APPENDIX

SUPPLEMENTARY INFORMATION ON METHODS

TABLE A1. Overview of the approach used for the computation of feed emissions in GLEAM

Species/system	Step 1 Categories of feed and feed materials included in feed basket	Step 2 Proportions of feed categories and materials in feed basket	Step 3 Amount of feed consumed by animals	Step 4 GHG emissions associated with feed production
Chicken backyard	Categories and relative materials in feed basket are: • feed crops, e.g. first grade crop products fed to animals, such as cassava and soybean • second grade crops, e.g. crop products not edible by humans and fed to animals, such as grains, pulses and bananas • crop residues, e.g. straw, maize stover • by-products, e.g. soybean cakes and brans • forage, e.g. material collected by free ranging, such as grass and legumes • swill	• All material locally-sourced • Proportion of each category in the feed basket based on literature and expert knowledge • Within categories, proportions of feed materials are defined as follows: - feed crops, second grade crops, crop residues and by products: estimated for each GIS cell, based on the relative proportion of materials in the country and agro-ecological zone where the cell is located - swill and material from free ranging: composition not specified	Based on energy requirements	Computed by material: • feed crops, second grade crops, crop residues and by products: estimate based on cropping parameters averaged over country and agro-ecological zone, allocation factors applied to all except feed crops • swill and material from free ranging: none
Chicken intensive broilers and laying hens	Categories and relative materials in feed basket are: • feed crops: first grade crop products fed to animals, e.g. cassava, soybean and grains • by-products, e.g. oilseed cakes and brans • non-crop feed, e.g. lime fishmeal and synthetic amino acids	• No material locally-sourced • Proportion of each category and material in the feed basket are based on literature and expert knowledge	Based on energy requirements; N consumption was checked to be aligned with requirements	Computed by material: • feed crops and by-products: estimate based on cropping parameters averaged over FAO regions (for imported materials, such as soybean, emissions computed as national average in country of origin) • lime, fish meal and synthetic amino acids: standard emission factors from literature and databases, e.g. ecoinvent • transport of feed, based on estimates of local and international transport
Pig backyard	As for backyard chicken.			

(cont.)

TABLE A1. *(cont.)*

Species/system	Step 1 Categories of feed and feed materials included in feed basket	Step 2 Proportions of feed categories and materials in feed basket	Step 3 Amount of feed consumed by animals	Step 4 GHG emissions associated with feed production
Pig intermediate	Categories and relative materials in feed basket are: • feed crops, e.g. first grade crop products fed to animals, such as cassava and soybean • second grade crops: crop products not edible by humans and fed to animals, e.g. grains, pulses and bananas • crop residues, e.g. straw and maize stover • by-products, e.g. soybean cakes • forage, e.g. material collected by free ranging, such as grass and legumes • swill • non-crop feed, e.g. fishmeal and synthetic amino acids	• Part of material locally-sourced (swill, forage, crop residues, second grade crops) and part exogenous to the production site (feed crops, by-products, non-crop feed) • Proportion of each category based on literature and expert knowledge • Proportion of feed materials within exogenous categories based on literature and expert knowledge • Proportion of feed materials within locally-sourced categories estimated for each GIS cell, based on the relative proportion of materials in the country and agro-ecological zone where the cell is located	Based on energy requirements; N consumption was checked to be aligned with requirements	Computed by material: • locally-sourced materials: emissions estimate based on cropping parameters averaged over country and agro-ecological zone - allocation factors applied to all except feed crops • exogenous materials: estimate based on cropping parameters averaged over FAO regions (for imported materials, such as soybean, emissions computed as national average in country of origin) • swill and material from free ranging: none
Pig industrial	As for intensive chicken. Same categories and material except for lime.			
Cattle and Small ruminants	Categories and relative materials in feed basket are: • roughage: fresh grass, hay, legumes and silage, crop residues, sugarcane tops and leaves • by-products: bran and oilseed meals • concentrate: grains, molasses, pulp, oilseed	• Categories and their relative proportions in the feed basket based on literature and expert knowledge; these vary by country, herd (dairy and beef) and also by animal category (females, males and fattening meat stock) • For developed countries, feed materials and their relative proportions established on the basis of literature and expert knowledge • For developing countries, feed materials and their relative proportions established on the basis of relative availability in GIS cell	Based on energy requirements	Computed by category: • roughage: estimate based on cropping parameters of the GIS cell • concentrate: estimate based on cropping parameters averaged over FAO regions (for imported materials, such as soybean, emissions computed as national average in country of origin) • transport of feed, based on estimates of local and international transport

GLEAM COMPARED WITH THE *LIVESTOCK'S LONG SHADOW* ASSESSMENT

Both, the 2006 assessment and this more recent assessment rely on an attritional LCA and post-farmgate use similar system boundaries, from cradle to farmgate. However, within this broad common framework, this assessment relies on an entirely new computation framework: GLEAM. The main differences are presented in Table A6 and summarized below:

- This analysis relies on the GIS-based GLEAM developed at FAO for the computation of emissions by species, commodities, farming systems and climatic zones, whereas the 2006 assessment is mostly based on statistical tables.
- This update is computed for a three-year average around 2005, whereas the 2006 assessment is based on the period 2001 to 2004.
- Both assessments essentially rely on IPCC guidelines for GHG emissions but the *Livestock's long shadow* assessment uses the 2001 version, whereas this assessment uses the 2006 version. Furthermore, the two assessments use different warming potentials to compute emissions in CO_2-eq units: 296 and 298, and 23 and 25, respectively for N_2O and CH_4 in the 2006 assessment and this present report.
- In line with IPCC (2006), this assessment assumes stable soil organic carbon stocks under constant land use, i.e. when land has stayed within the same broad land use class over the past 20 years (pasture, crop, forest). On the other hand, *Livestock's long shadow* estimates emissions from losses of organic matter in cultivated soils and from livestock-induced desertification of pasture; this accounts for 0.12 gigatonnes CO_2-eq.
- This assessment includes CH_4 emissions from the production of rice products used as feed that could not be estimated at the time of preparing the *Livestock's long shadow* report because the information available was too limited; the emissions amount to 26 million tonnes CO_2-eq.
- The *Livestock's long shadow* assessment includes GHG emissions related to the production of feed (including pasture) fed to all animal species (for a total of 2.7 gigatonnes CO_2-eq), whereas this report only accounts for feed materials fed to the studied species, i.e. poultry, cattle, pig, small ruminants and buffalo (for a total of 3.2 gigatonnes CO_2-eq including rice products).
- All manure emissions were accounted for in the *Livestock's long shadow* assessment (for a total of approx. 2.2 gigatonnes CO_2-eq), but only emissions related to manure management and manure application on feed crops or pasture are accounted for in this report (for a total of 0.7 gigatonnes CO_2-eq and 1.1 gigatonnes CO_2-eq, respectively).
- Both assessments include emissions related to land-use change from deforestation for pasture and feed crops and limit the scope of the analysis to the Latin American region. Emissions related in *Livestock's long shadow* assessment were estimated to be 2.4 gigatonnes CO_2-eq compared to 0.65 gigatonnes CO_2-eq in this report. The significant difference is explained by: (i) different reference periods (1990–2006 and 2000–2010 for this assessment and *Livestock's long shadow*, respectively) and land-use change data sources (FAOSTAT and Wassenaar *et al.* (2007) for this assessment and Livestock's long shadow, respectively); (ii) the limitation of feed crop expansion to soybean expansion in Brazil and Argentina only in this assessment, compared to the inclusion of all feed crop expansion in Brazil and Bolivia in *Livestock's long shadow*; and (iii) different versions of the IPCC guidelines – see above.
- Whereas this assessment uses the IPCC methodology as a basis for the quantification of land-use change emissions, the approach in *Livestock's long shadow* is based a land-use change modelling framework that predicted potential land-use changes to 2010 based on projections from FAO (2003) and changes in forest cover.
- Emissions related to buildings and equipment were not included in the *Livestock's long shadow* report because of the limited available information. They were estimated in this assessment and amount to 24 million tonnes CO_2-eq.

TABLE A2. Methods and data sources used in this update and in the *Livestock's long shadow* assessment

Part of supply chain	Methods used in this update	Methods used in *Livestock's long shadow*
Upstream – feed production	• Feed baskets were established by species and production systems; part of the information required to establish the feed baskets was gathered from literature and expert knowledge; the remaining information was modelled in GIS • Feed consumption was computed for each species, based on requirements • Emissions per unit of feed computed in GIS environment based on local and regionally averaged parameters; emissions from land-use change computed at national level • Emissions related to national and international transportation computed on the basis of trade matrices and emission factors	• No feed basket established by species • Aggregated feed consumption statistics retrieved from FAOSTAT • Emissions related to feed production computed as the addition of: - global estimate of emissions associated with global fertilizers applied to feed crop (manufacturing and application) - global estimate of emission from on-farm fossil fuel use (for feed and animal rearing) - estimated emissions from forest conversion in the neotropics based on literature and IPCC 2001 guidelines - global estimate of emissions from cultivated soils through losses of organic matter, liming; emissions from rice not included - global estimate of emissions from livestock-induced desertification
Upstream – non-feed production	• Building and equipment used in animal production estimated by species, farming system and climatic zone, extrapolating information from literature and expert knowledge; embedded energy and related emissions then computed from existing databases	• Not included
Livestock production	• Enteric CH_4 emissions based on IPCC (2006) Tier 2 guidelines; feed basket estimated as explained above; animal production and herd structure modelled within the LCA model • Nitrous oxide and CH_4 emissions related to manure storage computed using IPCC (2006) Tier 2 guidelines and GIS technology; amount and composition of manure computed for each GIS cell and climatic data used to estimate emission factors; estimates made about the extent of principal manure management practices for different species, farming systems, regions and climatic zones • Levels of mechanization estimated by species, farming system and climatic zone, extrapolating information from literature and expert knowledge; energy efficiency, energy sources and related emissions then computed from existing databases	• Enteric CH_4 emissions based on IPCC (2006) Tier 2 guidelines; parameters required to compute emissions estimated for each species/region and production system from FAO databases and literature • Nitrous oxide and CH_4 emissions related to manure storage computed using IPCC (2006) Tier 2 guidelines; manure management practices estimated by species, farming system and region • On-farm energy use globally estimated based on literature data (feed and non-feed not distinguished – see above)
Post farmgate	• Levels of processing and transport distances estimated by commodity, farming system and region; related energy requirements gathered from literature and emissions then computed drawing on existing databases on emission intensity of the energy sector; transport emissions estimated on the basis of published case study data and FAOSTAT trade matrices	• Estimates of emissions from processing generated at global level based on published case studies and relative contribution of farming systems to overall output; published case study data and FAOSTAT trade matrices used to compute international transport

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