Classification: Biological Sciences, Sustainability Science

Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems

SUPPORTING INFORMATION

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a. Livestock production systems

The livestock system classification used was developed in 1995 (1) and updated recently (2). It distinguishes solely livestock systems and mixed crop-livestock farming systems. Solely livestock systems are those in which more than 90 percent of dry matter fed to animals comes from rangelands, pastures, annual forages and purchased feeds and less than 10 percent of the total value of production comes from non-livestock farming activities. Mixed farming systems are those in which more than 10 percent of the dry matter fed to animals comes from crop by-products, stubble or more than 10 percent of the total value of production comes from non-livestock farming activities.

The solely livestock systems are split into two. The grassland-based systems are those in which more than 10 percent of the dry matter fed to animals is produced on the farm and in which annual average stocking rates are less than 10 temperate livestock units per hectare of agricultural land. The landless livestock production systems are those in which less than 10 percent of the dry matter fed to animals is produced on the farm and in which annual average stocking rates are above 10 temperate livestock units per hectare of agricultural land. The mixed systems are broken down into two categories:

- Rain-fed mixed farming systems, in which more than 90 percent of the value of non-livestock farm production comes from rain-fed land use.
- Irrigated mixed farming systems, in which more than 10 percent of the value of non-livestock farm production comes from irrigated land use.

The livestock-only and mixed farming systems are further characterised by agro-climatology, based on temperature and length of growing period (LGP), the number of days per year during which crop growth is possible:

- Arid and semi-arid, LGP ≤ 180 days.
- Humid and sub-humid, LGP > 180 days.
- Tropical highlands or temperate. Temperate regions are defined as those with one month or more with monthly mean temperature, corrected to sea level, below 5 °C. Tropical highlands are defined as those areas with a daily mean temperature, during the growing period, of between 5 and 20 °C.

This classification system cannot be mapped directly, because appropriate data at the farm level are simply not available. Many of the categories can be mapped using proxy variables for which global data exist, however; details of the methods used are given in (2). Briefly, cropland and rangeland are defined from GLC 2000 (3), modified by human population density thresholds from the 1-km Global Rural-Urban Mapping Project (GRUMP) data(4). Urban areas are defined based on a combination of the GRUMP dataset and the GLC 2000 urban class. Irrigated areas are based on the FAO Aquastat map Version 4.0.1 (5). The mixed rain-fed, mixed irrigated and rangeland system categories, as defined above, are subdivided based on LGP and climate data layers developed from the WorldCLIM 1-km data for 2000 (6) together with a "highlands" layer for the same year based on the same dataset (7).

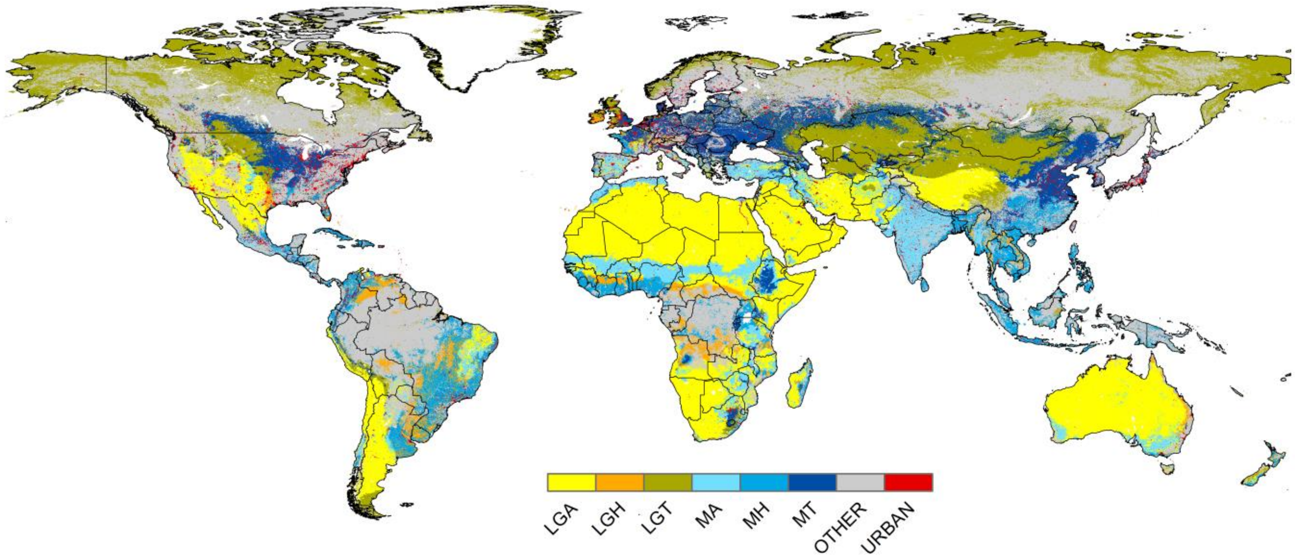


Figure S 1. Global livestock production systems. Adapted from (2).

b. Distribution of animal numbers

The animal distribution data was sourced from the “Gridded Livestock of the World” (GLW). This dataset includes global distribution maps for the following species of livestock: cattle, buffalo, sheep, goats, pigs and poultry/chickens.

The methodology for creating this dataset is described in detail in (8). In summary, the maps are created through the spatial disaggregation of sub-national statistical data based on empirical relationships with environmental variables in similar agro-ecological zones. The first stage in the mapping process is to collect available subnational livestock statistics. Complete subnational population datasets for all livestock species are not available for all countries. Therefore these incomplete datasets were, where possible, rectified by using data available for a higher administrative level. As a next step, the extent of land unsuitable for livestock production was delineated based on criteria such as protected areas, land cover, climate, topography and vegetation. Once the available agricultural statistics have been collected, standardized, enhanced with supplementary data and adjusted for the extent of land deemed suitable for livestock production, the resulting data archive provides a sound basis for statistical distribution modelling. Statistical relationships are established between observed livestock densities and predictor variables. The resulting equations are then applied to spatial data of the predictor variables so as to produce a predicted distribution map.

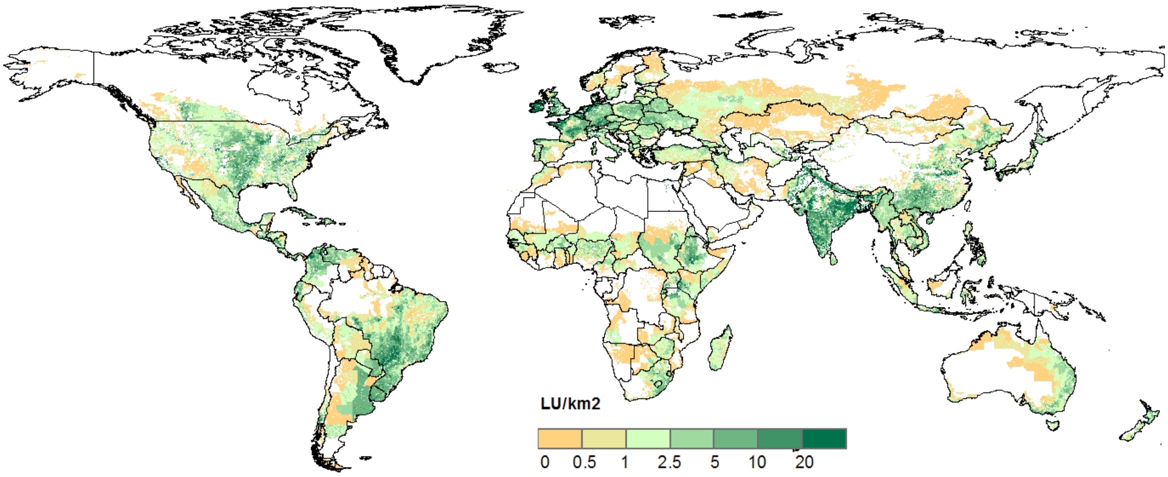


Figure S 2. Bovine livestock units density in the year 2000 (source: (8))

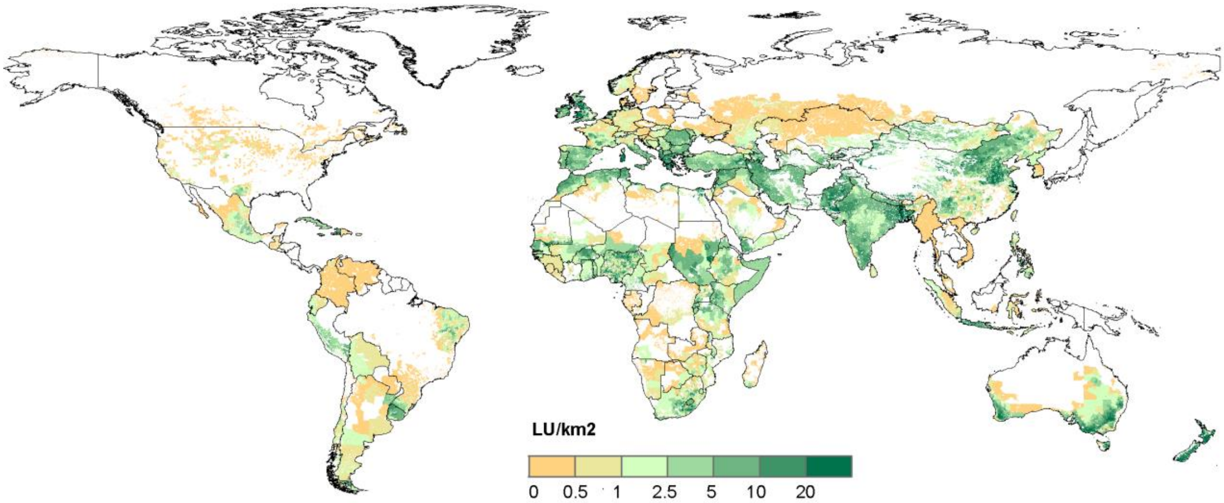


Figure S 3. Small ruminant livestock units density in the year 2000 (source:(8))

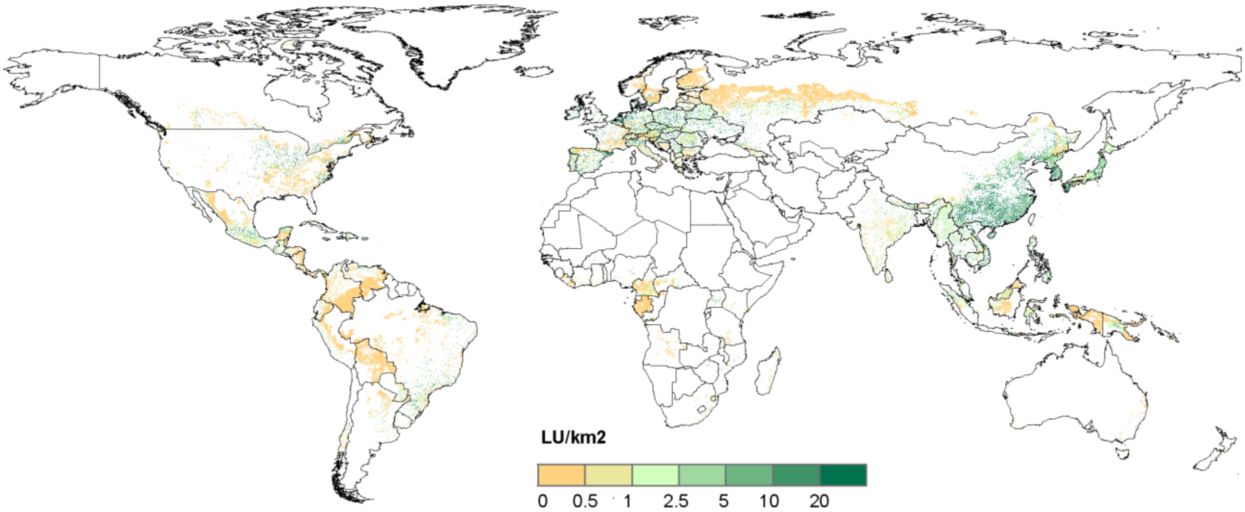


Figure S 4. Pig livestock units density in the year 2000 (source: (8))

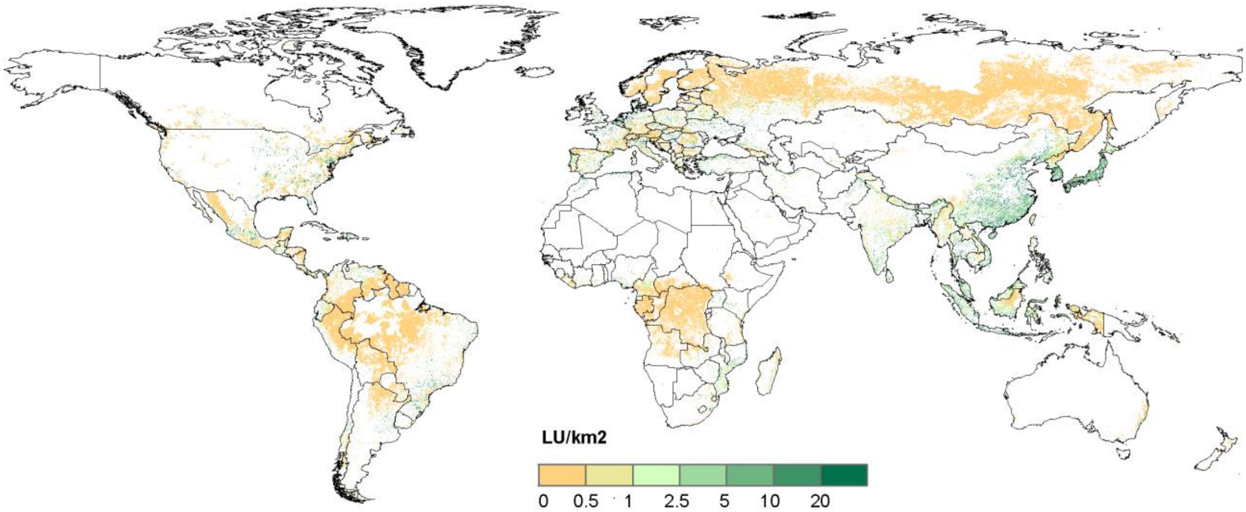


Figure S 5. Poultry livestock units density in the year 2000 (source: (8))

2. Global maps for results on biomass use, production and GHG emissions

a. Map coverage

Table S 1. List of high-resolution global livestock data layers for the year 2000.

Variable	Implemented for
Feed consumption (MT/km2/year)	
Total feed	Bovines, bovine products, SR, SR products, ruminants
Grazing	Bovines, bovine products, SR, SR products, ruminants
Stover	Bovines, bovine products, SR, SR products, ruminants
Grain	Bovines, bovine products, SR, SR products, ruminants, pigs and poultry
Occasional fodder	Bovines, bovine products, SR, SR products, ruminants
Total feed	Bovines, bovine products, SR, SR products, ruminants, pigs and poultry
Production (MT/km2/year)	
Meat	Bovines, SR, pigs, poultry
Milk	Bovines, SR
Eggs	Poultry
Manure (MT/km2/year)	Bovines, bovine products, SR and SR products, pigs, poultry
N excretion (kg/km2/year)	Bovines, bovine products, SR and SR products, pigs, poultry
GHG emissions (MT CO2eq/km2/year)	
N2O emissions	Bovines, bovine products, SR and SR products, pigs, poultry
Methane emissions	Bovines, bovine products, SR and SR products, pigs
GHG efficiency (kg CO2eq/kg)	
GHG efficiency per kg product	Bovine products, SR products, pork, poultry
GHG efficiency per kg edible protein	Bovine products, SR products, pork, poultry
Methane efficiency per kg product	Bovine products, SR products
Methane efficiency per kg edible protein	Bovine products, SR products
N2O efficiency per kg product	Bovine products, SR products
N2O efficiency per kg edible protein	Bovine products, SR products
Value Of Production (000 $/km2/yr)	All products , total
Nutritional Value (Kcal/person/day)	Ruminant products

b. Map results

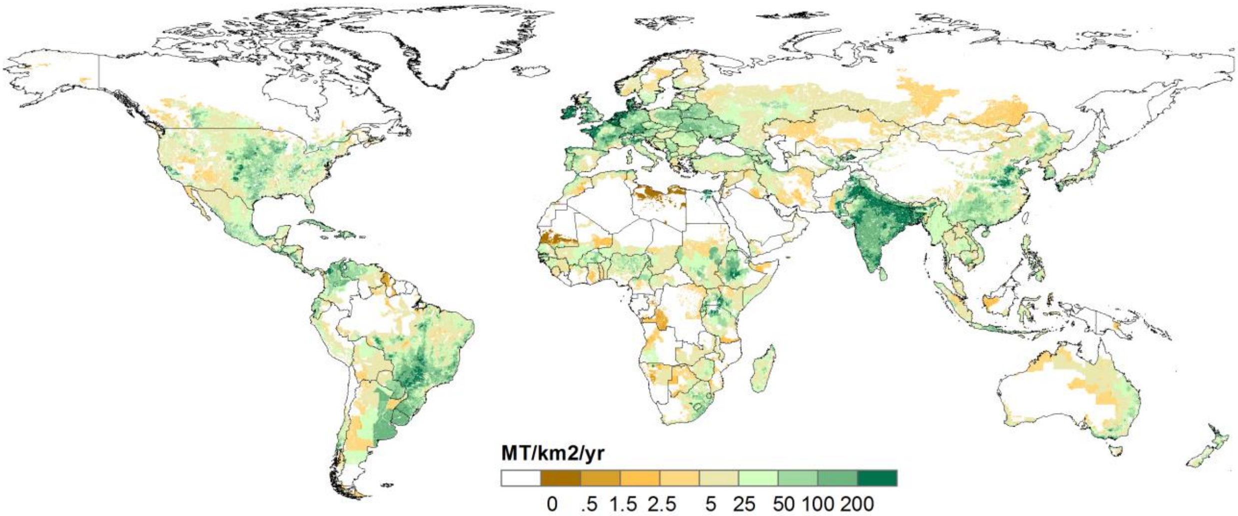


Figure S 6. Total feed biomass consumption by bovines in the year 2000

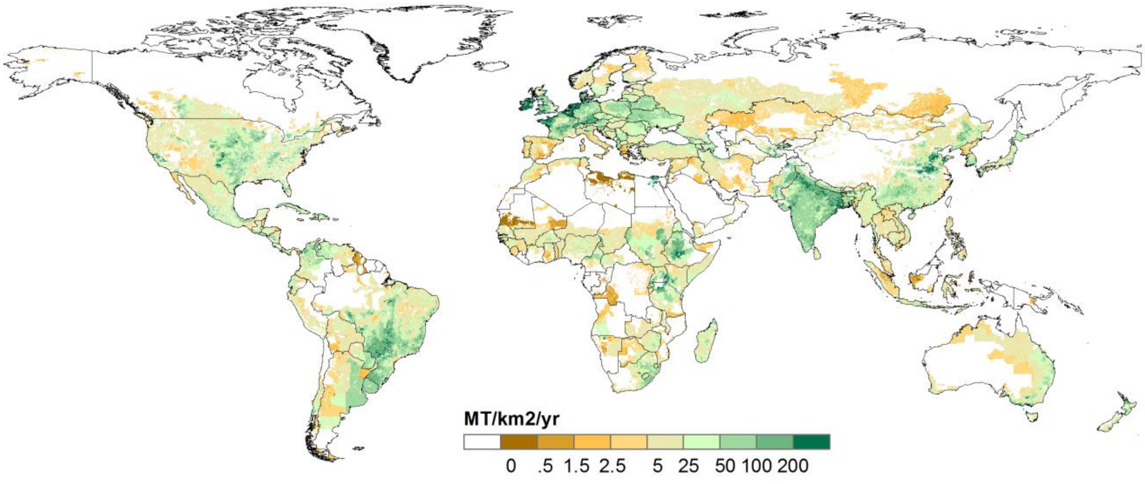


Figure S 7. Grazing biomass consumption by bovines in the year 2000

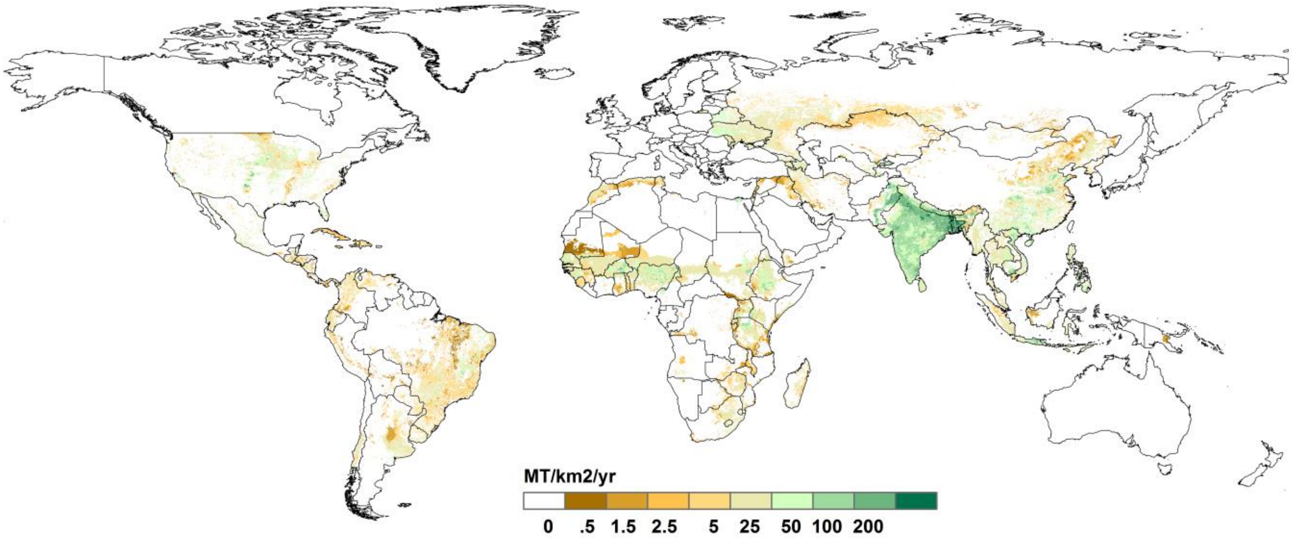


Figure S 8. Stover biomass consumption by bovines in the year 2000

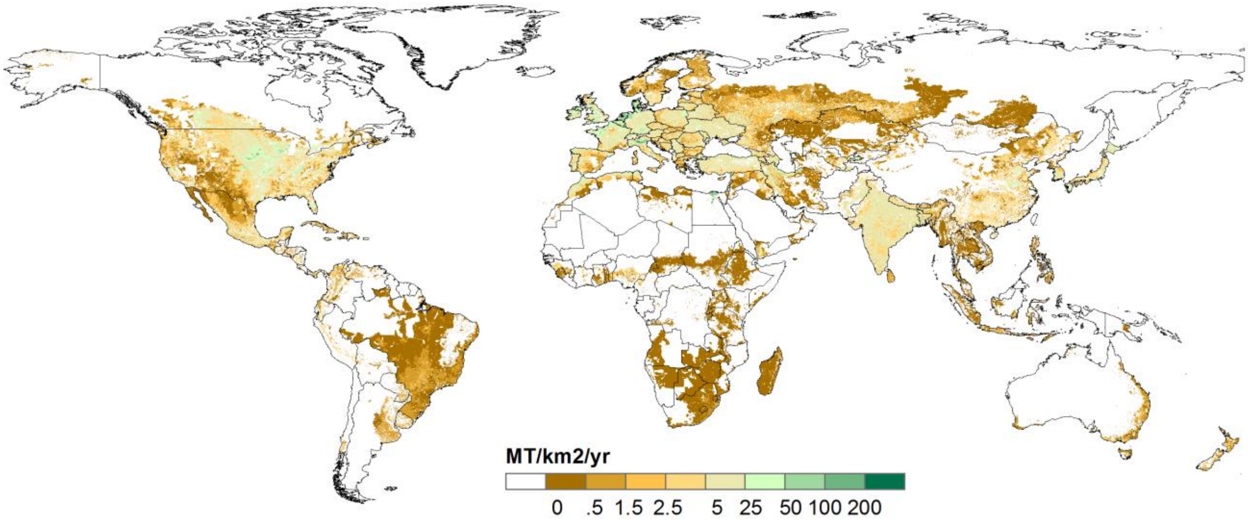


Figure S 9. Grain biomass consumption by bovines in the year 2000

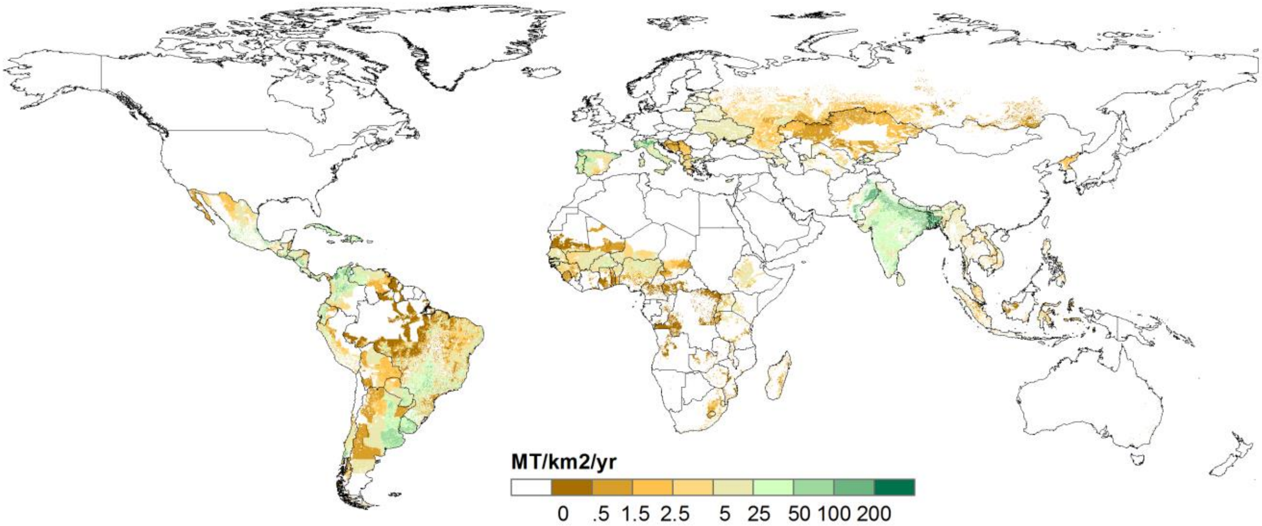


Figure S 10. Occasional biomass consumption by bovines in the year 2000

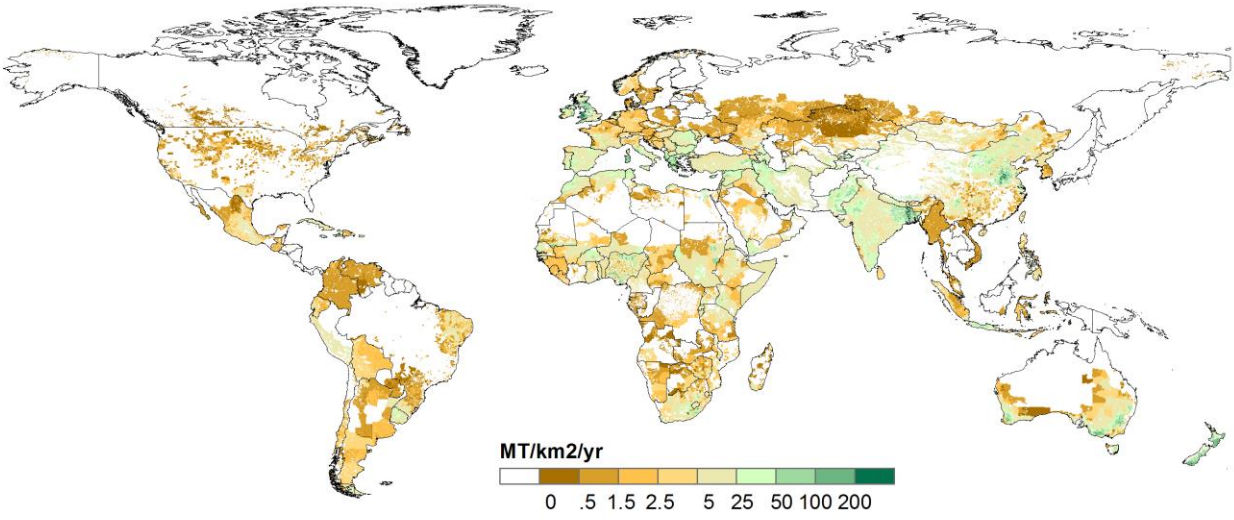


Figure S 11. Total biomass consumption by small ruminants in the year 2000

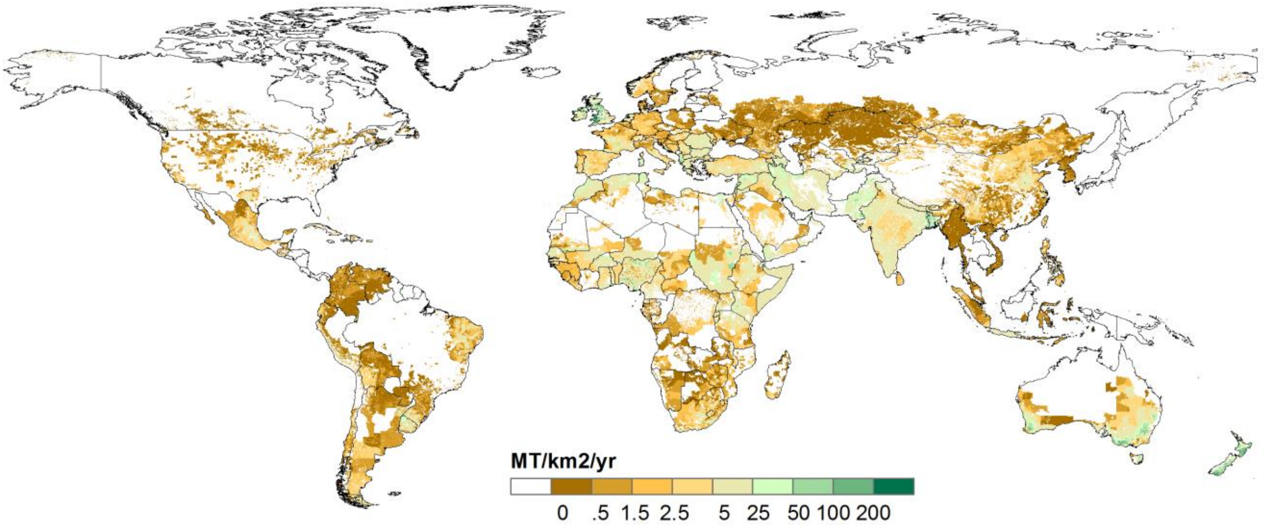


Figure S 12. Grazing biomass consumption by small ruminants in the year 2000

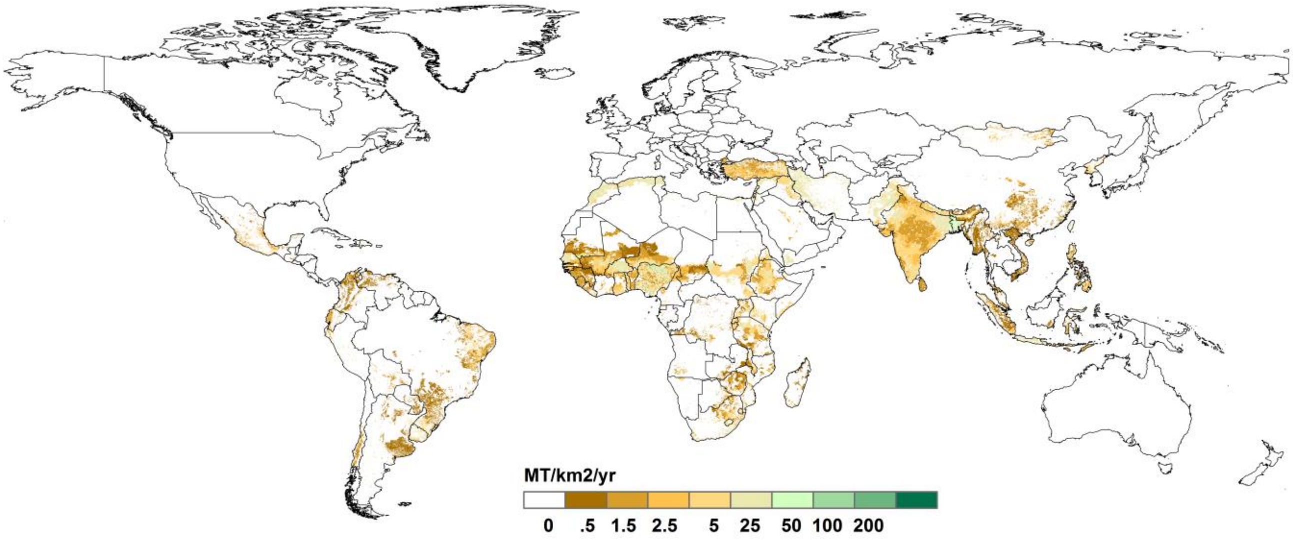


Figure S 13. Stover biomass consumption by small ruminants in the year 2000

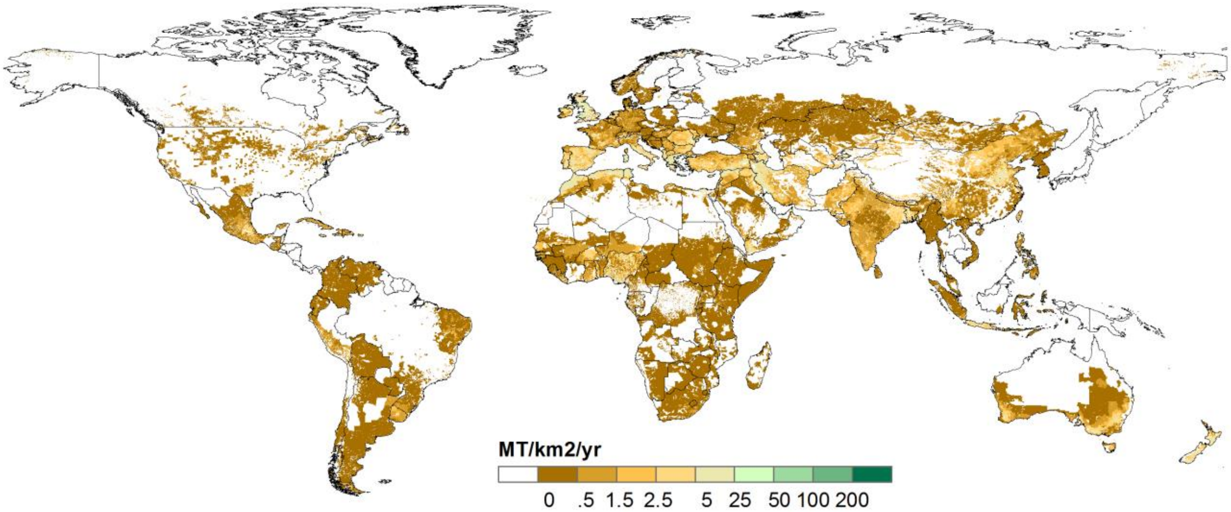


Figure S 14. Grain biomass consumption by small ruminants in the year 2000

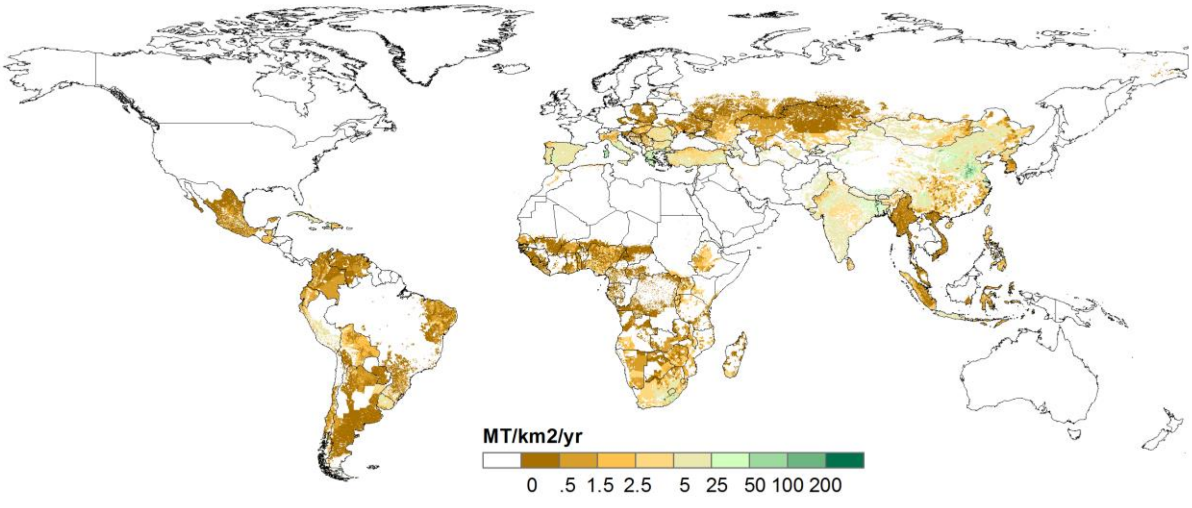


Figure S 15. Occasional biomass consumption by small ruminants in the year 2000

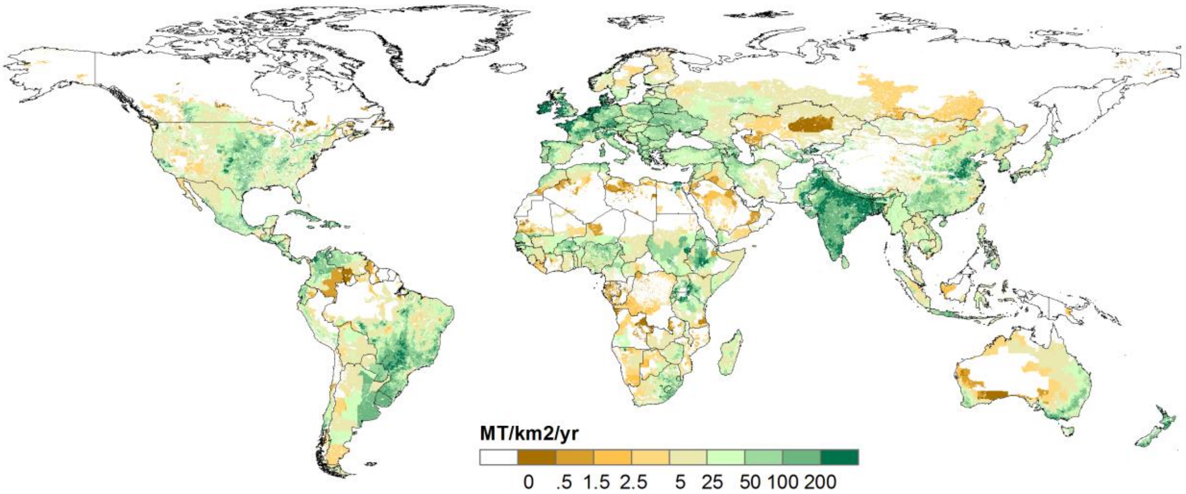


Figure S 16. Total biomass consumption by ruminants in the year 2000

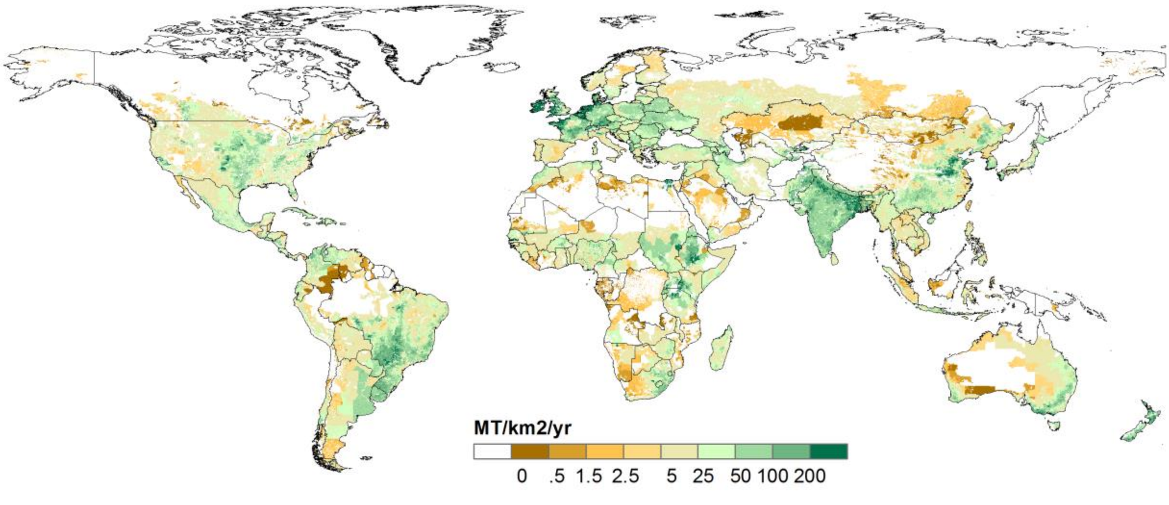


Figure S 17. Grazing Biomass consumption by ruminants in the year 2000

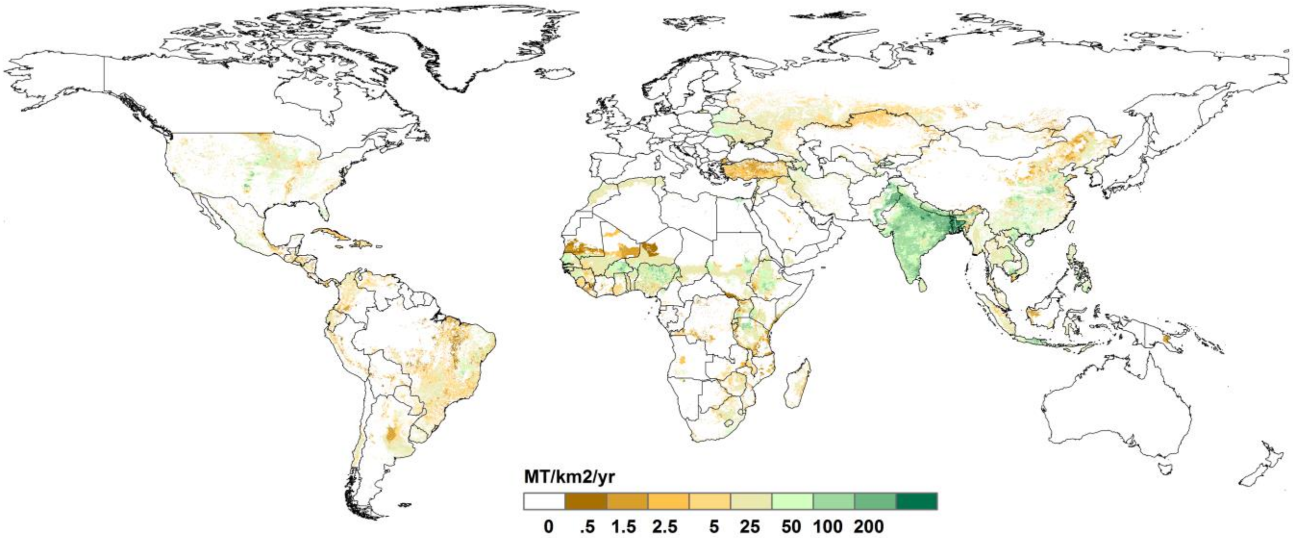


Figure S 18. Stover biomass consumption by ruminants in the year 2000

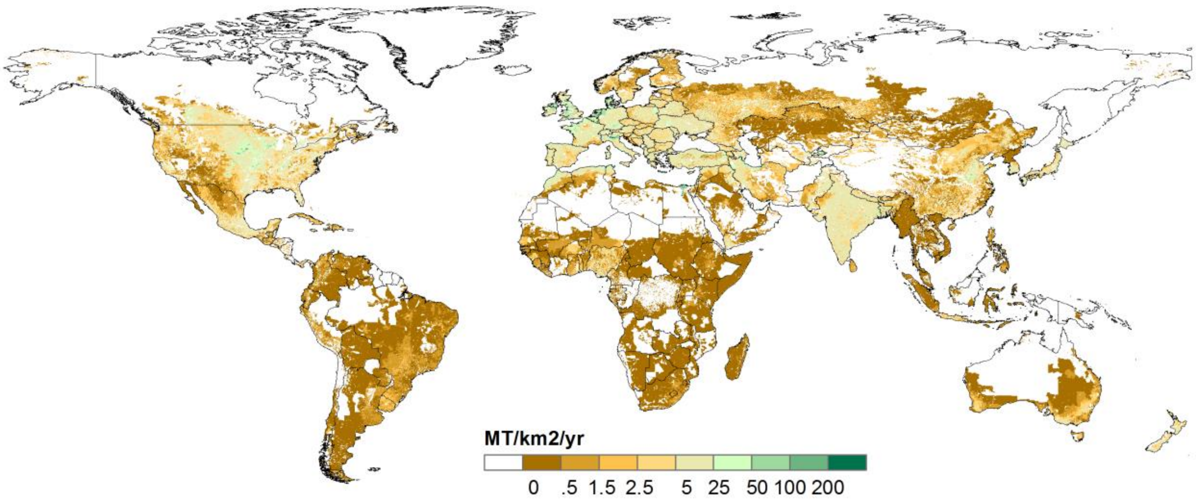


Figure S 19. Grain biomass consumption by ruminants in the year 2000

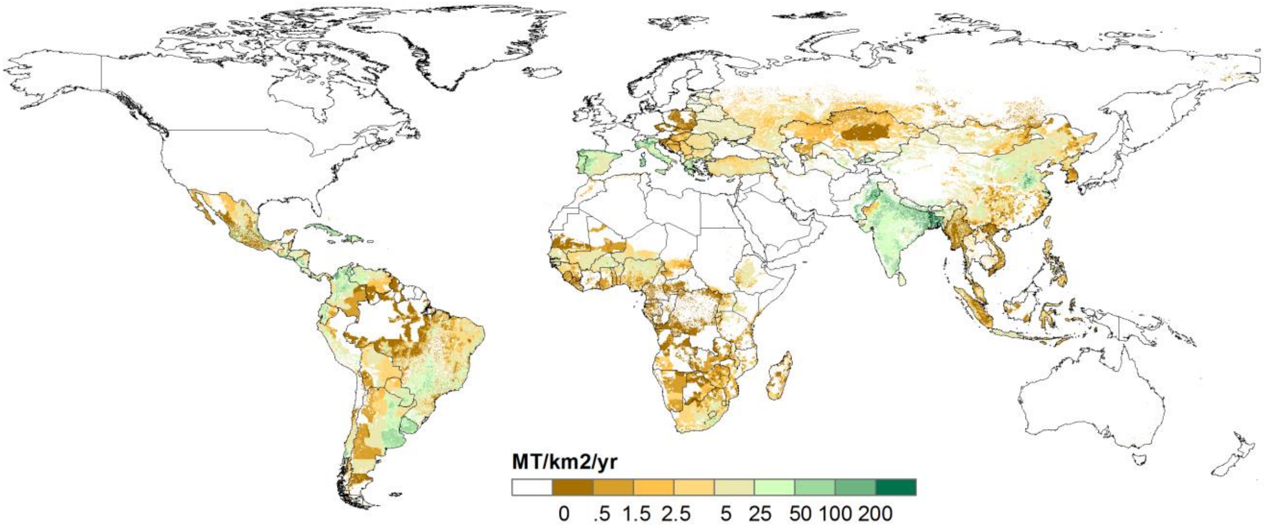


Figure S 20. Occasional biomass consumption by ruminants in the year 2000

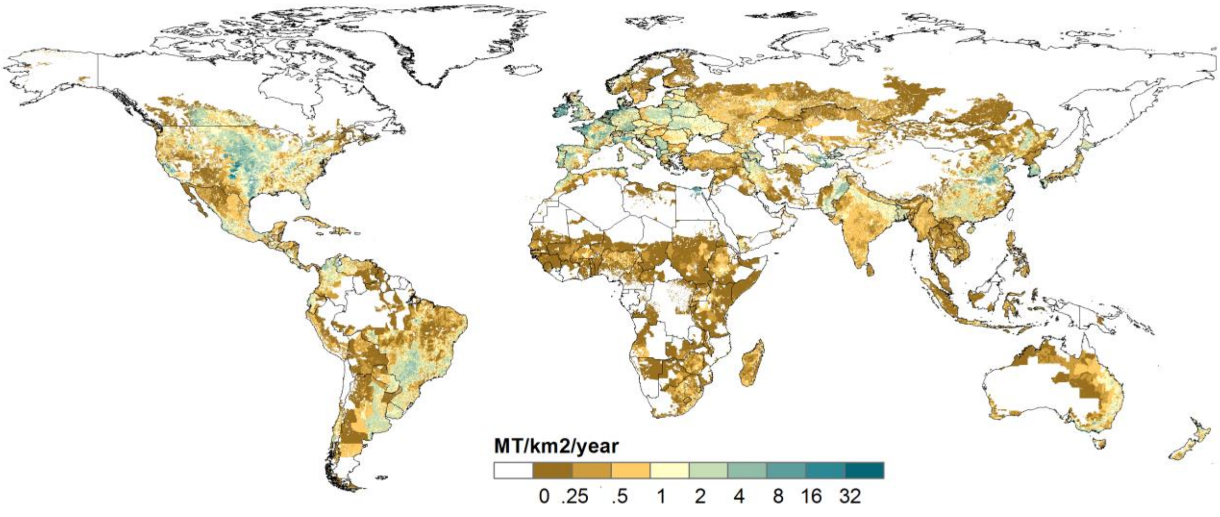


Figure S 21. Bovine meat production density in the year 2000

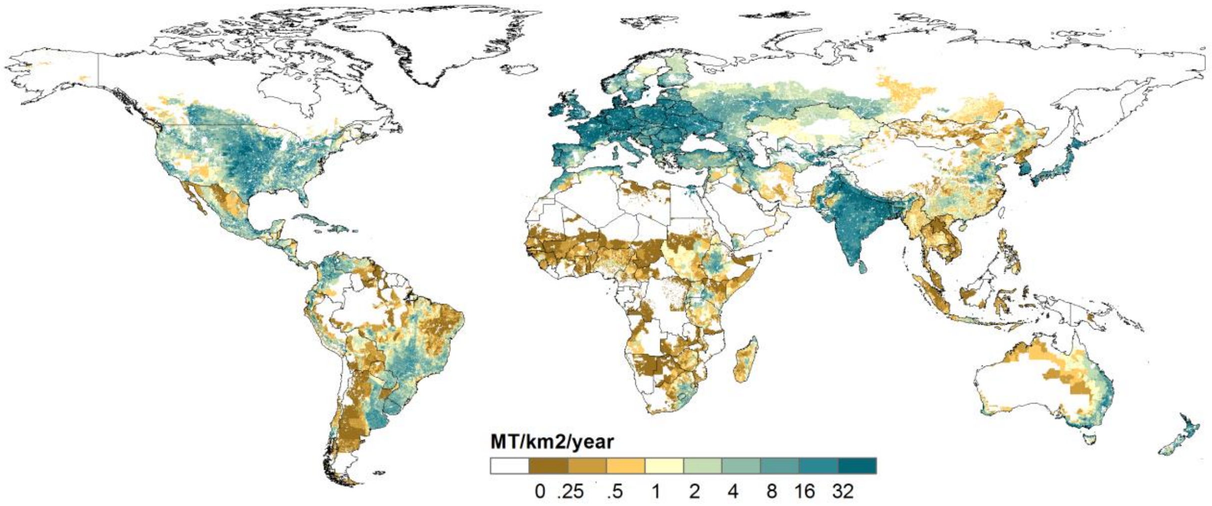


Figure S 22. Bovine milk production density in the year 2000

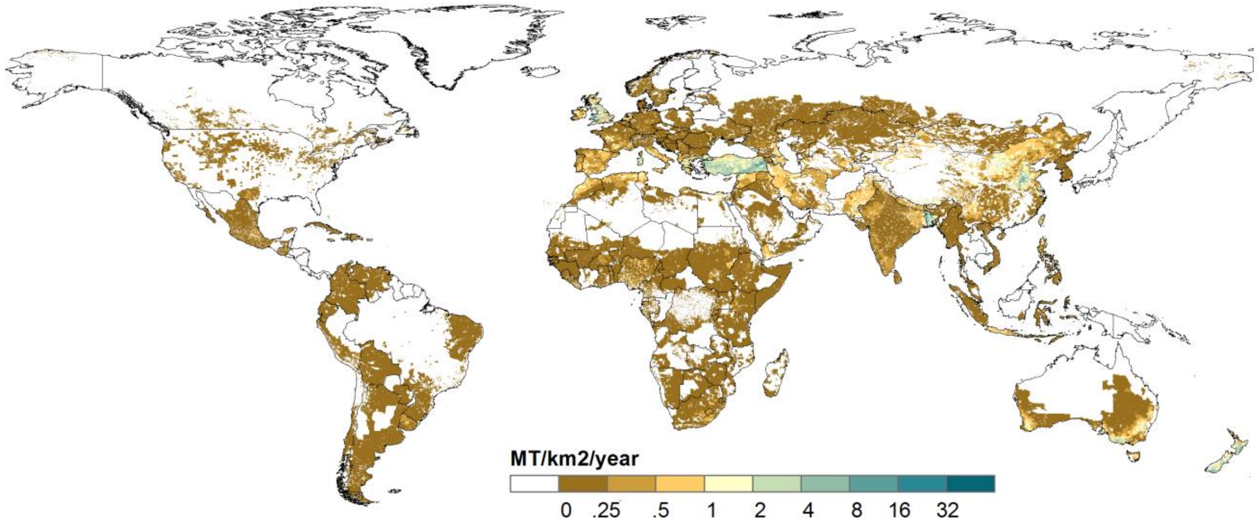


Figure S 23. Small ruminant meat production density in the year 2000

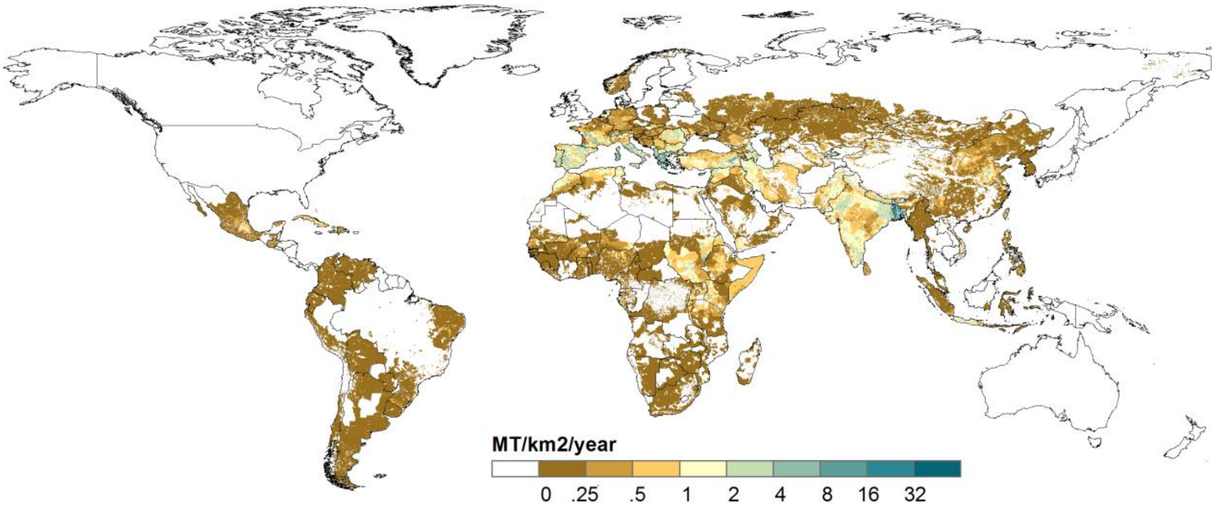


Figure S 24. Small ruminant milk production density in the year 2000

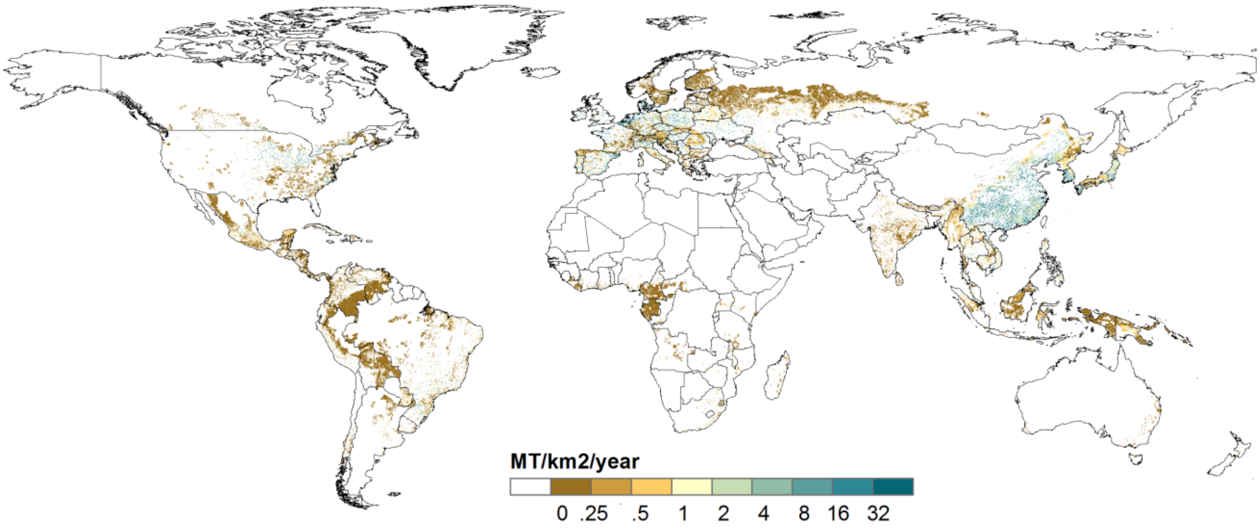


Figure S 25. Pig meat production density in the year 2000

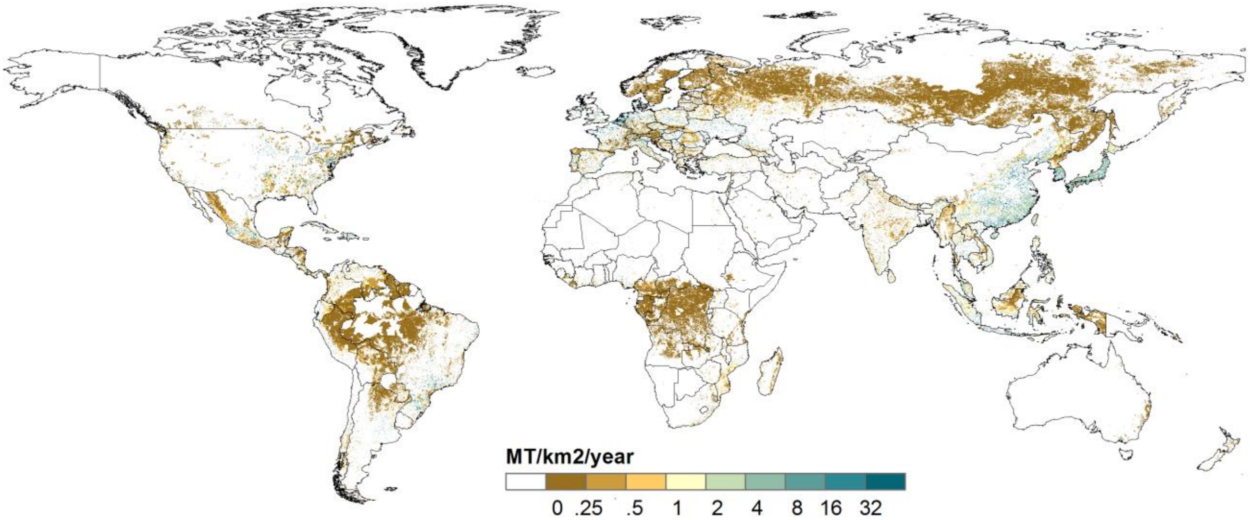


Figure S 26. Poultry eggs production density in the year 2000

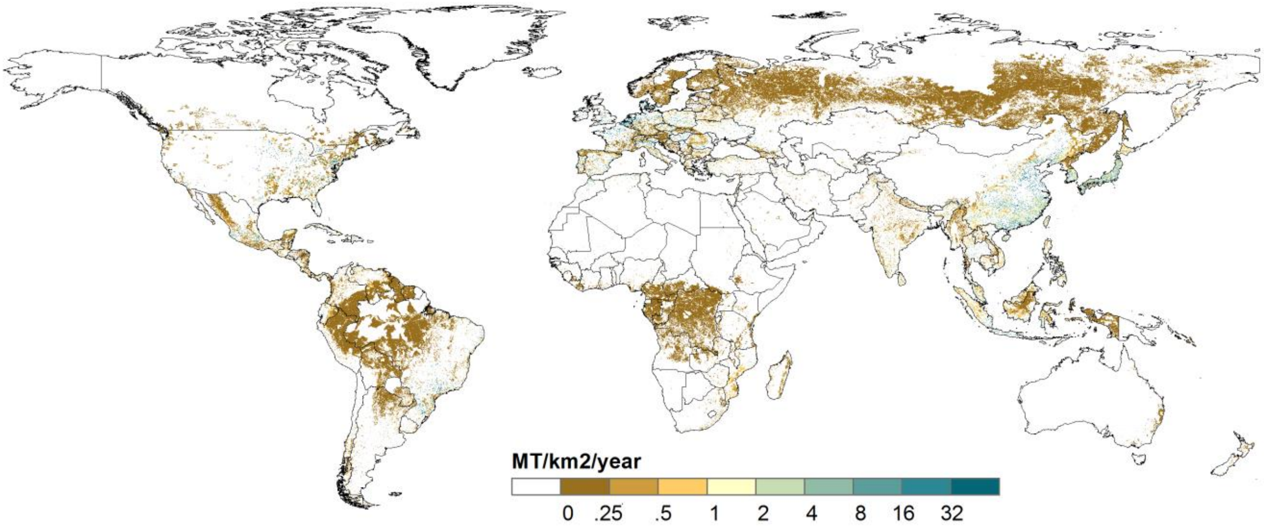


Figure S 27. Poultry meat production density in the year 2000

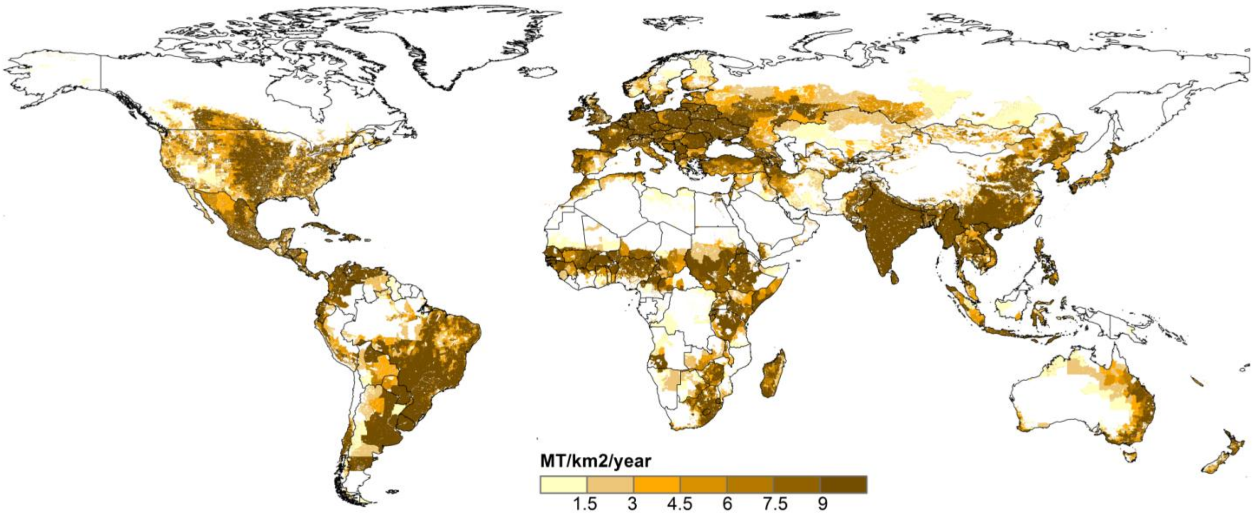


Figure S 28. Manure by bovines in the year 2000

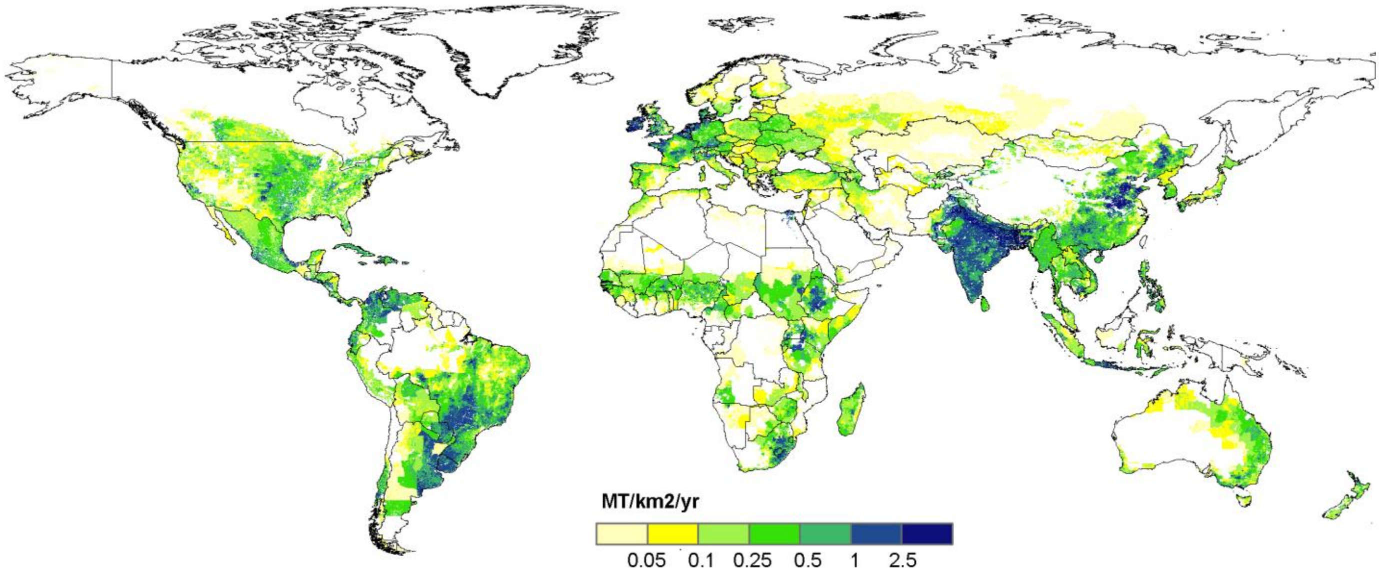


Figure S 29. Nitrogen excretion associated with bovine meat production in the year 2000

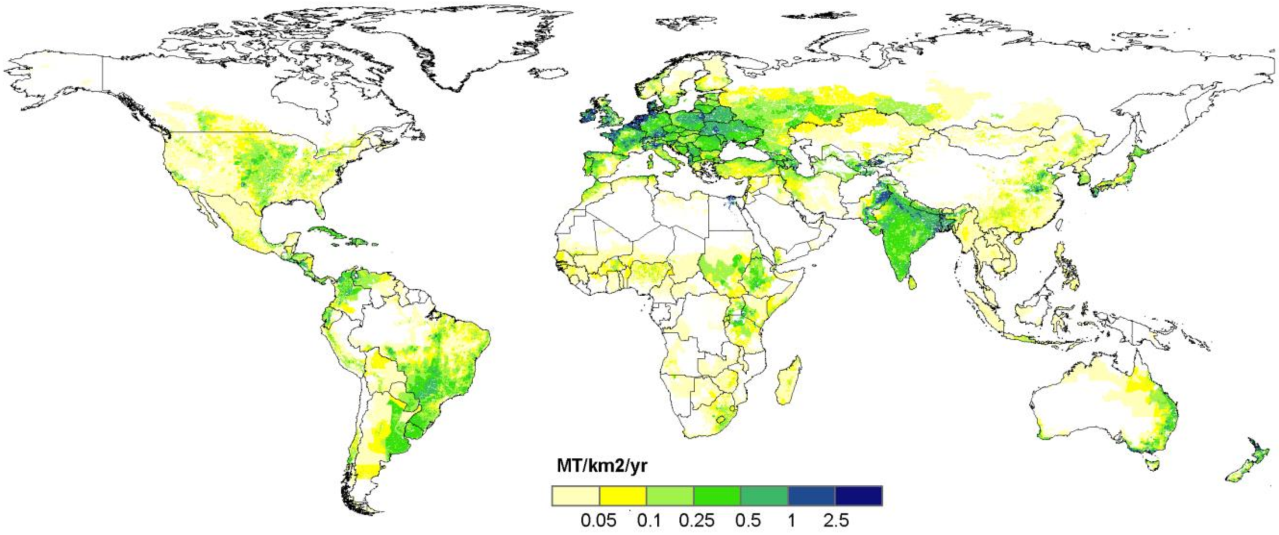


Figure S 30. Nitrogen Excretion associated with bovine milk production in the year 2000

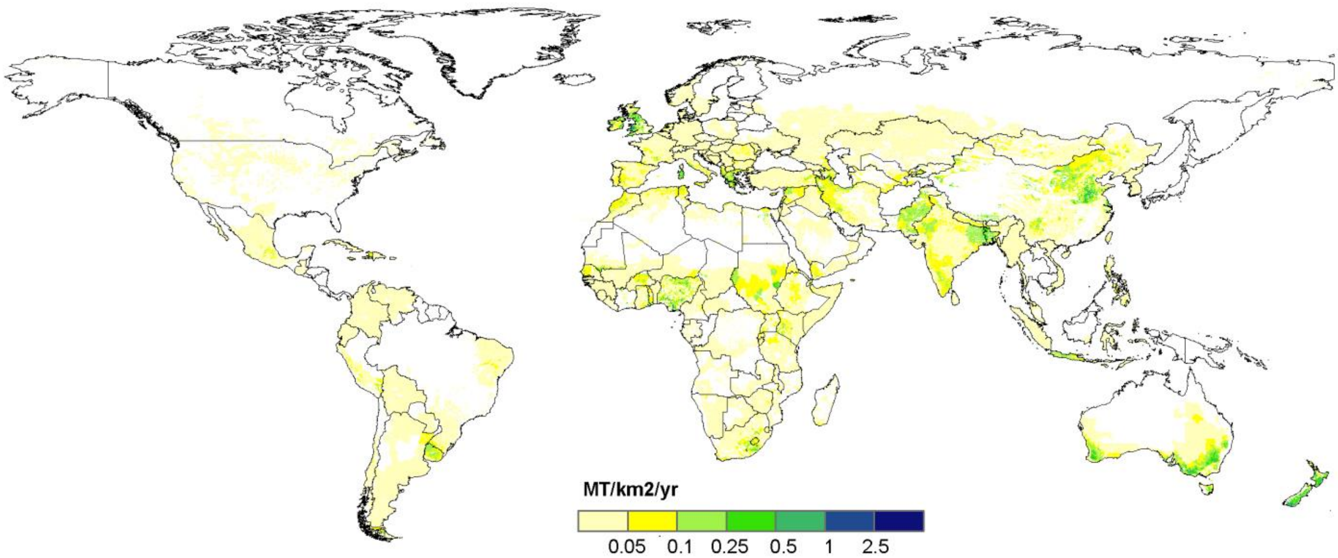


Figure S 31. Nitrogen Excretion associated with Small ruminant meat production in the year 2000

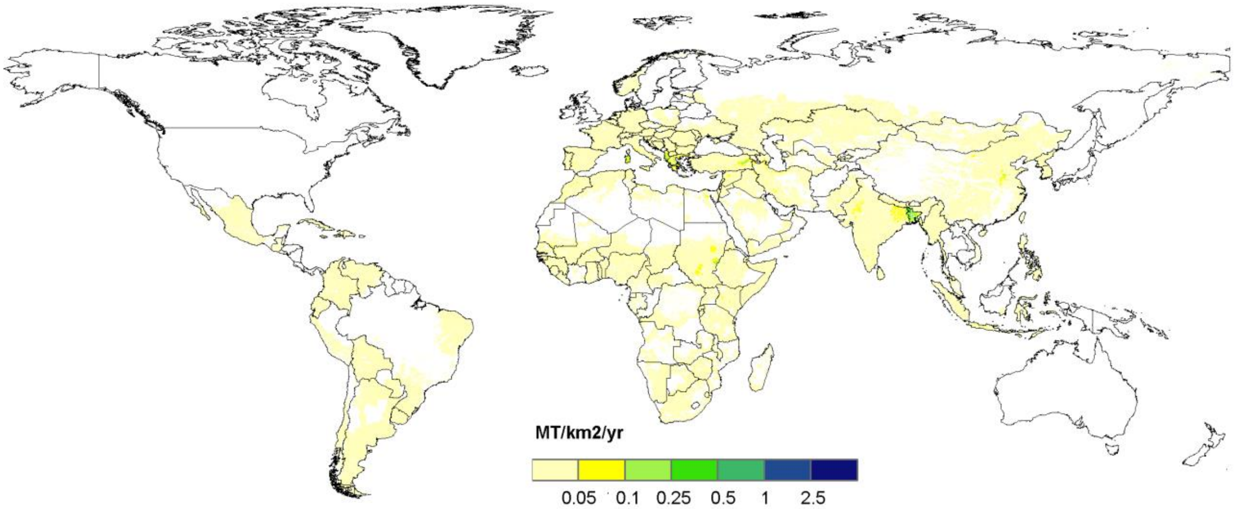


Figure S 32. Nitrogen excretion associated with small ruminant milk production in the year 2000

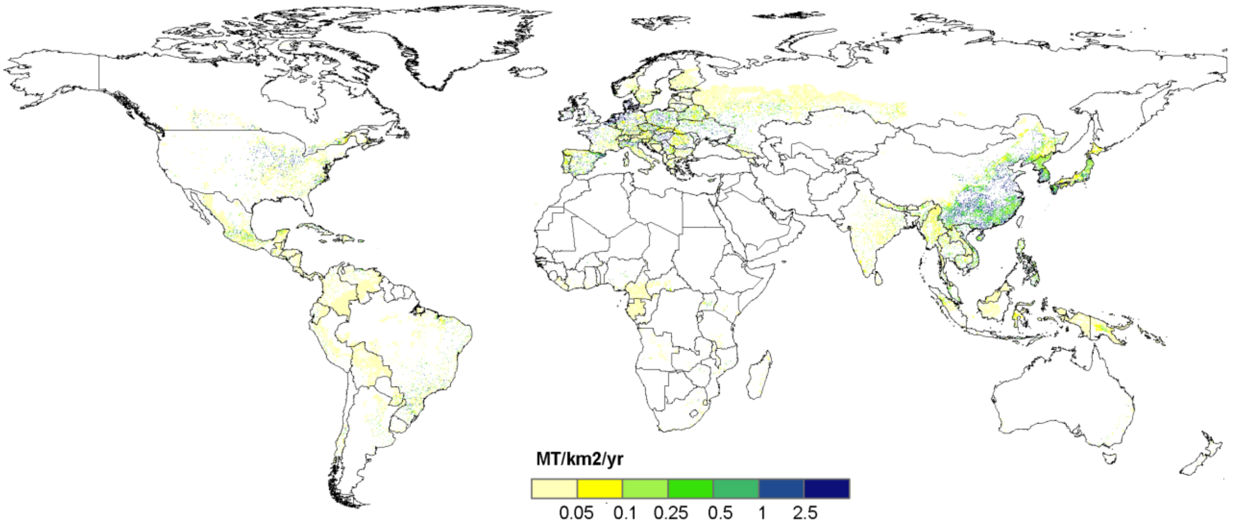


Figure S 33. Nitrogen excretion associated with pig meat production in the year 2000

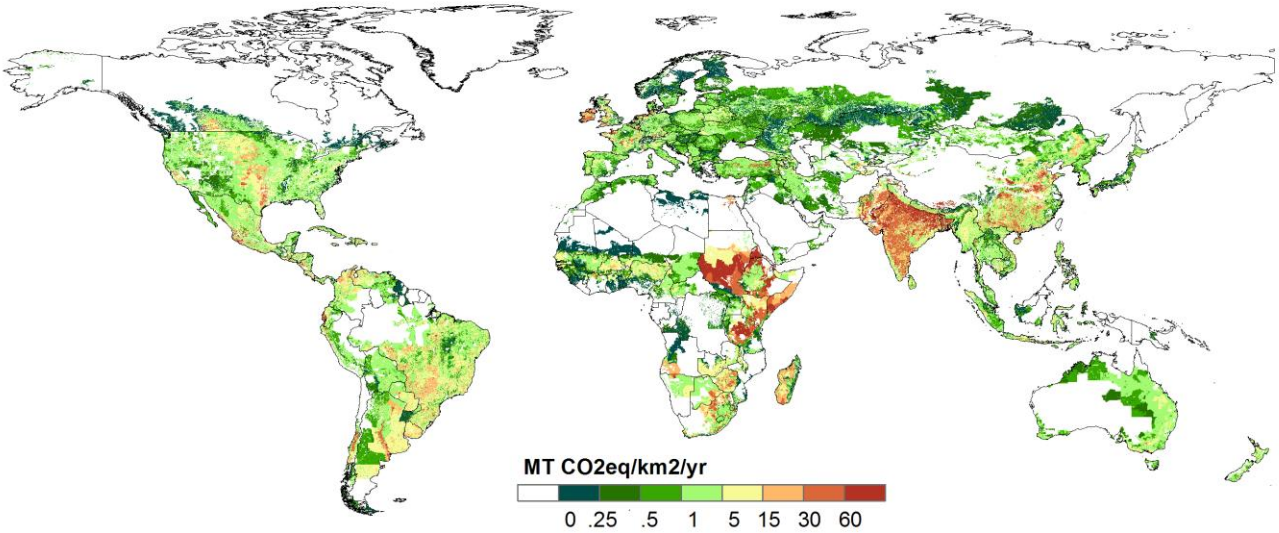


Figure S 34. Nitrous oxide emissions associated with bovine meat production in the year 2000

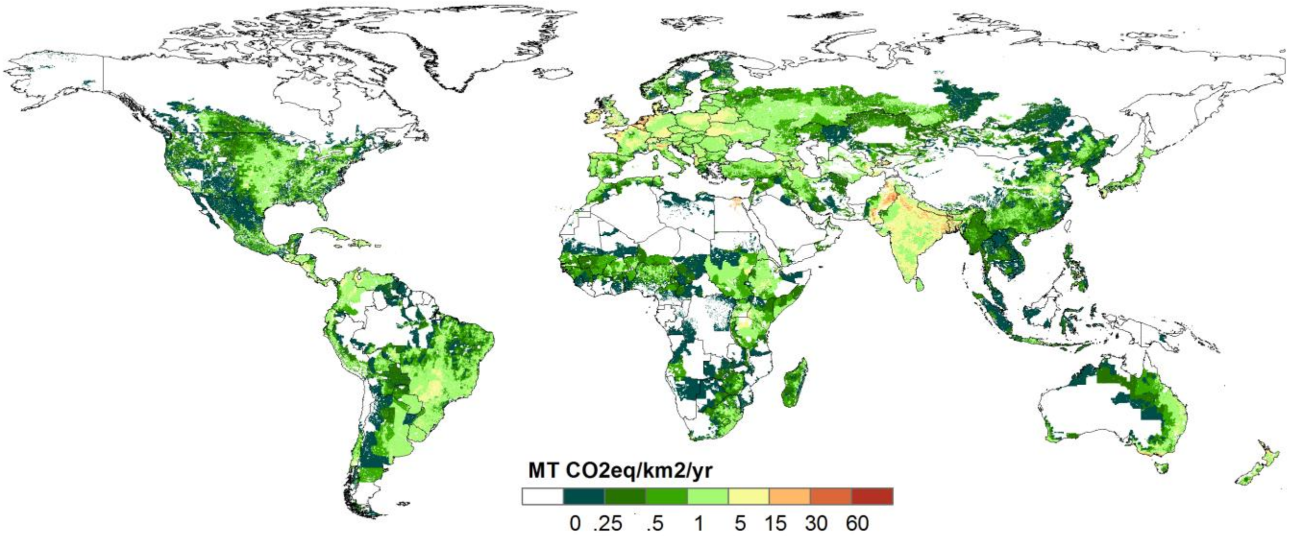


Figure S 35. Nitrous oxide emissions associated with bovine milk production in the year 2000

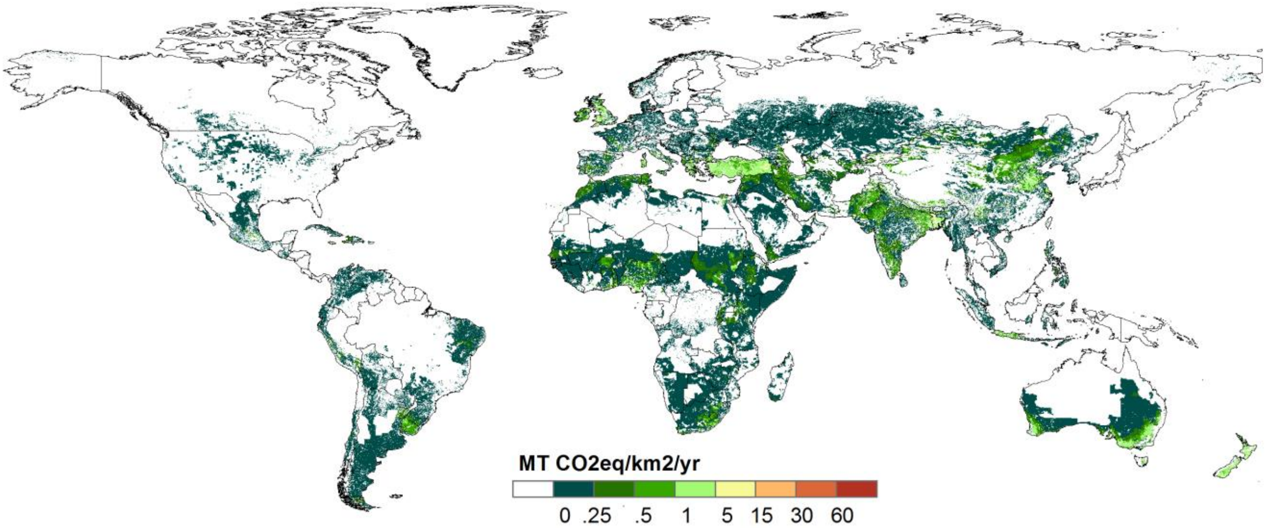


Figure S 36. Nitrous oxide emissions associated with small ruminant meat production in the year 2000

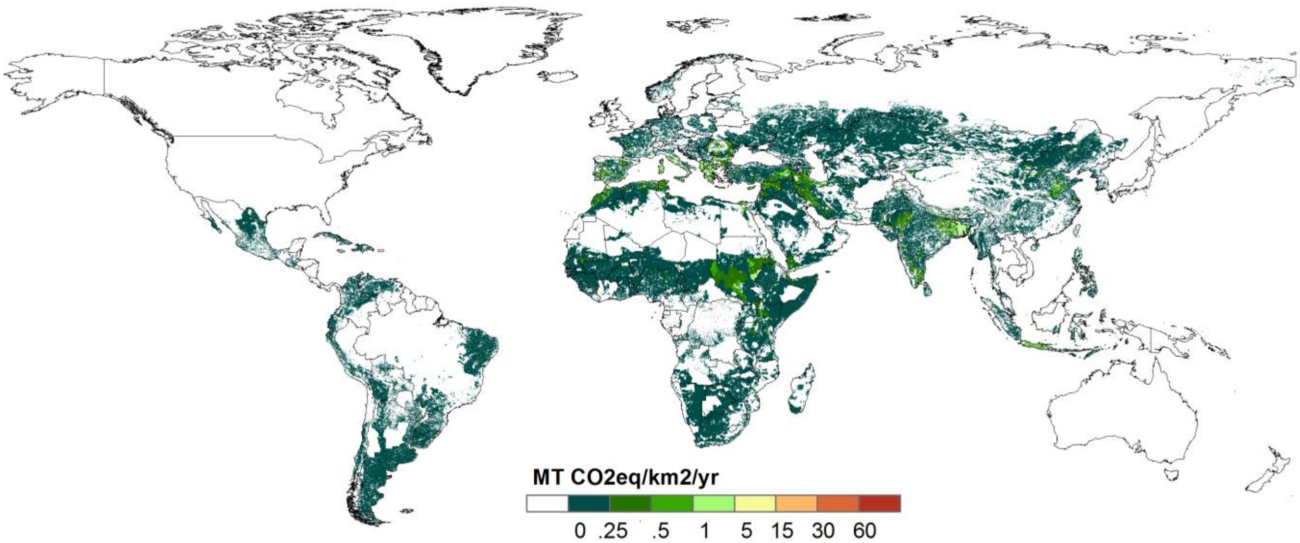


Figure S 37. Nitrous oxide Emissions associated with small ruminant milk production in the year 2000

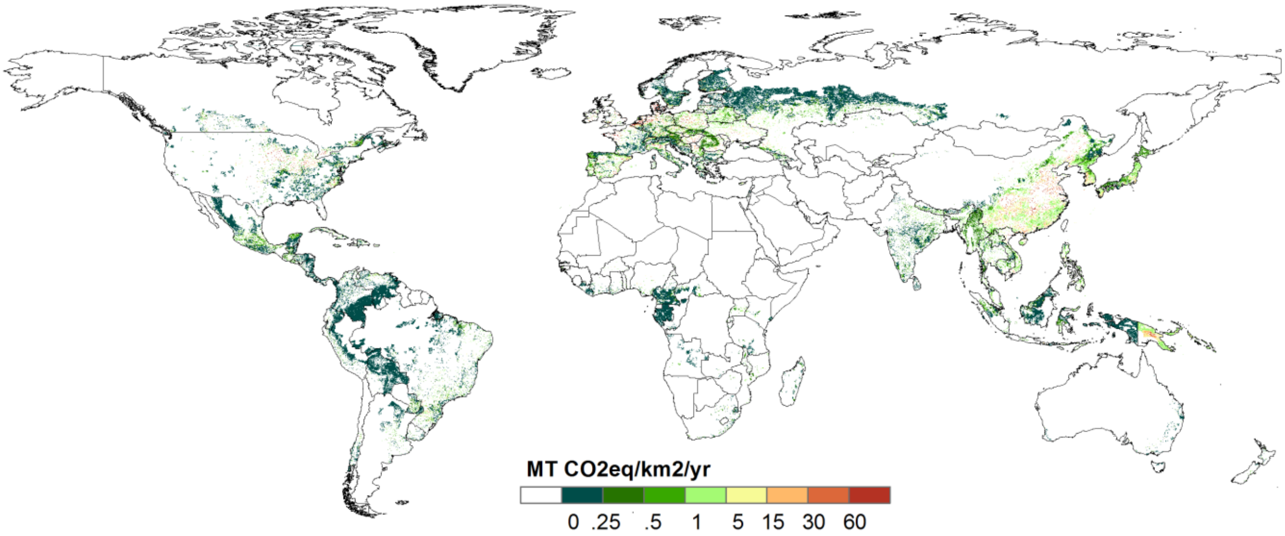


Figure S 38. Nitrous oxide emissions associated with pig meat production in the year 2000

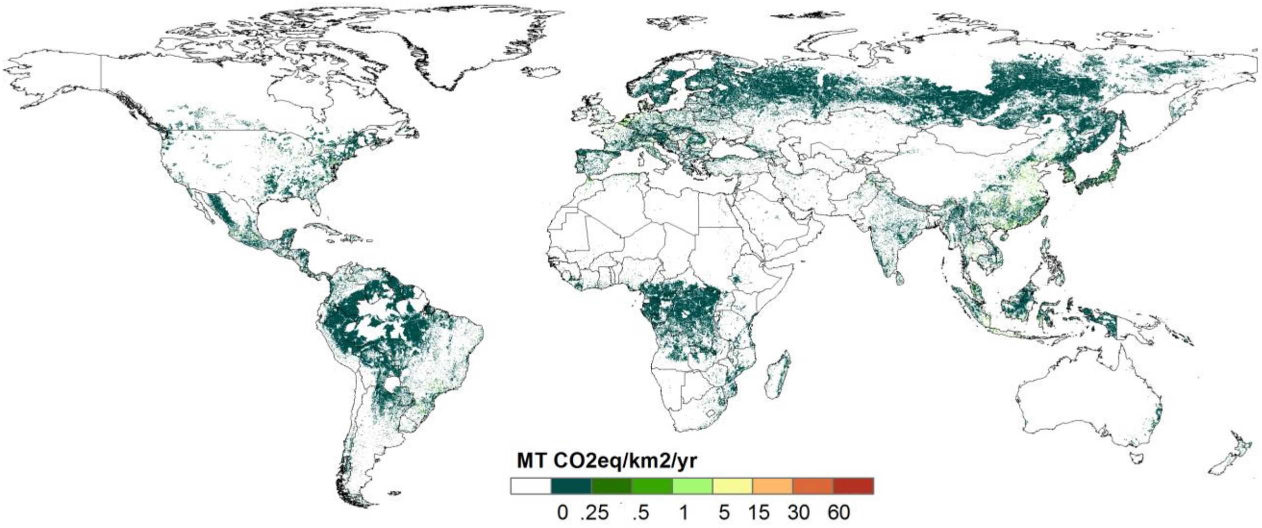


Figure S 39. Nitrous oxide Emissions associated with poultry production in the year 2000

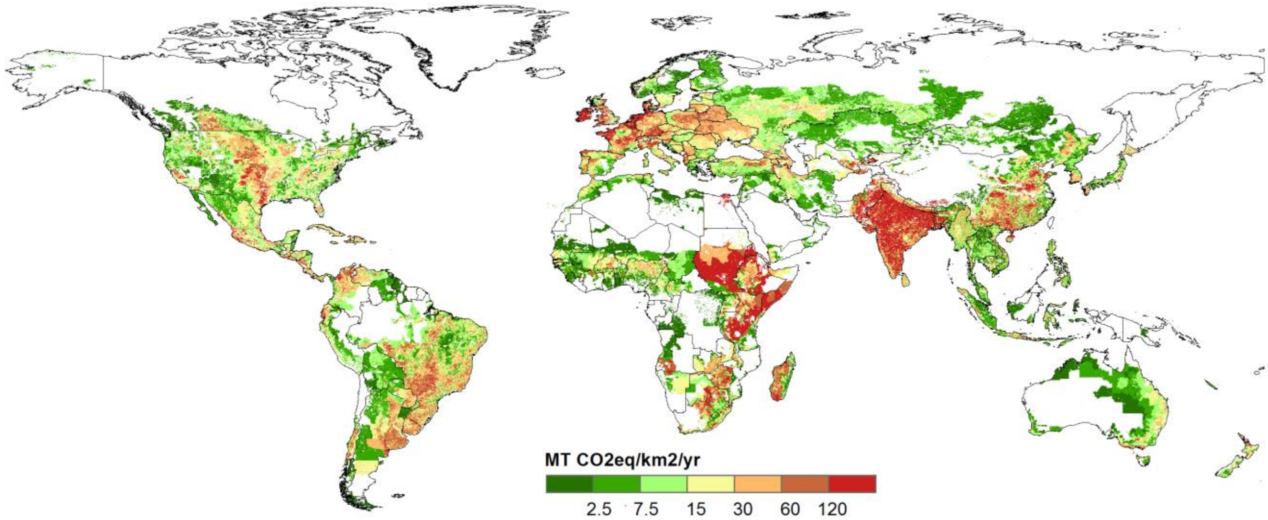


Figure S 40. Methane emissions by bovines in the year 2000

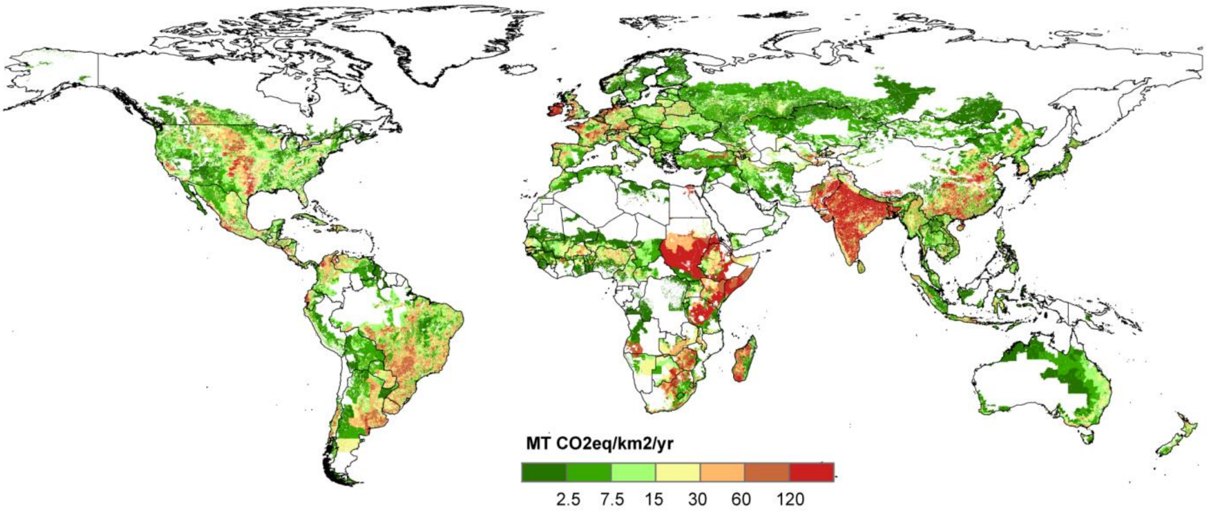


Figure S 41. Methane emission associated with bovine meat production in the year 2000

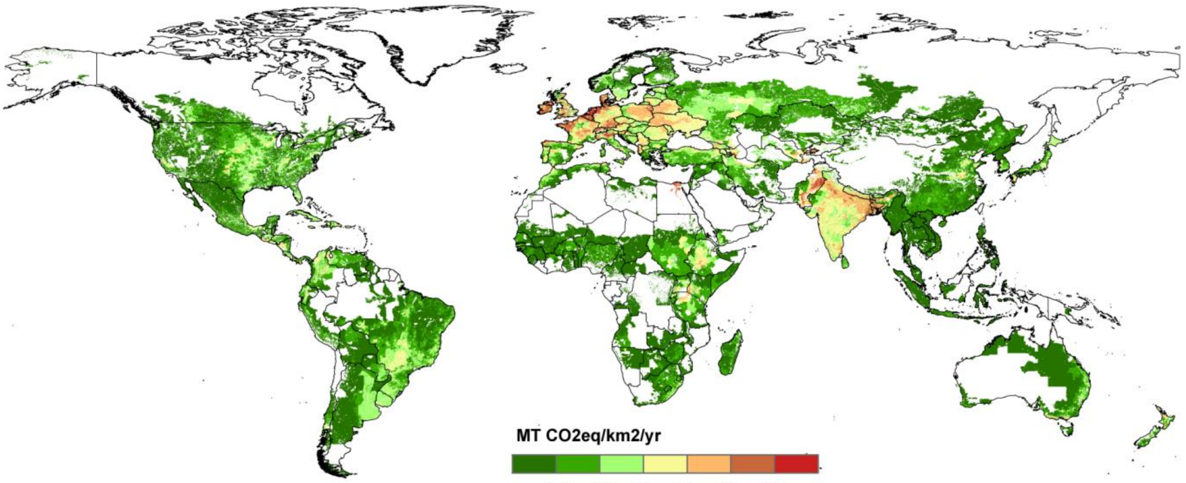


Figure S 42. Methane emissions associated with bovine milk production in the year 2000

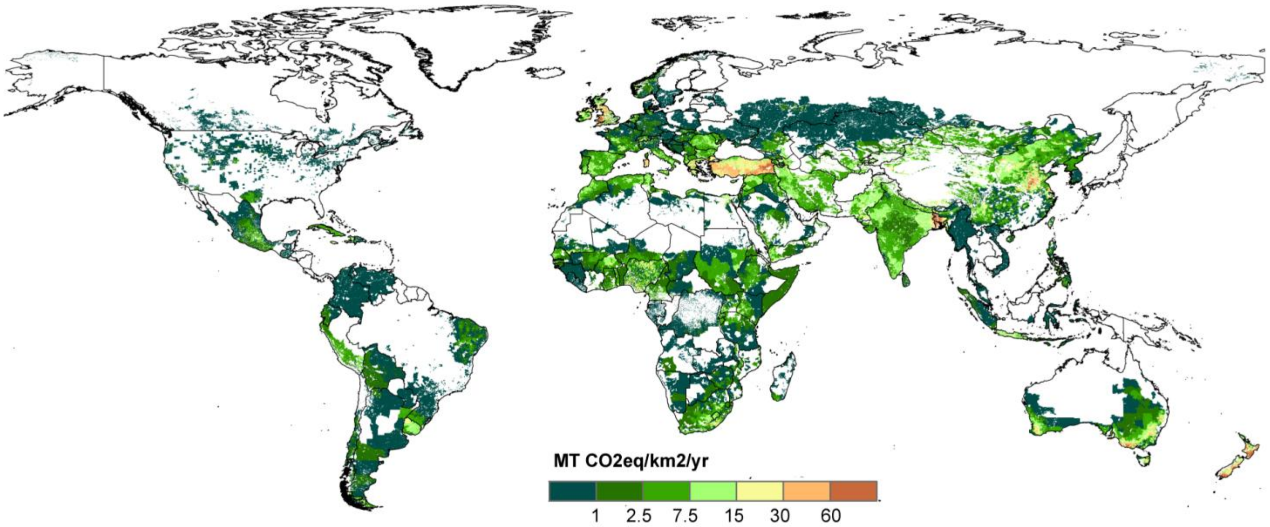


Figure S 43. Methane emissions associated with small ruminant meat production in the year 2000

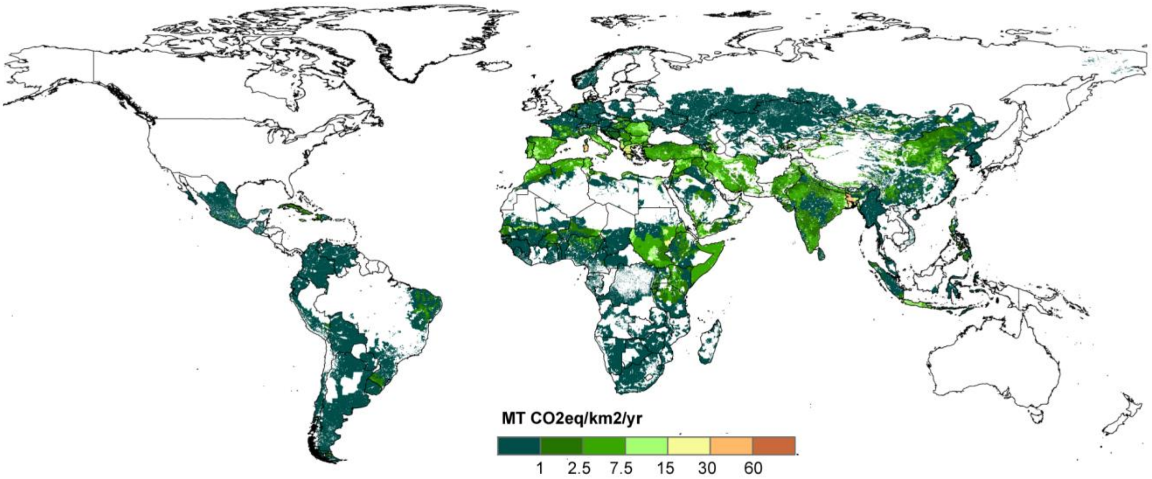


Figure S 44. Methane emissions associated with small ruminant milk production in the year 2000

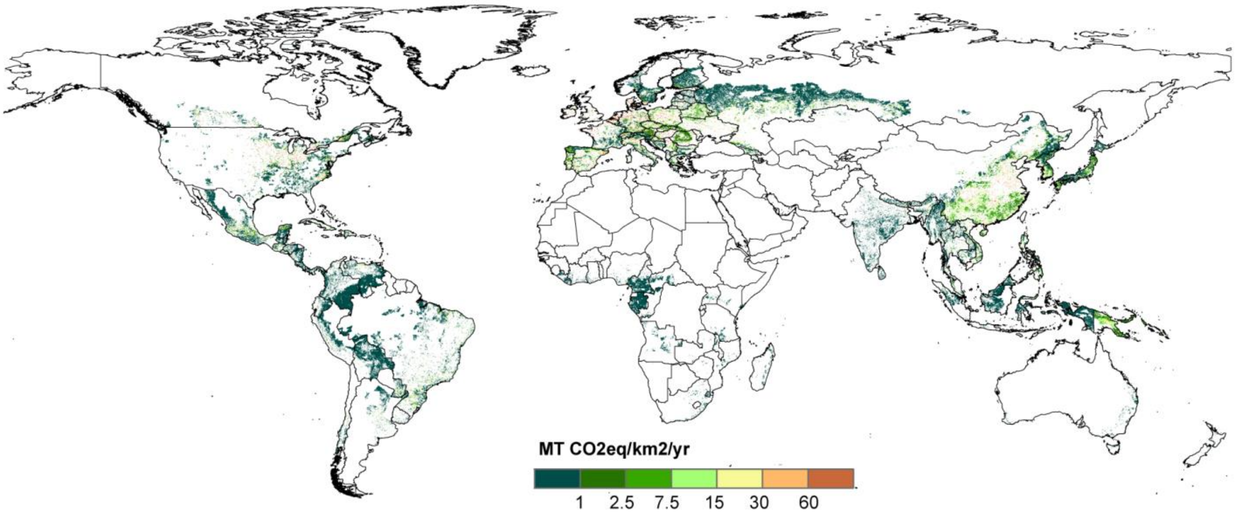


Figure S 45. Methane emissions from manure management associated with pig meat production in the year 2000

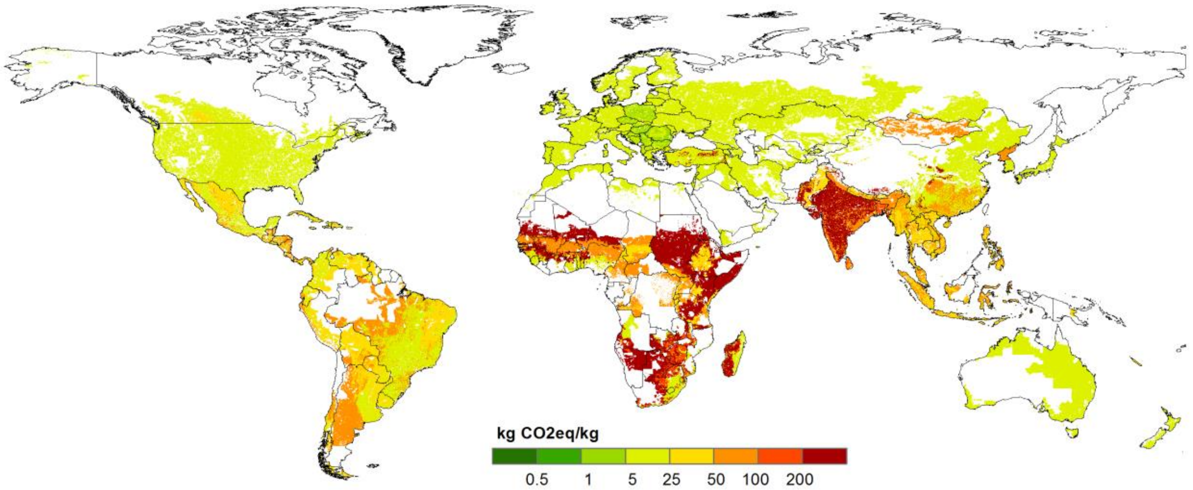


Figure S 46. GHG efficiency of bovine meat production (expressed in kg CO2eq/kg product) in the year 2000

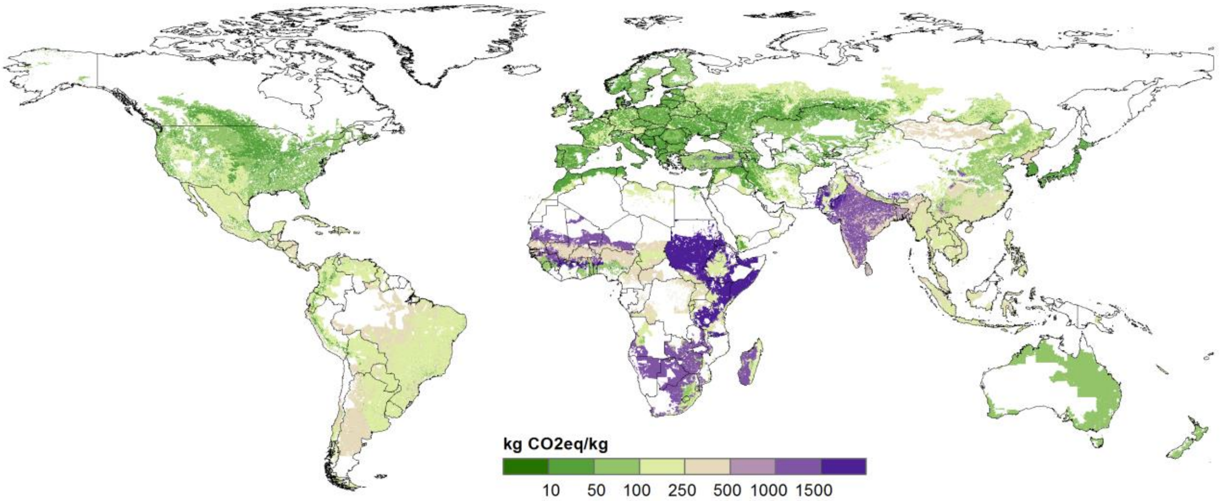


Figure S 47. GHG efficiency of bovine meat production (expressed in kg CO_2eq/g protein) in the year 2000

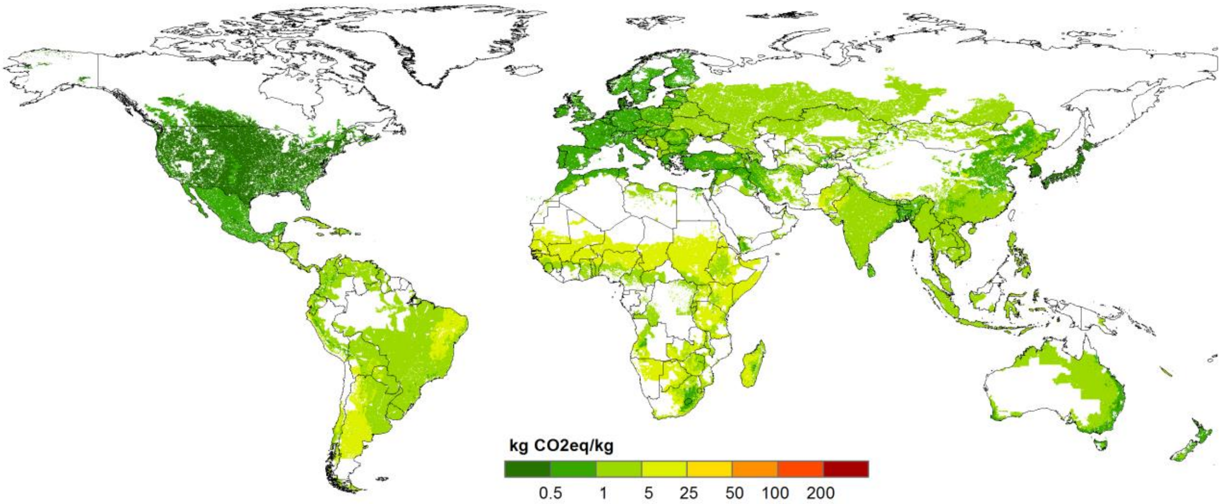


Figure S 48. GHG efficiency of bovine milk production (expressed in kg CO_2eq/kg product) in the year 2000

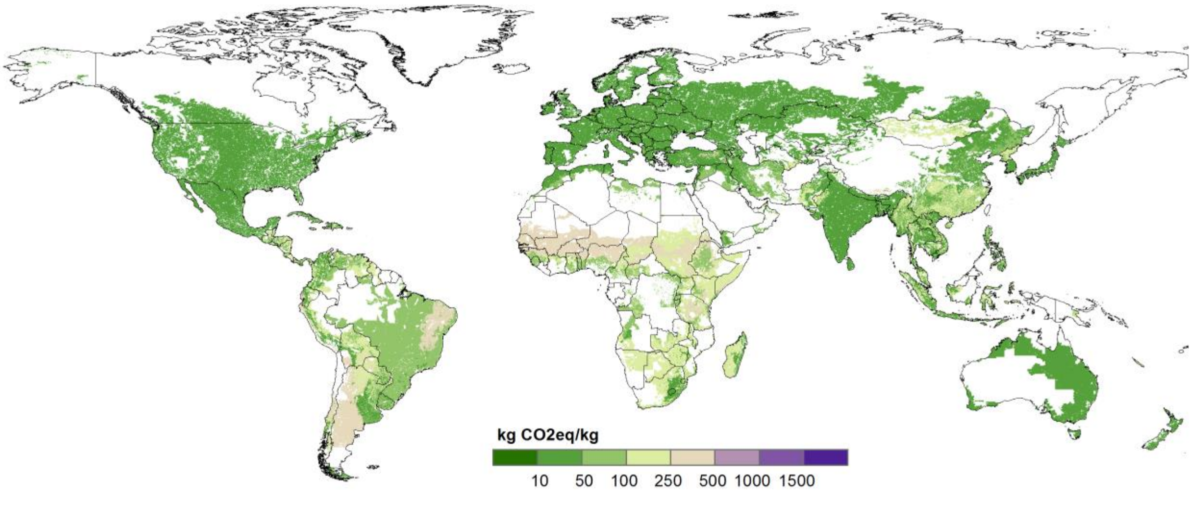


Figure S 49. GHG efficiency of bovine milk production (expressed in kg CO_2eq/g protein) in the year 2000

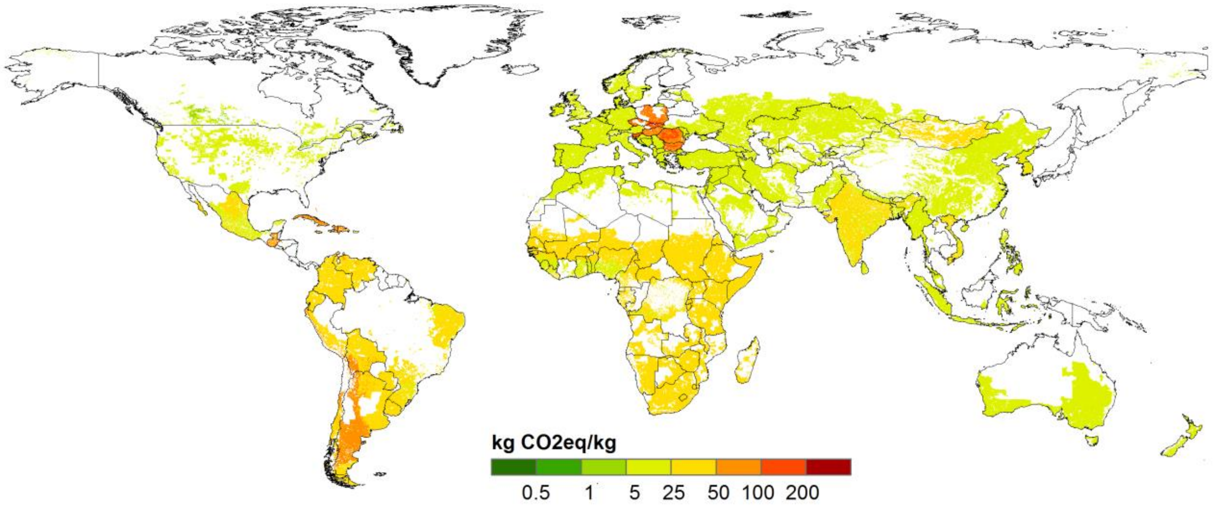


Figure S 50. GHG efficiency of small ruminant meat production (expressed in kg CO_2eq/kg product) in the year 2000

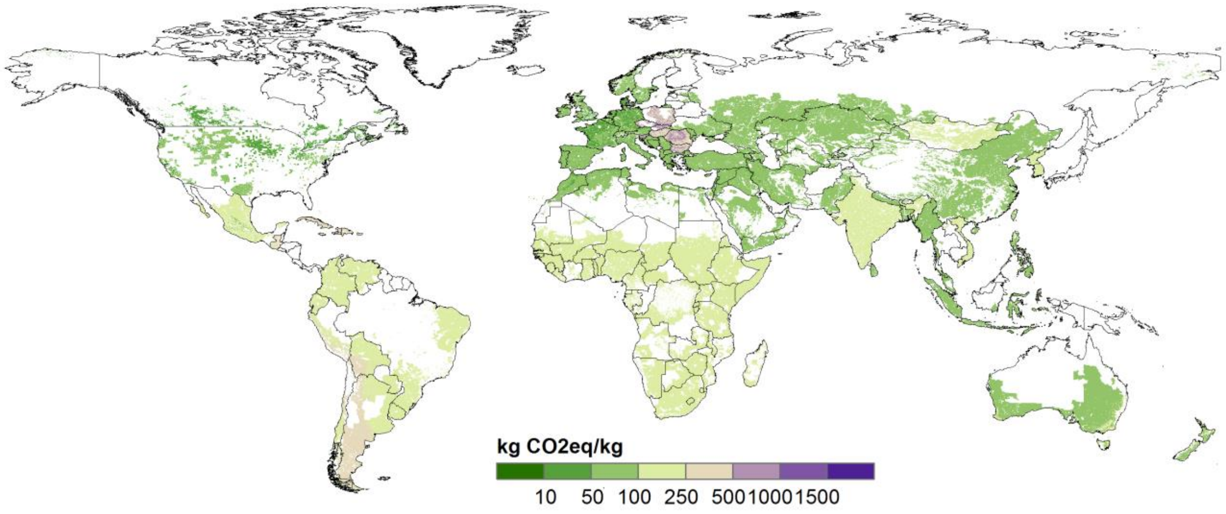


Figure S 51. GHG efficiency of small ruminant meat production (expressed in kg CO_2eq/g protein) in the year 2000

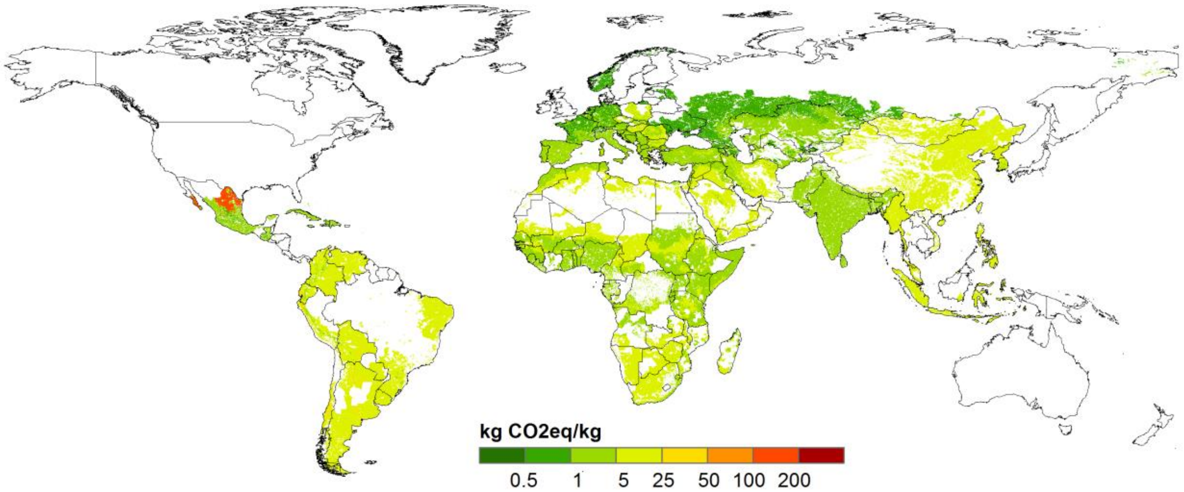


Figure S 52. GHG efficiency of small ruminant milk production (expressed in kg CO_2eq/kg product) in the year 2000

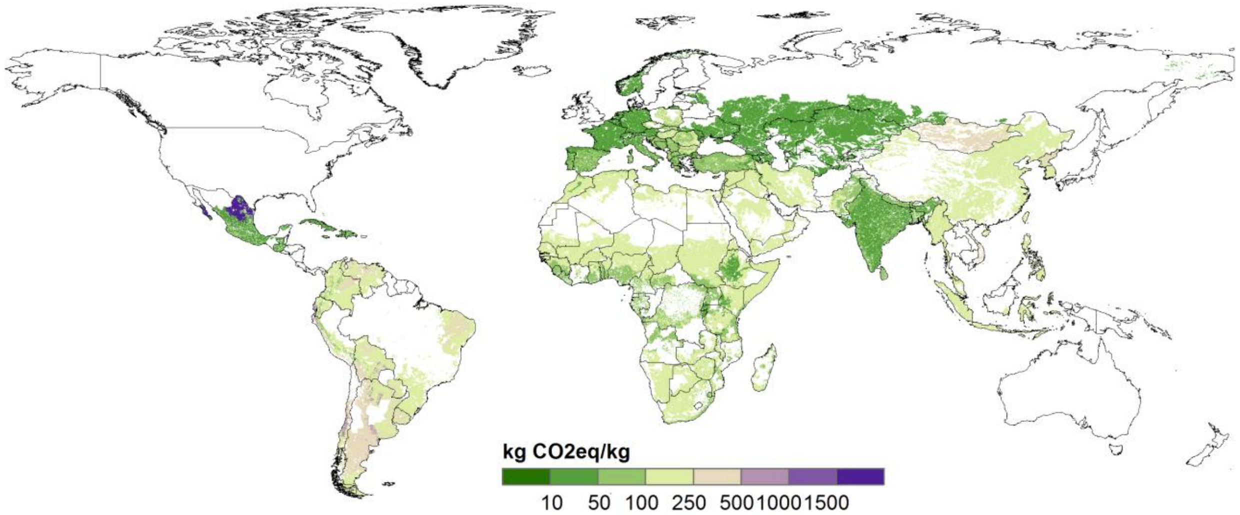


Figure S 53. GHG efficiency of small ruminant milk production (expressed in kg CO_2eq/g protein) in the year 2000

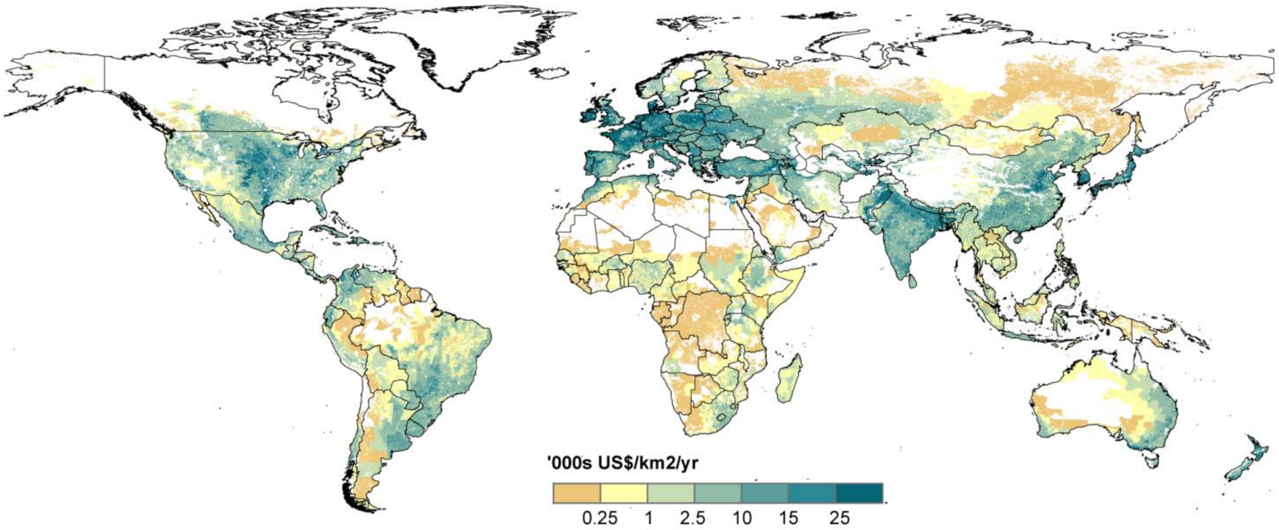


Figure S 54. Value of production of animal source foods (ruminants and monogatrics) in the year 2000

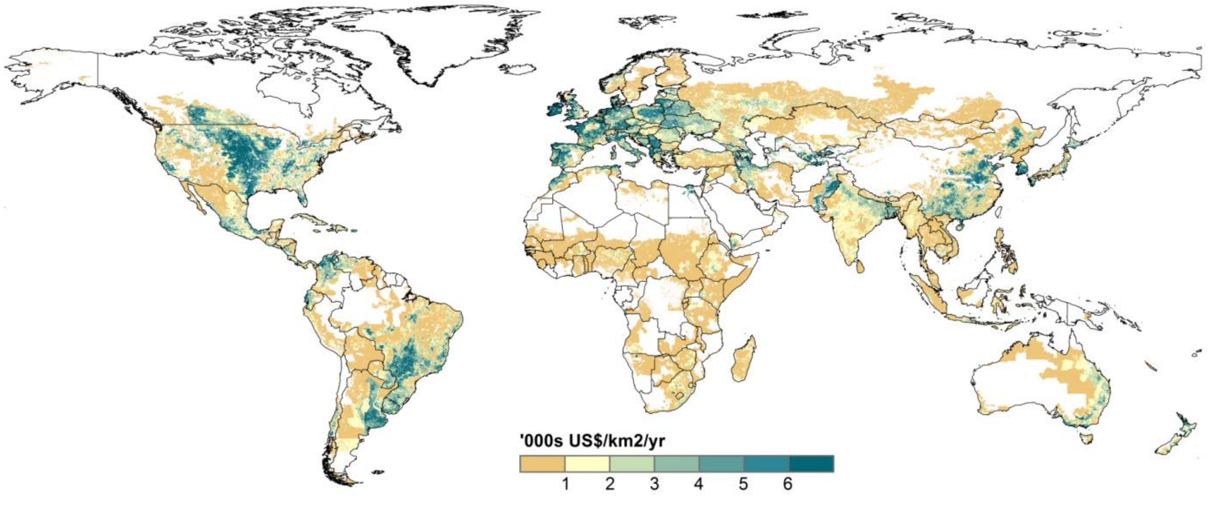


Figure S 55. Value of production of bovine meat in the year 2000

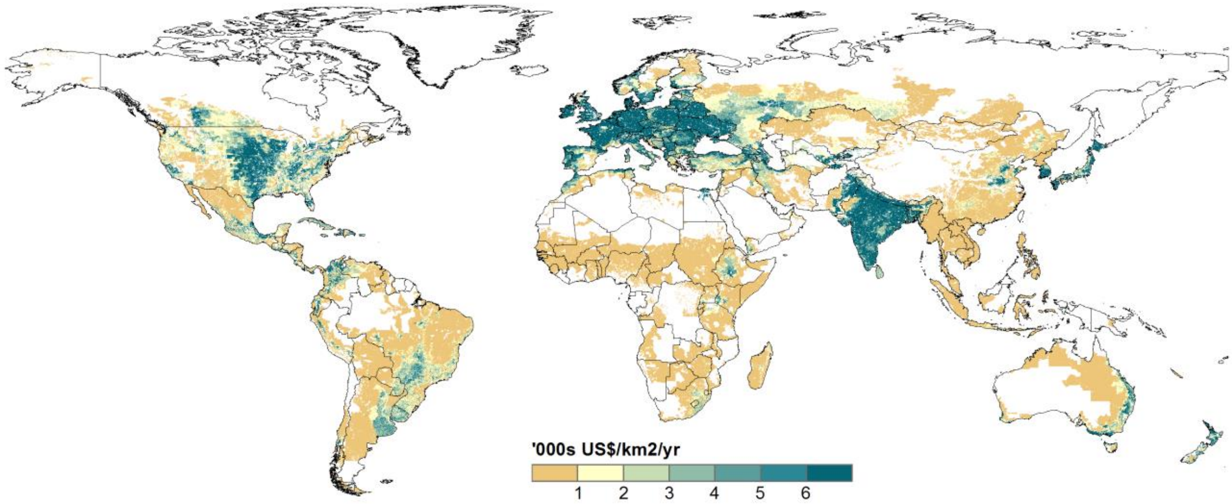


Figure S 56. Bovine milk, value of production of bovine milk in the year 2000

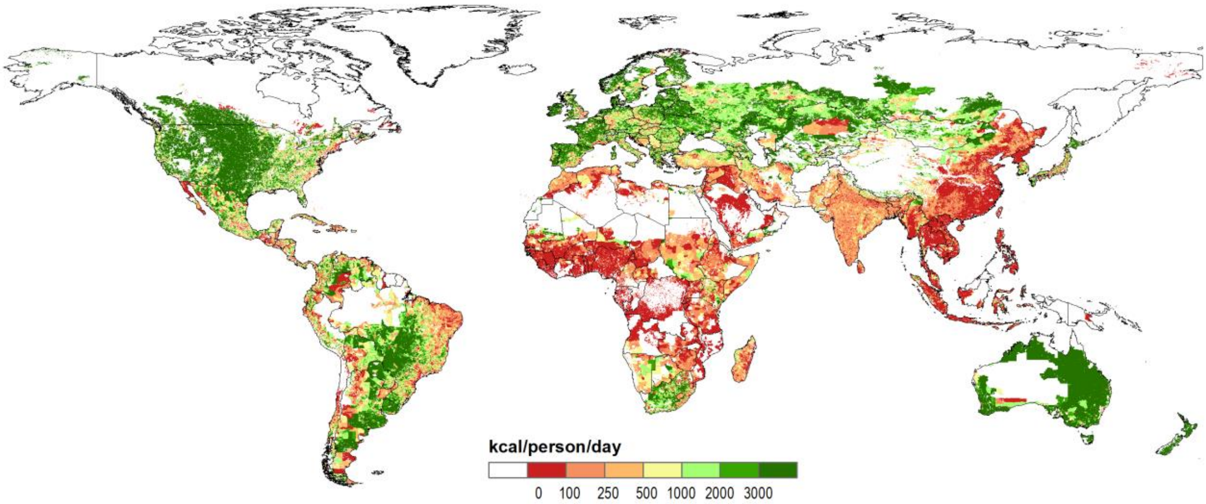


Figure S 57. Per capita nutritional value of ruminant products in the year 2000

c. Summary tables

Table S 2. Feed consumption at the world level per animal type, system and feed type (thousands tonnes)

		Grazing	**Occasional**	**Stover**	**Grains**	**All feed**
Cattle		**1,902,557**	**403,187**	**520,441**	**225,987**	**3,052,172**
	LGA	237,689	15,256	5,878	1,114	**259,937**
	LGH	133,285	13,914	22	733	**147,953**
	LGT	65,000	9,731	106	6,829	**81,667**
	MRA	338,742	150,439	264,856	38,677	**792,714**
	MRH	306,850	115,326	133,867	22,831	**578,874**
	MRT	296,118	27,590	76,912	108,861	**509,481**
	Other	408,842	35,283	24,366	30,543	**499,034**
	URBAN	116,030	35,647	14,434	16,400	**182,510**
Sheeps and Goats		**359,623**	**155,940**	**51,886**	**59,867**	**627,316**
	LGA	114,538	9,713	1,278	8,153	**133,682**
	LGH	18,021	1,450		1,726	**21,196**
	LGT	14,763	24,393		7,047	**46,203**
	MRA	97,831	40,070	33,971	17,127	**188,999**
	MRH	34,935	15,356	11,504	5,013	**66,808**
	MRT	22,293	39,604	3,038	11,277	**76,212**
	Other	39,166	19,596	1,327	6,180	**66,269**
	URBAN	18,076	5,758	767	3,345	**27,946**
Pigs					**537,129**	**537,129**
	Smallholders				67,983	**67,983**
	Industrials				469,146	**469,146**
Poultry					**476,329**	**476,329**
	Smallholders				76,144	**76,144**
	Industrials				400,185	**400,185**
LIVESTOCK TOTAL		**2,262,180**	**559,127**	**572,327**	**1,299,312**	**4,692,946**

Table S 3. GHG Emissions at the world level per animal type, system and GHG source (thousands tonnes CO_2eq)

		Manure Mgt CH_4	**Manure Crop N_2O**	**Manure pasture N_2O**	**Manure Mgt N_2O**	**Ent. Ferm. CH_4**	**Total**
Cattle		**96,397**	**35,595**	**340,766**	**150,596**	**1,273,087**	**1,896,441**
	LGA	3,777	553	33,354	7,742	118,180	**163,606**
	LGH	2,768	1,130	20,040	5,204	68,776	**97,918**
	LGT	3,071	517	8,176	3,848	37,526	**53,139**
	MRA	9,745	3,135	81,608	54,802	278,807	**428,098**
	MRH	15,810	8,888	77,803	16,672	244,688	**363,860**
	MRT	33,768	12,102	51,507	31,265	217,542	**346,185**
	Other	19,227	6,609	50,800	22,506	227,201	**326,343**
	URBAN	8,230	2,662	17,479	8,555	80,367	**117,293**
Sheep and Goats		**10,436**	**2,038**	**43,543**	**12,446**	**238,344**	**306,806**
	LGA	2,431	108	11,464	1,427	52,727	**68,157**
	LGH	411	90	1,941	245	8,592	**11,278**
	LGT	704	113	3,768	1,394	18,864	**24,842**
	MRA	3,180	325	14,837	4,930	67,484	**90,756**
	MRH	1,195	671	5,787	1,918	26,149	**35,720**
	MRT	968	732	5,744	2,419	28,428	**38,292**
	Other	1,093			79	25,253	**26,426**
	URBAN	453			35	10,847	**11,336**
Pigs		**137,805**	**25,246**	**10,307**	**28,894**		**202,252**
	Smallholders	5,483	1,597	10,307	6,141		**23,528**
	Industrials	132,322	23,648	0	22,753		**178,724**
Poultry		**6,659**	**20,695**	**11,675**	**15,875**		**54,903**
	Smallholders	2,604	1,162	11,675	2,128		**17,568**
	Industrials	4,055	19,533		13,748		**37,336**
LIVESTOCK TOTAL		**251,297**	**196,133**	**533,789**	**316,722**	**1,511,431**	**2,460,402**

3. Livestock system efficiencies

a. Level of aggregation used

Table S 4. List of region used in the analysis and country mapping

Region acronym	Data analysis level	Countries
EUR	**EU Baltic**	*Estonia, Latvia, Lithuania*
	EU Central East	*Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia*
	EU Mid-West	*Austria, Belgium, Germany, France, Luxembourg, Netherlands*
	EU North	*Denmark, Finland, Ireland, Sweden, United Kingdom*
	EU South	*Cyprus, Greece, Italy, Malta, Portugal, Spain*
	Former USSR	*Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan*
	RCEU	*Albania, Bosnia and Herzegovina, Croatia, Macedonia, Serbia-Montenegro*
	ROWE	*Gibraltar, Iceland, Norway, Switzerland*
OCE	**ANZ**	*Australia, New Zealand*
	Pacific Islands	*Fiji Islands, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga, Vanuatu*
NAM	**Canada**	
	United States of America (USA)	
LAM	**Brazil**	
	Mexico	
	RCAM	*Bahamas, Barbados, Belize, Bermuda, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Netherland Antilles, Panama, St Lucia, St Vincent, Trinidad and Tobago*
	RSAM	*Argentina, Bolivia, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela*
EAS	**China**	
	Japan	
	South Korea	
SEA	**RSEA OPA**	*Brunei Daressalaam, Indonesia, Singapore, Malaysia, Myanmar, Philippines, Thailand*
	RSEA PAC	*Cambodia, Korea DPR, Laos, Mongolia, Viet Nam*
SAS	**India**	
	RSAS	*Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan, Sri Lanka*
MNA	**Middle East and North Africa (MENA)**	*Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, Yemen*
	Turkey	
SSA	**Congo Basin**	*Cameroon, Central African Republic, Congo Republic, Democratic Republic of Congo, Equatorial Guinea, Gabon*
	Eastern Africa	*Burundi, Ethiopia, Kenya, Rwanda, Tanzania, Uganda*
	South Africa	
	Southern Africa (Rest of)	*Angola, Botswana, Comoros, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Swaziland, Zambia, Zimbabwe*
	West and Central Africa	*Benin, Burkina Faso, Cape Verde, Chad, Cote d'Ivoire, Djibouti, Eritrea, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Somalia, Sudan, Togo*

b. Productivity results

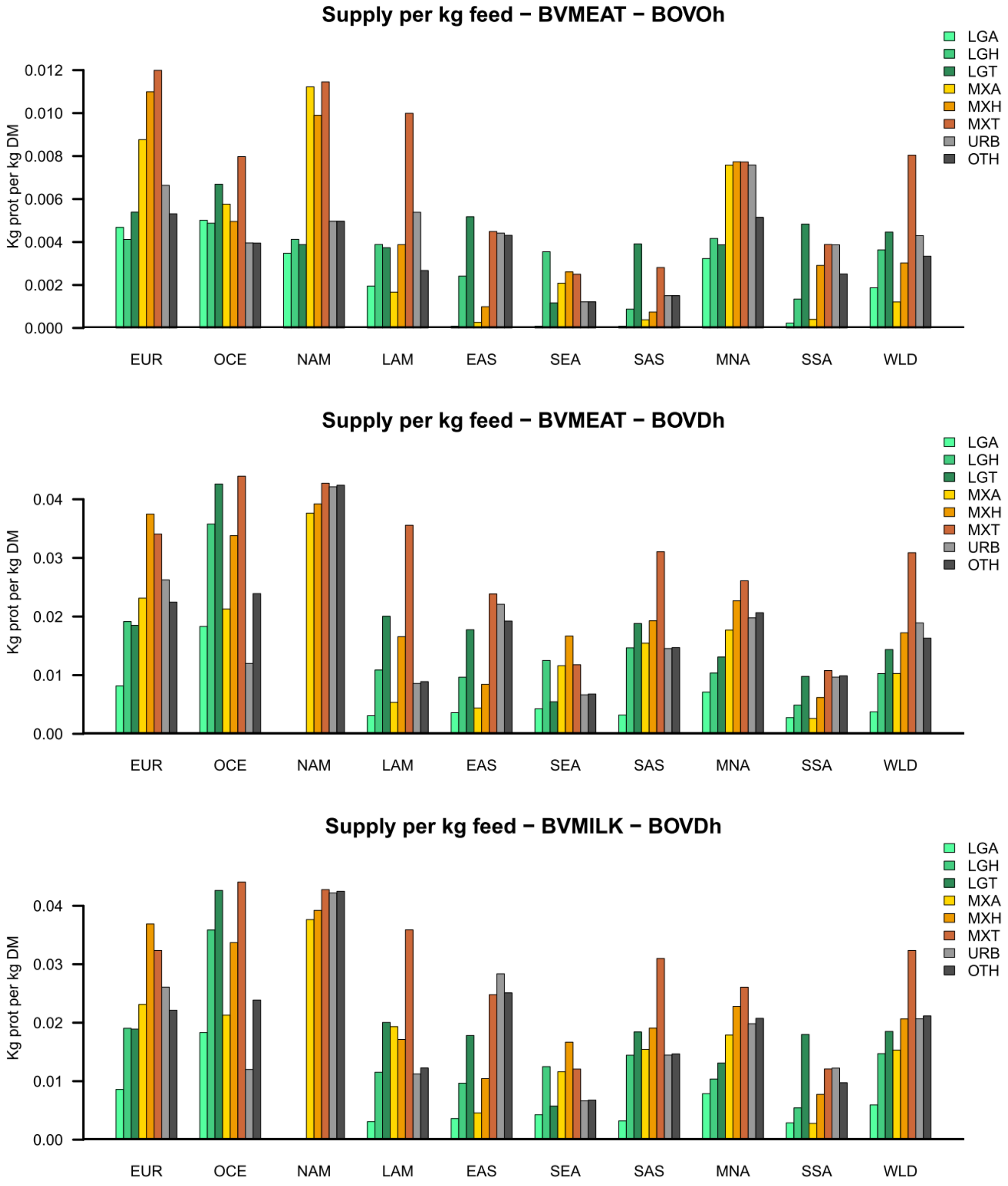


Figure S 58. Feed productivity for bovine meat from non-dairy cattle (top), meat from dairy cows (middle) and bovine milk (bottom) by systems and regions. Non-dairy cattle include here all cattle heads other than dairy cows.

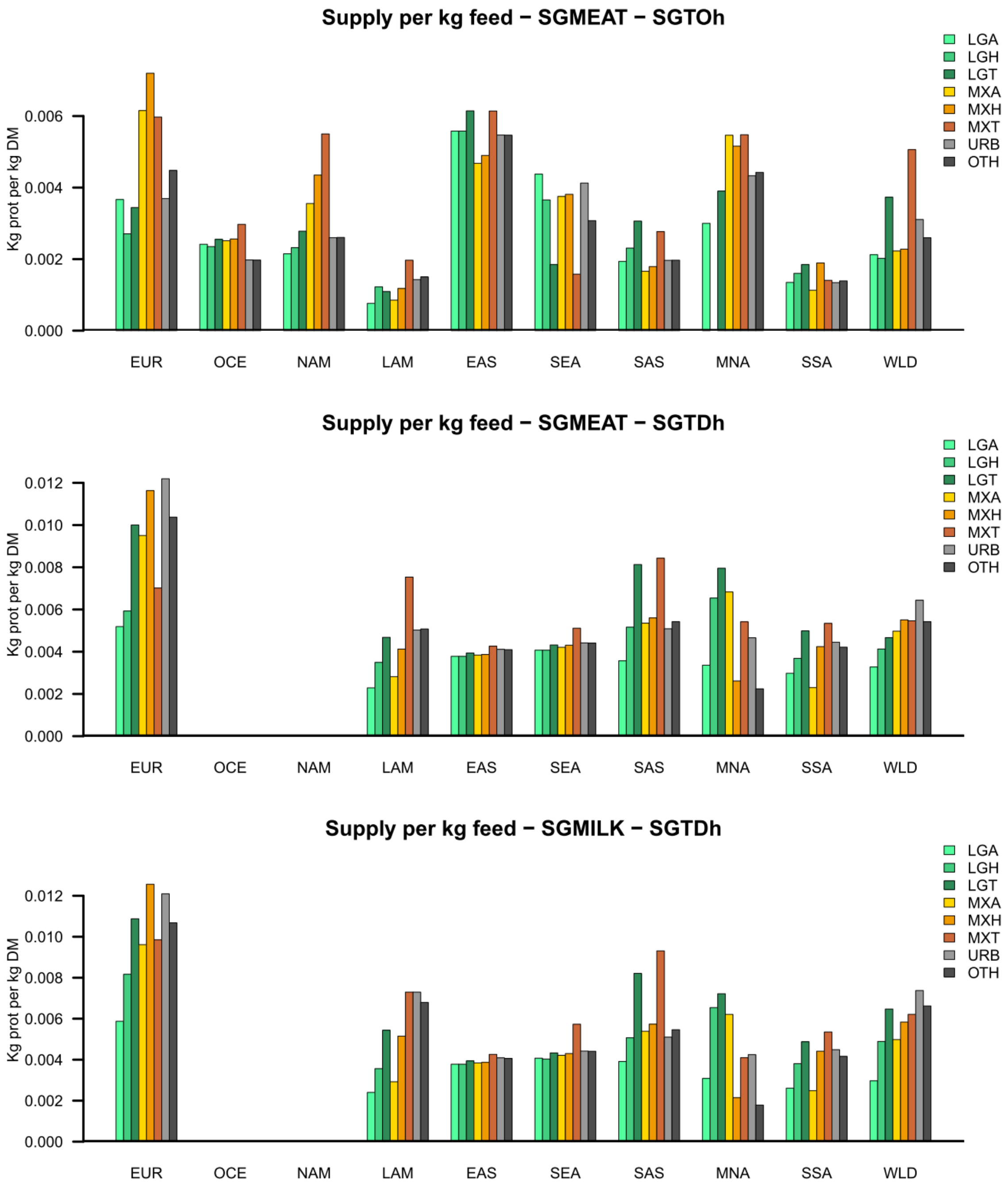


Figure S 59. Feed productivity for sheep and goat meat from non dairy herd (top), meat from dairy sheep and goat (middle) and small ruminant milk (bottom) by systems and regions.

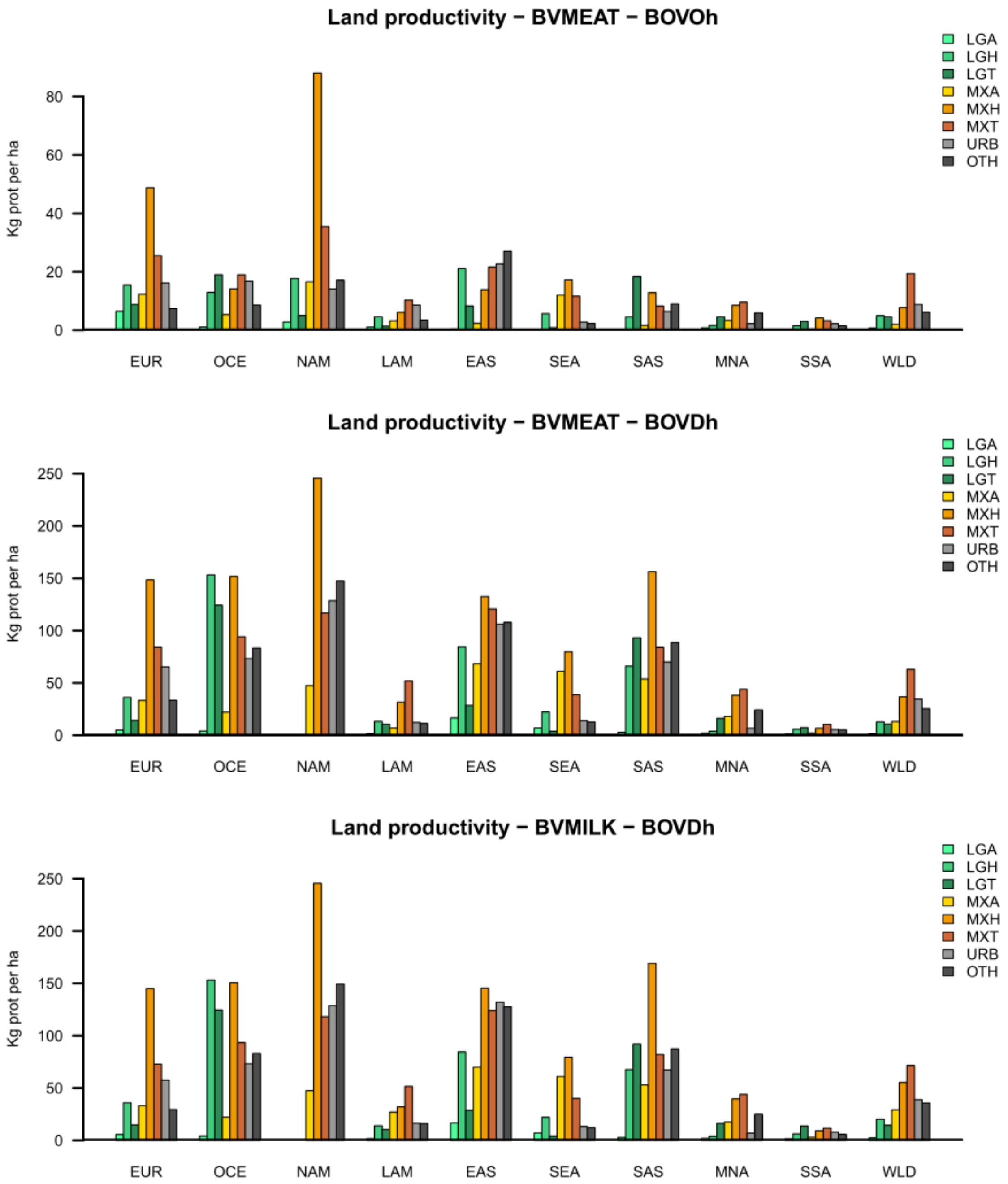
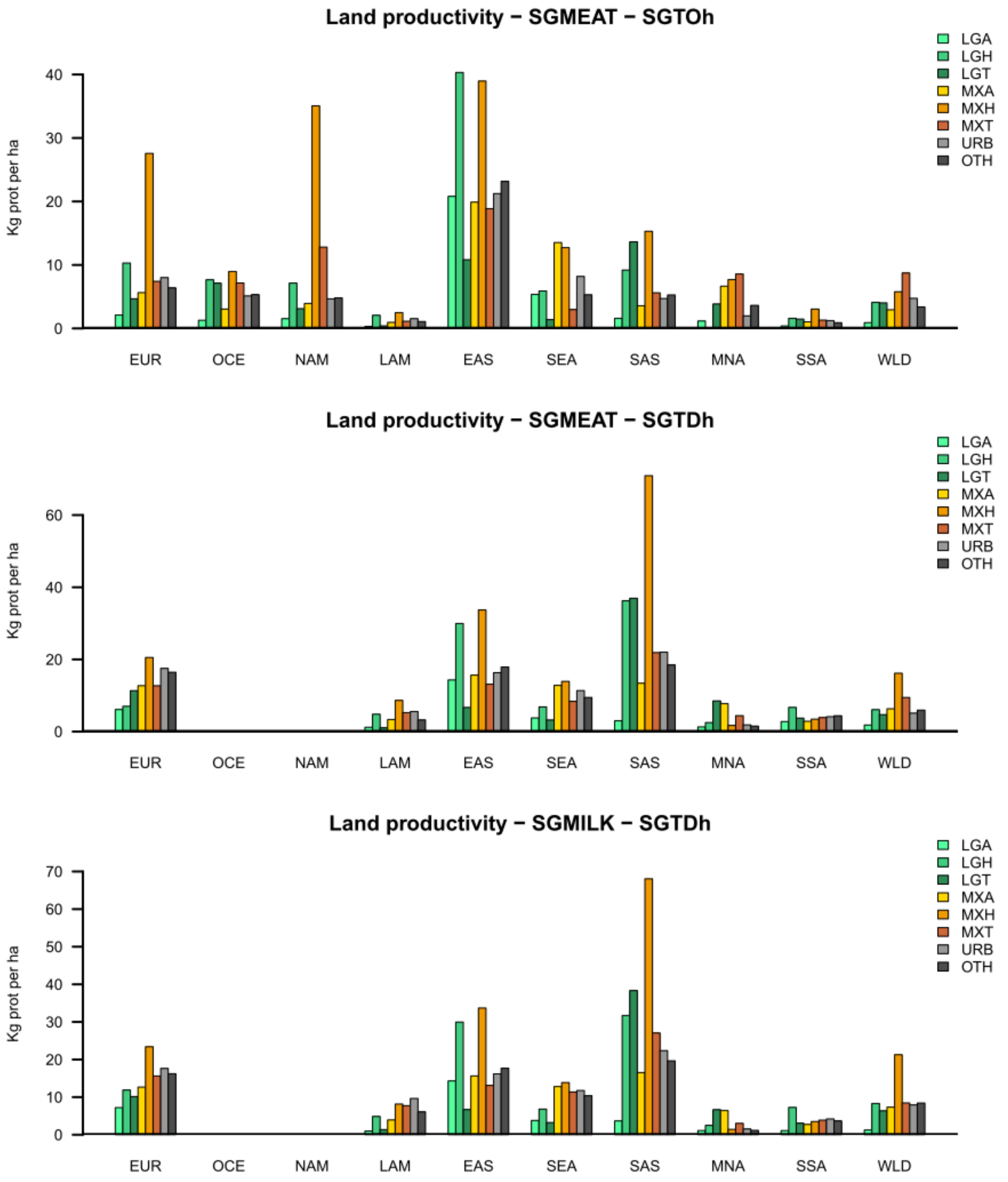


Figure S 60. Land productivity for bovine meat from non dairy cattle (top), meat from dairy cows (middle) and bovine milk (bottom) by systems and regions. Non dairy cattle include here all cattle heads other than dairy cows.


Land productivity − SGMEAT − SGTOh

Land productivity − SGMEAT − SGTDh

Land productivity − SGMILK − SGTDh

Figure S 61. Land productivity for sheep and goat meat from non dairy herd (top), meat from dairy sheep and goat (middle) and small ruminant milk (bottom) by systems and regions.

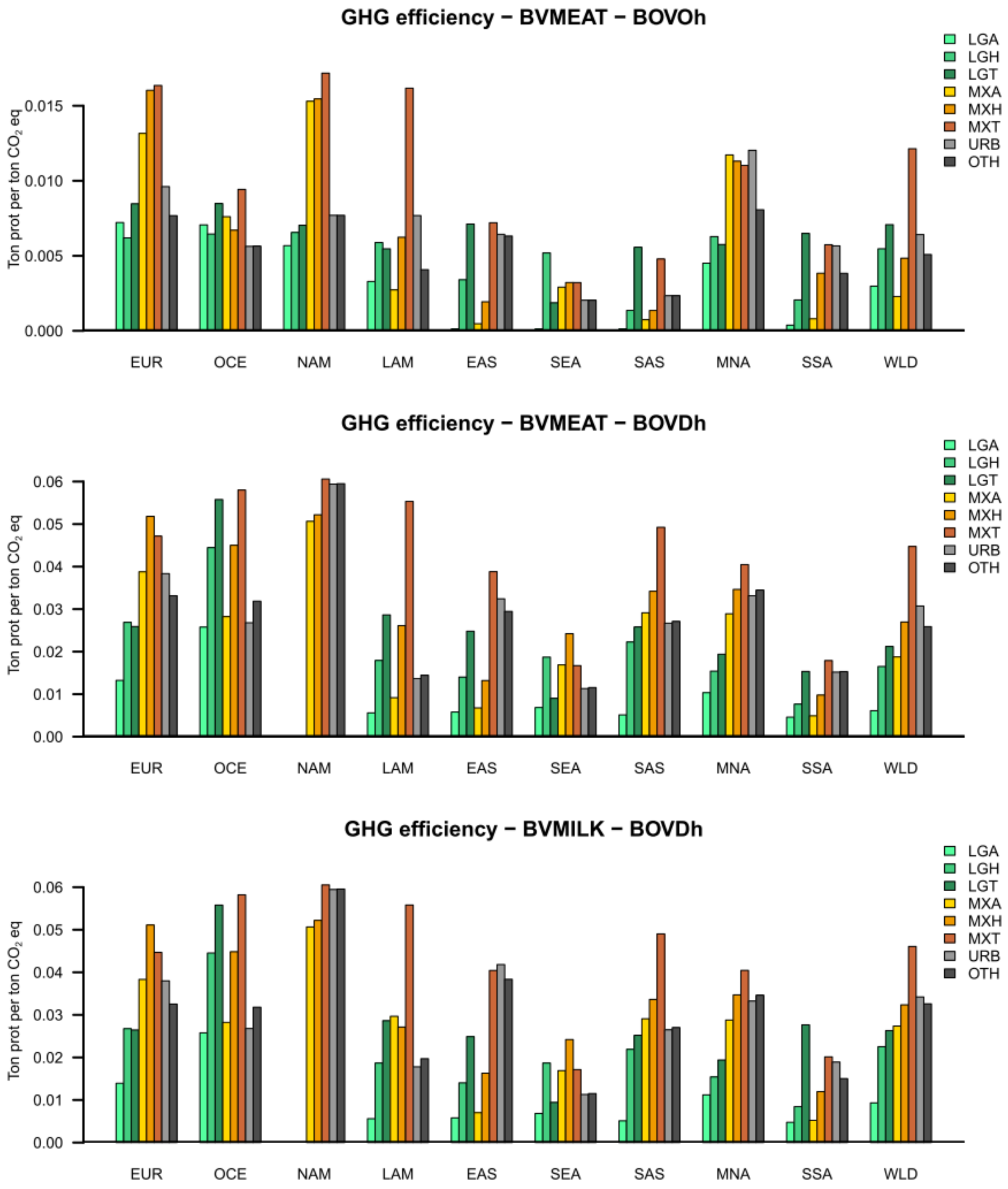


Figure S 62. GHG efficiency for bovine meat from non dairy cattle (top), meat from dairy cows (middle) and bovine milk (bottom) by systems and regions. Non dairy cattle include here all cattle heads other than dairy cows.

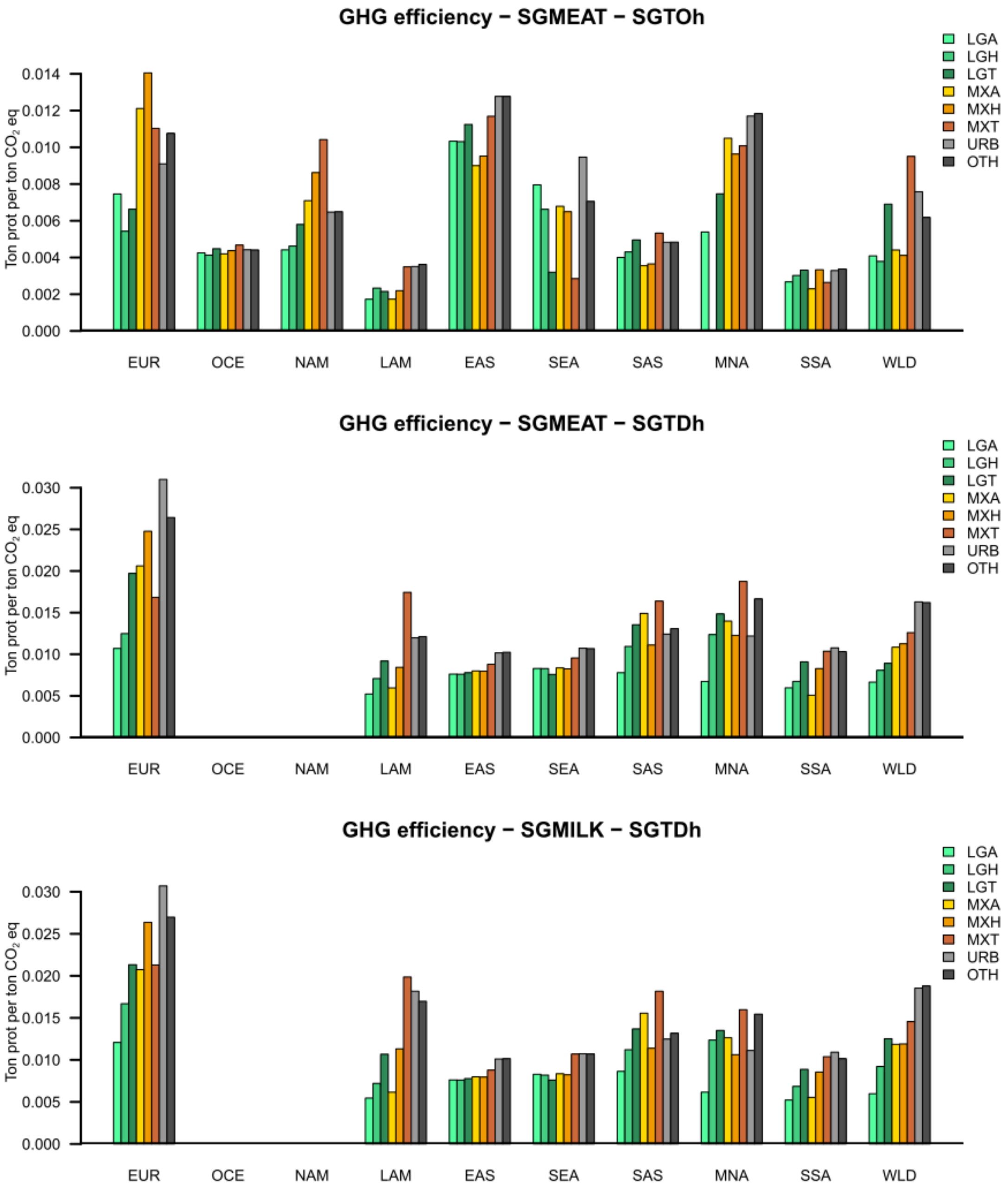


Figure S 63. GHG efficiency for sheep and goat meat from non dairy herd (top), meat from dairy sheep and goat (middle) and small ruminant milk (bottom) by systems and regions.

4. Disaggregation of monogastrics into smallholder and industrial systems

a. Background

Small farmers own 85% of the world’s 525 million farms, making them numerically the most important category of farmer (9). In line with the world’s population distribution, the overwhelming majority of small farms are located in Asia (87%), then Africa (8%) and Europe (4%) (10). A survey on livestock farm sizes was sent to the Veterinary authorities of all 172 member countries in 2008 and 119 responded. Veterinary authorities in developing countries estimated that 61% of all farms were small (11). This is probably an under-estimation as backyard production is often not considered as farming.

b. Pig farms

The intensive swine production system is economically viable in countries with shortage of land to grow feeds and in large cities because of availability of industrial by-products. It constitutes about 20% of total pig population raised in the third world countries whereas the traditional sector raises more than 70% of pigs (12).

Asia is the largest producer of pork in the world accounting for 55 percent of global pork production surpassing Europe (26%) and America (17%). There are varying reports on the importance of smallholder pork production in China (13). However the Chinese backyard system (farms with less than 40 pigs) which provided 73 percent of the production in 2002, had declined to 34 percent in 2010 (14), although 64% of pigs slaughtered came from farms with less than 500 pigs.

In the rest of SE Asia, large scale pig farms account for 15-20% of the total regional pig population (15). Of these, about 15% belongs to medium scale and 5% belongs to large scale (15). For example, nearly 70% of pigs in the Philippines, Vietnam, Cambodia and Laos are raised in small-scale farms (16, 17). In Vietnam, considering farms with less than 100 animals to be smallscale, these make up 95% of production (18) and models suggest industrial production will grow to meet no more than 12% of national supply in next ten years (19). In Myanmar, the percentage of smallholder production may go above 90% as commercial pig farming shares only a small portion of total pig production (20). Exceptionally, in Thailand around 80% of pigs produced are from intensive farming systems and 56% of these are from farms with over 1000 pigs (21).

India is the third largest pig producer in Asia (after China and Vietnam). The percentage of pigs under smallholders system is estimated at more than 95%, with around one third of production in the north-eastern states (20).

In most of sub-Saharan Africa, pig production is still mostly smallholder based. Pigs kept traditionally contributes about 80% of pigs kept in East Africa (Tanzania, Kenya and Uganda), 75% in Zimbabwe, 70% in Botswana, 65% in Sahel countries (Chad, Niger, Mali, Guinea Bissau, Senegal), 80% in Namibia (22, 23). For example, an estimated 80 percent of the pigs in Uganda are kept by smallholders (24), in Kenya the situation about 60 percent of the sector being smallholder based (25, 26). We used these rates to compute default continental values when country information was scarce.

c. Poultry farms

World-wide about 69 percent of the poultry was raised in 2005 under intensive conditions (2). This is the result of a strong commercialization trend in important producing countries. For example, in Thailand over the period 1993 to 2003 the number of backyard poultries (1-20 birds) declined by 78 percent, smallholder operations (20-99 birds) by 33 percent, whereas small sized commercial operators (100-999 birds) increased by 20 percent, medium sized operation (1000-9999 birds) by 9 percent and large-scale operators (over 10,000 birds) by 72 percent (27). Also in Vietnam, the small scale commercial poultry sector is growing fast and provided in 2006 28 percent of the broiler meat, up from 20 percent in 2005 (28). Finally, the number of poultry farms in China dropped from over 100 million in 1996 to 35 million in 2005 (29). Nonetheless, the majority of poultry production is in backyard systems (with Thailand again the exception).

Although the proportion of production by smallholder farms has declined dramatically in some countries, the proportion of smallholder farms remains high. For example, in 2008 in Thailand 68% of birds are in farms with more than 10,000 birds, yet 97% of the poultry farms kept less than 100 birds (30).

With the exception of South Africa, poultry production in sub-Saharan Africa is still largely a household activity.

Approximately 80% of chicken in Africa are reared by smallholders (31). For example, in 2003 in Tanzania, 87 percent of the national flock was still kept in flocks of 1 –49 birds, with an average of 9.7 birds per household (32). In Ethiopia, 99% of the 38 million poultry population are smallholder (33).

For the developed world (Europe, North America, Oceania) it was assumed that a maximum of 10% of monogastric production came for industrial systems (34). For Latin America, this was estimated at 10-15% of total production due to its growth in the industrial monogastric sector in the last 20 years (35).

Table S 5. Percentage of Poultry in different systems in South East Asia

Country	**Extensive/backyard**	**Semi-intensive**	**Intensive**
Laos	84	11	5
Myanmar	84	-	16
Cambodia	65	25	10
Vietnam	54	20	26
Indonesia	55	45	
Thailand	~20	~10	~70

Source: (18, 27, 28, 36, 37)

Monogastrics productivities were disaggregated from FAOSTAT and using reproductive and productivity rates of pigs and poultry reported in the literature described above. Our literature review led to the development of simple rules from the data analyses to disaggregrate monogastric production. First, the total production was split between the smallholder and industrial systems by calculating the relative pork and poultry yields in both systems. We used the following parameters for each species, irrespective of location, but only acknowledging differences between the systems. We acknowledge that variability in the output of industrial and smallholder systems in different countries can vary, however our objective was primarily to separate the proportion of production from the two systems in each region, and then to allocate this production to a biologically consistent number of animals, as reported in (2). For the latter we used simple spreadsheet herd and flock dynamics calculations (38).

Table S 6. Reproductive and productive parameters for pork production

Parameters	Industrial	Smallholder
No. cycles per sow per year	2.1	1.4
No. piglets per birth	9.5	7.0
Pre-weaning mortality /yr	5%	20%
Adult mortality / yr	2%	15%
Sow replacement rates / yr	30%	10%
Time to market (90kg weight)	6 months	9 months

Using the following parameters, we estimated that industrial systems produced at least 2-2.5 times the amount of pig meat per animal in the herd than smallholder systems. These estimates are conservative as our parameters reflect an industrial systems category that also included relatively small commercial operations or free range production units sometimes found in different regions.

For poultry, we estimated that industrial systems had four times the productivity of small holder systems for poultry meat, due to their higher number of cycles (8 vs 3 cycles per year, respectively for industrial and monogastric systems), their lower mortalities (5-10% vs 25-30%) and three times as high as in smallholder systems for eggs in industrial systems. Pig and poultry meat are directly calculated from the production and animal distribution across the systems. In order to remove some outliers, poultry meat yields in industrial systems are capped to 1200 kg per TLU (Tropical Livestock Unit). Only in cases, where both yields in industrial and smallholder systems of 1200 kg per TLU are not enough to match the statistics, they are allowed to go beyond this limit in both systems. In these cases also the feed requirements are adjusted proportionally. The egg yield in the industrial system is set at 15 kg per laying hen and year and the remainder of the egg production is allocated to smallholder systems. Figures Figure S 64-Figure S 67 show the percentages of production coming from the different systems and regions for the monogastric products.

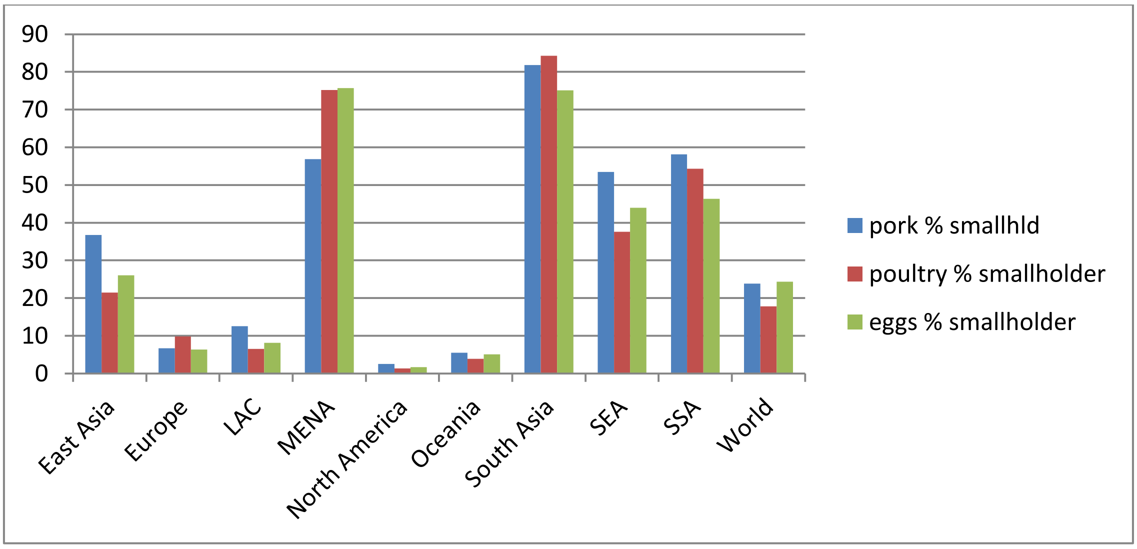


Figure S 64. Proportion of pork, poultry and eggs derived from smallholder systems in different regions.

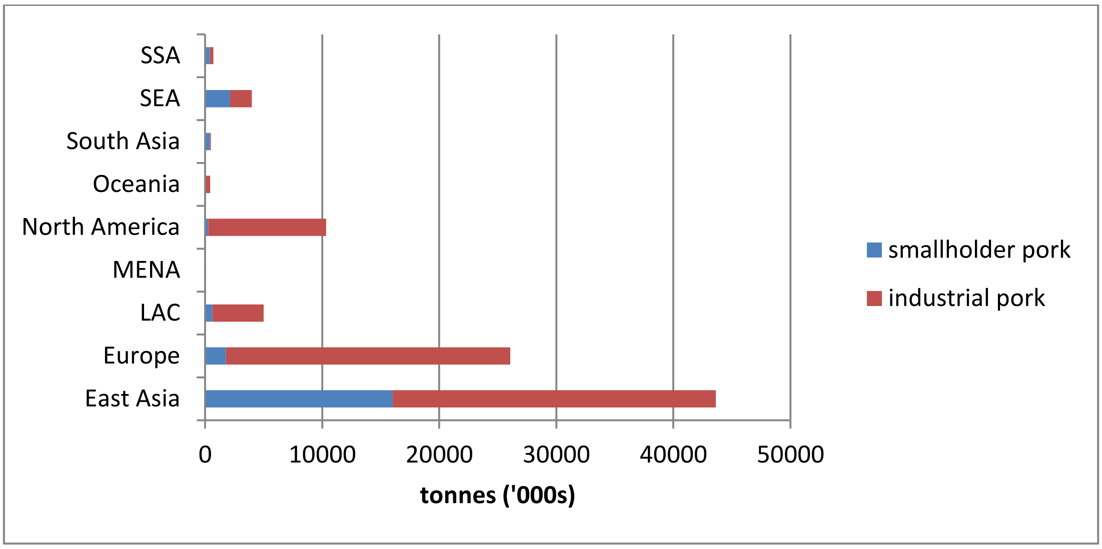


Figure S 65. Production of pork from smallholder an industrial systems in different regions

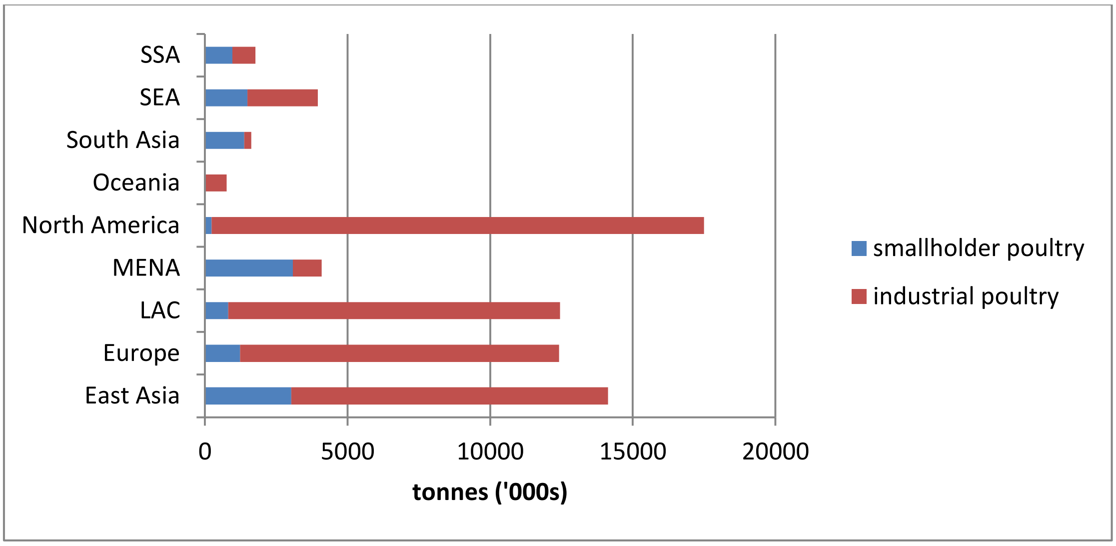


Figure S 66. Production of poultry meat from smallholder and industrial systems in different regions

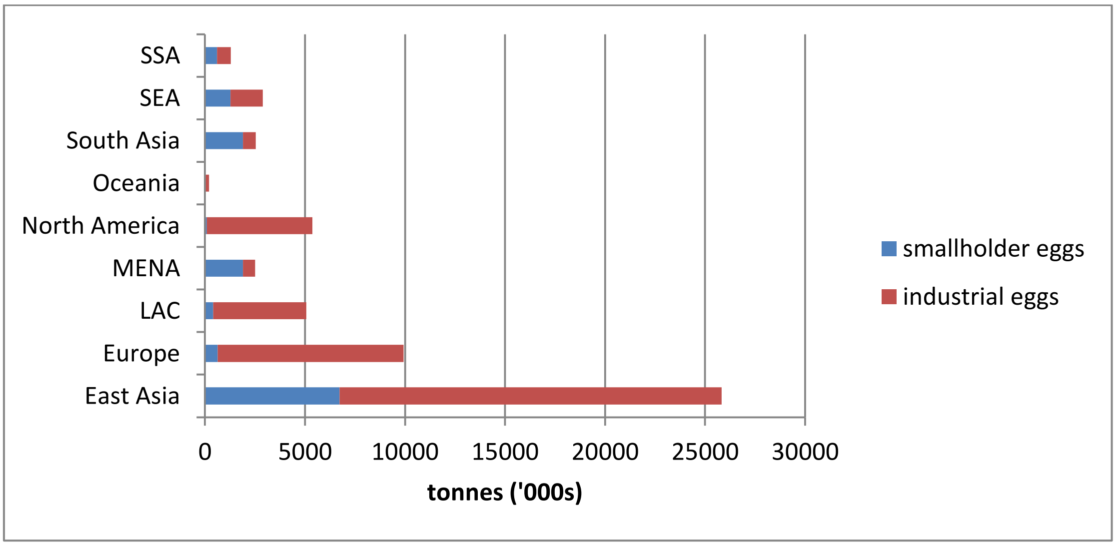


Figure S 67. Production of eggs from smallholder and industrial systems in different regions

5. Modelling intake, nutrient supply, excretion and methane emissions

a. Model general characteristics

The model (Ruminant, (39)), is designed to predict potential intake, digestion and animal performance of individual ruminants, consuming forages, grains and other supplements. The rationale behind the model is that a ruminant of a given body size, in a known physiological state, and with a target production level, will have a potential forage intake determined by physical or metabolic constraints imposed, both, by plant and animal characteristics. Potential forage intake is defined as the intake achievable without the constraints imposed by herbage mass, sward characteristics, or behavioural limitations (40).

The model assumes that the physically constrained rate of intake is determined by the rate of clearance of digesta from the reticulo-rumen through the processes of degradation and passage (41).

The model was largely derived from the work of Illius and Gordon (41), Cornell Net Carbohydrate and Protein System (CNCPS) (42) and UK Agriculture and Food Research Council (AFRC) (43). It is divided into two functional sections:

1) A nutrient supply section, which describes the flow and digestion of feeds through the gastrointestinal tract from which intake and digestibility are predicted, and from the digestion and fermentation of degraded fractions of the feed from which nutrient supply is estimated. This section consists of a series of first-order differential equations estimating intake, the pool sizes of feed fractions in the rumen, small and large intestines of the animal, the pools of digested material and excretion of indigestible residues. This section runs on an hourly basis, but results are aggregated to a day (24 h) for an appropriate coupling to the nutrient requirements section of the model. The iterative timestep of 1 h was chosen as an adequate timescale to represent digestion and passage of feeds through the gut of ruminants (42, 44-47).
2) A nutrient requirements section which estimates potential nutrient requirements of the animal, mainly on the basis of AFRC (43); readers are referred to this publication for a complete description of this system). The difference with AFRC, and the similarity with the CNCPS, is that the model predicts animal performance on a daily basis from the estimates of intake and nutrient supply obtained from the nutrient supply section of the model. This is a major step from requirements systems (i.e. AFRC (43), INRA (48), NRC (49, 50)), where animal performance is predicted from digestible of metabolisable energy estimates of feeds and where intake ‘predictions’ are obtained from linear or multiple regressions (i.e. NRC (49, 50); SCA (51); AFRC (43)). The CNCPS estimates nutrient supply from a dynamic model of digestion but still uses regression equations for intake prediction. This may reduce the flexibility and accuracy of model when extrapolating to situations beyond those used for derivation of the regression equations.

b. Feed fractions and their digestion and passage through the gut

Feed fractions

Feeds are described by four main constituents: ash, fat, carbohydrate and protein. Figure S 68 shows the main flows of carbohydrate and protein, which are the core of the nutrient supply section of the model. These are divided into soluble, insoluble but potentially degradable and indigestible fractions (43, 46).

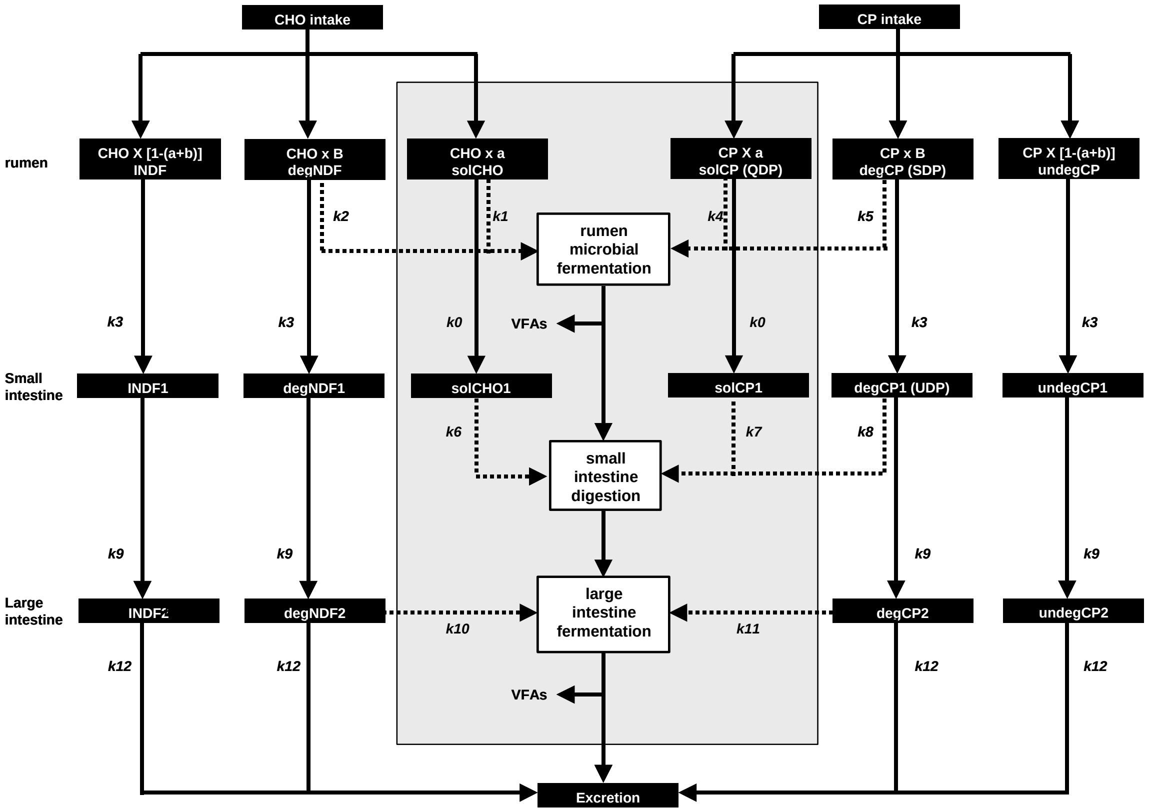


Figure S 68. General description of the model. See parameter definition in Table S 7.

Table S 7. Description of model parameters and key variables

Parameter	**Description**	**Units**
INDF	Pool of undegradable NDF in the rumen	g/kg
degNDF	Pool of degradable but insoluble NDF in the rumen	g/kg
solCHO	Pool of soluble carbohydrate in the rumen, including starch	g/kg
undegCP	Pool of undegradable crude protein in the rumen	g/kg
DegCP	Pool of degradable but insoluble crude protein in the rumen	g/kg
SolCP	Pool of soluble crude protein in the rumen	g/kg
INDF1	Pool of undegradable NDF in the small intestine	g/kg
degNDF1	Pool of degradable but insoluble NDF in the small intestine	g/kg
solCHO1	Pool of soluble carbohydrate in the small intestine, including starch	g/kg
undegCP1	Pool of undegradable crude protein in the small intestine	g/kg
DegCP1	Pool of degradable but insoluble crude protein in the small intestine	g/kg
solCP1	Pool of soluble crude protein in the small intestine	g/kg
INDF2	Pool of undegradable NDF in the large intestine	g/kg
degNDF2	Pool of degradable but insoluble NDF in the large intestine	g/kg
undegCP2	Pool of undegradable crude protein in the large intestine	g/kg
DegCP2	Pool of degradable but insoluble crude protein in the large intestine	g/kg
k0	Rumen liquid outflow rate	/h
k1	Rate of degradation of soluble carbohydrate in the rumen	/h
k2	Rate of degradation of NDF in the rumen	/h
k3	Rate of passage from the rumen to the small intestine	/h
k4	Rate of degradation of soluble crude protein	/h
k5	Rate of degradation of degradable but insoluble crude protein	/h
k6	Rate of degradation of soluble carbohydrate in the small intestine	/h
k7	Rate of degradation of soluble crude protein in the small intestine	/h
k8	Rate of degradation of degradable but insoluble crude protein in the small intestine	/h
k9	Rate of passage from the small to the large intestine	/h
k10	Rate of degradable but insoluble NDF in the large intestine	/h
k11	Rate of degradation of degradable but insoluble crude protein in the large intestine	/h
k12	Rate of passage from large intestine to excreta	/h

For the ith feedstuff, the carbohydrate fractions represent non-structural carbohydrates ($solCHO_i$), potentially digestible cell wall ($degNDF_i$), and the indigestible residue ($INDF_i$). For concentrate feeds, the proportion of starch in the $solCHO_i$ is also required (42). Starch and fat in forages are almost negligible (52), but they are be important fractions in grains (53, 54).

The protein fractions described here are the same as those estimated in the metabolisable protein (MP) system proposed by AFRC (43), with the difference that their representation in this model is dynamic. For example, the pools of soluble protein ($solCP_i$), degradable protein ($degCP_i$) and undegraded protein ($undegCP_i$) represent the terms quickly (QDP) and slowly (SDP) degraded crude protein, and undegraded (UDP) crude protein of the AFRC MP system, respectively.

The separation of dry matter into its basic chemical entities is important because different feed fractions of different forages have different degradation and passage rates (41, 55), and therefore have different digestibilities. Consequently, they supply different amounts of nutrients to the animal (56, 57). These fractionations are also important to predict effects of supplementation on the rate of cell wall digestion (58), to model protein/energy interactions (59), and to use standards of protein requirements (e.g. (43, 50, 60, 61)). Nevertheless, other authors consider that the nutritional description of the potentially degradable carbohydrate fractions of feedstuffs requires yet further fractionations (42, 45), to account mainly for soluble fibre fractions, although there is no evidence to suggest that they provide better predictions than the approach used here (47). Additionally, the analytical costs to estimate these fractions may be too high to countenance in most situations.

Forage intake and digestion and passage of feed components through the rumen

The representation of intake, digestion and passage of feed fractions was adapted from (41). Dry matter intake (DMI) over a 24 h period is determined by the clearance of digesta from the rumen due to degradation and passage. In order to achieve an overall mean rumen load, consumption of new feed commences when rumen load falls to 70% of rumen capacity and ceases when ruminal load reaches 120% of rumen capacity (41). Sensitivity analysis showed that alterations to this threshold value for recommencing a meal did not alter the daily intake estimations from the model. The maximum rumen capacity (Maxrumen, kg DM) is determined from the bodyweight (BW) of the animal as derived by (41):

$$\text{Maxrumen} = 0.021\ \text{BW} \qquad \text{(Eq. 1)}$$

The rumen load (RumenDM, kg DM) is the sum of the pool sizes of the different feed fractions plus ash, and fat, across all diet ingredients, plus the microbial DM pool:

$$RumenDM = \sum_{1}^{i} solCHO_i + \deg NDF_i + INDF_i + solCP_i + \deg CP_i + un\deg CP_i + ash_i + fat_i + MICROBES \qquad \text{(Eq. 2)}$$

where the pool sizes of feed constituents in the rumen are:

$$\frac{dsolCHO_i}{dt} = \sum_{1}^{i} \text{Intake rate} * \text{aCHO}_\text{i} * sCHO - \text{k1}_\text{i} * \text{solCHO}_\text{i} - \text{k0} * \text{solCHO}_\text{i} \qquad \text{(Eq. 3)}$$

$$\frac{d\deg NDF_i}{dt} = \sum_{1}^{i} \text{Intake rate} * \text{bNDF} * \text{NDF}_\text{i} - \text{k2}_\text{i} * \text{degNDF}_\text{i} - \text{k3}_\text{i}\,\text{degNDF}_\text{i} \qquad \text{(Eq. 4)}$$

$$\frac{\text{dINDF1}_\text{i}}{\text{dt}} = \sum_{\text{i}} \text{Intake rateINDF}_\text{i} - \text{k3}_\text{i}\,\text{INDF1}_\text{i} \qquad \text{(Eq. 5)}$$

$$\frac{\text{dSOLCP1}_\text{i}}{\text{dt}} = \sum_{\text{i}} \text{intake rateSCP}_\text{i} - \text{k5}_\text{i}\,\text{SOLCP1}_\text{i}\,\text{kQDP} - \text{k0SOLCP1}_\text{i} \qquad \text{(Eq. 6)}$$

$$\frac{\text{dDEGCP1}_\text{i}}{\text{dt}} = \sum_{\text{i}} \text{intake rateDCP}_\text{i} - \text{k6}_\text{i}\,\text{DEGCP1}_\text{i} - \text{k3}_\text{i}\,\text{DEGCP}_\text{i} \qquad \text{(Eq. 7)}$$

$$\frac{dUNDEGCP1_i}{dt} = \sum_i \text{intake rateUDCP}_i - k3_i\,UNDEGCP_i \qquad \text{(Eq. 8)}$$

The terms CC_i and SCP_i represent soluble carbohydrate and protein concentrations in the ith feedstuff, respectively. $DNDF_i$ and DCP_i represent insoluble but degradable cell wall and CP, respectively; while $INDF_i$ and $UDCP_i$ are indigestible residues of cell wall and CP. All have units g/kg DM and can be estimated using the appropriate solubility (A) and potential degradability (B) coefficients from *in vitro* or *in sacco* degradation kinetics studies, as described by the standard procedures of (46, 62), or from gas production studies (63).

The fractional rate constants $k1_i$ and $k5_i$, represent the digestion rates of soluble carbohydrate and protein, respectively; while $k2_i$ and $k6_i$ represent those of the potentially digestible cell wall and protein. Note that equation 6 contains the term kQDP which is the efficiency of utilisation of soluble N (43). Rate k0 is the liquid passage rate. $K3_i$ is the passage rate of the digestible cell wall fraction, which represent mostly small particles and is applied to both the digestible and indigestible fractions. Outflow of soluble protein is similar to the liquid passage rate (k0). Rumen passage rates of degradable and undegradable protein ($k7_i$) are similar to the passage rates $k3_{i,}$ (54, 64).

The model includes a lag phase (h) before fermentation of the cell wall fraction begins. This is calculated from the model of (62) to *in sacco* or *in vitro* degradation data.

Degraded material in the rumen (RD) is accumulated in the pools of digested carbohydrate and protein. These later become the major source of energy supply to the animal:

$$\frac{dRDCELLCC1_i}{dt} = \sum_i k1_i\,CELLCC1_i \qquad \text{(Eq. 9)}$$

$$\frac{dRDIGNDF1_i}{dt} = \sum_i k2_i\,DNDF1_i \qquad \text{(Eq. 10)}$$

$$\frac{dRDSOLCP_i}{dt} = \sum_i k5_i\,SOLCP1_i\,kQDP \qquad \text{(Eq. 11)}$$

$$\frac{dRDIGCP_i}{dt} = \sum_i k6_i\,DEGCP1_i \qquad \text{(Eq. 12)}$$

Digestion in the small and large intestines

Feed material escaping ruminal digestion flows to the small and large intestines. Amounts of soluble carbohydrate and nitrogen escaping digestion in the rumen are small, since they are immediate nutrient sources for rumen microbes (65, 66). However, if they pass the rumen, they are subsequently fully digested in the small intestine (41, 54). In the model they are described, respectively, by:

$$\frac{\mathrm{dSIDCELLCC1_i}}{\mathrm{dt}} = \sum_i \mathrm{k0CELLCC1_i} \qquad \text{(Eq. 13)}$$

$$\frac{\mathrm{dSIDSOLCP1_i}}{\mathrm{dt}} = \sum_i \mathrm{k0\ SOLCP1_i} \qquad \text{(Eq. 14)}$$

The only components that enter the large intestines are potentially degradable and undegradable residues of carbohydrate and protein that escaped ruminal digestion, and rumen microbes. Exceptions to this rule occur with feeds, especially grain supplements, containing large proportions of bypass protein, starch or fat (43). The pool sizes of carbohydrate and nitrogen in the large intestine are:

$$\frac{\mathrm{dDNDF2_i}}{\mathrm{dt}} = \sum_i \mathrm{k3_i DNDF1_i - k2_i DNDF2_i - k4_i DNDF2_i} \qquad \text{(Eq. 15)}$$

$$\frac{\mathrm{dINDF2_i}}{\mathrm{dt}} = \sum_i \mathrm{k3_i INDF1_i - k4_i INDF2_i} \qquad \text{(Eq. 16)}$$

$$\frac{\mathrm{dDEGCP2_i}}{\mathrm{dt}} = \sum_i \mathrm{k3_i DEGCP1_i - k6_i DEGCP2_i (1 - k8_i)} \qquad \text{(Eq. 17)}$$

$$\frac{\mathrm{dUNDEGCP2_i}}{\mathrm{dt}} = \sum_i \mathrm{k11_i UNDEGCP1_i - k6_i UNDEGCP2_i} \qquad \text{(Eq. 18)}$$

where, $\mathrm{k2_i}$ and $\mathrm{k4_i}$ are the digestion and passage rates of cell wall and residues in the large intestine, and $\mathrm{k8_i}$ is the digestion rates of undegradable N entering the large intestine. Note that $\mathrm{k2_i}$ is the same for rumen and large intestine (41). All others have been previously defined. The pools of digested cell wall ($\mathrm{LINDF2_i}$) and N ($\mathrm{LIDCP_i}$) in the large intestines then become:

$$\frac{dLINDF_i}{dt} = \sum_i k2_i DNDF2_i \quad \text{(Eq. 19)}$$

$$\frac{dLIDCP_i}{dt} = k1_i DEGCP2_i \quad \text{(Eq. 20)}$$

The final residual compartments are:

$$\frac{dCEXCRETION_i}{dt} = \sum_i k4_i INDF2_i + k4_i DNDF2_i \quad \text{(Eq. 21)}$$

$$\frac{dNEXCRETION_i}{dt} = \sum_i k6_i UNDEGCP2_i + k6_i DEGCP2_i (1 - k8_i) \quad \text{(Eq. 22)}$$

Estimation of the rates of passage

One of the crucial elements determining the accuracy and flexibility of the model is the estimation of the rates of passage. Passage rate estimates are not easy to find in the literature, and it would be a real disadvantage if these needed to be provided by the user of the model. The approach of (41) was chosen, since it predicts the passage rate estimates of animals of different body sizes by allometric scaling rules. This method is particularly useful for GHG inventory or LCA work because a generic description of a ruminant is provided, rates are adjusted according to animal size, and fundamentally, they are predicted from easily collectable observations.

However, the model does not consider explicitly particle dynamics and a simpler model was derived from (41). This simpler description is a summary model, and was obtained by implementing the model from (41), and calculating independently the contribution of large particles and small particles to passage of their proportional rumen dry matter contents. According to (41), the proportion of large particles entering the rumen is 0.66 and the rest are small particles. Since large particles are also comminuted to small particles, their real contribution to passage is small (67). Therefore the composite passage rate was inherently corrected for comminution and reflected largely the passage rate of the small particles. The model was run for bodyweights from 50 - 800 kg and for INDF concentrations of 0.2 - 0.6. The results demonstrated that a composite passage rate of 0.95*k3 gave quite similar intake results to the original model. The effects of bodyweight and INDF on large particle passage rate were very small (the coefficient changes from 0.94 - 0.96, since the largest effects were absorbed in the comminution-corrected passage of small particles. The same allometric equations for estimating body size effects on passage were used.

For example, whole tract mean retention time (MRT, h) is scaled to body weight by the equation:

$$MRT = 14.1 BW^{0.27}, r^2=0.76 \quad \text{(Eq. 23)}$$

The rumen (k3i) and large intestine (k4i) passage rates of small particles of digestible cell wall are then estimated from the MRT as:

$$k3_i = \frac{1}{0.75\text{MRT}} + \text{FLscaling} \qquad \text{(Eq. 24)}$$

$$k4_i = \frac{1}{0.2\text{MRT}} \qquad \text{(Eq. 25)}$$

Feeding level affects ruminal passage rates of carbohydrate and protein fractions (42, 43, 68). Feeding level effects on passage rates were not estimated in (41). Therefore, a scaling rule for feeding level (FLscaling) was derived from the data of (42) and applied to the predicted passage rates:

$$\text{FLscaling} = 0.25\text{FLk}_i \qquad \text{(Eq. 26)}$$

where FL = feeding level expressed as multiples above maintenance and k_i the rate constant predicted by the model, to be scaled.

The liquid passage rate (k0) was estimated from the composition of the basal forage diet and the body weight of the animal as:

$$k0 = (-0.0487 + 0.176\text{CC}_{\text{forage}} + 0.145\text{DNDF}_{\text{forage}} + 0.0000231\text{BW}) + \text{FLscaling} \qquad \text{(Eq. 27)}$$

For concentrate feeds, the model estimates the rates of passage as described by (42) from the equivalent rates for the basal forage diet (ki_{forage}). This applies to rates $k3_i$ and $k4_i$, and the equations have the following form:

$$k_i = [-0.424 + (1.45 * (ki_{\text{forage}} * 100))] / 100 \qquad \text{(Eq. 29)}$$

where k_i is the respective rate to be calculated.

Microbial growth and nutrient supply from digested feed fractions

The pools of digested nutrients obtained from the model were used to calculate the supply of nutrients, namely metabolisable energy (ME) and protein (MP), to the animals. The model takes as inputs the quantities of fermentable nutrients available in a particular timestep and returns as outputs the products of fermentation. The inputs are (i) fermentable carbohydrate separated into simple sugars, starch and cell wall material, (ii) fermentable nitrogen separated into ammonia and protein and (iii) lipid, each summed across the various feed constituents, together with the microbial pool size. The outputs are the quantities of new microbial matter, the individual volatile fatty acids acetate, propionate and butyrate, methane, ammonia and unfermented carbohydrates.

It is assumed that there is only a single pool of microorganisms of fixed composition (69). The microbial maintenance requirement was set at 1.63 mmoles ATP per g of microbial dry matter per hour (59). The requirements of nutrients for microbial growth were taken from (59). An outline of the processes described is shown in Figure 2.

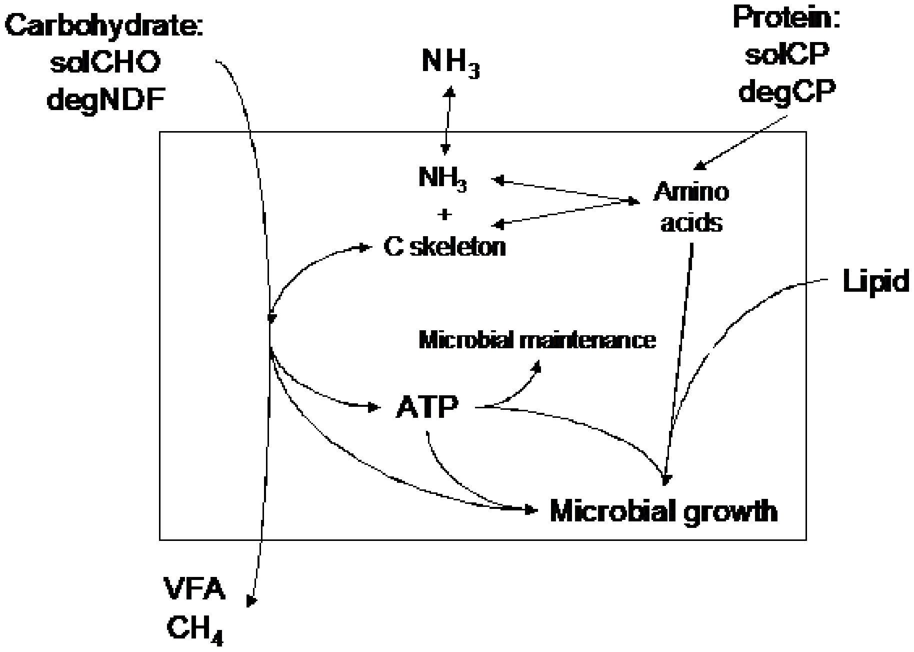


Figure S 69. Schematic representaion of the nutrient supply, methnae production and microbial growth section in the model.

The initial assumption was that supplied amino acids are used with a biological value (BV) of 0.64 for microbial growth. This determines the potential for microbial growth and the quantity of hexose required for direct incorporation into new microbial matter is calculated. The remaining hexose is available for fermentation to provide ATP and the yield of ATP is determined. This is compared with the ATP required for microbial maintenance and potential growth.

If ATP yield is limiting, then the biological value with which amino acids are used is reduced, iteratively, until either BV reaches zero or ATP yield matches ATP requirement. Reduction of BV results in (i) greater quantities of amino acids being fermented, increasing ATP yield, and (ii) a lower potential microbial growth, reducing ATP and hexose requirement for growth thus increasing the amount of hexose fermented.

If ATP yield is greater than ATP requirement, the available hexose supply is greater than that of amino acids. In such cases, the potential for microbial growth from ammonia is calculated. This is limited either by ammonia or hexose availability.

Finally, the quantities of individual VFAs and methane produced are calculated based on the quantities of different substrates fermented using the stoichiometries of (69). The quantity of ammonia used or produced is calculated and ammonia pools within the gut are updated.

Microbial growth is thus dependant on both fermentable nitrogen (either as protein or ammonia) and fermentable carbohydrate supply. There is no fixed upper limit to the quantity of microbial matter produced; the lower limit is zero growth. If fermentable nitrogen supply limits the amount of fermentable carbohydrate that can be used, unfermented carbohydrate is returned to the appropriate rumen pool, thus reducing the effective rate of carbohydrate fermentation.

The effects of low pH caused by feeding grain supplements to ruminants consuming forage diets (e.g. (53) was incorporated using the empirical relationship proposed by (58). According to these authors, the digestion rate of the cell wall fraction diminishes linearly below pH 6.2; and ceases at around pH 5.4. Similar relationships were reported by (42). Interaction between forages and high levels of grain supplements was obtained with this relationship.

The volatile fatty acids produced from fermentation in the rumen and large intestine, digested microbial true protein and protein, soluble sugars, starch and fat from feed ingredients that escaped ruminal fermentation were accumulated over each 24 h period. The quantities produced, multiplied by their energy content (70) were used to determine metabolisable energy and protein supply on a daily basis.

c. Evaluation of the model

The intake section of the model was tested first using the datasets given in Table S 8.

Table S 8. General characteristics of the experimental datasets used for evaluating the performance of the model for predicting intake.

Reference	Species	BW (kg)	Diets
Ref (71)	Sheep	20	*Eragostis teff* supplemented with different levels of *Chamaecitisus palmensis* and/or supplemented with *Sesbania sesban*
ILRI data (unpublished)	Sheep	28	Mixtures of veld hay, Napier hay and groundnut hay with or without urea at 1 or 2% of the diet
Ref (72)	Steers Heifers	411 144	Napier grass (*Pennisetum purpureum*) supplemented with graded levels of *Desmodium intortum*, lucerne (*Medicago sativa*) or sweet potato vines (*Ipomoea batatus*)
Ref (73)	Steers	144	Diets consisting of Napier grass, groundnut hay, belabela bean straw, Guatemala grass
Ref (74)	Sheep	18	Maize stover supplemented with different levels of *Desmodium intortum*
Ref (75)	Steers	350	Three varieties of *Panicum maximum* under grazing
University of Edinburgh, Langhill experimental dairy farm (unpublished)	Dairy cows	540 to 680	Total mixed rations consisting of first cut ryegrass silage (55%), whole crop wheat (15%) and commercial dairy concentrates (30%)
Ref (76)	Dual purpose cows	450 to 503	*Brachiaria mutica* or *Brachiaria decumbens* under grazing plus 3 kg commercial dairy concentrates

ILRI data (unpublished)	Sheep	20	Millet stover (*Pennisetum glaucum*) plus high protein supplements
ILRI data (unpublished)	Sheep	20	Millet stover (*Pennisetum glaucum*) plus different levels of cowpea hay
Ref (77)	Dairy cows	500	Kikuyu grass (*Pennisetum clandestinum*) under grazing

Body weight ranged from 18 - 680 kg, while NDF varied from 446 - 881 g/kg DM, with potential diet digestibilities and cell wall rates of degradation of 0.4 - 0.78 and 0.016 - 0.01/h, respectively. Protein was non-limiting in all situations and therefore average parameters for grasses were used (see below). Since the model estimates the physically constrained intake of each animal on the particular diet, most data are from experiments in which the overall quality of the diet was low. The data are shown in Figure S 70 and it can be seen that there is good agreement between predicted and observed results.

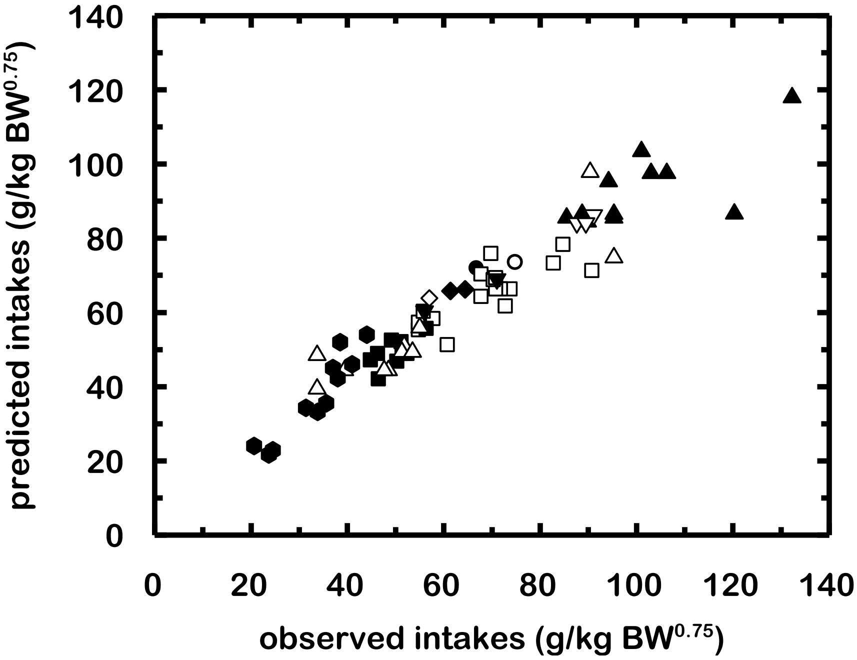


Figure S 70. Performance of the model for intake prediction of tropical forages

Experimental observations have also been included for a high quality diet, based on ryegrass silage. This was fed to high yielding dairy cows at around peak lactation when, again, it would be expected that physical constraints determined animal intake. The performance of the model in predicting the intake of the dairy cows is shown in Figure S 71. The differences between observed and predicted intakes are shown and average 0.5 kg/d on a total intake of approx. 20 kg/d. Use of the intake prediction equation of AFRC (43) for these animals gave predicted intakes that averaged 2 kg/d less than observed. The mean residual error of the whole dataset is +/- 5 g/kg $BW^{0.75}$ for an average intake of 82 g/kg $BW^{0.75}$.

Since the primary intake sections of the model were directly derived from the previously validated model from (41), it was not surprising that model performance was relatively similar. The model explained 65% of the variation in observed intakes, with a mean prediction error of 7% (± 4.72 g/kg

$BW^{0.75}$). The model was slightly biased towards overestimating intake at high observed intakes, and this is probably due to the simplification of the model in the estimation of passage rates. In terms of sensitivity of the quality variables, the most sensitive variables were the cell wall concentration and its potential degradation, which is also in line with the observations in (41).

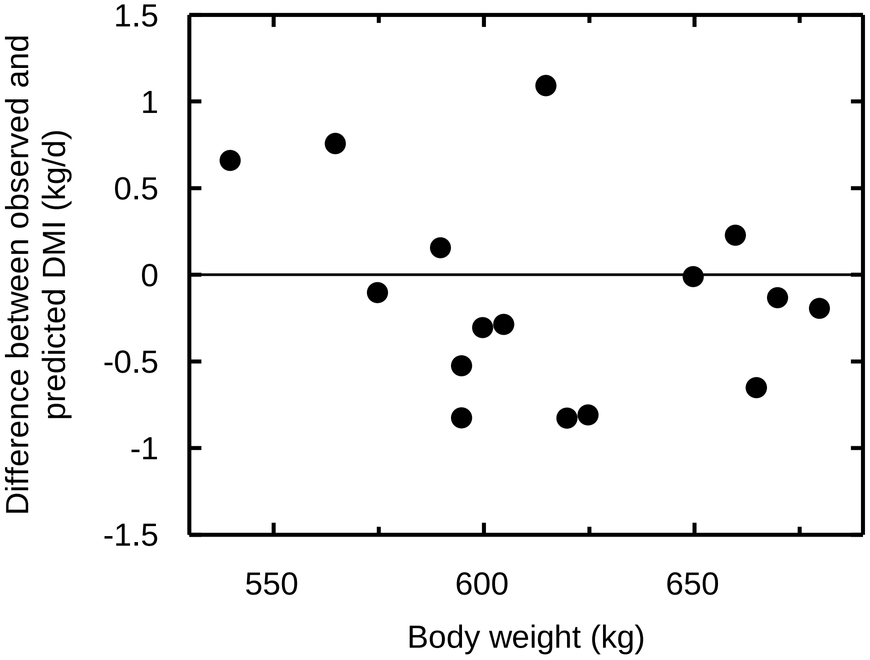


Figure S 71. Performance of the model on total mixed rations composed of first-cut ryegrass silage (55%), whole crop wheat (15%) and dairy concentrates (30%). For cows between 540-680 kg and intakes on average 19.9 kg (range 18.6 – 21.6 kg DM), milk yields 33.5 average (range 27.3 – 37.8 kg), animals were 3rd parity on a high forage system.

6. Diets for different livestock species

Estimation of the diets for different livestock species in different production systems and in different regions of the world was one of the essential steps for estimating biomass use, production, excretion. A similar methodology as that one employed for Africa in (78), and more recently by FAO for the dairy sector (79), and in (80) for studying mitigation options was implemented.

For each system and region we characterised typical diets for each animal species and feeding group using 4 types of main feeds. These were grazed grass, crop residues (stovers and straws), grains (grain-based supplements) and other feeds (cut and carry fodders, legumes, other planted forage).

a. Key sources of information and parameters.

The percentage of inclusion of each of the four ingredients in the diet of different animal species was obtained from extensive literature reviews (81-118) while nutritional quality parameters for each feed ingredient were obtained from extensive databases of feed composition for ruminants (43, 119-122). These data are presented in Table S 10.

b. Model results and GHG emissions

Productivity results and associated manure and N excretion and GHG emissions are presented in Table S 11. Results for animal productivity in this table are displayed in kg of product per tropical livestock unit. Conversion to protein, when used in this paper, is based on the average protein content of one kg of products at the world level, based on FAOSTAT as reported in Table S 9.

Table S 9. Conversion coefficient used for protein content of livestock products

Livestock product	**Protein content (g/kg)**
Bovine meat	138
Sheep and goat meat	137
Pig meat	106
Poultry meat	127
Milk	33
Eggs	111

Table S 10. The composition of the diet and parameters describing its nutritive value for different species, production systems and regions (BOVD = dairy cattle, BOVO = beef cattle and dairy followers, SGTD = small ruminants dairy, SGTO = small ruminants for meat). Variables description in Table S 7.

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
BOVD																		
CIS																		
LGA	90	0.3	100	0.6	0.5	100	10	8.5	700	0.300	0.150	0.045	0.070		100			
LGT	120	0.3	100	0.6	0.5	120	10	9.3	650	0.300	0.150	0.044	0.070		100			
MRA	152	0.3	100	0.6	0.5	121	14	8.9	604	0.300	0.170	0.045	0.078	0.9	54	10	36	
MRH	157	0.3	100	0.6	0.5	127	15	9.1	591	0.300	0.170	0.046	0.080	0.9	57	12	31	
MRT	179	0.3	100	0.6	0.5	146	36	9.7	600	0.300	0.180	0.062	0.084	0.9	52	18	30	
Other	147	0.3	100	0.6	0.5	106	37	9.4	633	0.300	0.170	0.059	0.078	0.9	90	10		
URBAN	147	0.3	100	0.6	0.5	106	37	9.4	633	0.300	0.170	0.059	0.078	0.9	90	10		
EAS																		
LGA	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
LGH	83	0.3	100	0.8	0.5	121	10	8.8	686	0.300	0.150	0.042	0.070		100			
LGT	163	0.3	100	0.6	0.5	162	17	9.9	549	0.300	0.170	0.047	0.078	0.9	90	10		
MRA	77	0.3	100	0.5	0.5	173	10	8.6	777	0.300	0.160	0.031	0.068	0.9	1	0	87	12
MRH	130	0.3	100	0.6	0.5	183	20	9.4	685	0.300	0.170	0.044	0.080	0.9	20	13	67	
MRT	227	0.3	100	0.6	0.5	179	30	11	510	0.300	0.200	0.063	0.093	0.9	42	28	30	
Other	195	0.4	100	0.7	0.4	141	27	10	537	0.300	0.180	0.072	0.082	0.9	86	14		
URBAN	212	0.4	100	0.7	0.4	152	25	11	506	0.300	0.190	0.078	0.084	0.9	83	17		
EUR																		
LGA	133	0.3	99	0.6	0.5	116	33	9.3	634	0.300	0.160	0.065	0.071	0.7	97	3		
LGH	153	0.4	98	0.6	0.5	130	32	9.7	597	0.300	0.170	0.071	0.074	0.7	91	9		
LGT	225	0.6	93	0.8	0.3	189	26	11	454	0.300	0.220	0.096	0.084	0.7	73	27		
MRA	225	0.4	98	0.7	0.4	134	36	11	502	0.300	0.190	0.078	0.100	0.8	71	17		12
MRH	204	0.5	92	0.7	0.3	178	33	12	458	0.300	0.210	0.089	0.095	0.8	71	27		3
MRT	212	0.5	90	0.8	0.4	174	40	12	452	0.300	0.210	0.087	0.097	0.7	64	36		
Other	202	0.4	97	0.7	0.4	135	36	11	522	0.300	0.190	0.075	0.096	0.8	74	18		9
URBAN	210	0.4	96	0.7	0.4	143	37	11	501	0.300	0.190	0.078	0.098	0.8	70	21		8
LAM																		
LGA	73	0.3	100	0.5	0.5	94	10	8.4	785	0.300	0.150	0.032	0.070		87			13
LGH	121	0.3	100	0.6	0.5	102	12	8.8	668	0.300	0.160	0.046	0.073	0.9	87	3		10
LGT	122	0.3	100	0.6	0.5	160	10	9.5	598	0.300	0.150	0.038	0.070	0.9	100	0		
MRA	159	0.4	97	0.6	0.4	132	17	9.7	623	0.300	0.190	0.060	0.077	0.7	49	13	21	17
MRH	144	0.3	100	0.6	0.5	124	16	9.1	655	0.300	0.170	0.047	0.077	0.9	50	9	25	17
MRT	237	0.3	95	0.6	0.5	183	31	11	475	0.300	0.210	0.063	0.090	0.9	31	33	12	24
Other	120	0.3	99	0.6	0.5	112	14	9.2	705	0.300	0.170	0.041	0.075	0.8	76	6		18
URBAN	118	0.3	99	0.6	0.5	110	14	9.2	711	0.300	0.170	0.040	0.074	0.8	76	5		19
MNA																		
LGA	84	0.3	100	0.8	0.5	118	10	8.8	687	0.300	0.150	0.042	0.070		100			
LGH	120	0.3	100	0.6	0.5	120	10	9.3	650	0.300	0.150	0.044	0.070		100			
LGT	120	0.3	100	0.6	0.5	160	10	9.5	600	0.300	0.150	0.038	0.070		100			
MRA	244	0.3	100	0.5	0.5	155	34	10	534	0.300	0.210	0.058	0.103	0.9	23	42	35	
MRH	291	0.3	100	0.6	0.6	154	39	11	457	0.300	0.220	0.066	0.110	0.9	31	50	19	
MRT	286	0.3	100	0.6	0.6	162	37	11	428	0.300	0.220	0.064	0.107	0.9	47	46	7	
Other	271	0.3	100	0.6	0.5	127	37	11	471	0.300	0.220	0.068	0.106	0.9	55	45		
URBAN	271	0.3	100	0.6	0.5	127	37	11	471	0.300	0.220	0.068	0.106	0.9	55	45		

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
NAM																		
MRA	236	0.6	92	0.8	0.3	198	25	12	434	0.300	0.230	0.100	0.085	0.7	70	30		
MRH	258	0.5	90	0.8	0.4	201	31	12	408	0.300	0.240	0.100	0.091	0.7	58	42		
MRT	247	0.5	87	0.8	0.4	192	42	12	397	0.300	0.240	0.096	0.102	0.7	50	50		
Other	205	0.6	92	0.8	0.3	185	33	12	442	0.300	0.220	0.093	0.094	0.7	70	30		
URBAN	203	0.6	92	0.8	0.3	185	33	12	444	0.300	0.220	0.093	0.094	0.7	70	30		
OCE																		
LGA	120	0.3	100	0.6	0.5	160	10	9.5	600	0.300	0.150	0.038	0.070		100			
LGH	187	0.3	100	0.7	0.5	180	22	10	469	0.300	0.180	0.061	0.084	0.9	82	18		
LGT	291	0.6	100	0.7	0.3	187	31	12	377	0.300	0.230	0.106	0.094	0.9	70	30		
MRA	120	0.3	100	0.6	0.5	147	16	9.4	614	0.300	0.150	0.043	0.070		100			
MRH	185	0.3	100	0.7	0.5	164	27	10	497	0.300	0.170	0.062	0.083	0.9	84	16		
MRT	284	0.5	100	0.7	0.4	166	38	11	407	0.300	0.220	0.097	0.096	0.9	68	32		
Other	149	0.3	100	0.6	0.5	155	14	9.8	576	0.300	0.170	0.039	0.079	0.9	89	11		
URBAN	218	0.3	100	0.6	0.5	138	14	11	568	0.300	0.210	0.041	0.078	0.9	0	10		90
SAS																		
LGA	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
LGH	120	0.3	100	0.6	0.5	120	10	9.3	650	0.300	0.150	0.044	0.070		100			
LGT	110	0.3	100	0.7	0.5	180	10	9.6	550	0.300	0.150	0.048	0.070		100			
MRA	244	0.3	100	0.6	0.5	101	35	9.3	521	0.300	0.200	0.066	0.098	0.9	30	35	35	
MRH	240	0.3	100	0.6	0.5	110	33	9.6	517	0.300	0.200	0.064	0.096	0.9	35	32	32	
MRT	283	0.3	100	0.7	0.5	138	40	10	425	0.300	0.210	0.073	0.104	0.9	29	42	28	
Other	247	0.3	100	0.6	0.5	92	36	9	525	0.300	0.210	0.065	0.100	0.9	7	37	56	
URBAN	247	0.3	100	0.6	0.5	92	36	9	525	0.300	0.210	0.065	0.100	0.9	7	37	56	
SEA																		
LGA	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
LGH	120	0.3	100	0.6	0.5	120	10	9.3	650	0.300	0.150	0.044	0.070		100			
LGT	92	0.3	100	0.6	0.5	102	10	8.5	695	0.300	0.150	0.045	0.070	0.9	100	0		
MRA	130	0.3	100	0.6	0.5	145	17	9.1	678	0.300	0.170	0.046	0.078	0.9	48	10	41	
MRH	180	0.3	100	0.6	0.5	173	26	9.7	618	0.300	0.180	0.053	0.088	0.9	20	23	57	
MRT	130	0.3	100	0.6	0.5	178	19	9.3	687	0.300	0.170	0.045	0.080	0.9	20	13	67	
Other	120	0.3	100	0.6	0.5	100	10	8.8	677	0.300	0.160	0.043	0.070		80			20
URBAN	120	0.3	100	0.6	0.5	100	10	8.8	677	0.300	0.160	0.043	0.070		80			20
SSA																		
LGA	100	0.3	100	0.5	0.5	90	10	8.3	700	0.300	0.150	0.044	0.070	0.9	92	0	4	4
LGH	99	0.3	100	0.6	0.5	104	11	8.7	687	0.300	0.150	0.045	0.071	0.9	99	1		
LGT	162	0.3	100	0.7	0.5	139	19	9.6	567	0.300	0.170	0.053	0.080	0.9	77	12	11	
MRA	104	0.3	100	0.5	0.5	92	14	8	713	0.300	0.160	0.040	0.073	0.9	53	4	33	10
MRH	131	0.3	100	0.6	0.5	102	19	8.5	667	0.300	0.170	0.045	0.079	0.9	60	11	27	2
MRT	177	0.3	100	0.6	0.5	105	24	8.9	609	0.300	0.180	0.051	0.086	0.9	51	17	29	2
Other	117	0.3	100	0.6	0.5	113	10	9	663	0.300	0.150	0.043	0.071	0.9	91	1	6	2
URBAN	133	0.3	100	0.6	0.5	120	12	9.2	630	0.300	0.160	0.047	0.076	0.9	88	3	5	4

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
WRD																		
LGA	96	0.3	100	0.6	0.5	103	10	8.6	696	0.300	0.150	0.042	0.070	0.9	95	0	2	3
LGH	129	0.3	100	0.6	0.5	114	14	9	641	0.300	0.160	0.049	0.074	0.9	88	5		7
LGT	132	0.3	100	0.6	0.5	131	12	9.5	623	0.300	0.160	0.049	0.072	0.8	96	3	1	
MRA	218	0.3	99	0.6	0.5	113	30	9.4	549	0.300	0.200	0.063	0.093	0.9	38	29	31	2
MRH	177	0.3	99	0.6	0.5	133	23	9.6	588	0.300	0.180	0.058	0.084	0.9	50	18	24	8
MRT	209	0.4	94	0.7	0.5	164	37	11	499	0.300	0.200	0.076	0.093	0.8	55	31	13	1
Other	181	0.4	98	0.6	0.5	124	30	9.9	573	0.300	0.180	0.064	0.087	0.8	67	18	9	6
URBAN	210	0.4	98	0.6	0.5	128	32	10	533	0.300	0.200	0.068	0.093	0.8	52	24	13	12

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
BOVO																		
CIS																		
LGA	120	0.3	100	0.6	0.5	104	35	9	661	0.300	0.150	0.060	0.070		100			
LGT	207	0.3	100	0.6	0.5	139	11	10	580	0.300	0.200	0.040	0.073	0.9		4		96
MRA	85	0.5	98	0.6	0.4	146	27	10	635	0.300	0.150	0.064	0.086		65		35	
MRH	127	0.5	99	0.6	0.4	147	30	11	593	0.300	0.180	0.058	0.098	0.9	50	17	33	
MRT	145	0.5	99	0.6	0.4	145	32	11	571	0.300	0.180	0.059	0.102	0.9	50	21	29	
Other	120	0.3	100	0.6	0.5	104	35	9	661	0.300	0.150	0.060	0.070		100			
URBAN	120	0.3	100	0.6	0.5	104	35	9	661	0.300	0.150	0.060	0.070		100			
EAS																		
LGA	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
LGH	83	0.3	100	0.8	0.5	121	10	8.8	686	0.300	0.150	0.042	0.070		100			
LGT	161	0.3	100	0.6	0.5	162	17	9.9	551	0.300	0.160	0.046	0.078	0.9	91	9		
MRA	77	0.3	100	0.6	0.5	129	14	8.4	740	0.300	0.150	0.039	0.070	0.9	56	0	44	
MRH	124	0.3	100	0.6	0.5	123	16	8.7	687	0.300	0.160	0.044	0.076	0.9	44	8	47	
MRT	147	0.3	100	0.6	0.5	168	16	9.7	587	0.300	0.160	0.045	0.077	0.9	76	8	16	
Other	127	0.3	100	0.7	0.5	124	15	9.5	629	0.300	0.150	0.051	0.073	0.9	98	2		
URBAN	133	0.4	100	0.7	0.5	128	14	9.6	620	0.300	0.160	0.054	0.073	0.9	98	2		
EUR																		
LGA	153	0.3	100	0.6	0.5	119	25	9.5	630	0.300	0.170	0.052	0.070		58			42
LGH	130	0.4	100	0.6	0.5	118	31	9.3	634	0.300	0.160	0.066	0.070		99			1
LGT	159	0.5	71	0.7	0.4	105	28	10	641	0.300	0.170	0.067	0.080	0.7	86	11		3
MRA	255	0.4	99	0.6	0.4	131	22	11	493	0.300	0.190	0.062	0.112	0.9	26	8		66
MRH	138	0.6	84	0.7	0.3	132	33	11	549	0.300	0.170	0.074	0.100	0.7	80	10		9
MRT	151	0.6	83	0.8	0.3	142	37	12	523	0.300	0.180	0.077	0.099	0.7	77	19		4
Other	176	0.3	98	0.6	0.5	119	30	9.8	591	0.300	0.170	0.061	0.085	0.7	68	6		26
URBAN	186	0.3	98	0.6	0.5	120	35	9.9	576	0.300	0.180	0.065	0.085	0.8	72	13		16
LAM																		
LGA	91	0.3	100	0.5	0.5	104	10	8.4	697	0.300	0.150	0.045	0.070		80			20
LGH	134	0.3	100	0.6	0.5	135	10	9.5	624	0.300	0.160	0.042	0.070		82			18
LGT	120	0.3	100	0.6	0.5	126	10	9.3	642	0.300	0.150	0.043	0.070		100			
MRA	96	0.3	100	0.5	0.5	148	10	8.6	726	0.300	0.160	0.036	0.070		5		50	46
MRH	202	0.3	100	0.6	0.5	113	10	9.3	583	0.300	0.180	0.053	0.080	0.7	70	0		29
MRT	344	0.3	92	0.6	0.5	139	27	10	431	0.300	0.240	0.069	0.098	0.8	14	20		66
Other	127	0.3	100	0.6	0.5	124	13	9.2	641	0.300	0.160	0.044	0.072	0.9	86	3		11
URBAN	193	0.3	100	0.6	0.5	134	12	10	595	0.300	0.190	0.042	0.072	0.9	15	2		82
MNA																		
LGA	111	0.3	100	0.7	0.5	119	14	9.1	660	0.300	0.160	0.043	0.077	0.9	91	9		
LGH	143	0.3	100	0.6	0.5	120	13	9.6	627	0.300	0.160	0.045	0.077	0.9	91	9		
LGT	125	0.3	100	0.6	0.5	159	11	9.6	596	0.300	0.150	0.038	0.071	0.9	98	2		
MRA	221	0.3	100	0.6	0.5	124	29	10	533	0.300	0.200	0.057	0.099	0.9	64	36		
MRH	228	0.3	100	0.6	0.5	129	27	11	521	0.300	0.200	0.057	0.095	0.9	69	31		
MRT	228	0.3	100	0.6	0.5	158	27	11	484	0.300	0.200	0.054	0.094	0.9	70	30		
Other	184	0.3	100	0.6	0.5	113	24	9.6	584	0.300	0.190	0.055	0.090	0.9	75	25		
URBAN	234	0.3	100	0.6	0.5	118	31	10	527	0.300	0.210	0.058	0.102	0.9	60	40		

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
NAM																		
LGA	120	0.3	100	0.6	0.5	104	35	9	661	0.300	0.150	0.060	0.070		100			
LGH	131	0.4	100	0.6	0.5	119	31	9.3	633	0.300	0.160	0.067	0.070		100			
LGT	172	0.6	49	0.8	0.4	86	27	11	663	0.300	0.180	0.066	0.087	0.7	82	18		
MRA	95	0.5	96	0.6	0.4	169	30	11	592	0.300	0.160	0.070	0.092	0.7	62	8	31	
MRH	122	0.5	94	0.7	0.4	177	33	11	570	0.300	0.180	0.067	0.094	0.7	50	19	31	
MRT	163	0.5	88	0.7	0.4	173	37	12	521	0.300	0.190	0.074	0.099	0.7	50	30	20	
Other	140	0.3	98	0.6	0.5	113	37	9.4	629	0.300	0.160	0.063	0.074	0.7	92	8		
URBAN	140	0.3	98	0.6	0.5	113	37	9.4	629	0.300	0.160	0.063	0.074	0.7	92	8		
OCE																		
LGA	130	0.4	100	0.6	0.5	165	10	9.7	583	0.300	0.160	0.049	0.070		100			
LGH	132	0.4	100	0.7	0.4	134	10	9.6	621	0.300	0.160	0.055	0.070		100		0	
LGT	121	0.4	100	0.7	0.5	181	10	9.8	542	0.300	0.160	0.056	0.070		100		0	
MRA	136	0.4	100	0.6	0.4	168	10	9.9	573	0.300	0.160	0.055	0.070		100			
MRH	141	0.4	100	0.7	0.4	144	10	9.8	598	0.300	0.170	0.064	0.070		99		1	
MRT	133	0.4	100	0.7	0.4	181	10	10	538	0.300	0.170	0.065	0.070		99		1	
Other	120	0.3	100	0.6	0.5	120	10	9.3	651	0.300	0.150	0.044	0.070		100		0	
URBAN	120	0.3	100	0.6	0.5	120	10	9.3	650	0.300	0.150	0.044	0.070		100		0	
SAS																		
LGA	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
LGH	103	0.3	100	0.6	0.5	94	10	8.5	693	0.300	0.150	0.044	0.070		100			
LGT	119	0.3	100	0.6	0.5	129	10	9.3	636	0.300	0.150	0.045	0.070		100			
MRA	102	0.3	100	0.5	0.5	117	10	8.5	725	0.300	0.160	0.038	0.070		42		39	19
MRH	114	0.3	100	0.6	0.5	118	10	8.8	707	0.300	0.160	0.037	0.070		33		40	26
MRT	119	0.3	100	0.6	0.5	135	10	9.1	666	0.300	0.160	0.040	0.070		46		29	25
Other	105	0.3	100	0.6	0.5	105	10	8.8	691	0.300	0.150	0.041	0.070		79		21	
URBAN	105	0.3	100	0.6	0.5	105	10	8.8	691	0.300	0.150	0.041	0.070		79		21	
SEA																		
LGA	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
LGH	120	0.3	100	0.6	0.5	120	10	9.3	650	0.300	0.150	0.044	0.070		100			
LGT	93	0.3	100	0.6	0.5	106	10	8.6	690	0.300	0.150	0.045	0.070		100			
MRA	91	0.3	100	0.5	0.5	149	10	8.8	722	0.300	0.160	0.044	0.070		56		44	
MRH	94	0.4	100	0.6	0.4	197	10	9.3	714	0.300	0.160	0.050	0.070		29		71	
MRT	86	0.4	100	0.6	0.4	190	10	9.1	732	0.300	0.160	0.045	0.070		28		72	
Other	120	0.3	100	0.6	0.5	100	10	8.8	677	0.300	0.160	0.043	0.070		80			20
URBAN	120	0.3	100	0.6	0.5	100	10	8.8	677	0.300	0.160	0.043	0.070		80			20
SSA																		
LGA	96	0.3	100	0.6	0.5	91	10	8.3	703	0.300	0.150	0.044	0.070		92		4	4
LGH	95	0.3	100	0.6	0.5	107	10	8.7	688	0.300	0.150	0.044	0.070		100			
LGT	112	0.3	100	0.7	0.5	165	10	9.5	576	0.300	0.150	0.047	0.070		100			
MRA	85	0.3	100	0.5	0.5	110	11	8.1	732	0.300	0.150	0.038	0.070		52		35	12
MRH	92	0.3	100	0.6	0.5	156	12	8.9	721	0.300	0.160	0.038	0.073	0.9	46	4	47	3
MRT	137	0.3	100	0.6	0.5	160	10	9.6	650	0.300	0.170	0.040	0.070	0.9	30	1	29	41
Other	119	0.3	100	0.6	0.5	113	10	9.1	657	0.300	0.150	0.045	0.073	0.9	97	1		2
URBAN	134	0.3	100	0.6	0.5	134	10	9.4	605	0.300	0.150	0.047	0.079	0.9	91	1		8

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
WRD																		
LGA	105	0.3	100	0.6	0.5	107	14	8.7	676	0.300	0.150	0.047	0.070	0.9	91	0	2	6
LGH	129	0.3	100	0.6	0.5	130	13	9.4	633	0.300	0.160	0.046	0.070	0.9	88	0	0	12
LGT	157	0.4	79	0.7	0.4	119	20	10	626	0.300	0.170	0.055	0.078	0.7	77	9	0	14
MRA	104	0.3	100	0.5	0.5	120	12	8.6	711	0.300	0.160	0.040	0.072	0.9	45	2	36	17
MRH	159	0.3	99	0.6	0.5	127	12	9.2	634	0.300	0.170	0.049	0.077	0.7	56	2	22	20
MRT	158	0.4	94	0.7	0.4	160	25	11	564	0.300	0.180	0.058	0.088	0.8	58	16	17	9
Other	129	0.3	100	0.6	0.5	116	18	9.2	645	0.300	0.160	0.049	0.073	0.8	87	3	3	7
URBAN	148	0.3	99	0.6	0.5	118	20	9.5	628	0.300	0.170	0.051	0.075	0.8	72	5	6	17

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
SGTD																		
CIS																		
LGA	120	0.3	100	0.6	0.5	104	35	9	661	0.300	0.150	0.060	0.070		100			
LGT	120	0.3	100	0.6	0.5	104	35	9	661	0.300	0.150	0.060	0.070		100			
MRA	134	0.3	100	0.6	0.5	105	36	9.2	646	0.300	0.160	0.059	0.074	0.9	95	5		
MRH	134	0.3	100	0.6	0.5	105	36	9.2	646	0.300	0.160	0.059	0.074	0.9	95	5		
MRT	148	0.3	100	0.6	0.5	106	37	9.4	632	0.300	0.170	0.059	0.078	0.9	89	11		
Other	134	0.3	100	0.6	0.5	105	36	9.2	646	0.300	0.160	0.059	0.074	0.9	95	5		
URBAN	134	0.3	100	0.6	0.5	105	36	9.2	646	0.300	0.160	0.059	0.074	0.9	95	5		
EAS																		
LGA	96	0.3	100	0.5	0.5	90	10	8.4	715	0.300	0.150	0.042	0.070		100			
LGH	96	0.3	100	0.5	0.5	90	10	8.4	715	0.300	0.150	0.042	0.070		100			
LGT	96	0.3	100	0.5	0.5	90	10	8.4	715	0.300	0.150	0.042	0.070		100			
MRA	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
MRH	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.043	0.070		100		0	0
MRT	100	0.3	100	0.6	0.5	90	11	8.4	700	0.300	0.150	0.043	0.070		100			0
Other	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			0
URBAN	100	0.3	100	0.6	0.5	90	11	8.4	700	0.300	0.150	0.043	0.070		100			0
EUR																		
LGA	106	0.3	100	0.6	0.5	95	11	8.5	688	0.300	0.150	0.046	0.070	0.7	99	1		
LGH	127	0.4	98	0.6	0.5	107	21	8.6	643	0.300	0.170	0.043	0.073	0.7	93	7		
LGT	190	0.3	97	0.6	0.5	140	19	10	568	0.300	0.200	0.054	0.077	0.7	42	14		44
MRA	228	0.3	100	0.6	0.5	121	34	10	554	0.300	0.200	0.061	0.096	0.9	67	32		0
MRH	190	0.4	98	0.7	0.5	123	34	9.8	540	0.300	0.190	0.059	0.090	0.8	77	23		0
MRT	131	0.3	99	0.6	0.5	112	19	9.1	631	0.300	0.160	0.052	0.078	0.8	71	8		22
Other	193	0.3	99	0.6	0.5	119	40	9.7	561	0.300	0.180	0.068	0.084	0.9	78	19		3
URBAN	219	0.3	99	0.7	0.5	124	44	10	527	0.300	0.190	0.072	0.089	0.9	74	25		1
LAM																		
LGA	91	0.3	100	0.5	0.5	90	10	8.4	730	0.300	0.150	0.040	0.070		99			1
LGH	102	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.071		99			1
LGT	125	0.3	100	0.6	0.5	153	12	9.5	608	0.300	0.150	0.040	0.072	0.9	97	3		
MRA	96	0.3	100	0.5	0.5	121	10	8.7	726	0.300	0.160	0.038	0.070		65		22	13
MRH	346	0.3	100	0.6	0.5	89	18	8.8	466	0.300	0.220	0.076	0.105	0.7	40	7	5	47
MRT	436	0.3	88	0.6	0.5	135	42	10	338	0.300	0.270	0.085	0.115	0.8	18	29	0	53
Other	142	0.3	100	0.6	0.5	114	15	9.1	631	0.300	0.160	0.048	0.075	0.9	85	7		8
URBAN	166	0.3	100	0.6	0.5	128	18	9.5	589	0.300	0.170	0.050	0.079	0.9	80	11		9
MNA																		
LGA	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
LGH	120	0.3	100	0.6	0.5	120	10	9.3	650	0.300	0.150	0.044	0.070		100			
LGT	120	0.3	100	0.6	0.5	160	10	9.5	600	0.300	0.150	0.038	0.070		100			
MRA	129	0.3	100	0.5	0.5	126	16	9.1	684	0.300	0.170	0.041	0.081	0.9	57	14	28	
MRH	195	0.3	100	0.5	0.5	137	17	10	600	0.300	0.180	0.045	0.101	0.9	44	19	25	12
MRT	207	0.3	100	0.5	0.5	152	19	10	567	0.300	0.190	0.043	0.104	0.9	41	24	24	12
Other	136	0.4	100	0.6	0.5	99	10	8.8	655	0.300	0.160	0.048	0.087		87			13
URBAN	90	0.3	100	0.6	0.5	100	10	8.5	700	0.300	0.150	0.045	0.070		100			

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
SAS																		
LGA	104	0.3	100	0.5	0.5	100	10	8.6	688	0.300	0.150	0.044	0.070		87			13
LGH	109	0.3	100	0.5	0.5	119	10	8.8	666	0.300	0.150	0.044	0.070		56			44
LGT	110	0.3	100	0.7	0.5	180	10	9.6	550	0.300	0.150	0.048	0.070		100			
MRA	139	0.3	100	0.4	0.5	121	17	8.7	632	0.300	0.160	0.052	0.078	0.9	10	10		80
MRH	150	0.3	100	0.6	0.5	123	13	9.5	622	0.300	0.170	0.045	0.073	0.9	72	4	4	21
MRT	194	0.3	100	0.6	0.5	146	25	9.6	506	0.300	0.180	0.060	0.087	0.9	56	22	22	
Other	115	0.3	100	0.6	0.5	112	12	9	660	0.300	0.150	0.041	0.070		100			
URBAN	115	0.3	100	0.6	0.5	111	13	8.9	661	0.300	0.150	0.040	0.070		100			
SEA																		
LGA	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
LGH	100	0.3	100	0.6	0.5	90	10	8.4	700	0.300	0.150	0.044	0.070		100			
LGT	120	0.3	100	0.6	0.5	160	10	9.5	600	0.300	0.150	0.038	0.070		100			
MRA	101	0.3	100	0.6	0.5	91	12	8.4	697	0.300	0.150	0.045	0.070		100			
MRH	101	0.3	100	0.6	0.5	91	12	8.4	697	0.300	0.150	0.045	0.070		100			
MRT	138	0.3	100	0.6	0.5	148	16	9.3	576	0.300	0.160	0.048	0.076	0.9	79	7	14	
Other	102	0.3	100	0.6	0.5	92	12	8.5	695	0.300	0.150	0.045	0.070		100			
URBAN	102	0.3	100	0.6	0.5	91	12	8.4	697	0.300	0.150	0.045	0.070		100			
SSA																		
LGA	90	0.3	100	0.6	0.5	104	11	8.6	696	0.300	0.150	0.045	0.070		100			
LGH	117	0.3	100	0.6	0.5	116	10	9.2	657	0.300	0.150	0.044	0.070	0.9	100	0		
LGT	110	0.3	100	0.7	0.5	179	10	9.6	551	0.300	0.150	0.048	0.070		100			
MRA	118	0.3	100	0.6	0.5	90	10	8.3	689	0.300	0.150	0.044	0.081		73		19	9
MRH	174	0.3	100	0.6	0.5	118	12	9.6	608	0.300	0.170	0.048	0.087	0.9	65	0	2	33
MRT	203	0.4	100	0.6	0.4	145	13	10	528	0.300	0.170	0.052	0.098		57			43
Other	154	0.3	100	0.6	0.5	126	10	9.5	611	0.300	0.160	0.045	0.082		76			24
URBAN	170	0.4	100	0.6	0.5	120	10	9.6	603	0.300	0.160	0.047	0.088		74			26
WRD																		
LGA	96	0.3	100	0.6	0.5	97	11	8.5	698	0.300	0.150	0.045	0.070	0.7	99	0		1
LGH	118	0.3	99	0.6	0.5	109	14	8.9	660	0.300	0.150	0.044	0.071	0.7	98	2		0
LGT	112	0.3	100	0.6	0.5	117	13	8.9	662	0.300	0.150	0.044	0.071	0.7	96	1		3
MRA	136	0.3	100	0.5	0.5	113	16	8.8	661	0.300	0.170	0.047	0.081	0.9	50	10	15	25
MRH	162	0.3	100	0.6	0.5	114	15	9.3	615	0.300	0.170	0.049	0.077	0.8	75	5	3	17
MRT	137	0.3	100	0.6	0.5	109	16	9	642	0.300	0.160	0.048	0.079	0.9	81	6	3	9
Other	151	0.3	100	0.6	0.5	112	23	9.2	620	0.300	0.160	0.054	0.079	0.9	87	8		5
URBAN	142	0.3	100	0.6	0.5	109	22	9.1	632	0.300	0.160	0.053	0.077	0.9	91	8		1

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
SGTO																		
CIS																		
LGA	164	0.3	100	0.6	0.5	112	40	9.5	602	0.300	0.170	0.066	0.078	0.9	90	10		
LGT	241	0.3	100	0.6	0.5	145	18	11	528	0.300	0.210	0.049	0.079	0.9		12		88
MRA	150	0.4	99	0.6	0.4	125	40	10	565	0.300	0.160	0.074	0.087	0.9	90	10		
MRH	158	0.4	99	0.7	0.4	167	28	11	488	0.300	0.170	0.065	0.092	0.9	84	16		
MRT	202	0.4	99	0.7	0.4	146	30	11	501	0.300	0.200	0.063	0.094	0.9	37	16		47
Other	163	0.3	100	0.6	0.5	112	40	9.5	604	0.300	0.170	0.066	0.078	0.9	90	10		
URBAN	163	0.3	100	0.6	0.5	112	40	9.5	604	0.300	0.170	0.066	0.078	0.9	90	10		
EAS																		
LGA	241	0.3	100	0.6	0.5	145	18	11	528	0.300	0.210	0.049	0.079	0.9		12		88
LGH	241	0.3	100	0.6	0.5	145	18	11	528	0.300	0.210	0.049	0.079	0.9		12		88
LGT	259	0.3	100	0.6	0.5	147	22	11	504	0.300	0.220	0.053	0.083	0.9		17		83
MRA	214	0.3	100	0.6	0.5	128	21	10	568	0.300	0.200	0.051	0.079	0.9	12	12	12	65
MRH	236	0.3	100	0.6	0.5	128	22	10	545	0.300	0.210	0.052	0.084	0.9	0	18	18	64
MRT	259	0.3	100	0.6	0.5	147	22	11	503	0.300	0.220	0.053	0.083	0.9	0	17		83
Other	236	0.3	100	0.6	0.5	143	20	11	532	0.300	0.210	0.051	0.080	0.9	6	12		82
URBAN	237	0.3	100	0.6	0.5	143	20	11	533	0.300	0.210	0.051	0.079	0.9	6	12		82
EUR																		
LGA	233	0.3	100	0.6	0.5	141	21	11	536	0.300	0.210	0.051	0.079	0.9	10	12		78
LGH	179	0.3	100	0.6	0.5	124	34	9.8	578	0.300	0.180	0.067	0.078	0.9	78	10		11
LGT	217	0.5	59	0.8	0.4	102	32	11	589	0.300	0.190	0.073	0.093	0.8	71	25		4
MRA	296	0.4	100	0.6	0.4	136	22	11	465	0.300	0.210	0.060	0.109	0.9	6	16		78
MRH	239	0.4	89	0.7	0.4	136	30	11	487	0.300	0.200	0.069	0.105	0.9	43	20		36
MRT	202	0.5	79	0.8	0.4	138	39	12	501	0.300	0.200	0.078	0.101	0.8	65	28		7
Other	229	0.3	99	0.6	0.5	128	29	10	531	0.300	0.190	0.063	0.093	0.9	45	13		42
URBAN	247	0.3	99	0.6	0.5	129	36	10	505	0.300	0.200	0.069	0.096	0.9	49	21		30
LAM																		
LGA	144	0.3	100	0.6	0.5	111	18	9	628	0.300	0.170	0.054	0.079	0.9	77	12		12
LGH	187	0.3	100	0.6	0.5	158	18	10	537	0.300	0.180	0.048	0.079	0.9	68	12		20
LGT	170	0.3	100	0.7	0.5	129	18	9.8	583	0.300	0.170	0.053	0.079	0.9	88	12		0
MRA	146	0.3	100	0.5	0.5	145	19	9.2	634	0.300	0.170	0.050	0.080	0.9	40	13	25	22
MRH	196	0.3	100	0.6	0.5	155	19	10	578	0.300	0.190	0.049	0.080	0.9	27	13	20	41
MRT	244	0.2	94	0.6	0.5	170	27	11	489	0.300	0.220	0.054	0.083	0.9	15	26		59
Other	233	0.3	100	0.6	0.5	138	20	10	535	0.300	0.210	0.052	0.081	0.9	17	14		69
URBAN	230	0.3	100	0.6	0.5	134	22	10	537	0.300	0.200	0.054	0.082	0.9	24	15		60
MNA																		
LGA	139	0.3	100	0.8	0.5	128	18	9.4	615	0.300	0.170	0.051	0.079	0.9	86	11		2
LGH	170	0.3	100	0.7	0.5	127	18	9.8	585	0.300	0.170	0.053	0.079	0.9	88	12		
LGT	210	0.3	100	0.6	0.5	152	18	10	533	0.300	0.190	0.049	0.079	0.9	39	12		50
MRA	235	0.3	100	0.6	0.5	157	31	11	533	0.300	0.210	0.056	0.099	0.9	25	36	27	12
MRH	240	0.3	100	0.6	0.5	158	30	11	528	0.300	0.210	0.057	0.096	0.9	25	33	27	15
MRT	256	0.3	100	0.6	0.5	161	29	11	499	0.300	0.210	0.057	0.094	0.9	16	31	17	36
Other	231	0.3	100	0.6	0.5	127	27	10	526	0.300	0.200	0.059	0.092	0.9	49	28		23
URBAN	225	0.3	100	0.6	0.5	122	29	10	531	0.300	0.200	0.061	0.095	0.9	62	31		7

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
NAM																		
LGA	164	0.3	100	0.6	0.5	112	40	9.5	602	0.300	0.170	0.066	0.078	0.9	90	10		
LGH	170	0.3	100	0.6	0.5	121	37	9.6	586	0.300	0.170	0.070	0.078	0.9	90	10		
LGT	216	0.5	55	0.8	0.4	94	33	11	600	0.300	0.190	0.072	0.095	0.8	73	27		
MRA	157	0.4	98	0.7	0.4	134	41	11	536	0.300	0.170	0.078	0.092	0.8	86	14		
MRH	173	0.6	75	0.7	0.3	125	38	11	540	0.300	0.180	0.078	0.100	0.8	79	21		
MRT	195	0.5	76	0.8	0.4	135	40	12	508	0.300	0.190	0.080	0.102	0.8	71	29		
Other	175	0.3	99	0.6	0.5	117	41	9.7	585	0.300	0.170	0.068	0.080	0.8	85	15		
URBAN	175	0.3	99	0.6	0.5	117	41	9.7	585	0.300	0.170	0.068	0.080	0.8	85	15		
OCE																		
LGA	177	0.4	100	0.6	0.5	166	18	10	529	0.300	0.170	0.055	0.079	0.9	88	12		
LGH	176	0.4	100	0.7	0.5	135	18	10	568	0.300	0.170	0.059	0.079	0.9	88	11		0
LGT	162	0.3	100	0.7	0.5	181	17	10	498	0.300	0.170	0.061	0.078	0.9	90	10		
MRA	182	0.4	100	0.6	0.5	168	18	10	522	0.300	0.180	0.059	0.079	0.9	88	12		
MRH	183	0.4	100	0.7	0.4	143	18	10	551	0.300	0.180	0.066	0.079	0.9	88	11		0
MRT	172	0.4	100	0.7	0.5	182	18	10	490	0.300	0.180	0.067	0.079	0.9	89	11		0
Other	170	0.3	100	0.7	0.5	127	18	9.8	585	0.300	0.170	0.053	0.079	0.9	88	12		0
URBAN	170	0.3	100	0.7	0.5	127	18	9.8	585	0.300	0.170	0.053	0.079	0.9	88	12		0
SAS																		
LGA	157	0.3	100	0.6	0.5	101	19	9	623	0.300	0.170	0.054	0.080	0.9	87	13		
LGH	170	0.3	100	0.7	0.5	127	18	9.8	585	0.300	0.170	0.053	0.079	0.9	88	12		
LGT	159	0.3	100	0.7	0.5	180	18	10	499	0.300	0.170	0.056	0.079	0.9	89	11		
MRA	178	0.3	100	0.6	0.5	109	19	9.3	610	0.300	0.180	0.051	0.080	0.9	48	13	13	26
MRH	178	0.3	100	0.6	0.5	114	19	9.4	613	0.300	0.180	0.049	0.080	0.9	36	13	26	26
MRT	176	0.3	100	0.6	0.5	155	18	9.9	540	0.300	0.180	0.052	0.079	0.9	53	12	12	23
Other	162	0.3	100	0.6	0.5	119	18	9.5	608	0.300	0.170	0.051	0.079	0.9	77	12	12	
URBAN	162	0.3	100	0.6	0.5	119	18	9.5	608	0.300	0.170	0.051	0.079	0.9	77	12	12	
SEA																		
LGA	241	0.3	100	0.6	0.5	145	18	11	528	0.300	0.210	0.049	0.079	0.9		12		88
LGH	241	0.3	100	0.6	0.5	145	18	11	528	0.300	0.210	0.049	0.079	0.9		12		88
LGT	241	0.3	100	0.6	0.5	145	18	11	528	0.300	0.210	0.049	0.079	0.9	0	12		88
MRA	207	0.3	100	0.6	0.5	163	19	10	573	0.300	0.200	0.051	0.080	0.9	6	12	25	57
MRH	188	0.3	100	0.6	0.5	176	19	10	592	0.300	0.190	0.055	0.080	0.9	15	13	38	34
MRT	189	0.3	100	0.6	0.5	174	19	10	599	0.300	0.190	0.052	0.081	0.9	8	13	40	38
Other	241	0.3	100	0.6	0.5	145	18	11	529	0.300	0.210	0.049	0.079	0.9		12		88
URBAN	241	0.3	100	0.6	0.5	145	18	11	529	0.300	0.210	0.049	0.079	0.9		12		88
SSA																		
LGA	174	0.3	100	0.6	0.5	137	19	9.7	572	0.300	0.180	0.050	0.080	0.9	71	12	3	14
LGH	166	0.3	100	0.7	0.5	138	18	9.8	577	0.300	0.170	0.051	0.079	0.9	82	12		6
LGT	215	0.3	100	0.6	0.5	144	18	10	540	0.300	0.200	0.051	0.079	0.9	31	12		57
MRA	166	0.3	100	0.6	0.5	121	18	9	617	0.300	0.170	0.049	0.079	0.9	55	12	31	2
MRH	191	0.3	100	0.6	0.5	156	20	9.9	572	0.300	0.180	0.050	0.094	0.9	51	16	23	10
MRT	160	0.3	100	0.6	0.5	149	17	9.8	607	0.300	0.170	0.052	0.079	0.9	64	11	20	5
Other	168	0.3	100	0.6	0.5	118	19	9.5	597	0.300	0.170	0.054	0.081	0.9	80	12		7
URBAN	186	0.3	100	0.6	0.5	116	19	9.6	587	0.300	0.180	0.053	0.084	0.9	62	12		26

	solCHO	solCP	Ash	degNDF	degCP	CP	Fat	ME	NDF	k1	k4	k2	k5	Starch	Grass (%)	grain (%)	stover (%)	occasional (%)
WRD																		
LGA	167	0.3	100	0.7	0.5	134	19	9.6	582	0.300	0.170	0.052	0.079	0.9	74	12	1	13
LGH	178	0.3	100	0.6	0.5	139	22	9.9	564	0.300	0.170	0.056	0.079	0.9	78	11		10
LGT	235	0.3	93	0.7	0.5	138	22	11	533	0.300	0.200	0.056	0.083	0.9	24	16		60
MRA	191	0.3	100	0.6	0.5	131	21	9.7	578	0.300	0.180	0.053	0.085	0.9	49	17	18	17
MRH	192	0.3	99	0.6	0.5	144	20	10	573	0.300	0.180	0.054	0.086	0.9	45	14	19	21
MRT	232	0.3	97	0.7	0.5	147	24	11	517	0.300	0.210	0.057	0.086	0.9	21	18	4	58
Other	203	0.3	100	0.6	0.5	129	22	10	561	0.300	0.190	0.055	0.083	0.9	49	13	2	36
URBAN	213	0.3	100	0.6	0.5	127	26	10	550	0.300	0.190	0.058	0.086	0.9	50	17	2	31

Table S 11. Ruminant numbers, productivity per tropical livestock unit and associated manure, N excretion and GHG emissions for different species, production systems and regions (BOVD = dairy cattle, BOVO = beef cattle and dairy followers, SGTD = small ruminants dairy, SGTO = small ruminants for meat; BW = body weight)

	Number (productive)	Number (herd)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermentation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ kgBW$^{0.75}$/yr)	(kg/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)
BOVD											
CIS											
ANY	18727	25607	9.1		9.72	0.44	12.66	0.65	1.60	1.03	2.52
LGA	329	494	3.0		8.82	0.29	9.50	0.07	2.05	0.78	0.35
LGT	2859	3989	7.2		9.25	0.39	12.14	0.24	1.65	0.77	1.72
MRA	725	1021	8.7		7.86	0.37	10.34	0.17	1.90	0.60	0.64
MRH	48	65	9.0		8.04	0.38	10.44	1.27	1.60	0.74	2.39
MRT	9828	13104	10.8		9.80	0.50	13.59	0.85	1.65	1.25	2.93
Other	4191	5884	7.3		10.25	0.39	11.91	0.66	1.40	0.90	2.73
URBAN	748	1050	7.3		10.35	0.39	12.03	0.66	1.42	0.91	2.75
EAS											
ANY	7328	10622	7.1		11.22	0.62	14.89	0.48	2.60	2.36	0.41
LGA	32	51	0.5		9.74	0.29	10.58	0.02	2.30	0.51	0.21
LGH	1	2	2.5		12.00	0.49	14.99	0.19	3.45	0.60	0.52
LGT	188	277	4.7		10.35	0.63	13.84	0.14	3.88	2.55	0.23
MRA	149	229	0.8		11.71	0.38	12.05	0.11	1.61	2.39	0.25
MRH	1291	1874	2.3		11.07	0.40	11.63	0.37	2.44	0.69	0.48
MRT	3006	4209	7.4		10.87	0.71	14.92	0.66	2.36	2.28	0.48
Other	1993	2981	9.3		11.84	0.63	16.42	0.37	2.85	3.14	0.34
URBAN	669	1000	10.7		11.40	0.68	17.23	0.39	3.09	3.40	0.33
EUR											
ANY	2426	3503	14.4		9.19	0.55	14.02	0.85	2.05	1.24	2.40
LGA	34	51	7.8		9.42	0.38	11.39	0.09	2.67	1.01	0.38
LGH	53	77	20.1		9.48	0.46	12.58	0.74	1.94	0.97	1.78
LGT	259	386	20.3		9.79	0.86	17.54	0.53	3.65	1.71	1.89
MRA	95	133	8.9		8.54	0.33	11.41	0.15	1.71	0.54	0.68
MRH	152	208	20.0		9.76	0.41	11.91	1.38	1.75	0.81	2.87
MRT	750	1022	21.5		9.72	0.45	12.57	0.77	1.49	1.13	2.88
Other	813	1212	16.1		8.65	0.57	14.72	0.97	2.07	1.33	2.37
URBAN	270	414	17.6		8.63	0.62	15.26	1.05	2.24	1.44	2.38
LAM											
ANY	21677	32626	5.7		9.33	0.36	10.24	0.26	2.46	0.66	0.68
LGA	437	656	0.6		9.60	0.30	8.41	0.06	2.16	0.84	0.31
LGH	2780	4169	3.7		9.96	0.32	10.20	0.16	2.24	0.91	0.32
LGT	256	397	8.0		7.31	0.44	9.50	0.12	2.68	1.72	0.24
MRA	1267	1870	6.9		7.97	0.45	10.22	0.10	2.74	1.80	0.26
MRH	10291	15534	6.1		10.19	0.37	10.65	0.30	2.59	0.45	0.88
MRT	944	1415	17.8		6.88	0.49	11.76	0.32	2.56	1.09	0.62
Other	4844	7288	4.2		8.25	0.33	9.48	0.27	2.28	0.53	0.66
URBAN	858	1297	3.9		8.17	0.32	9.24	0.26	2.20	0.51	0.65

	Number (productive)	Number (herd)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermentation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ $kgBW^{0.75}$/yr)	(kg/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)
MNA											
ANY	10110	15121	5.4		10.95	0.49	13.98	0.31	2.57	1.71	0.61
LGA	2470	3801	2.3		10.91	0.43	13.44	0.08	3.04	1.22	0.34
LGH	0	0	3.4		9.23	0.39	11.90	0.27	2.37	1.56	0.30
LGT	63	90	3.4		11.32	0.67	13.88	0.39	3.05	1.53	1.10
MRA	5056	7546	6.0		10.66	0.46	14.00	0.16	2.40	1.81	0.40
MRH	188	276	8.2		11.59	0.63	15.76	1.74	2.69	1.43	1.58
MRT	532	760	8.7		11.51	0.77	15.11	1.21	2.54	2.02	1.84
Other	816	1200	6.9		11.72	0.57	14.34	0.73	2.30	1.84	1.36
URBAN	985	1449	6.9		11.37	0.54	13.91	0.46	2.41	2.24	0.83
NAM											
ANY	10223	16566	27.6		11.44	1.10	23.31	0.93	6.13	2.78	2.02
MRA	2061	3255	22.2		11.75	1.11	22.07	0.30	6.82	4.40	0.49
MRH	690	1184	27.1		11.82	1.15	23.79	1.75	7.04	1.79	2.81
MRT	3955	6591	32.8		12.17	1.21	25.46	1.21	6.27	2.32	2.85
Other	2753	4311	24.9		10.42	0.97	21.63	0.81	5.42	2.57	1.83
URBAN	763	1225	25.0		10.22	0.95	21.09	0.80	5.30	2.51	1.81
OCE											
ANY	5038	7577	11.6		13.96	1.07	20.35	0.68	7.34	2.14	1.59
LGA	1033	1549	7.9		14.16	0.86	18.38	0.18	6.07	2.37	0.85
LGH	697	1045	16.1		15.18	0.91	23.43	0.47	6.44	2.62	0.92
LGT	70	108	21.6		14.39	0.96	22.63	0.27	5.89	3.78	0.90
MRA	315	465	8.4		12.73	0.68	18.89	0.15	4.18	2.75	0.77
MRH	790	1193	16.3		16.26	0.87	23.01	0.72	6.14	1.07	2.63
MRT	18	26	20.1		14.04	0.71	21.70	0.45	3.66	1.56	2.32
Other	1047	1575	9.3		12.58	0.70	18.14	0.56	4.80	1.12	1.87
URBAN	1068	1615	11.3		12.95	1.99	20.71	1.59	13.61	3.15	1.95
SAS											
ANY	42377	64341	3.7		14.47	0.25	12.71	0.11	1.21	1.29	0.63
LGA	1429	2286	0.5		11.94	0.36	12.96	0.03	2.88	0.63	0.38
LGH	20	31	3.4		13.69	0.58	17.65	0.23	4.08	0.71	1.18
LGT	21	31	5.3		15.09	1.03	19.30	0.23	6.29	4.12	0.49
MRA	26649	40999	3.7		14.53	0.25	12.68	0.07	1.06	1.57	0.47
MRH	5368	7779	4.9		15.14	0.33	14.61	0.30	2.01	0.56	1.31
MRT	661	918	8.2		15.39	0.41	17.36	0.38	1.34	1.30	1.35
Other	5127	7661	2.9		14.19	0.19	11.11	0.11	0.84	0.93	0.68
URBAN	3102	4636	2.9		14.20	0.18	11.12	0.11	0.83	0.91	0.68
SEA											
ANY	2254	3323	2.5		9.66	0.47	10.92	0.31	2.60	1.47	0.57
LGA	1	2	0.5		8.97	0.26	9.74	0.02	2.10	0.46	0.29
LGH	161	247	3.4		10.36	0.43	13.35	0.17	3.06	0.53	0.90
LGT	477	701	1.2		10.62	0.36	10.87	0.08	2.20	1.44	0.34
MRA	112	172	2.7		8.84	0.49	10.81	0.14	2.08	3.08	0.29
MRH	708	1026	4.0		8.49	0.64	10.77	0.59	3.91	1.10	0.75
MRT	142	197	2.4		7.77	0.58	10.40	0.54	1.92	1.85	0.68
Other	620	927	1.4		10.61	0.35	10.67	0.20	1.60	1.76	0.51
URBAN	33	50	1.4		10.62	0.35	10.68	0.20	1.60	1.76	0.51

	Number (productive)	Number (herd)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermentation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ kgBW$^{0.75}$/yr)	(kg/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)
SSA											
ANY	19755	30717	1.2		14.22	0.47	13.95	0.27	2.51	1.83	0.62
LGA	5772	8838	0.6		14.00	0.43	14.46	0.08	3.02	1.22	0.45
LGH	621	1032	1.6		14.84	0.52	15.43	0.36	3.16	2.08	0.48
LGT	281	471	5.1		12.58	0.67	14.57	0.20	4.12	2.63	0.41
MRA	7058	10584	0.6		16.27	0.48	14.19	0.14	2.49	2.48	0.52
MRH	2101	3382	1.4		12.85	0.47	12.45	0.93	1.98	1.22	1.10
MRT	2508	4150	3.8		11.32	0.50	12.99	0.52	1.64	1.57	0.98
Other	1213	1942	2.6		11.77	0.45	13.53	0.29	2.13	2.11	0.58
URBAN	200	317	3.6		13.31	0.56	15.54	0.36	2.67	2.63	0.66
WRD											
ANY	139914	210001	6.9		12.04	0.45	13.48	0.36	2.35	1.40	1.08
LGA	11538	17727	1.7		12.75	0.44	13.91	0.08	3.19	1.21	0.44
LGH	4333	6605	5.5		11.31	0.43	12.80	0.24	2.95	1.28	0.45
LGT	4475	6450	7.3		9.55	0.44	12.48	0.23	2.10	1.11	1.42
MRA	43487	66273	4.6		13.89	0.36	13.33	0.10	1.77	1.86	0.47
MRH	21626	32521	6.1		11.81	0.41	12.54	0.44	2.64	0.64	1.10
MRT	22343	32393	13.5		10.47	0.63	15.43	0.81	2.46	1.56	2.24
Other	23417	34980	7.9		10.89	0.43	12.88	0.42	2.21	1.26	1.31
URBAN	8696	13054	7.9		11.95	0.58	13.77	0.50	3.28	1.60	1.18

	Number (total)	Number (no follow-ers)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermen-tation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ kgBW$^{0.75}$/yr)	(kg/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)
BOVO											
CIS											
ANY	21751	14871		692	16.50	0.96	23.96	1.06	5.10	1.76	4.04
LGA	400	235		245	20.57	0.79	22.19	0.12	6.35	1.27	0.80
LGT	3451	2321		468	14.05	0.75	22.16	0.38	3.87	1.21	1.63
MRA	874	579		621	14.65	0.84	21.52	0.30	5.15	3.13	0.86
MRH	41	24		774	16.33	1.37	25.24	3.01	8.42	1.72	5.17
MRT	11160	7884		1017	15.38	1.13	25.83	1.42	5.88	1.96	5.59
Other	4951	3257		244	20.28	0.78	22.03	0.99	4.26	1.56	3.35
URBAN	874	571		244	20.34	0.79	22.09	1.00	4.27	1.56	3.36
EAS											
ANY	73315	70021		315	10.40	0.57	13.14	0.38	3.31	1.30	0.50
LGA	364	345		14	9.63	0.31	10.44	0.03	2.52	0.55	0.20
LGH	16	15		179	11.80	0.53	14.69	0.14	4.21	0.94	0.27
LGT	2130	2042		380	10.09	0.67	13.42	0.12	4.74	1.92	0.29
MRA	1694	1615		24	11.52	0.40	11.78	0.09	2.47	1.62	0.23
MRH	14113	13529		90	10.57	0.39	10.73	0.31	2.77	0.48	0.48
MRT	32543	31339		397	10.02	0.67	13.42	0.49	3.49	1.49	0.58
Other	17049	16061		357	10.82	0.53	14.39	0.31	3.31	1.46	0.44
URBAN	5406	5075		366	10.87	0.55	14.51	0.33	3.44	1.52	0.45
EUR											
ANY	2598	1522		873	22.01	1.73	35.34	2.02	9.33	3.22	6.22
LGA	31	14		249	43.87	1.83	47.95	0.28	14.66	2.93	1.75
LGH	43	18		440	41.04	3.14	52.41	4.13	16.25	5.45	3.93
LGT	425	298		514	13.62	1.18	21.48	0.60	6.11	1.91	1.66
MRA	86	47		621	32.71	1.91	48.05	0.67	11.74	7.13	1.91
MRH	95	39		880	43.80	3.69	66.03	8.09	22.59	4.61	14.29
MRT	644	373		1131	26.10	2.16	44.48	2.70	11.21	3.73	10.09
Other	959	560		818	20.50	1.51	32.21	1.93	8.23	3.01	5.88
URBAN	316	172		1180	20.93	1.76	36.51	2.24	9.59	3.51	6.73
LAM											
ANY	160404	149455		253	10.44	0.46	12.08	0.22	3.64	0.91	0.40
LGA	7709	7490		131	10.07	0.39	10.68	0.05	3.12	0.65	0.35
LGH	20797	19407		275	10.37	0.50	13.35	0.17	3.98	0.85	0.41
LGT	2089	1949		268	7.05	0.36	8.95	0.08	2.56	1.02	0.28
MRA	8494	7891		116	10.46	0.42	10.82	0.07	2.94	1.20	0.36
MRH	74296	69053		278	10.97	0.49	12.71	0.26	3.90	0.87	0.44
MRT	4550	4078		848	7.12	0.47	10.17	0.27	2.91	1.98	0.43
Other	36502	34059		153	10.19	0.42	10.85	0.23	3.25	0.84	0.35
URBAN	5968	5529		378	9.59	0.53	13.33	0.29	4.11	1.07	0.43
MNA											
ANY	12151	7195		477	23.82	1.22	30.47	0.45	7.95	3.72	1.35
LGA	3423	2092		224	23.80	1.09	30.78	0.13	8.71	1.85	0.85
LGH	0	0		332	25.19	1.22	30.46	0.69	8.63	3.52	1.02
LGT	69	42		282	20.05	1.32	24.83	0.60	7.40	2.48	1.03
MRA	5917	3427		605	24.36	1.31	31.43	0.33	8.03	5.18	1.12
MRH	187	98		659	25.73	1.47	33.77	2.63	9.02	2.15	3.83
MRT	588	360		608	19.76	1.40	26.20	1.53	7.26	2.61	3.07
Other	841	457		376	24.11	1.10	27.94	0.99	6.24	2.92	2.32
URBAN	1183	719		554	23.17	1.14	28.71	0.70	6.66	3.60	2.02

	Number (total)	Number (no follow-ers)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermen-tation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ kgBW$^{0.75}$/yr)	(kg/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)
NAM											
ANY	100215	93871		637	12.35	0.65	17.19	0.42	4.35	2.17	0.79
LGA	11870	11870		245	13.37	0.50	14.42	0.06	3.99	0.83	0.58
LGH	3064	3064		294	13.10	0.57	14.84	0.24	4.60	0.35	0.60
LGT	10634	10634		546	9.21	0.36	11.69	0.13	2.21	1.40	0.60
MRA	8167	6974		953	13.36	0.86	20.83	0.17	6.10	2.44	1.01
MRH	3494	3001		1010	10.37	0.78	19.11	0.53	6.22	1.34	0.98
MRT	28561	25925		1163	10.72	0.84	20.36	0.73	5.17	3.33	1.02
Other	27121	25563		375	14.22	0.61	16.73	0.44	3.95	2.15	0.69
URBAN	7303	6840		375	14.20	0.61	16.70	0.44	3.95	2.15	0.69
OCE											
ANY	27859	25320		333	15.82	0.96	20.66	0.27	7.50	1.85	0.93
LGA	11407	10891		359	15.34	1.05	19.31	0.14	8.42	1.74	0.65
LGH	2971	2622		306	15.04	0.80	21.59	0.27	6.41	1.38	1.04
LGT	193	155		510	19.12	1.46	26.52	0.32	10.33	4.11	1.43
MRA	2997	2847		401	14.53	1.03	19.95	0.18	7.31	2.98	1.10
MRH	2787	2385		339	16.60	0.98	22.48	0.54	7.84	1.74	1.26
MRT	128	119		571	15.19	1.17	23.63	0.67	7.14	4.82	1.28
Other	5277	4749		264	16.34	0.76	20.90	0.42	5.91	1.56	1.10
URBAN	2100	1553		267	19.77	0.94	25.40	0.51	7.33	1.90	1.31
SAS											
ANY	140642	118678		54	12.13	0.51	12.58	0.21	3.22	1.58	0.61
LGA	3167	2310		4	17.02	0.55	18.44	0.05	4.45	0.98	0.52
LGH	73	62		31	10.19	0.36	11.44	0.10	2.89	0.65	0.33
LGT	73	63		289	11.80	0.63	15.14	0.11	4.43	1.80	0.47
MRA	85284	70934		30	11.72	0.48	11.65	0.11	2.95	1.93	0.37
MRH	21969	19557		80	13.44	0.62	14.33	0.49	4.35	0.76	1.24
MRT	1949	1692		226	14.73	0.86	18.08	0.62	4.46	1.90	1.54
Other	17830	15295		101	11.48	0.45	12.81	0.27	2.83	1.25	0.73
URBAN	10298	8764		101	11.89	0.47	13.27	0.28	2.93	1.29	0.75
SEA											
ANY	35338	34270		135	10.01	0.65	12.65	0.45	4.45	1.12	0.91
LGA	24	23		4	10.62	0.35	11.50	0.03	2.77	0.61	0.32
LGH	1839	1753		267	12.52	0.58	16.09	0.16	4.67	1.05	0.49
LGT	1371	1146		77	14.41	0.56	14.93	0.10	3.94	1.60	0.47
MRA	1010	950		132	10.33	0.64	12.87	0.14	3.93	2.57	0.42
MRH	19763	19445		153	8.18	0.76	12.22	0.61	5.34	0.93	1.06
MRT	735	680		143	8.73	0.76	12.83	0.56	3.96	1.69	1.09
Other	9645	9338		85	12.59	0.46	12.62	0.28	2.89	1.27	0.77
URBAN	951	935		85	12.38	0.46	12.42	0.27	2.84	1.25	0.76
SSA											
ANY	93499	82537		105	14.49	0.54	15.39	0.21	3.56	1.54	0.63
LGA	25741	22675		15	16.02	0.53	16.54	0.06	4.28	0.91	0.49
LGH	3929	3518		109	16.56	0.64	18.46	0.36	4.51	1.84	0.54
LGT	1843	1654		398	11.62	0.79	14.84	0.19	5.61	2.22	0.47
MRA	33112	29586		28	16.75	0.57	16.55	0.13	3.51	2.30	0.51
MRH	8845	7563		200	12.11	0.51	14.37	0.72	3.11	0.84	1.18
MRT	12896	11254		304	7.45	0.40	9.69	0.29	2.06	0.87	0.79
Other	5936	5208		212	13.00	0.55	15.29	0.28	3.25	1.84	0.76
URBAN	1196	1079		359	13.16	0.66	16.25	0.34	3.91	2.21	0.83

	Number (total)	Number (no follow-ers)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermen-tation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ kgBW$^{0.75}$/yr)	(kg/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)
WRD											
ANY	667773	597741		273	12.22	0.57	14.26	0.30	3.81	1.46	0.70
LGA	64136	57947		145	15.19	0.60	16.58	0.07	4.85	1.02	0.52
LGH	32731	30458		259	12.00	0.55	14.99	0.21	4.31	1.02	0.49
LGT	22279	20304		305	10.56	0.54	13.97	0.17	3.42	1.53	0.67
MRA	147635	124849		120	13.32	0.54	13.77	0.12	3.38	2.10	0.46
MRH	145589	134695		228	11.16	0.55	13.09	0.40	4.10	0.84	0.75
MRT	93753	83702		715	10.29	0.71	15.53	0.60	3.87	1.87	1.24
Other	126110	114548		233	12.12	0.51	13.89	0.33	3.41	1.37	0.69
URBAN	35595	31238		290	12.47	0.56	15.14	0.35	3.70	1.54	0.76

	Number (productive)	Number (herd)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermentation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ kgBW$^{0.75}$/yr)	(kg/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)
SGTD											
CIS											
ANY	481	820	0.7		16.24	0.50	14.36	0.14	1.81	0.59	0.49
LGA	10	18	0.7		16.93	0.50	14.61	0.03	2.24	0.27	0.51
LGT	116	210	0.7		16.93	0.50	14.61	0.06	2.11	0.53	0.51
MRA	34	61	0.7		16.06	0.48	14.29	0.03	2.19	0.26	0.49
MRH	1	1	0.7		16.06	0.48	14.29	0.15	2.18	0.26	0.49
MRT	254	458	0.7		15.97	0.51	14.26	0.23	2.06	0.83	0.49
Other	48	86	0.7		16.06	0.50	14.29				0.49
URBAN	19	34	0.7		16.06	0.50	14.29				0.49
EAS											
ANY	3856	6947	0.2		8.71	0.21	6.67	0.06	0.65	0.26	0.18
LGA	190	343	0.2		8.30	0.21	6.48	0.01	0.93	0.12	0.18
LGH	0	0	0.2		8.30	0.21	6.48	0.02	0.92	0.12	0.18
LGT	809	1456	0.2		8.30	0.20	6.48	0.03	0.76	0.46	0.18
MRA	77	139	0.2		9.05	0.23	6.78	0.02	0.93	0.39	0.19
MRH	136	245	0.2		8.75	0.22	6.71	0.12	0.88	0.39	0.19
MRT	2013	3626	0.2		8.84	0.21	6.73	0.10	0.76	0.26	0.19
Other	407	735	0.2		8.95	0.22	6.75				0.19
URBAN	223	402	0.2		8.83	0.22	6.73				0.19
EUR											
ANY	413	635	0.4		11.98	0.28	7.98	0.05	0.81	0.20	0.36
LGA	15	27	0.2		12.58	0.27	7.47	0.01	1.20	0.14	0.38
LGH	16	29	0.3		12.57	0.26	7.52	0.12	1.04	0.42	0.38
LGT	20	39	0.5		12.40	0.36	9.03	0.04	1.54	0.38	0.37
MRA	62	111	0.4		11.65	0.26	7.82	0.01	1.17	0.14	0.35
MRH	77	139	0.4		11.65	0.24	7.82	0.08	1.08	0.13	0.35
MRT	104	188	0.4		11.65	0.27	7.87	0.12	1.09	0.44	0.35
Other	92	168	0.4		12.41	0.30	8.20				0.37
URBAN	27	49	0.4		12.45	0.30	8.28				0.37
LAM											
ANY	858	2044	0.4		8.48	0.23	6.67	0.02	0.73	0.18	0.27
LGA	178	436	0.1		8.71	0.19	6.31	0.01	0.86	0.11	0.28
LGH	74	181	0.2		8.78	0.17	6.67	0.02	0.75	0.09	0.28
LGT	33	80	0.5		7.09	0.33	6.73	0.02	1.49	0.19	0.23
MRA	143	351	0.2		8.80	0.21	6.99	0.02	0.86	0.37	0.28
MRH	200	491	0.5		8.16	0.15	5.98	0.03	0.66	0.09	0.26
MRT	26	63	1.2		10.37	1.09	9.11	0.30	4.41	1.96	0.34
Other	174	426	0.4		8.31	0.25	7.16				0.27
URBAN	31	75	0.6		7.82	0.25	6.86				0.25
MNA											
ANY	8999	15018	0.3		10.87	0.34	8.54	0.04	1.26	0.31	0.32
LGA	3793	6754	0.2		11.29	0.29	8.52	0.01	1.32	0.17	0.35
LGH	0	1	0.4		9.98	0.34	10.33	0.04	1.52	0.19	0.32
LGT	61	92	0.4		9.37	0.48	9.07	0.05	2.08	0.44	0.23
MRA	3960	6649	0.3		10.54	0.26	8.28	0.02	1.14	0.26	0.30
MRH	36	60	0.7		10.56	1.41	10.73	0.85	5.74	2.32	0.30
MRT	415	629	0.7		9.97	0.96	9.71	0.44	3.57	2.40	0.25
Other	270	428	0.4		10.83	1.05	9.58				0.28
URBAN	463	800	0.3		11.21	0.32	9.11				0.34

	Number (productive)	Number (herd)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermentation CH$_4$	Manure mgmt CH$_4$	Manure mgmt N$_2$O	Manure cropland N$_2$O	Manure grassland N$_2$O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ kgBW$^{0.75}$/yr)	(kg/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)
OCE											
ANY	0	0									
SAS											
ANY	5388	9698	0.5		9.94	0.45	7.64	0.10	1.65	0.69	0.32
LGA	383	690	0.3		9.70	0.30	7.43	0.01	1.35	0.18	0.31
LGH	2	3	0.5		9.58	0.43	7.98	0.04	1.94	0.26	0.31
LGT	3	5	0.7		8.83	0.51	8.81	0.08	1.92	1.16	0.28
MRA	2253	4055	0.6		10.46	0.59	6.20	0.06	2.39	1.02	0.33
MRH	1853	3335	0.5		9.69	0.39	9.22	0.22	1.58	0.70	0.31
MRT	63	114	0.8		9.39	0.34	8.11	0.15	1.21	0.42	0.30
Other	472	849	0.4		8.93	0.29	7.99				0.28
URBAN	359	645	0.4		9.60	0.30	8.25				0.31
SEA											
ANY	1182	2128	0.3		6.75	0.18	5.41	0.07	0.53	0.24	0.21
LGA	0	0	0.2		8.81	0.22	6.65	0.01	1.01	0.13	0.28
LGH	10	19	0.2		8.81	0.22	6.65	0.02	1.01	0.13	0.28
LGT	296	533	0.4		2.00	0.07	1.94	0.01	0.27	0.16	0.06
MRA	6	10	0.3		8.65	0.22	6.79	0.02	0.90	0.39	0.28
MRH	546	983	0.3		8.65	0.22	6.79	0.13	0.90	0.40	0.28
MRT	58	105	0.6		4.82	0.22	4.27	0.10	0.79	0.27	0.15
Other	201	362	0.3		8.38	0.21	6.59				0.27
URBAN	65	117	0.3		8.57	0.22	6.73				0.27
SSA											
ANY	8541	15374	0.3		11.99	0.39	10.15	0.03	1.61	0.32	0.38
LGA	4339	7810	0.3		12.65	0.41	10.52	0.02	1.84	0.23	0.40
LGH	281	505	0.4		10.95	0.40	10.84	0.05	1.80	0.23	0.35
LGT	37	66	0.6		7.64	0.47	7.62	0.02	2.13	0.26	0.25
MRA	3179	5721	0.3		11.82	0.33	9.78	0.02	1.43	0.38	0.38
MRH	149	267	0.7		8.60	0.44	8.75	0.28	1.77	0.78	0.28
MRT	205	369	0.9		7.26	0.56	8.34	0.27	2.00	1.66	0.24
Other	320	576	0.6		10.90	0.49	10.23				0.35
URBAN	33	60	0.6		11.31	0.49	11.17				0.36
WRD											
ANY	29719	52664	0.4		10.61	0.35	8.51	0.05	1.31	0.37	0.32
LGA	8909	16077	0.3		11.78	0.34	9.36	0.01	1.55	0.20	0.37
LGH	383	738	0.4		10.53	0.34	9.77	0.04	1.54	0.21	0.34
LGT	1375	2481	0.3		7.74	0.22	6.38	0.03	0.90	0.39	0.19
MRA	9714	17098	0.4		10.93	0.36	8.28	0.03	1.52	0.48	0.33
MRH	2998	5521	0.5		9.36	0.35	8.40	0.19	1.41	0.60	0.29
MRT	3139	5552	0.4		9.50	0.37	7.88	0.17	1.37	0.70	0.23
Other	1984	3631	0.4		9.73	0.41	8.26				0.28
URBAN	1219	2182	0.3		10.18	0.29	8.36				0.30

	Number (total)	Number (no follow-ers)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermen-tation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ $kgBW^{0.75}$/yr)	(kg/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)	($kgCO_2$-eq/ $kgBW^{0.75}$/yr)
SGTO											
CIS											
ANY	5287	4948		95	11.16	0.62	12.72	0.13	2.30	0.63	0.52
LGA	448	440		73	13.09	0.56	12.14	0.03	2.52	0.30	0.52
LGT	1963	1870		77	10.11	0.55	11.96	0.06	2.34	0.58	0.46
MRA	587	560		109	12.15	0.65	13.02	0.03	2.93	0.35	0.56
MRH	1	1		112	14.42	1.16	16.29	0.36	5.22	0.61	0.71
MRT	1695	1491		123	10.24	0.71	13.53	0.31	2.87	1.16	0.56
Other	434	396		76	14.51	0.61	13.34				0.57
URBAN	206	191		76	14.28	0.60	13.12				0.56
EAS											
ANY	23806	20715		85	9.99	0.60	11.67	0.18	1.89	0.76	0.33
LGA	1176	1024		77	9.83	0.58	11.63	0.02	2.63	0.34	0.31
LGH	1	1		77	9.83	0.58	11.63	0.06	2.62	0.35	0.31
LGT	4995	4348		89	9.97	0.62	11.75	0.10	2.34	1.42	0.33
MRA	478	416		65	10.65	0.52	11.09	0.05	2.10	0.89	0.32
MRH	841	732		67	10.28	0.51	10.58	0.29	2.07	0.92	0.31
MRT	12427	10814		89	9.97	0.62	11.75	0.28	2.20	0.76	0.33
Other	2513	2185		76	9.99	0.58	11.60				0.32
URBAN	1376	1197		76	9.99	0.58	11.60				0.32
EUR											
ANY	610	388		119	13.14	0.94	16.34	0.15	2.43	0.65	0.66
LGA	12	0		72	294.23	12.93	272.72	0.67	58.40	6.91	11.59
LGH	14	1		74	87.11	6.45	89.01	2.98	25.99	10.54	3.65
LGT	126	108		113	8.17	0.72	11.43	0.09	3.08	0.77	0.42
MRA	54	5		109	89.58	4.93	95.99	0.25	22.26	2.63	4.09
MRH	62	0		112	978.48	79.02	1105.34	24.76	355.77	41.86	48.20
MRT	172	88		131	11.64	0.88	15.80	0.39	3.54	1.43	0.65
Other	229	153		118	11.43	0.74	13.80				0.56
URBAN	56	33		132	12.88	0.88	15.58				0.65
LAM											
ANY	6843	5657		63	16.80	0.90	15.89	0.08	2.76	0.60	0.73
LGA	1104	846		39	22.37	0.90	17.23	0.04	4.08	0.50	0.87
LGH	379	272		59	21.10	1.36	19.58	0.16	6.11	0.78	0.90
LGT	627	579		54	11.51	0.58	10.96	0.03	2.63	0.33	0.48
MRA	827	620		42	23.91	1.02	18.71	0.11	4.10	1.76	0.94
MRH	1143	853		66	18.59	1.16	19.40	0.21	5.22	0.69	0.84
MRT	578	541		101	11.18	0.90	12.93	0.25	3.65	1.62	0.58
Other	2005	1753		75	13.47	0.75	14.25				0.62
URBAN	238	194		72	17.54	0.96	18.22				0.80
MNA											
ANY	14396	8377		78	21.70	1.11	22.68	0.08	4.48	0.92	0.95
LGA	6393	3433		55	24.15	1.13	25.01	0.05	5.10	0.64	1.00
LGH	0			54							
LGT	69	38		67	17.88	1.13	18.43	0.09	4.96	0.89	0.67
MRA	6497	3808		99	20.41	1.12	22.01	0.08	4.81	1.18	0.94
MRH	60	37		97	18.52	1.03	19.15	0.60	4.24	1.60	0.86
MRT	542	328		102	16.33	1.11	17.20	0.51	4.16	2.69	0.71
Other	450	292		82	17.26	0.86	16.30				0.75
URBAN	779	442		81	21.31	1.01	19.21				0.96

	Number (total)	Number (no followers)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermentation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ kgBW$^{0.75}$/yr)	(kg/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)	(kgCO$_2$-eq/ kgBW$^{0.75}$/yr)
NAM											
ANY	1380	1380		94	18.08	0.85	18.82	0.06	2.59	0.44	0.79
LGA	475	475		73	21.27	0.87	19.73	0.04	3.95	0.49	0.84
LGH	14	14		79	20.84	0.95	20.18	0.13	4.26	0.52	0.84
LGT	173	173		70	12.78	0.53	14.79	0.05	2.27	0.59	0.61
MRA	92	92		129	18.20	1.09	21.04	0.04	4.93	0.62	0.90
MRH	9	9		144	13.07	0.88	18.96	0.21	3.96	0.50	0.79
MRT	198	198		172	12.32	0.92	19.20	0.24	3.95	1.04	0.78
Other	339	339		84	19.53	0.86	18.76				0.79
URBAN	80	80		84	19.48	0.86	18.71				0.79
OCE											
ANY	15970	15970		66	16.09	0.92	16.51	0.08	3.54	0.83	1.02
LGA	4335	4335		66	16.00	0.98	15.91	0.04	4.41	0.54	1.02
LGH	1318	1318		66	16.66	0.79	17.32	0.09	3.56	0.45	1.04
LGT	410	410		81	18.18	1.25	17.99	0.06	5.62	0.70	1.17
MRA	5046	5046		68	15.47	0.98	16.10	0.11	3.94	1.69	1.00
MRH	2605	2605		72	15.97	0.84	17.66	0.15	3.79	0.50	1.04
MRT	125	125		89	16.63	1.19	18.64	0.32	4.79	2.12	1.11
Other	1904	1904		54	17.12	0.73	16.39				1.02
URBAN	228	228		54	17.12	0.73	16.39				1.02
SAS											
ANY	24363	20053		39	20.55	0.81	17.80	0.13	2.75	1.06	0.82
LGA	3035	2729		34	20.87	0.62	17.05	0.02	2.80	0.36	0.81
LGH	5	3		54	24.78	1.07	23.72	0.10	4.82	0.64	1.04
LGT	15	13		74	20.48	1.37	20.92	0.22	5.18	3.13	0.91
MRA	13511	11709		37	18.56	0.76	16.18	0.08	3.09	1.31	0.74
MRH	3361	1878		40	30.35	1.29	27.32	0.73	5.21	2.32	1.24
MRT	370	319		62	20.44	1.23	20.04	0.56	4.39	1.51	0.89
Other	2588	2210		44	21.22	0.82	18.09				0.86
URBAN	1478	1191		44	22.65	0.87	19.30				0.91
SEA											
ANY	4530	3584		72	12.40	0.83	14.43	0.22	2.71	1.42	0.59
LGA	0	0		77	11.65	0.72	13.77	0.02	3.24	0.42	0.56
LGH	31	23		77	11.24	0.69	13.29	0.07	3.13	0.41	0.54
LGT	1921	1684		77	13.82	0.87	16.34	0.14	3.31	2.00	0.66
MRA	16	11		63	10.22	0.71	11.14	0.07	2.87	1.22	0.49
MRH	1409	972		65	10.27	0.78	11.59	0.44	3.16	1.41	0.49
MRT	347	300		54	11.72	0.90	13.01	0.40	3.19	1.10	0.56
Other	679	518		80	12.11	0.75	14.30				0.58
URBAN	127	75		80	13.40	0.83	15.83				0.65
SSA											
ANY	33131	26298		50	17.26	0.80	15.30	0.14	3.17	0.85	0.71
LGA	10141	6670		50	20.47	1.00	18.16	0.04	4.53	0.57	0.85
LGH	1036	811		56	18.20	0.92	17.73	0.11	4.16	0.53	0.77
LGT	644	614		71	10.79	0.62	11.84	0.03	2.81	0.35	0.49
MRA	11610	9067		41	18.66	0.76	15.37	0.06	3.25	0.87	0.74
MRH	4684	4565		62	14.05	0.76	13.25	0.49	3.08	1.35	0.61
MRT	2244	2080		62	12.35	0.61	12.40	0.29	2.16	1.80	0.54
Other	2142	1886		49	15.19	0.63	13.99				0.62
URBAN	630	603		50	13.82	0.54	12.42				0.57

	Number (total)	Number (no follow-ers)	Average milk yield	Weight gain per day	Manure	N Excretion	Enteric fermen-tation CH_4	Manure mgmt CH_4	Manure mgmt N_2O	Manure cropland N_2O	Manure grassland N_2O
	(1000)	(1000)	(kg/d)	(g/d)	(kg/ kgBW$^{0.75}$/yr)	(kg/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)	(kgCO_2-eq/ kgBW$^{0.75}$/yr)
WRD											
ANY	130316	107371		64	16.17	0.80	15.74	0.13	2.91	0.87	0.71
LGA	27120	19951		54	19.57	0.93	18.22	0.04	4.19	0.53	0.87
LGH	2799	2444		61	17.68	0.90	17.73	0.11	4.05	0.52	0.93
LGT	10942	9836		81	11.21	0.68	12.88	0.09	2.71	1.18	0.47
MRA	38718	31334		54	18.21	0.84	16.59	0.08	3.49	1.21	0.80
MRH	14175	11652		60	16.93	0.89	16.71	0.42	3.70	1.25	0.80
MRT	18698	16285		90	10.79	0.67	12.48	0.30	2.45	1.04	0.42
Other	13282	11635		63	15.35	0.71	14.91				0.68
URBAN	5197	4233		64	16.45	0.74	15.53				0.68

c. Concentrate composition for different species

Table S 12 to Table S 14 present the ranges needed for allowing the model to harmonise the baseline grain with the FAO commodity balance sheets.

Table S 12. Minimum and maximum percentage inclusion of feed ingredients in grain concentrates for dairy and beef cattle

	Europe min	Europe Max	US Min	US max	Brazil min	Brazil max	China min	China max	LAC min	LAC max	Other	Other
Maize	30	50	50	65	65	70	55	65	60	70	50	60
Wheat	20	55	10	20	5	10	5	10	5	10	10	30
Barley	10	15	0	0	0	0	0	0	0	0	0	0
sorghum/millet	0	0	0	0	0	5	0	0	0	20	0	20
Rice	0	10	0	0	0	0	0	0	0	0	0	15
Rye	5	20	0	0	0	0	0	0	0	0	0	0
Soymeal	35	45	35	45	30	40	20	30	30	40	20	35
Rapeseed	4	8	0	0	0	0	0	0	0	0	0	0
Peas	0	5	0	0	0	0	0	0	0	0	0	0
fish meal	0	5	0	0	0	0	0	3	0	5	0	5
Other	5	15	5	20	5	15	5	30	5	15	5	15

Table S 13. Minimum and maximum percentage inclusion of feed ingredients in grain concentrates for pigs

	Europe min	Europe Max	US Min	US max	Brazil min	Brazil max	China min	China max	LAC min	LAC max	Other	Other
maize	10	25	60	65	65	70	55	65	60	70	50	70
wheat	20	45	8	12	5	10	4	8	5	10	0	15
barley	8	15	0	0	0	0	0	0	0	0	0	0
sorghum/millet	0	0	0	0	0	5	0	0	0	20	0	20
rice	0	0	0	0	0	0	0	0	0	0	0	15
rye	10	20	0	0	0	0	0	0	0	0	0	0
soymeal	10	20	10	15	15	22	15	20	15	20	15	25
rapeseed	4	8	0	0	0	0	0	0	0	0	0	0
peas	3	15	0	0	0	0	0	0	0	0	0	0
fish meal	0	5	0	0	0	0	0	3	0	5	0	5
other	5	15	5	20	5	15	20	30	5	15	5	15

Notes:

Southern cone of LAC can use wheat up to 30% and maize down to a max of 55% (Argentina, Chile and Uruguay).
Sorghum can be used 30-45% in Africa, which can substitute maize partially
Middle East countries can use wheat from 20 to 45% as in Europe

Table S 14. Minimum and maximum percentage inclusion of feed ingredients in grain concentrates for poultry

	Europe min	Europe Max	US Min	US max	Brazil min	Brazil max	China min	China max	LAC min	LAC max	Other min	Other max
Maize	20	30	55	65	62	70	60	70	65	70	30	70
Wheat	25	45	5	8	0	5	0	0	0	10	0	10
Barley	5	10	0	0	0	0	0	0	0	0	0	0
sorghum/millet	0	10	0	0	0	5	0	0	0	20	0	20
Rice	0	0	0	0	0	0	0	0	0	0	0	15
Rye	0	0	0	0	0	0	0	0	0	0	0	0
Soymeal	10	20	20	25	20	25	10	20	20	25	15	25
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0
Peas	0	5	0	0	0	0	0	0	0	0	0	0
fish meal	0	5	0	0	0	0	0	0	0	5	0	5
Other	5	10	2	20	5	15	10	30	5	15	5	15

Notes:

Southern cone of LAC can use wheat up to 30% and maize down to a max of 55% (Argentina, Chile and Uruguay).
Sorghum can be used 30-45% in Africa, which can substitute maize partially
Middle East countries can use wheat from 20 to 45% as in Europe

7. Estimation of N_2O emissions from manure management

a. Introduction

We explain the main assumptions used to estimate N_2O-N emissions from manure management for each of the livestock systems, indicating continental and regional differences. The estimations of direct and indirect emissions from manure management follow the guidelines of IPCC (123). Emission factors for N_2O-N, losses through volatilisation, leaching and total losses were estimated from experimental and expert data for the different livestock production systems defined by Sere and Seinfeld (1), modified to include monogastric livestock. Fraction of manure managed for different system was estimated from livestock management data: time spent grazing, and sort of housing facilities. Manure allocated to other uses than agriculture was that used for biogas production and directly used as fuel.

b. Feeding and manure management

Manure management is closely associated to livestock feeding management. Livestock in permanent confinement, such as dairy and fattening systems, are typical of areas densely populated and with good access to markets. In these systems most manure could be recycled. Urinary-N direct losses are relatively large and their magnitude depends on diets, the use of bedding and frequency of removal of the manure from the housing facilities. Ideally, up to 90-95% of manure could be recycled, with inevitable losses of NH_3-N during excretion, for livestock fed N-rich diets (124). Common recovery from livestock housing would be around 60-80%, with extremes of 30-95%.

Semi-confined livestock systems are typical of intensified livestock systems, which make use of seasonal grazing. About 50-60% of manure is commonly managed because livestock are usually confined during the night and during the cool season. Management of urine varies across systems and the magnitude of the N losses depends on use of and type of bedding, and housing facilities. In cases of poor quality of housing, and no use of bedding recycling of manure could be as low as 20-30%.

Free-grazing with night stalling is probably the most wide-spread feeding management in extensive livestock systems. Livestock graze in rangeland and cropland and is kept overnight in stalls or pens, where it may receive supplementary feeds. At best 40-50% of manure can be recycled, when bedding is used. Otherwise, manure recycled would be 20-40% of the manure excreted provided that there is frequent removal. An additional fraction is left in cropland and directly recycled, exposed to nutrient losses.

Free-grazing using night corralling is a system in which livestock overnight in relatively small areas of cropland to manure the land. Manuring contracts are often used in the West African savannas (Niger, Mali, Burkina Faso, Chad, Mauritania, Northern Nigeria, Northen Cameroon), where large amounts of manure are excreted in relatively small areas, leading to relatively large nutrient losses though volatilization and leaching (125). System wise, land manured through manuring contracts does not represent a large area.

Free-grazing is typical of pastoral systems, where manure is practically not recycled in cropland, though partly used as fuel and building material. These systems are observed in large parts of Africa and Central Asia, and in the South American Antiplano and the Patagonia.

c. Manure management

Emissions from manure depend on collection and storage management before application to arable land. Across continents, the fate of manure excreted in housing facilities differ: In Europe, strong regulations lead to full recycling of manures, partly in grasslands and croplands, and partly for biogas production (126). In Africa, most manure is not returned to grasslands. In intensive livestock systems, composted manure may be applied to fodder crops, but the large majority is applied to food and cash crops (e.g. coffee, tea, tobacco). In highly populated areas of Asia, most manure is destined to different and competing uses such as organic fertiliser, feed for fish ponds, biogas production, and biofuel (i.e. burnt for cooking). In North America, manure is not fully recycled. There are livestock systems in which manure is indirectly discharged into waterbodies (127). Use of manure for biogas production is increasingly gaining attention but it is not yet widespread (128).

d. Emission factors for manure management

We used equation 10.25 to 10.29 from IPCC (123) to estimate emissions from manure management. For that purpose we gathered estimates of: fraction of manure managed (MS), fraction of manure allocated to other uses, direct emission factor for excreted manure (EF_3), fraction lost through volatilisation ($Frac_{GasMS}$), emission factor from volatilised N (EF_4), fraction leached ($Frac_{leachMS}$), emission factor for leached N, and total N loss during management ($Frac_{LossMS}$).

To select values for emission factors, we considered the most typical manure management for each livestock system. For example in mixed highland systems in Africa manure can be: i) directly applied to cropland, ii) piled in heaps or placed in pits mixed with bedding material, iii) left to accumulate during the dry season in the livestock facilities and then applied to cropland, iv) left to accumulate in the corral, and removed periodically for composting.

The values of the emission factors proposed by IPCC (123) were compared with measurements by (129-133).

N excreted by ruminants (cattle, sheep and goats) for different livestock system has been calculated using the RUMINANT model. That includes the $N_{(T)}$ and $N_{ex(T)}$ of equation 10.25 in IPCC (123). For pigs and poultry excretion rates have been extracted from the literature and are presented in Table S 15 and Table S 16. Fraction managed ($MS_{(T,S)}$), is the manure available for recycling in agricultural land. Fraction managed is considered the amount of excreta that may be recycled because it accumulates in corrals, stalls, pens, sheepfolds, and other livestock housing. Other uses of manure include burning, material for building, and biogas. Thus, it excludes manure that is used as fuel, or as construction material. The fraction managed depends largely on the feeding system.

e. Indirect N_2O emissions from manure management

After excretion, manure is exposed to losses through volatilisation and leaching. The value of the fraction lost through volatilisation ($Frac_{GasMS}$), and of the fraction leached during storage ($Frac_{leachMS}$) depends on manure management methods and duration of the storage. The default emission factors for volatilised losses (EF_4) and for leached losses (EF_5) were compared to those reported in the literature (129, 134-138).

We indicate ranges for coefficients for each of the 4 methods of manure management:

i. Manure directly applied: $Frac_{GasMS}$ 3-10% depending on the management of the urine, $Frac_{leachMS}$ <5% because of the short exposure to water throughput.
ii. Manure stored solid in heaps, pits or stock piled: $Frac_{GasMS}$ 15-50% depending on the length of the storage, the use of cover, and type of floor (e.g. heaps volatilise more N than pits), $Frac_{leachMS}$ <5-30%, pits lose considerably more than heaps if they are unsealed. Leaching can be minimised with a solid floor and cover to prevent rain throughput.
iii. Manure stored solid in livestock housing (e.g. deep litter or corrals), and then applied to cropland: $Frac_{GasMS}$ 15-50% depending on the length of the storage, $Frac_{leachMS}$ <20-30% depending on rain throughput.
iv. Manure stored in corrals and collected for composting: similar to previous, losses smaller ($Frac_{GasMS}$ 30-50%) depending on the length of the storage, $Frac_{leachMS}$ <10-20% depending on rain throughput.
v. Manure stored in lagoons: gaseous losses will depend on whether lagoons form a crust or not, ($Frac_{GasMS}$ 20-30%), leaching will depend on type of lagoon ($Frac_{leachMS}$ 0-20%)

f. Livestock systems assumptions

Livestock Grazing Temperate/tropical highlands (LGT)

In Africa, the livestock feeding management of LGT is characterised by free-grazing and free-grazing with night corralling. Most excreta from grazing small ruminants is left in grazing land (139, 140). Small amounts of manure may be collected from cattle sheds and applied without composting to croplands: about 30-40% for dairy cows, and substantially less for other cattle and small ruminants, which spent more time in the range (141). A small fraction of that manure is used as fuel for cooking (less than 20%). Manures contain relatively small amount of mineral N, which is mostly lost soon after excretion. Emission factors of N_2O-N during manure management will correspond to those of dry lots. Volatilisation and leaching are limited by low availability of mineral N and slow decomposition rates.

The highlands of Latin America (i.e. the Andean region) represent LGT. Small ruminants and camelids are the main livestock species. Manure is mainly recycled in small-scale farms of the Antiplano and in the highlands of Colombia, Ecuador, Peru and Bolivia. Because livestock graze in paddocks or open grasslands during the day and overnight in pens or sheds, we assumed that only up to 30-40% of the manure may be recycled for dairy system, while considerably less for other cattle and small ruminants (142, 143). A substantial amount of the collected manure (10-20%) is directly used as fuel, or to produce biogas in the Antiplano (144, 145).

In Asia, LGT are represented by the vast rangelands of central Asia. Manure that accumulates in livestock facilities (e.g. sheepfolds) is recycled and used as fuel (146, 147). Emission factors correspond to those of dry lots.

In Europe, LGT is represented in northern UK, and Scandinavia, with ruminant systems based on grazing. Manure is left in grasslands and what accumulates (30-40%) in livestock facilities is stored solid or as slurry and applied to grasslands (148). A small proportion (less than 10%) is used to produce biogas (149).

For North America, similar figures to those of Europe were assumed: most manure is left in rangelands (50-60%), and from the proportion accumulates in housing facilities; a small part (0-5%) is destined to biogas production (128, 150, 151). Emission factors are those for dry lots and solid storage. N losses from manure management can be between 20-40% (152).

Livestock Grazing Humid-Subhumid Tropics and Subtropics (LGH)

In Africa, LGH is represented by cattle ranching systems, with little recycling of manure to agricultural land. Small ruminants are kept for local consumption but their manure is usually not recycled. Manure accumulates in livestock facilities exposed to losses and removed with a low frequency (e.g. once a year) to be sold to crop farmers, to be applied to arable land or to be used as fuel (less than 20%) (153, 154). The total fraction recycled for dairy cattle is about 30-40%. Manure management is considered waste management from animal production, and often left unused (155). Emissions of N_2O-N during manure management will correspond to those of solid and pit storages. Nutrient losses through volatilisation (30-40%) and leaching (10-20%) are relatively larger than in LGT due to richer diets, higher temperatures and moisture regimes than LGT.

In Latin America, LGH is represented by typical ranches in the lowlands, and in the Amazonian region. Small proportion of the manure is managed (20-30%), which accumulate in the livestock facilities. Total N losses can be high (50-70%) due to poor management, prolonged storage periods, and the hot and humid climate(156).

In Asia, LGH is represented by small areas in SE Asia, e.g. Thailand, Indonesia, Myanmar, Laos and Papua New Guinea. Because of the high mobility of livestock and the free grazing, small amounts of manure are recycled into cropland (157, 158).

In Europe, LGH is only represented in small areas of Ireland and France. This system is similar to LGT with 50-60% of the manure that accumulates in livestock facilities being recycled, and slightly larger losses due to volatilisation (20-30%) (159).

In North America, LGH is represented by relatively small areas in Texas, Florida and Oklahoma. It was assumed that only 20-30% of the manure is recycled because livestock remains longer outdoors than in the European LGH system. The rest of the emission factors were assumed to be similar to those of the European LGH.

Livestock Grazing Arid/semiarid (LGA)

In LGA in Africa, pastoralist systems dominate, with farmers keeping cattle, small ruminants and camels. There is much mobility in these systems (155, 160), determining that little manure is recycled (i.e. 10-20%). Cropping is not very important in these systems, and therefore only manure that accumulates in temporary corrals (kraals) may be collected to be used in crop production (161-163). Losses through leaching are smaller than in LGT (125, 164). Emission factor for direct losses during manure storage is that of corresponding to dry lots.

In Latin America, LGA is presented by the Grand Chaco, the Patagonia, and the Mexican matorrales and Venezuela double purpose systems. Recycling of manure in agriculture varies according to the management of the different livestock species. While in sheep-dominated systems cycling could be little of the excreted N (165, 166), in systems with dairy cattle cycling may rise to about 40%. We assumed an average of 10-20% for cattle systems in Latin America to account for the inherent heterogeneity. In the extensive sheep systems of the Patagonia there is almost no recycling of manure into cropping land, whereas in the more intensive cattle and goat systems of the Grand Chaco and the matorrales, manure is often used in agriculture (166).

In Asia, LGA occurs in Central and Western China, Tibet, Afghanistan, Iran, Pakistan and in the Arabian Peninsula. Because of the mobility of livestock in search of good grazes in inherently poor environments, manure recycling in agriculture is limited. We assumed that only 20-30% of excreted manure can be recycled; this is the manure that accumulates in stalls and is used for cultivation during the summer months (167, 168).

In Europe, LGA occupies relatively small areas in Greece and Cyprus. It was assumed that in this system a combination of small ruminants and cattle coexist, 30-40% of manure is managed mainly as solid storage.

In North America, LGA occupies vast areas in the US (i.e. Arizona, Nevada, New Mexico, Texas, Utah, Colorado and California). In this system there is a combination of small and large ruminants, with intensive and extensive management. Recyclable manure is assumed to be between 30-40% to account for the extensive small ruminant systems (169-171). Manure is managed mainly as dry lots.

Mixed Farming Rainfed Temperate /tropical highlands (MRT)

In African mixed systems of highly populated areas, manure is intensively recycled in agricultural land. Depending on feeding methods, from 50 to 70% of manure N excreted can be recovered and utilised (172). Nitrogen losses through volatilisation of NH_3-N and NO_x-N can be large (30-40%), as well as losses through leaching with poor management (173-175). Collected manure is stored in heaps or pits usually mixed with plant residues, and therefore NO_2 emission factors are relatively smaller than for other systems. Small proportion of the collected manure is used to produce biogas (176).

In Europe, dairy and beef cattle are mostly kept confined with seasonal grazing. Pigs and poultry are fully managed in confinement. Between 60-70% of the manure is collected in housing systems whereas the rest is left unmanaged in grazing land (126). More than half of the manure is managed as slurry or liquid (in northern Europe) and the rest solid (mainly in Eastern Europe, UK and France). Manure use for biogas production is only important in Germany, Austria and Denmark (177). Ammonia losses from dairy and beef production systems were taken from (178, 179).

Mixed Farming Rainfed Humid-Subhumid Tropics and Subtropics (MRH)

These systems differ from MRT basically in the smaller fraction of manure managed (i.e. 50-60%) and relatively larger losses due to poor management between collection and relatively little application of manure to soils (154). Losses through volatilisation may be smaller than for the highland system, because diets are poorer in N, but losses through leaching are larger due to more rainfall and poorer management (180). Little manure is used for other purposes (i.e. 10-20%) than organic fertilizer (176).

For North America and Europe, we assumed N_2O emissions during composting to be 1-6% of total losses (181). The use of manure as fertiliser for rice and vegetables is widespread throughout SE Asia (182). In India the use of manure as fuel is widespread especially in the central states. It is estimated that between 50-60% of total ruminant manure is recycled and 40% of that is used a biofuel (183, 184).

Mixed Farming Rainfed Arid/semiarid (MRA)

MRA comprises mostly free-grazing systems with night stalling or corralling which limits the amounts of manure that can be recycled to 40-50% (125, 163). Manure management is usually poor, left to accumulate in livestock facilities with or without bedding and not composted or composted for short periods (185) and applied to crops (162). Emission factors for nitrous oxides will be those of dry lots. Losses due to volatilisation are relatively larger than losses due to leaching because storage usually takes place in the dry season.

In India and Bangladesh between 70-80% of the households use cow manure for as fuel for cooking (186-188). From the manure available for recycling, farmers use about 50% as fuel (189), use increasing from South to North. However the use of manure as biofuel in China is minimal (188).

Temperate/tropical highlands (MIT), Humid/subhumid (MIH), Arid/semiarid (MIA): similar to the non-irrigated MRT, MRH and MRA. Irrigated systems are usually more intensively managed, so recycling of manure would be relatively larger as well as losses due to volatilisation and leaching.

Pigs smallholder (PIsm)

Excretion rates for pigs vary between 10-20 kg N per year (190-192). For the traditional systems rates vary between 11-16 kg N per year, while the industrial rates systems rates are higher. Annual excretion rates are reported in (193) to be for pigs of 4.9-8.4 kg N per head, and for poultry about 0.17-0.43 kg N per bird per year.

Free range is mostly practiced by pig smallholder farmers in Africa, Latin America and SE Asia. Smallholder pig farms are not common in Europe and North America, although they are observed in Eastern Europe.

In Africa, the traditional system represents between 60-80% of the pigs population (12). Pigs usually roam around during the day and are kept in a pen during the night, or are tethered at the house compounds. In West Africa, (i.e. Burkina Faso, Senegal, Cameroon, Ghana, Nigeria) pigs are tethered during the cropping season to avoid damage to crops, and in some others they are fully confined (194-198). For example, in western Kenya, most pig farms do not use housing, but most pigs are tethered. Most pig shelters have mud floors which are hardly cleaned. Few farmers (<2%) keep their pigs indoors (26). In southern Africa (i.e Zambia, Mozambique, Botswana) pigs are mostly managed under free-ranging, with few farmers using a combination of free ranging and confinement with penning during the night; few farmers clean their pigs' pens (199-201). Recyclable manure is around 40-50% during free ranging and 60-80% during confinement. Small amounts of manure are recycled and applied to crops (i.e. 0-25%), the fraction that accumulates in the pens after relatively large N losses (202). Emissions from the pens can be large, although smallholders usually keep few animals (one to five). Direct emissions from manure are assumed to be that of solid storage. In Africa pig manure is not used to produce biogas (176).

In Latin America, smallholders keep their pigs free-ranging in some places, and are confined only during the cropping season, with no or little recycling of the manure (203). The north of Brazil has a large concentration of smallholder pig farms, commonly known as backyard production (204).

In Asia, smallholder farm pigs are mostly managed in confinement (205). Vietnam has the largest pig population in SE Asia, with more than 70% households keeping pigs (206). Manure that accumulates in pens is used mainly as fertiliser for crops, for fish ponds, and in a small extent to produce biogas, in general less efficiently used than in industrial farms. About 50-60% of the manure can be managed. Estimates of (207) for Vietnam indicate that almost half of the manure is used for biogas production, and the other half is more or less equally partitioned between crops, fish ponds, for sale and discharged.

In northern Laos, most pigs are kept in smallholder farms and are managed using a free and semi-scavenging feeding system. Pig manure is usually collected and used as fertiliser on rice and other crops. There are not many biodigesters in Laos but if people have it they will certainly use pig manure to feed into the biodigester. In Cambodia, biodigesters are gaining popularity and pig manure is used to produce biogas (208).

Pig production in NE India consists of small farms keeping their pigs fully confined (209) and stall-fed with locally available feeds. About sixty percent of the farmers use the manure for composting and application to crops, or to feed fish ponds. The rest leaves the manure unused (210). When compost is prepared, manure is mixed with the bedding materials.

Pigs industrial (PIin)

Industrial or commercial pig farms in Africa are characterized by confined animals, of better breeds and feeds than the traditional system (12).

In Latin America, Brazil is the larger pig producer (4th largest in the world). The Santa Catarina state in South Brazil has traditionally had the largest concentration of industrial pig farms in Latin America (204). In the last decade, pig production has intensified and expanded into the Central and West region (211). In these intensive systems, pigs are mostly kept in confinement, and manure managed as slurry in lagoons and applied to the soil afterwards. A fraction of the manure is used to produce biogas, or alternatively composted to reduce transport cost and increase fertiliser value.

In Asia, most pigs are concentrated in China (212). Industrial pig farms are concentrated around urban areas such as Hanoi, Bangkok, Manila, Guangzhou, and in highly populated areas such as the SE Chinese coast or the area between Shanghai and Beijing, and in India in the Ganges basin (193). These farms keep their animals confined, so most of the manure is managed (70-80%). Little manure is applied to cropland due to fears of contamination and nutrient overdoses, instead manure is preferentially used to feed fish ponds or for biogas production (213). Manure is managed mostly as slurry or solid manure. Slurry is used for biogas or directly fed to fish ponds. Solid manure can be composted in heaps and applied to crops. N losses before application are estimated to be 20-30% for covered containers and between 60-80% for uncovered containers (214). Large-scale farms often sell manure to crop farmers, or to be used as cattle feed. In Vietnam, most farmers house their pigs, and almost half of the pig farms use manure for biogas production, and few applied it to the land (207). Sheds are usually cleaned daily. A large proportion of the pig manure (ca. 20%) is discharged into the sewage system. Emission factors for manure management are assumed to be those for solid storage and anaerobic lagoons.

European pig production is most developed in eight countries/regions: Denmark, Belgium, Netherlands, northern Germany, Brittany (France), Catalonia and Aragon (Spain) and Po valley (Italy). In the United States, the case of North Carolina is another example of concentrated area where the use of anaerobic lagoons dominates (215).

In Europe, the pig industry uses to handle manure mainly tanks, anaerobic lagoons, and in smaller scale aerobic processing and anaerobic digestion (215). Losses of N have been estimated from (216, 217). Manure is increasingly being used for biogas production, with estimates for Belgium, The Netherlands, UK, and Italy of 30-40% (126). Emission factors are those for anaerobic lagoons. Emission of ammonia from housing ranges between 40-55%, and between 3-23% for storage, leaching represents a small amount of the total losses (130, 218).

In the intensive pig production systems of North America, manure is mostly managed as slurry and storedin lagoons, and to a smaller extent as solid manure, both applied to the land (219). The pig industry in the US in concentrated in the Mid-West and has been shifting towards southeast (169, 170). In Canada, most pig farms are concentrated in Eastern Coast especially the St. Lawrence Lowlands and Manitoulin Lake Simcoe-Frontenac Axis. Most manure is managed N (70-80%), although with relatively large ammonia volatilisation losses (i.e. 30-50%) (220).

Poultry smallholder (POsm)

Most poultry production takes place in E and SE Asia (China, Thailand, Vietnam, Malaysia, Philippines, South Korea, Cambodia, Laos,, and Myanmar), followed by the Americas (212). Excretion rates vary between 0.3-0.6 kg N per year per bird (190-192). The low end of the range corresponds to the traditional system, and the high end to the industrial ones.

Most egg and broiler production in India comes from the states of Andhra Pradesh, Maharashtra, Tamil Nadu, Punjab, Haryana and Karnataka (221). Smallholder poultry production in Africa is based on free scavenging systems dominated by indigenous chicken. The small proportion of manure that is recycled is subjected to large losses as is exposed to weather and air dried for conservation. Total N losses are of the order of 70-80% (222). In Latin America, most poultry systems produce solid manure, with or without litter. In smallholder systems poultry manure accumulates where the birds overnight. In some places, people build containment structures, which are not so often cleaned. Manure mixed with litter is usually composted and applied in vegetable production.

Poultry industrial (POin)

Modern large-scale layer and broiler operations belong to the group of concentrated animal feeding operations (CAFO). Manure recycling depends on the management system: in deep litter houses, manure is collected only once a year for laying hens and after each batch for broilers. In battery cage units, manure is removed, once a month, it depends on the fly problems. Poultry manure from battery cages is sometimes used to feed cattle. Poultry manure managed by water flushing can be used to produce biogas through anaerobic digestion, although it is not widely applied.

In Africa, industrial poultry production is still incipient, mostly due to the difficulties to compete with international markets. There is some development around African cities where manure is mostly managed with litter (223).

In North America, most pig and poultry production takes place in small to medium AFOs (Animal Feeding Operations) (224). Majority of poultry farmers lease the birds from integrators who are responsible of hatcheries, feed mills and processing plants (225). Broiler growers working with integrators usually do not treat waste because of the added costs (226). It is estimated that about 20-35% of poultry litter is fed to cattle in the US (227). In Canada, broilers are raised in single floor barns on a bed of straw or wood chip litter (228). Barns are fully cleaned once per cycle, when new litter is added. In the US, new litter is added after each cycle but barns are usually cleaned once a year (229).

High-rise and manure-belt houses are the two most common housing types used by layer operations in the US and in Canada. In the high rise houses, solid manure is stored for about a year before removal. Manure in manure-belt houses drops onto a belt beneath cages and is frequently removed from the house, e.g. two to seven times a week (228, 230). Manure can be either stored as slurry in tanks or removed from barns frequently. The majority of poultry farmers in Canada store the manure uncovered and spread it directly to the land (228).

In the UK, about 70% of the poultry operations use litter to manage manure, while for the rest droppings are collected without litter (231). About 25% of layers hens are kept in free-range systems. Most broiler farmers (63%) store the manure during the production cycle in uncovered piles or heaps. The rest applies it directly to the field. About 60% of the farmers use belt and scrapper systems, and the rest deep litter (231).

8. Estimation of CH_4 emissions from manure management

We follow Tier 2 from IPCC (123) (Eq. 10.22). To estimate $ET_{(T)}$, we provide estimates of $VS_{(T)}$, $Bo_{(T)}$, $MCF_{S,k}$. Fraction of manure managed (MS) is extracted from the tables to estimate nitrous oxides emissions.
$VS_{(T)}$ has been estimated using Eq. 10.24 and qualities of the diets of animals (section 6).
To estimate MCFs, we use average annual temperature per pixel and the dominant manure management system for each species group: dairy, other cattle, small ruminants, and poultry and pigs (Table S 22 - Table S 25). We have chosen a dominant manure management system for most regions except for Europe and North America cattle where combinations of solid storage and slurry dominate. When that is the case, we indicate the proportion of total manure (e.g. 1/3) that is allocated to one management system. See Table S 22-Table S 23. $MCF_{S,k}$ can be extracted from Tables 10A-4, 10A-5, 10A-7 from IPCC (123). There are no coefficients for small ruminants, so we used those of other cattle (Table 10A-5). We choose the coefficients of emissions due to other uses assuming that in Europe, North America all manure for other uses goes to biogas production (digester in the Tables). In Latin America manure from pigs and dairy destined to other uses would be used for biogas production, and the rest to feed other livestock. In Asia and Africa, manure destined to other uses is assumed to be burnt for fuel.
To calculate the methane emission factor $ET_{(T)}$, we use Eq. 10.23 from (123). The values for $Bo_{(T)}$, are also reported in tables 10A-4, 10A-5, 10A-7, with some differences across regions.

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Table S 15. Excretion rates for pigs for smallholder and industrial systems across continents

Livestock system	Pigs				
	Smallholder		Industrial		References
	Dry matter (kg pig^{-1} d^{-1})	N (g pig^{-1} d^{-1})	Dry matter (kg pig^{-1} d^{-1})	N (g pig^{-1} d^{-1})	
Africa –growing (28 kg)	0.17-0.21	15.5-16.5			(232)
Africa –piglets (15 kg)			0.07-0.12	6.5-9.1	(233)
Latin America – piglets (20 kg)	0.12-0.14	8.8-9.8	-	5.6-7.0	(234, 235)
Latin America – growing (40 kg)	0.25-0.32	21.8-45.4	0.32-0.44	27.0-27.6	(236, 237)
Europe					
Northern – growing (50-80 kg)			0.20-0.30	21.1-34.3	(238, 239)
Southern – heavy pigs (80-160 kg)			-	26.9-37.8	(240, 241)
Southern – growing (20-40 kg)			-	14.5-26.1	(242)
North America					
US – growing (50 kg)			0.14-0.27	7.0-18.9	(243)
Canada – growing (20-32 kg)			-	9.4-26.2	(244, 245)
Asia – growing (50 kg)	0.20-0.38	13.5-25.9	0.20-0.30	12.1-18.7	(246, 247)
Asia – piglets (10 kg)	0.20-0.25	3.0-4.0			(248)
China – pigs average			0.20-0.50	12.3	(249)
Korea - finishing			0.26-0.27	8-29	(250)

Table S 16. Excretion rates for poultry for smalholder and industrial systems across continents

Livestock system	Poultry Smallholder Dry matter (kg bird^{-1} d^{-1})	N (g bird^{-1} d^{-1})	Industrial Dry matter (kg bird^{-1} d^{-1})	N (g bird^{-1} d^{-1})	References
Africa - broilers	0.013-0.017	-	0.044-0.054	0.3-0.7	(251, 252)
Africa – finishing broilers	0.064-0.073	1.6-1.7			(253)
Latin America					
Broilers				0.7-1.3	(254)
Hens			0.027-0.029	1.2-1.3	(255)
Europe					
Northern - hens			0.034	1.8	(256)
Northern - broilers			0.036	1.4	(256)
Southern					
Eastern - broilers				1.2-1.4	(257)
North America					
Canada - hens			0.027-0.028	1.3-2.0	(228, 258)
Canada – broilers					
US - hens			0.026	1.0-1.5	(259, 260)
US - broilers				1.1-2.3	(261, 262)
Asia					
China average poultry			0.021-0.048	0.8-1.0	(249)
Korea - Broilers		0.5-1.9		1.2-1.5	(263, 264)
India - Broilers			0.019-0.038	0.5-1.3	(265)

Table S 17. N_2O emissions from manure management for livestock production systems in sub-Saharan Africa

	Livestock system	Fraction[*] manure N managed (%) $MS_{(T,S)}$	Fraction manure to other uses (%)	N_2O emission factor (kg kg^{-1} manure N excreted) $EF_{3(S)}$	NH_3+NO_x volatilisation (fraction) $Frac_{GasMS}$	N_2O emission factor (kg kg^{-1} NH_3+NO_x volatilised) EF_4	N leached from manure (fraction) $Frac_{leachMS}$	Total N loss from MMS $Frac_{LossMS}$	N_2O emission factor (kg kg^{-1} N leached) EF_5	Examples of systems
Rangeland-based systems	LGT – dairy	30-40	10-20	0.02	20-30	0.01	<5	50-60	0.0075	Ethiopia, South Africa
	Other cattle	20-30	0-10	0.02						
	Small ruminants	0-10	0	0.02						
	LGH – dairy	30-40	10-20	0.02	30-40	0.005-0.01	10-20	50-70	0.0075	Angola, Benin, Cameroon, Central African Republic, Congo, Cote d' Ivoire, Guinea, Nigeria, Sudan
	Other cattle	20-30	0-10	0.02						
	Small ruminants	0-10	0	0.02						
	LGA– dairy	20-30	5-10	0.02	20-30	0.01	<5	50-60	0.0005	Angola, Botswana, Chad, Ethiopia, Kenya, Madagascar, Mali, Mauritania, Mozambique, Namibia, Niger, Somalia, South Africa, Sudan, Zambia
	Other cattle	10-20	0-10	0.02						
	Small ruminants	0-10	0	0.02						
Mixed farming systems (Rainfed)	MRT – dairy	60-70	10-20	0.005	30-40	0-0.005	20-30	40-70	0.0075	Highlands of East and Central Africa
	Other cattle	40-50	10-20	0.005						
	Small ruminants	20-30	0	0.02						
	MRH – dairy	50-60	10-20	0.005	30-40	0.005-0.01	10-20	50-70	0.0075	Cameroon, Congo, Cote d'Ivoire, Ghana, Nigeria
	Other cattle	30-40	0-10	0.005						
	Small ruminants	10-20	0	0.02						
	MRA – dairy	40-50	10-20	0.02	30-40	0.01	<5	50-60	0.0075	Botswana, Burkina Faso, Chad, Kenya, Mali, Mozambique, Niger, Nigeria, South Africa, Sudan, Tanzania, Zambia, Zimbabwe
	Other cattle	30-40	10-20	0.02						
	Small ruminants	0-20	0	0.02						
Mixed farming systems (Irrigated)	MIT – dairy	60-70	10-20	0.005	30-50	0-0.005	20-30	50-70	0.0075	Ethiopia, South Africa
	Other cattle	40-50	10-20	0.005						
	Small ruminants	20-30	0	0.02						
	MIH – dairy	50-60	10-20	0.005	30-40	0.005-0.01	10-20	50-70	0.0075	Ethiopia
	Other cattle	30-40	0-10	0.005						
	Small ruminants	10-20	0	0.02						
	MIA – dairy	40-50	10-20	0.02	40-50	0.01	10-20	50-60	0.0075	South Africa, Sudan
	Other cattle	30-40	10-20	0.02						
	Small ruminants	0-20	0	0.02						
Poultry	Smallholder (POsm)	10-30	0-20	0.001	50-60	0.01	10-20	50-70	0.0075	Spread
	Industrial (POin)	100	40-50	0.001	30-40	0.01	0-20	50-60	0.0075	Peri-urban and urban areas
Pigs	Smallholder (PIsm)	0-25	0-10	0.005	30-40	0.01	10-20	50-70	0.0075	Spread
	Industrial (PIsm)	100	30-40	0.005	40-50	0.01	0-20	60-80	0.0075	Peri-urban and urban areas

Table S 18. N_2O emissions from manure management for livestock production systems in Latin America

	Stocking rates (TLU km^2)	Livestock system	Fraction manure N managed (%) $MS_{(T,S)}$	Fraction manure to other uses (%)	N_2O emission factor (kg kg^{-1} manure N excreted) $EF_{3(S)}$	NH_3+NO_x volatilisation (fraction) $Frac_{GasMS}$	N_2O emission factor (kg kg^{-1} NH_3+NO_x volatilised) EF_4	N leached from manure (fraction) $Frac_{leachMS}$	Total N loss from MMS $Frac_{LossMS}$	N_2O emission factor (kg kg^{-1} N leached) EF_5	Examples of systems
Rangeland-based systems		LGT – dairy	30-40	10-20	0.02	30-40	0.01	10-20	40-70	0.0075	Dairy Bogota, Colombia, Peru, Bolivia Altiplano camelid and sheep systems South Patagonia, and NW Argentina
		Other cattle	20-30	0-10	0.02						
		Small ruminants	0-10	0	0.02						
		LGH – dairy	20-30	10-15	0.02	30-40	0.01-0.02	10-30	50-70	0.0075	Ranching South American lowlands, Amazonian ranching,
		Other cattle	10-20	0-10	0.02						
		Small ruminants	0-10	0	0.02						
		LGA– dairy	20-30	0-10	0.02	20-30	0.01	<5	50-70	0.0005	Patagonia, The Grand Chaco, Mexico and Venezuela beef-dairy systems
		Other cattle	10-20	0-5	0.02						
		Small ruminants	0-10	0	0.02						
Mixed farming systems (Rainfed)		MRT – dairy	40-50	20-30	0.005	30-40	0-0.005	10-30	50-70	0.0075	Pampas, South Brazil and Uruguay
		Other cattle	30-40	10-20	0.02						
		Small ruminants	10-20	0-10	0.02						
		MRH – dairy	20-30	10-15	0.005	30-40	0.01-0.02	10-30	60-70	0.0075	Brazilian Cerrados, The Argentine Humid Grand Chaco,
		Other cattle	10-20	0-10	0.02						
		Small ruminants	0-10	0-10	0.02						
		MRA – dairy	30-40	10-20	0.02	30-40	0.01	5-10	50-70	0.0005	NE Brazil, NW Argentina, Central and N Mexico
		Other cattle	20-30	0-10	0.02						
		Small ruminants	10-20	0	0.02						
Mixed farming systems (Irrigated)		MIT – dairy	40-50	20-30	0.005	40-50	0-0.005	20-30	50-70	0.0075	Central highlands in Chile and Mexico
		Other cattle	30-40	10-20	0.02						
		Small ruminants	10-20	0-10	0.02						
		MIH – dairy	20-30	10-15	0.005	30-40	0.01-0.02	20-30	50-70	0.0075	Cuba and Colombia
		Other cattle	10-20	0-10	0.02						
		Small ruminants	0-10	0-10	0.02						
		MIA – dairy	30-40	10-20	0.02	40-50	0.01	10-20	50-60	0.0005	North Mexico, Central West Argentina
		Other cattle	20-30	0-10	0.02						
		Small ruminants	10-20	0	0.02						
Poultry		Smallholder (POsm)	0-20	20-30	0.001	50-60	0.01	10-20	50-70	0.0005	Spread
		Industrial (POin)	100	40-50	0.001	30-40	0.01	10-30	50-60	0.0005	Peri-urban and urban areas
Pigs		Smallholder (PIsm)	0-25	10-20	0.005	30-50	0.01	10-20	50-70	0.0005	Spread
		Industrial (PIsm)	100	20-30	0-0.005	20-40	0.01	0-10	60-80	0.0005	Santa Catarina State in Brazil, central Chile, Jalisco and Michoacan in Mexico

Table S 19. N_2O emissions from manure management for livestock production systems in Asia

	Stocking rates (TLU km^2)	Livestock system	Fraction manure N managed (%) $MS_{(T,S)}$	Fraction manure to other uses (%)	N_2O emission factor (kg kg^{-1} manure N excreted) $EF_{3(S)}$	NH_3+NO_x volatilisation (fraction) $Frac_{GasMS}$	N_2O emission factor (kg kg^{-1} NH_3+NO_x volatilised) EF_4	N leached from manure (fraction) $Frac_{leachMS}$	Total N loss from MMS $Frac_{LossMS}$	N_2O emission factor (kg kg^{-1} N leached) EF_5	Examples of systems
Rangeland-based systems		LGT – dairy	30-40	20-30	0.02	20-30	0.01 (0.002-0.05)	10-20	50-70	0.0075 (0.0005-0.025)	Mongolia steppe, Kazakhstan, Uzbekistan, Turkmenistan, and large areas of central and NE China
		Other cattle	20-30	10-20	0.02						
		Small ruminants	10-30	0-10	0.02						
		LGH – dairy	20-30	15-20	0.005	30-40	0.01	10-30	50-70	0.0075	Small areas in SE Asia: Indonesia, Papua New Guinea, Myanmar, Laos
		Other cattle	10-20	0-10	0.02						
		Small ruminants	0-10	0	0.02						
		LGA– dairy	10-20	10-20	0.02	20-30	0.01	<5	50-70	0.0075	Central W China, Afghanistan, Iran, Pakistan, Saudi Arabia, Yemen
		Other cattle	10-20	0-10	0.02						
		Small ruminants	0-10	0	0.02						
Mixed farming systems (Rainfed)		MRT – dairy	60-70	20-30	0.005	30-40	0.01	10-30	40-70	0.0075	N Kazakhstan, north and central E China, Turkey
		Other cattle	40-50	10-20	0.005						
		Small ruminants	20-30	0-10	0.005						
		MRH – dairy	30-40	20-40	0.005	30-40	0.01-0.02	10-20	50-70	0.0075	SE China, SE Asia (Indonesia, Thailand, Philippines, Myanmar, Vietnam)
		Other cattle	20-30	10-20	0.005						
		Small ruminants	10-20	0	0.02						
		MRA – dairy	50-60	20-40	0.02	20-30	0.01	5-10	50-70	0.0075	India and Pakistan, Afghanistan, Iran, and most Turkey
		Other cattle	30-40	10-20	0.02						
		Small ruminants	10-20	0-10	0.02						
Mixed farming systems (Irrigated)		MIT – dairy	60-70	20-30	0.005	30-40	0.01	20-30	40-70	0.0075	East China, Far East Asia irrigated rice/dairy systems
		Other cattle	40-50	10-20	0.005						
		Small ruminants	20-30	0-10	0.005						
		MIH – dairy	30-40	20-40	0.005	30-40	0.01-0.02	10-20	40-60	0.0075	Rice-buffalo systems Philippines, Vietnam and India
		Other cattle	20-30	10-20	0.005						
		Small ruminants	10-20	0	0.02						
		MIA – dairy	50-60	20-40	0.02	20-30	0.01	10-20	50-70	0.0075	Mainly buffalo production systems from India and Pakistan,
		Other cattle	30-40	10-20	0.02						
		Small ruminants	10-20	0-10	0.02						
Poultry		Smallholder (POsm)	30-40	20-30	0.001	50-60	0.01	10-20	50-70	0.0075	
		Industrial (POin)	100	40-50	0.001	30-40	0.01-0.02	0-10	50-60	0.0075	
Pigs		Smallholder (PIsm)	50-60	30-40	0.005	20-30	0.01	10-20	50-60	0.0075	
		Industrial (PIsm)	100	50-60	0-0.005	30-40	0.01-0.02	0-10	40-70	0.0075	

Table S 20. N_2O emissions from manure management for livestock production systems in Europe

	Stocking rates (TLU km^2)	Livestock system	Fraction manure N managed (%) $MS_{(T,S)}$	Fraction manure to other uses (%)	N_2O emission factor ($kg\ kg^{-1}$ manure N excreted) $EF_{3(S)}$	NH_3+NO_x volatilisation (fraction) $Frac_{GasMS}$	N_2O emission factor ($kg\ kg^{-1}$ NH_3+NO_x volatilised) EF_4	N leached from manure (fraction) $Frac_{leachMS}$	Total N loss from MMS $Frac_{LossMS}$	N_2O emission factor ($kg\ kg^{-1}$ N leached) EF_5	Examples of systems
Rangeland-based systems Livestock only: More than 90% of the feed comes from rangelands, pastures, annual forages and purchased feeds and less than 10% from crops.		LGT – dairy	50-60	0-10	0.005	15-20	0.01 (0.002-0.05)	10-15	30-40	0.0075 (0.0005-0.025)	Northern UK, Ireland, Scandinavia
		Other cattle	40-50	0-10	0.005						
		Small ruminants	0-20	0	0.02						
		LGH – dairy	50-60	0-10	0.005	20-30	0.01	10	30-40	0.0075	Small areas in Ireland and France
		Other cattle	40-50	0-10	0.005						
		Small ruminants	10-20	0	0.02						
		LGA– dairy	20-30	0-5	0.02	15-20	0.01	0-5	40-50	0.0075	Small areas Greece and Cyprus
		Other cattle	10-20	0-5	0.02						
		Small ruminants	0-10	0	0.02						
Mixed farming systems (Rainfed) More than 10% of feed comes from crop by-products or more than 10% percent of the total value of production comes from non-livestock farming activities.		MRT – dairy	60-70	10-20	0.005	20-25	0.01	10-15	40-50	0.0075	Spread all over East and northern Europe
		Other cattle	40-50	0-20	0.005						
		Small ruminants	10-20	0-10	0.02						
		MRH – dairy	50-60	5-10	0.005	15-20	0.01-0.02	10	30-40	0.0075	Small areas in NW France, and in Central Italy
		Other cattle	30-40	0-10	0.005						
		Small ruminants	0-10	0-10	0.02						
		MRA – dairy	40-50	0-5	0.005	15-20	0.01	0-5	40-50	0.0075	Spain, Italy, Portugal, Greece
		Other cattle	30-40	0-5	0.02						
		Small ruminants	0-10	0	0.02						
Mixed farming systems (Irrigated) These are similar to the previous systems, but more than 10% of the value of non-livestock farm produce comes from irrigated land use. These systems are very rare in Africa.		MIT – dairy	60-70	10-20	0.005	25-30	0.01	10-15	40-50	0.0075	Mainly in the Netherlands and Denmark but also some areas in Italy, Hungary and Bulgaria
		Other cattle	40-50	0-20	0.005						
		Small ruminants	10-20	0-10	0.02						
		MIH – dairy	50-60	5-10	0.005	20-25	0.01-0.02	10	30-40	0.0075	Small areas in Portugal, Spain and France
		Other cattle	30-40	0-10	0.005						
		Small ruminants	0-10	0-10	0.02						
		MIA – dairy	40-50	0-5	0.005	15-20	0.01	5-10	40-50	0.0075	Small areas in Spain, Italy, Portugal, Greece, Cyprus,
		Other cattle	30-40	0-5	0.02						
		Small ruminants	0-10	0	0.02						
Poultry		Smallholder (POsm)	60-70	20-30	0.001	40-50	0.01	0-20	40-50	0.0075	
		Industrial (POin)	100	30-40	0.001	20-30	0.01	0-10	30-40	0.0075	
Pigs		Smallholder (PIsm)	60-70	30-40	0.005	40-50	0.01	10-20	40-50	0.0075	
		Industrial (PIsm)	100	30-40	0-0.001	15-30	0.01	0-10	30-40	0.0075	Netherlands, Denmark, Italy, Brittany in France

Table S 21. N_2O emissions from manure management for livestock production systems in North America

	Liv population (%)	Area (%)	Livestock system	Fraction manure N managed (%) $MS_{(T,S)}$	Fraction manure to other uses (%)	N_2O emission factor (kg kg^{-1} manure N excreted) $EF_{3(S)}$	NH_3+NO_x volatilisation (fraction) $Frac_{GasMS}$	N_2O emission factor (kg kg^{-1} NH_3+NO_x volatilised) EF_4	N leached from manure (fraction) $Frac_{leachMS}$	Total N loss from MMS $Frac_{LossMS}$	N_2O emission factor (kg kg^{-1} N leached) EF_5	Examples of systems
Rangeland-based systems	9.5	17.9	LGT – dairy	40-50	0-10	0.005	15-20	0.01 (0.002-0.05)	10-15	40-50	0.0075 (0.0005-0.025)	Most of Alaska, Montana, Kansas, Nebraska and South Dakota. In Canada: Nunavut, NW territories and Yukon territory, British Columbia, Alberta
			Other cattle	30-40	0-5	0.02						
			Small ruminants	0-20	0	0.02						
	3.4	1.5	LGH – dairy	30-40	0-5	0.005	20-30	0.01-0.02	10	30-40	0.0075	Small areas in Texas, Florida a Oklahoma
			Other cattle	10-20	0-5	0.005						
			Small ruminants	0-10	0	0.02						
	12.6	17.7	LGA– dairy	20-30	0-5	0.02	15-20	0.01	0-5	50-60	0.0075	Arizona, Nevada, New Mexic Texas, Utah, Colorado and California
			Other cattle	10-20	0-5	0.02						
			Small ruminants	0-10	0	0.02						
Mixed farming systems (Rainfed)	18.1	10.7	MRT – dairy	40-50	10-20	0.005	20-25	0.01	10-15	40-50	0.0075	Illinois, Iowa, Minnesota, Nort Dakota In Canada: Saskatchewan, Pri Ed Isl. Alberta, Manitoba
			Other cattle	30-40	0-10	0.02						
			Small ruminants	0-20	0-5	0.02						
	2.5	1.7	MRH – dairy	30-40	5-10	0.005	15-20	0.01-0.02	10	40-60	0.0075	North Carolina, South Carolin Alabama, Florida and Georgia
			Other cattle	10-20	0-5	0.02						
			Small ruminants	0-10	0	0.02						
	<0.1	<0.1	MRA – dairy	30-40	0-10	0.02	15-20	0.01	0-5	50-60	0.0075	Small areas in Colorado, Oklahoma, Montana
			Other cattle	20-30	0-10	0.02						
			Small ruminants	0-10	0	0.02						
Mixed farming systems (Irrigated)	5.6	2.9	MIT – dairy	40-50	10-20	0.005	25-30	0.01	10-15	40-50	0.0075	Nebraska, Arkansas, Idaho
			Other cattle	30-40	0-10	0.02						
			Small ruminants	0-20	0-5	0.02						
	1	0.9	MIH – dairy	30-40	5-10	0.005	20-25	0.01-0.02	10	40-60	0.0075	Small areas in Florida, Georgi Louisiana, and Mississippi
			Other cattle	10-20	0-5	0.02						
			Small ruminants	0-10	0	0.02						
	7.4	2.9	MIA – dairy	30-40	0-10	0.02	15-20	0.01	0-5	50-60	0.0075	Texas, California, Colorado
			Other cattle	20-30	0-10	0.02						
			Small ruminants	0-10	0	0.02						
Poultry			Smallholder (POsm)	40-50	20-30	0.001	40-50	0.01	10-20	40-50	0.0075	Rhode Island, New Jersey, Massachusetts, Connecticut, Delaware
			Industrial (POin)	100	30-40	0.001	20-30	0.01	10-20	30-40	0.0075	
Pigs			Smallholder (PIsm)	30-40	20-30	0.005	40-50	0.01	10-20	40-50	0.0075	
			Industrial (PIsm)	100	20-30	0.005-0.01	20-40	0.01	0-10	30-40	0.0075	Spread across states in the NE and E of US. Most Canada (59%) largely classified as ‘other’

Table S 22. Manure management for dairy systems across livestock systems and regions

		Africa	Latin America	Asia	Europe	North America
Rangeland-based systems	LGT	Range/dry lot	Range/dry lot	Range/dry lot	Semi-confined/solid storage (2/3) and slurry (1/3)	Semi-confined/solid storage
	LGH	Range/dry lot	Range/dry lot	Range/solid storage	Semi-confined/solid storage (2/3) and slurry (1/3)	Semi-confined/solid storage
	LGA	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot
Mixed farming systems (Rainfed)	MRT	Semi-confined/solid storage	Semi-confined/solid storage	Semi-confined/solid storage	Semi-confined/ slurry (2/3) and solid storage (1/3)	Semi-confined/solid storage (2/3) and slurry (1/3)
	MRH	Semi-confined/solid storage	Semi-confined/solid storage	Semi-confined/solid storage	Semi-confined/slurry (2/3) and solid storage (1/3)	Semi-confined/solid storage (2/3) and slurry (1/3)
	MRA	Range/dry lot	Semi-confined/dry lot	Semi-confined/dry lot	Semi-confined/solid storage	Semi-confined/dry lot
Mixed farming systems (Irrigated)	MIT	Semi-confined/solid storage	Semi-confined/dry lot	Semi-confined/solid storage	Semi-confined/ slurry (2/3) and solid storage (1/3)	Semi-confined/solid storage (2/3) and slurry (1/3)
	MIH	Semi-confined/solid storage	Semi-confined/dry lot	Semi-confined/solid storage	Semi-confined/slurry (2/3) and solid storage (1/3)	Semi-confined/solid storage (2/3) and slurry (1/3)
	MIA	Range/dry lot	Semi-confined/dry lot	Semi-confined/dry lot	Semi-confined/ solid storage	Semi-confined/dry lot

Table S 23. Manure management for other cattle across livestock systems and regions

		Africa	Latin America	Asia	Europe	North America
Rangeland-based systems	LGT	Range/dry lot	Range/dry lot	Range/dry lot	Semi-confined/solid storage	Semi-confined/dry lot
	LGH	Range/dry lot	Range/dry lot	Range/dry lot	Semi-confined/solid storage	Range/dry lot
	LGA	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot
Mixed farming systems (Rainfed)	MRT	Range/solid storage	Range/dry lot	Semi-confined/solid storage	Semi-confined/slurry (1/3) and solid storage(2/3)	Semi-confined/dry lot
	MRH	Semi-confined/solid storage	Semi-confined/dry lot	Semi-confined/solid storage	Semi-confined/slurry (1/3) and solid storage(2/3)	Range/dry lot
	MRA	Range/dry lot	Semi-confined/dry lot	Semi-confined/dry lot	Range/dry lot	Range/dry lot
Mixed farming systems (Irrigated)	MIT	Semi-confined/solid storage	Semi-confined/dry lot	Semi-confined/solid storage	Semi-confined/slurry (1/3) and solid storage(2/3)	Semi-confined/dry lot
	MIH	Semi-confined/solid storage	Semi-confined/dry lot	Semi-confined/solid storage	Semi-confined/slurry (1/3) and solid storage(2/3)	Range/dry lot
	MIA	Range/dry lot	Semi-confined/dry lot	Semi-confined/dry lot	Range/dry lot	Range/dry lot

Table S 24. Manure management for small ruminants across livestock systems and regions

		Africa	Latin America	Asia	Europe	North America
Rangeland-based systems	LGT	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot
	LGH	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot
	LGA	Range	Range	Range	Range	Range
Mixed farming systems (Rainfed)	MRT	Range/dry lot	Range/dry lot	Semi-confined/dry lot	Semi-confined/dry lot	Range/dry lot
	MRH	Range/dry lot	Range/dry lot	Semi-confined/dry lot	Range/dry lot	Range/dry lot
	MRA	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot
Mixed farming systems (Irrigated)	MIT	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot
	MIH	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot
	MIA	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot	Range/dry lot

Table S 25. Manure management for pigs and poultry across livestock systems and regions

		Africa	Latin America	Asia	Europe	North America
Poultry	PoSm	Free range/without litter	Free range/without litter	Free range/without litter	Free range/with litter	Free range/with litter
	PoIn	Confined/with litter	Confined/with litter	Confined/with litter	Confined/with litter	Confined/with litter
Pigs	PiSm	Scavenging/solid storage	Free range/solid storage	Scavenging/solid storage	Confined/deep bedding	Confined/deep bedding
	PiIn	Confined/solid storage	Confined/lagoons and solid storage	Confined/lagoons and solid storage	Confined/lagoons	Confined/lagoons

9. Estimation of N_2O direct emissions from managed soils

a. Direct N_2O emissions from managed soils

We followed the method of IPCC (123) to estimate the direct emissions N_2O from managed soils, for each livestock system. We estimated direct emissions using equation 11.1, and literature to select emission coefficients. Addition of manures to soil (F_{AM}) was calculated using the fraction of manure managed (MS), manure destined to other uses (MSO), and subtracting total manure N losses ($Frac_{LossMS}$). IPCC (123) recommends the use of one emission factor for N inputs (EF_1) for direct emissions, and two emission factors for direct deposition of manure on grazing land ($EF3_{PRP}$), one for cattle pigs and poultry and one for sheep and other livestock. The selection of EF_1 across systems was based on main characteristics of the dominant soils at each of the systems, and supported on the work of (266-268). The emission coefficients for direct depositions ($EF3_{PRP}$) were taken from (269).

b. Indirect N_2O emissions from managed soils

Calculating N_2O losses from atmospheric deposition (equation 11.9) requires defining $Frac_{GASF}$ and $Frac_{GASM}$, the fractions of applied fertiliser and applied manure which is lost through volatilisation, and a emission factor (EF_4), which is applied to the total N lost through volatization. We used default IPCC values for both $Frac_{GASF}$ and $Frac_{GASM}$, following (270). For EF_4, we took the recommended values by (271).

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