous oxide from manure management and agricultural soils. These data are sourced from a US EPA study (EPA, 2006) of global non CO_2 GHG emissions. In that study, global emissions up to the year 2000 were based on actual data in national inventory reports where available, thereafter emissions were projected for each country. The individual country data in that study have been aggregated into a larger number of world regions than published in the study. These data estimated total global emissions of enteric methane to be 1,929 Mt CO_2 equivalent (CO_2e), or 91.9 Mt CH_4 in the year 2005 (a global warming potential (GWP) of 21 was used for methane). This is slightly greater than the estimate in FAO (2006a) of 85.63 Mt CH_4 which was for 2004. Asia is the source of most enteric methane emissions, with one third of global emissions coming from this continent, and China and India being the dominant countries (Table 3). FAO (2006a) estimated India to have greater emissions than China, whereas EPA (2006) estimated the reverse. The FAO (2006a) report carried out it own calculations whereas the EPA (2006) report was based on national inventory reports to a large extent. Other world regions with large shares of global enteric methane emissions are Latin America (23.9%), Africa (14.5%), Western Europe (8.3%) and North America (7.1%). The breakdown of global enteric methane emissions by animal species is reported by FAO (2006a), and reproduced in Figure 1. As expected, it is dominated by emissions from the cattle herd.

[Table 3 near here]

Global greenhouse gas emissions from manure management total 446 million tonnes of CO_2e, with 53% of this being methane and 47% nitrous oxide (Table 3). Asia, particularly China, Western Europe and North America are the regions with the greatest GHG emissions from manure management. This global estimate of methane emissions from this source is significantly lower than the estimate of FAO (2006a), which is 368 million tonnes of CO_2e using a GWP of 21. FAO (2006a) does not give a separate estimate of nitrous oxide emissions from manure management. The breakdown of methane emissions from manure management by animal species according to FAO (2006a) is shown in Figure 2. In contrast to enteric methane emissions, over half the total emissions from this source come from monogastrics, with pigs by far the dominant species.

Table 3 also shows emissions of nitrous oxide from agricultural soils. This includes emissions that result from spreading of stored manures, direct deposition of urine on pastures, and emissions resulting from application of nitrogen fertilizer to agricultural soils. Not all this latter category relates to livestock production, as much of the nitrogen fertilizer used in the world is used for crop production. It is not possible from EPA (2006) to distinguish between these sources. According to FAO (2006a), the regions with the greatest emissions of nitrous oxide related to storage, spreading and direct deposition of animal excreta are Asia, Central and South America, Sub-Saharan Africa, Western Europe, North America, and Eastern Europe and Commonwealt of Independent States.

Methane and nitrous oxide are direct emissions related to animal agriculture. As FAO (2006a) outlined, there are also other emissions associated with livestock production. These include emissions associated with fertiliser manufacture, fossil fuel usage, transport and processing of agricultural products, but the main source of additional emissions is deforestation. Overall, UNFCCC (2008) reported that emissions from deforestation are greater than total agricultural emissions. Not all deforestation relates to bringing land into agriculture for livestock production, but FAO (2006a) estimated deforestation was responsible for 34% of global emissions from the livestock sector, calculated using a lifecycle analysis approach. This includes cleared land sown to pasture for grazing, and croplands where the crops (or their by-products) are used for animal feeding.

Livestock related greenhouse gas emissions in relation to food production

The main livestock derived products are food: meat, milk and eggs. Global production of these commodities from the main livestock species are shown in Tables 4 and 5. In addition, livestock provide other goods and services such as hides and wool, draught power, fuel and social goods. These are not quantified here, but represent a very significant contribution from livestock, particularly in some regions of the world.

Global production of meat was 244.7 million tonnes in 2005, of which 30.8% is ruminant meat, mainly beef. Ruminant meat production was greatest in Asia, Latin America, North America and Western Europe. Pig meat is the meat produced in the highest quantity in the world, and is concentrated in China, Western Europe and North America. Chicken meat production is higher than global beef production, and is distributed across all regions of the world.

[Table 4 near here]

World milk production is dominated by cow's milk, which makes up 84% of total milk production. Cow's milk production is concentrated in Western Europe, the Americas, and the non EU former Soviet Union. Egg production is distributed throughout the world, and is greatest in Asia (particularly China), the Americas, and Western Europe.

[Table 5 near here]

The quantities of animal products cannot be compared simply by weight. Dry matter content will vary, especially between milk, eggs and meat. Comparisons could be made on the basis of economic value, or protein content (as recently used in FAO, 2010), but in this analysis, the energy content of the commodities are used to put them all in a common currency. Milk, meat and egg production were converted to energy values using energy values for whole milk, eggs and whole dressed carcasses from McCance and Widdowson (1978), as outlined in Table 6. The resulting energy corrected output of meat and milk and eggs are shown in Tables 7 and 9. The regional distribution of these follows the same trend as outlined above for the commodities.

[Table 6 near here]

[Table 7 near here]

[Table 8 near here]

Total energy from ruminant milk and meat production was compared with total greenhouse gas emissions from enteric fermentation in Figure 3. This is not a completely satisfactory index of ruminant emissions, as manure related emissions and emissions of nitrous oxide from soils are not included. Neither are upstream or downstream emissions of related emissions from deforestation. Nevertheless, it does provide a reasonable assessment of regional emissions from ruminants. Where the bar for milk and ruminant meat energy production is higher than the bar for enteric methane emissions (both as a percentage of global totals), this indicates that a region is efficient at producing milk and meat, i.e. the higher the ratio between the percentage of global totals, the more efficient production is. The top four most efficient regions are Eastern and Western Europe, North America, and the non-EU FSU. Together, these produced 46.3% of ruminant meat and milk energy and only 25.5% of enteric methane emissions in 2005. In comparison, the three least efficient producers (Asia including China and India, Africa and Latin America) produced an equivalent amount (47.1%) of ruminant meat and milk energy and almost three times (69%) as much enteric methane emissions in 2005. In both India and Australia/New Zealand, the share of global energy from ruminant milk and meat production was similar to methane emissions from enteric fermentation: 11.4 and 11.1% respectively for India and 4.4 and 4.2% respectively for Australia/New Zealand. There are of course very significant inter-regional differences between individual countries which are not discussed here.

In Figure 4, total energy from meat and milk production was compared with total greenhouse gas emissions from enteric fermentation, manure management and agricultural soils. The trends are much the same as in Figure 3, although the differences between regions have narrowed somewhat. The improvement in the position of China when total energy from milk and meat production is considered (Figure 4) compared to when only ruminant meat and milk was considered (Figure 3) is noteworthy. This is due to the very large pigmeat production in China which increased total food energy production significantly but which did not contribute much GHG to the categories considered in Figure 4. It should be noted that the emissions considered in both Figures 3 and 4 do not include emissions associated with land-use change which are particularly relevant for grain-fed meat and milk production.

Future trends in livestock related emissions

In a business as usual scenario, emissions from livestock and agriculture in general are expected to grow, as food productions expands to keep pace with a growing world population. World population is expected to reach 8.3 billion by 2030 and 9.1 billion by 2050 (UN, 2008), with most of this growth projected to occur in Asia and Africa. Greenhouse gas emissions projections are subject to uncertainty in the amount and composition of the diet of this expanding population. In particular, the amount of meat consumption is dependent on living standards, particularly in countries of Asia where the population is expanding rapidly and living standards are rising. FAO (2006b) projected demand for all food commodities (crop and livestock based) will rise by 1.5% per annum to 2030, and by 0.9% per annum thereafter to 2050. By 2030, food demand would have risen by 56% compared to 2000, and by 2050, the increase would be 86%, according to these growth rates. Bovine meat production is expected to have a higher growth rate in the period 2000 – 2030 (1.3% p.a.) than it had in the nineties (0.7% p.a.). Production of milk and dairy produce is expected to expand by 1.4% p.a. in the period 2000 - 2030, up from 1.1% p.a. in the nineties. Figure 5 shows projections for growth in production of bovine and ovine meat, and milk to 2050, using production growth projections from FAO (2006b). These projections are for increases of 72%, 110% and 82% in bovine meat, ovine meat and milk production, respectively, by 2050 compared with 2000. The increase in ovine meat is large but is from a small base (Table 4) and is projected to be higher in developing countries. In the absence of mitigation, these increases in milk and meat production are likely to lead to large increases in related greenhouse gas emissions.

In the absence of mitigation, agricultural emissions were projected to rise from 5.6 (in 2005) to 8.2 billion tonnes of CO_{2e} in 2030 by the IPCC Fourth Assessment Report (Smith et al., 2007). This was based on emissions in 2020 forecast by EPA (2006) and projecting these forward to 2030. Figure 6 uses data from EPA (2006) to show emission projections to 2020. These projections were built up country by country from National Inventory Reports. The greatest growth is in enteric methane emissions, which are projected to grow by over 30% from 2000 to 2020. The smaller manure sources are also projected to grow over this period: nitrous oxide by 29% and methane by 20%. FAO (2003) projected that global emissions of methane from enteric fermentation and manure management would rise by 60% by 2030 compared with the base period (1997-99), and nitrous oxide emissions from agriculture would rise by 50% over this period. The higher emissions projections compared with EPA (2006) can be at least partly attributed to the longer period.

Emissions may not rise on a pro rata basis in line with the projected increases in food production outlined above. It is anticipated that most of the increased food production will be met from farms with greater intensity of production than current farms (FAO, 2003), which will permit a reduction in the emissions per kg of product (Lovett et al., 2006; FAO, 2010). On the other hand, the extra emissions associated with deforestation to bring extra land into production either for pastures, for production of animal feed, or where livestock are fed by-products from crop production could greatly increase emissions associated with livestock production from these regions (FAO, 2006a). It has been estimated that deforestation accounted for over 30% of total emissions associated with livestock production in 2005 (FAO, 2006a).

Mitigation possibility on a global scale

The mitigation potential for agricultural emissions to 2030 has recently been comprehensively assessed in the IPCC Fourth Assessment Report (Smith et al., 2007). This report showed a significant technical mitigation potential for agricultural emissions of 5,500 – 6,000 Mt CO_2e/yr by 2030 (in comparison to total projected emissions in 2030 of 8,200 Mt CO_2e/yr). Most of this is related to soil carbon sequestration, which was estimated to contribute 89% of the technical mitigation potential. The technical mitigation potential for methane (both enteric fermentation, manure management, and rice management) was only 9% of the total, or approximately 500 Mt CO_2e/yr. Less than half of this was related to enteric fermentation.

The mitigation potential for enteric methane emissions was considered under three broad headings: improved feeding practices (includes replacing roughage with concentrate, improving forages/inclusion of legumes and feeding extra dietary oil), specific agents and dietary additives (includes bovine somatotrophin, growth hormones, ionophores and propionate precursors), and longer term structural and management changes and animal breeding. The highest proportional reductions were from improved feeding practices, particularly with dairy cows, where the technical mitigation potential was 22% from improved feeding practices in the Oceania region. The regions which had the highest mitigation potential were developed regions of

Europe, North America, Japan and Oceania. However, many of the technical mitigation options have cost implications for producers, and thus the actual potential is lower than the technical potential, and will depend on the price that would be paid per tonne of CO_2e mitigated. At a price of \$20 per tonne of CO_2e, the mitigation potential for enteric methane was reduced to less than 150 Mt CO_2e/yr. Manure management mitigation potential was very low, and while there was significant technical potential to reduce emissions due to improved grazing land management (c. 800 Mt CO_2e/yr), this is mostly related to increased soil carbon, and has significant costs. At a price of \$20 per tonne of CO_2e, the mitigation potential for improved grazing land management was reduced to less than 200 Mt CO_2e/yr.

In summary, while there is significant technical mitigation potential for livestock related emissions, the cost of implementing the measures will reduce this potential significantly. This is with currently available technologies, which outlines the need to develop new technologies, or ways to implement existing technologies in a more cost effective manner.

Conclusions

Livestock production is a significant source of greenhouse gases, which will increase over the next 40 years as a consequence of increased food production unless there is major progress in mitigation technologies. There is significant regional variation in the efficiency of food production from a greenhouse gas perspective, but it must also be considered that livestock contribute significant non-food goods in many less developed regions. There are mitigation possibilities with currently available technologies, but they are limited, and there are cost implications which will limit their implementation. This highlights the need to develop new technologies, or ways to implement existing technologies in a more cost effective manner.

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Table 1. Livestock related GHG emission estimates from FAO (2006a) allocated to IPCC emission source category

	IPCC Agriculture sector	IPCC Other sectors
CO_2		
N fertiliser production		0.04
On farm fossil fuel, feed		0.06
On farm fossil fuel, livestock related		0.03
Deforestation		2.4
Cultivated soils, tillage		0.02
Cultivated soils, liming		0.01
Desertification of pasture		0.1
Processing		0.075
Transport		0.001
CH_4		
Enteric fermentation	1.8	
Manure management	0.37	
N_2O		
N fertilizer application	0.1	
Indirect fertilizer emission		0.1
Leguminous feed cropping	0.2	
Manure management	0.33	
Manure application/deposition	0.84	
Indirect manure emission	0.62	
Total	4.26	2.836

All figures in billion tonnes of CO_2e

Table 2. Regional distribution of the global populations (000 head) of cattle, buffaloes, sheep and goats for the year 2005

	Cattle	**Buffaloes**	**Goats**	**sheep**
Africa	251,513	3,898	273,478	274,925
Latin America	392,769	1,180	34,899	82,892
North America	110,364	0	2,745	7,113
Non EU former Soviet Union	54,153	383	10,464	65,472
Eastern Europe	14,653	38	2,996	17,832
Western Europe	92,304	315	19,042	128,322
India	180,837	98,875	124,906	62,854
China	90,134	22,365	152,134	152,035
Asia (excl. China and India)	113,206	46,675	158,025	60,084
Australia/New Zealand	37,293	0	616	141,005
Middle East	13,346	798	42,590	97,878
World	1,350,571	174,526	821,895	1,090,410

Source: FAOSTAT (2010)

Table 3. Regional emissions of major agricultural greenhouse gases (million tonnes of CO_2e)

	Enteric fermentation (methane)	Manure (methane)	Manure (nitrous oxide)	Soils (nitrous oxide)
Africa	280	14	6	361
Latin America	460	17	11	394
North America	136	43	22	300
Non EU former Soviet Union	97	12	28	76
Eastern Europe	28	7	12	43
Western Europe	160	69	26	257
India	218	23	0	58
China	259	22	69	536
Asia (excl. China and India)	175	24	35	192
Australia/New Zealand	88	3	1	32
Middle East	27.3	1.6	0.7	50.7
World	1,929	235	211	2,299

Source: EPA (2006) data reworked by author

Table 4. Global production of meat (000 tonnes) by world region in 2005

	Cattle meat	Buffalo meat	Sheep meat	Goat meat	Chicken meat	Pig meat	Total ruminant meat	Total meat
Africa	4,601	270	1,205	1,073	3,276	820	7,149	11,245
Latin America	16,527	0	305	126	15,737	5,695	16,958	38,390
North America	12,707	0	103	0.001	16,869	11,303	12,810	40,982
Non EU former Soviet Union	3,866	0	535	46	2,128	2,650	4,447	9,225
Eastern Europe	930	0.2	117	20	1,868	4,089	1,067	7,024
Western Europe	7,935	8	1,299	132	7,827	18,717	9,374	35,918
India	1,334	1,501	234	527	1,900	497	3,596	5,993
China	5,357	345	1,800	1,704	9,964	46,622	9,207	65,793
Asia (excl. China and India)	2,786	1,025	387	806	7,052	8,074	5,004	20,130
Australia/New Zealand	2,814	0	1,138	23	917	441	3,974	5,332
Middle East	720	22	766	233	2,912	20	1,740	4,672
World	59,576	3,172	7,888	4,691	70,451	98,927	75,327	244,705

Source: FAOSTAT (2010)

Table 5. Global production of whole fresh milk (000 tonnes) and eggs (million) by region in 2005

	Cow milk	Buffalo milk	Sheep milk	Goat milk	Total whole milk	Hen eggs, in shell (Number)
Africa	23,861	2,300	1,632	3,181	30,974	46,340
Latin America	68,060	0	36	539	68,635	112,163
North America	88,062	0	0	0	88,062	96,945
Non EU former Soviet Union	65,786	0	202	745	66,733	61,046
Eastern Europe	28,467	7	829	267	29,571	27,954
Western Europe	140,852	253	2,890	2,063	146,058	103,328
India	39,759	52,070		3,790	95,619	46,231
China	27,837	2,800	1,115	256	32,008	420,951
Asia (excl. China and India)	25,111	21,045	363	2,889	49,408	122,134
Australia/New Zealand	24,765	0	0	0	24,765	3,341
Middle East	10,787	414	1,686	828	13,715	26,024
World	543,347	78,889	8,753	14,559	645,548	1,066,457

Source: FAOSTAT (2010)

Table 6. Energy value of foods

	kJ per 100g
Beef, dressed carcass raw	1,168
Lamb, dressed carcass raw	1,377
Goat carcass	Assume 0.8 that of lamb carcass[1]
Buffalo	Assume same as beef
Pork, dressed carcass raw	1,397
Chicken, raw meat	508
Cow’s milk, whole	272
Buffalo milk, whole	Assume same as cow’s milk
Goat milk, whole	296
Sheep milk, whole	388
Eggs, whole raw	612

Source: McCance and Widdowson (1978)

[1] based on carcass composition of sheep and goats in Sen et al. (2004)

Table 7. Global meat energy production (million MJ) by world region in 2005

	Cattle meat	Buffalo meat	Sheep meat	Goat meat	Chicken meat	Pig meat	Total ruminant meat	Total meat
Africa	53,744	3,154	16,599	11,815	16,640	11,450	85,313	113,402
Latin America	193,031	0	4,197	1,393	79,945	79,559	198,621	358,126
North America	148,422	0	1,414	0	85,695	157,900	149,837	393,432
Non EU former Soviet Union	45,153	0	7,366	510	10,812	37,022	53,029	100,862
Eastern Europe	10,864	3	1,607	221	9,487	57,125	12,695	79,307
Western Europe	92,678	91	17,889	1,459	39,763	261,470	112,117	413,350
India	15,579	17,530	3,222	5,805	9,652	6,943	42,137	58,732
China	62,571	4,035	24,786	18,775	50,620	651,308	110,167	812,095
Asia (excl. China and India)	32,536	11,978	5,326	8,878	35,826	112,798	58,717	207,341
Australia/New Zealand	32,864	0	15,670	250	4,658	6,161	48,785	59,604
Middle East	8,406	255	10,546	2,564	14,792	276	21,771	36,839
World	695,849	37,046	108,623	51,671	357,890	1,382,012	893,189	2,633,091

Source: FAOSTAT (2010) and author calculations

454 Table 8. Global milk and egg[1] energy production (million MJ) by region in 2005

	Cow milk	Buffalo milk	Sheep milk	Goat milk	Total whole milk	Hen eggs, in shell
Africa	64,901	6,256	6,332	9,417	86,906	14,180
Latin America	185,122	0	138	1,597	186,857	34,322
North America	239,528	0	0	0	239,528	29,665
Non EU former Soviet Union	178,939	0	782	2,206	181,927	18,680
Eastern Europe	77,431	19	3,217	791	81,458	8,554
Western Europe	383,116	689	11,213	6,106	401,125	31,618
India	108,144	141,630	0	11,218	260,993	14,147
China	75,718	7,616	4,326	758	88,418	128,811
Asia (excl. China and India)	68,302	57,241	1,410	8,553	135,506	37,373
Australia/New Zealand	67,361	0	0	0	67,361	1,022
Middle East	29,341	1,126	6,542	2,450	39,459	7,963
World	1,477,903	214,578	33,961	43,095	1,769,538	326,336

455 Source: FAOSTAT (2010) and author calculations

456 [1]Average weight of egg without shell assumed to equal 50g

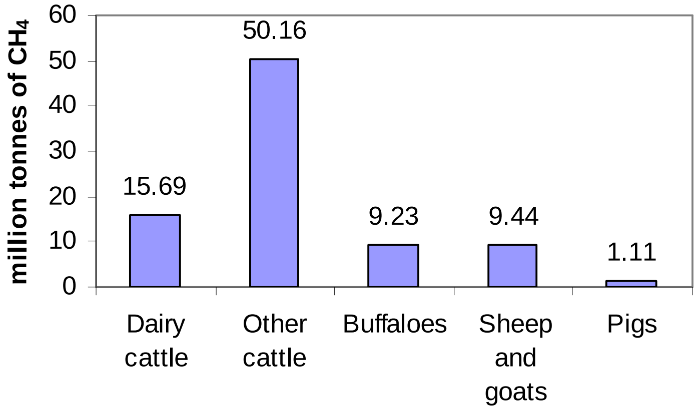

Figure 1. Global emissions of methane from enteric fermentation by animal type in 2004 (drawn from data in FAO, 2006a)

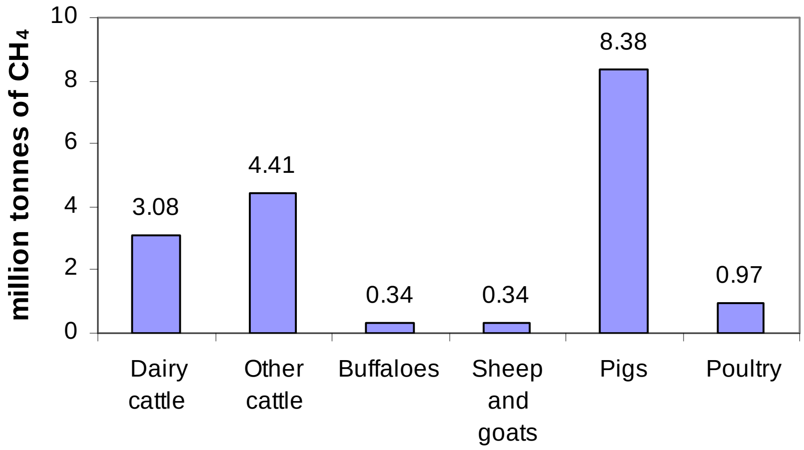

Figure 2. Global emissions of methane from manure management by animal type in 2004 (drawn from data in FAO, 2006a)

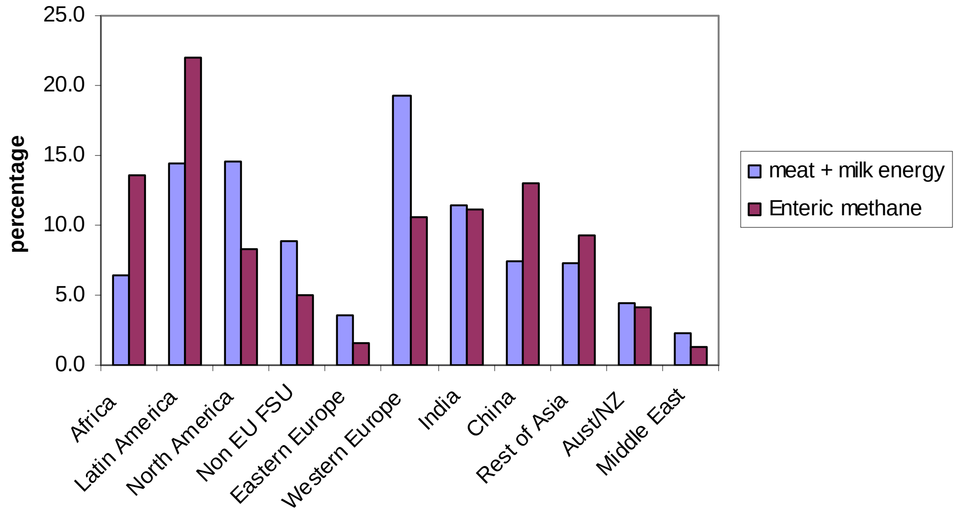

Figure 3. Relative contribution of world regions to milk and ruminant meat energy production and methane emissions from enteric fermentation

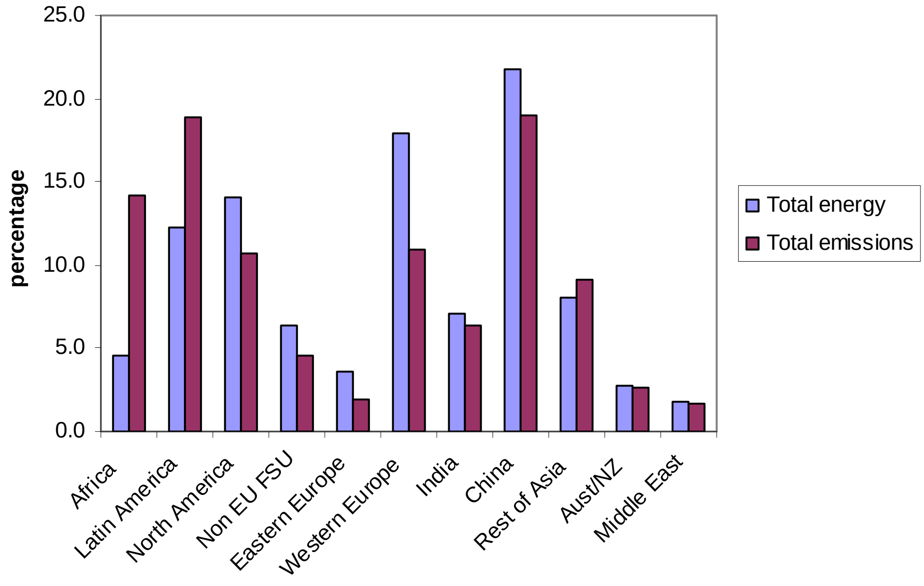

Figure 4. Relative contribution of world regions to milk and meat energy production and greenhouse emissions from enteric fermentation, manure management and agricultural soils

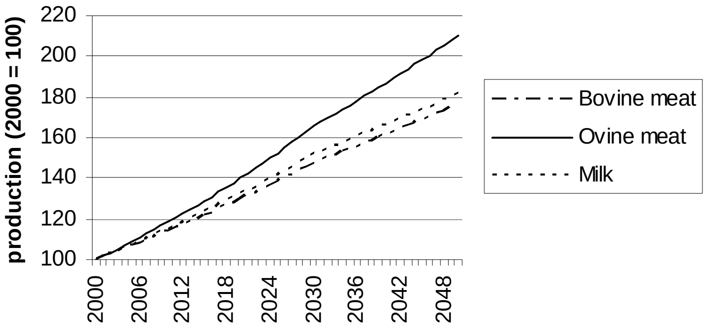

Figure 5. Projected growth of global milk and meat production to 2050 using production growth projections from FAO (2006b)

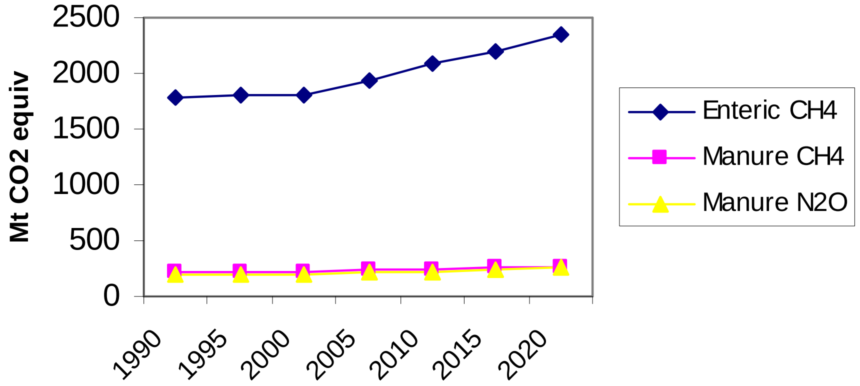

Figure 6. Global growth in GHG emissions from livestock sources to 2000 and projections to 2020 (drawn from data in EPA, 2006)