GLEAM
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THE GLOBAL LIVESTOCK ENVIRONMENTAL ASSESSMENT MODEL

A global LCA model of livestock supply chains

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EXPLORE ENVIRONMENTAL IMPLICATIONS OF MAJOR LIVESTOCK COMMODITIES PRODUCTION PRACTICES

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Produce disaggregated assessments

Carry out economic analyses

Engage in multi-stakeholder initiatives on methods and practice change

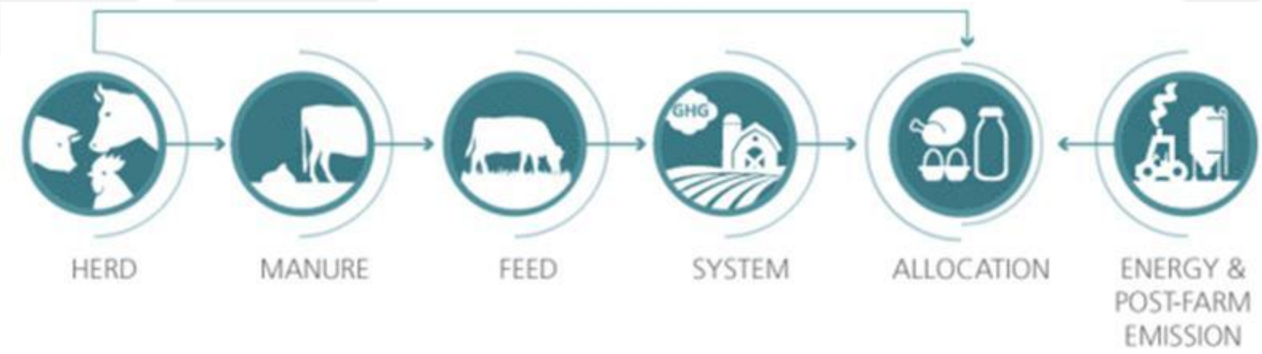
GLEAM
GLOBAL LIVESTOCK ENVIRONMENT ASSESSMENT MODEL

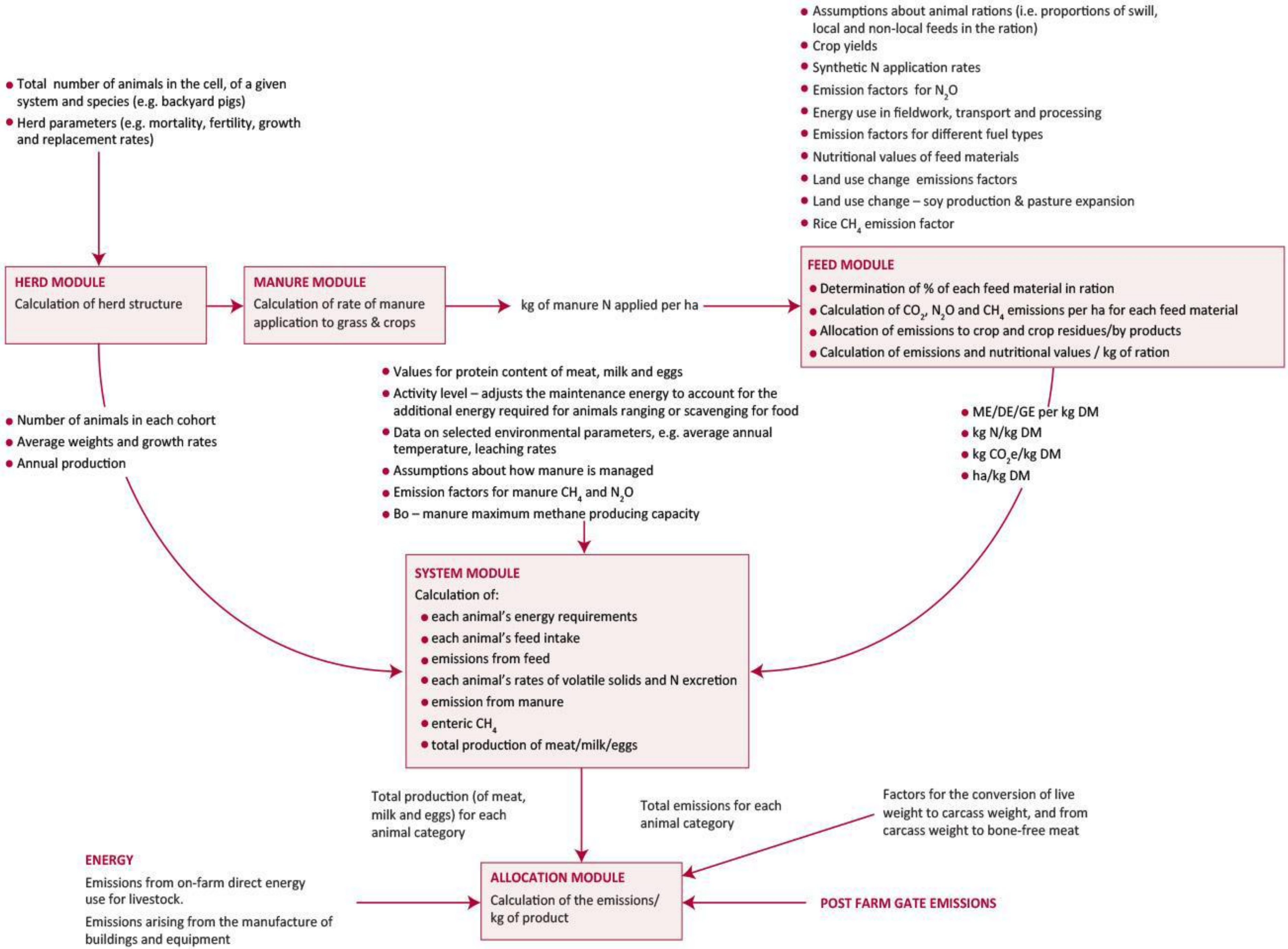
- Life Cycle Assessment modelling
- Cradle to retail, all major sources of emissions included
- Computes emissions at local level – GIS-based
- Can generate averages and ranges at different scales
- Developed at FAO, in collaboration with other partners
- Allows for scenario analysis -

A tool to improve the quantification of GHG emissions from livestock supply chains

Will be expanded to other livestock-environment interactions (e.g. nutrients, water, etc)

GLEAM MODULES




• Total number of animals in the cell, of a given system and species (e.g. backyard pigs)
• Herd parameters (e.g. mortality, fertility, growth and replacement rates)
• Assumptions about animal rations (i.e. proportions of swill, local and non-local feeds in the ration)
• Crop yields
• Synthetic N application rates
• Emission factors for N_2O
• Energy use in fieldwork, transport and processing
• Emission factors for different fuel types
• Nutritional values of feed materials
• Land use change emissions factors
• Land use change – soy production & pasture expansion
• Rice CH_4 emission factor
HERD MODULE
Calculation of herd structure
MANURE MODULE
Calculation of rate of manure application to grass & crops
kg of manure N applied per ha
FEED MODULE
• Determination of % of each feed material in ration
• Calculation of CO_2, N_2O and CH_4 emissions per ha for each feed material
• Allocation of emissions to crop and crop residues/by products
• Calculation of emissions and nutritional values / kg of ration
• Number of animals in each cohort
• Average weights and growth rates
• Annual production
• Values for protein content of meat, milk and eggs
• Activity level – adjusts the maintenance energy to account for the additional energy required for animals ranging or scavenging for food
• Data on selected environmental parameters, e.g. average annual temperature, leaching rates
• Assumptions about how manure is managed
• Emission factors for manure CH_4 and N_2O
• Bo – manure maximum methane producing capacity
• ME/DE/GE per kg DM
• kg N/kg DM
• kg CO_2e/kg DM
• ha/kg DM
SYSTEM MODULE
Calculation of:
• each animal's energy requirements
• each animal's feed intake
• emissions from feed
• each animal's rates of volatile solids and N excretion
• emission from manure
• enteric CH_4
• total production of meat/milk/eggs
Total production (of meat, milk and eggs) for each animal category
Total emissions for each animal category
Factors for the conversion of live weight to carcass weight, and from carcass weight to bone-free meat
ENERGY
Emissions from on-farm direct energy use for livestock.
Emissions arising from the manufacture of buildings and equipment
ALLOCATION MODULE
Calculation of the emissions/ kg of product
POST FARM GATE EMISSIONS

GLEAM INPUT DATA

GLEAM INPUT DATA

DATA RESOLUTION
AND DISAGGREGATION

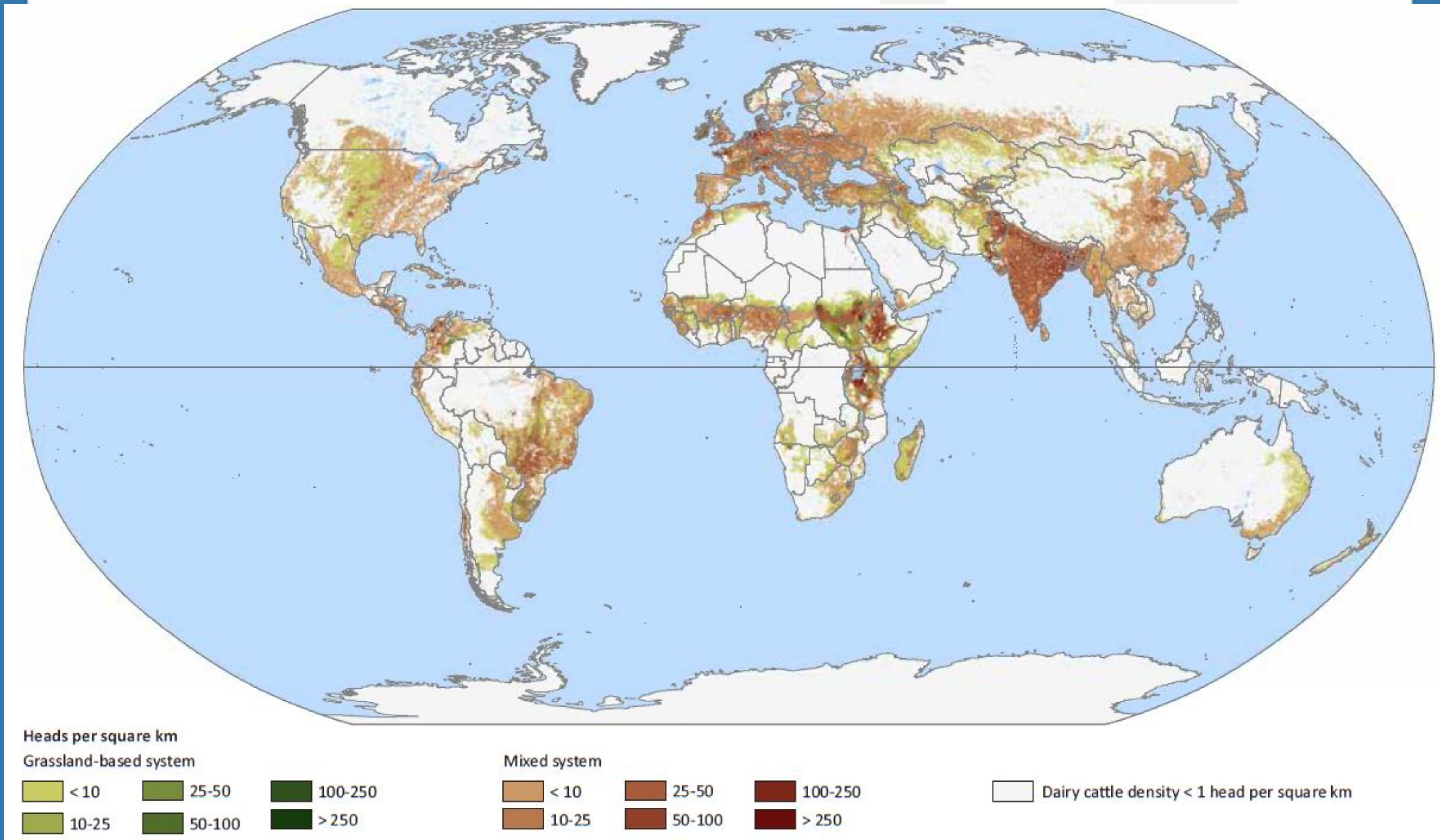
- Calculations done at 5 x 5 km at the equator: GIS captures heterogeneity and allows aggregation at various scales
- Primary data: animal numbers and distributions, crop areas, crop yields, herd parameters, mineral fertilizer application rates, etc.
- Intermediate data: animal growth rates, feed rations, animal energy requirements, etc.

GLEAM INPUT DATA

LIVESTOCK
DISTRIBUTION
MAPS

- Gridded Livestock of the World
- Sere & Steinfeld system classification:
  . Grazing and mixed ruminants systems
  . Backyard, intermediate & industrial pig systems
  . Backyard, layers & broilers chicken systems

DISTRIBUTION OF DAIRY CATTLE POPULATION



GLEAM INPUT DATA

- Fertility, growth rate, replacement rate...
- Specific values for different production systems and AEZ
- Extensive literature research, expert consultation and surveys

HERD PARAMETERS

Parameters	N. America	Russian Fed.	W. Europe	E. Europe	NENA	E & SE Asia	Oceania	South Asia	LAC	SSA
	Weights *(kg)*									
Adult cow	747	500	593	518	371	486	463	346	551	325
Adult bull	892	653	771	673	477	326	601	502	717	454
Calves at birth	41	33	38	36	20	28	31	23	38	20
Slaughter female	564	530	534	530	329	256	410	87	540	274
Slaughter male	605	530	540	530	367	243	410	141	540	278
	Rate *(percentage)*									
Replacement adult cow	35	31	31	27	15	28	22	21	21	10
Fertility	77	83	83	84	73	80	80	75	80	72
Death rate female calves	8	8	8	8	20	15	10	22	9	20
Death rate male calves	8	8	8	8	20	15	10	50	9	20
Death rate other animals	3	4	4	4	6	6	4	8	9	6
Age at first calving (years)	2.1	2.3	2.3	2.2	3.4	2.5	2.1	3.1	2.6	4.0

LIVESTOCK POPULATIONS

Disaggregation of herd structure
Emissions and production varies markedly between different animals categories > need to know herd structure.

Herd module determines the herd structure using data on key parameters e.g. fertility, AFC, growth and replacement rates

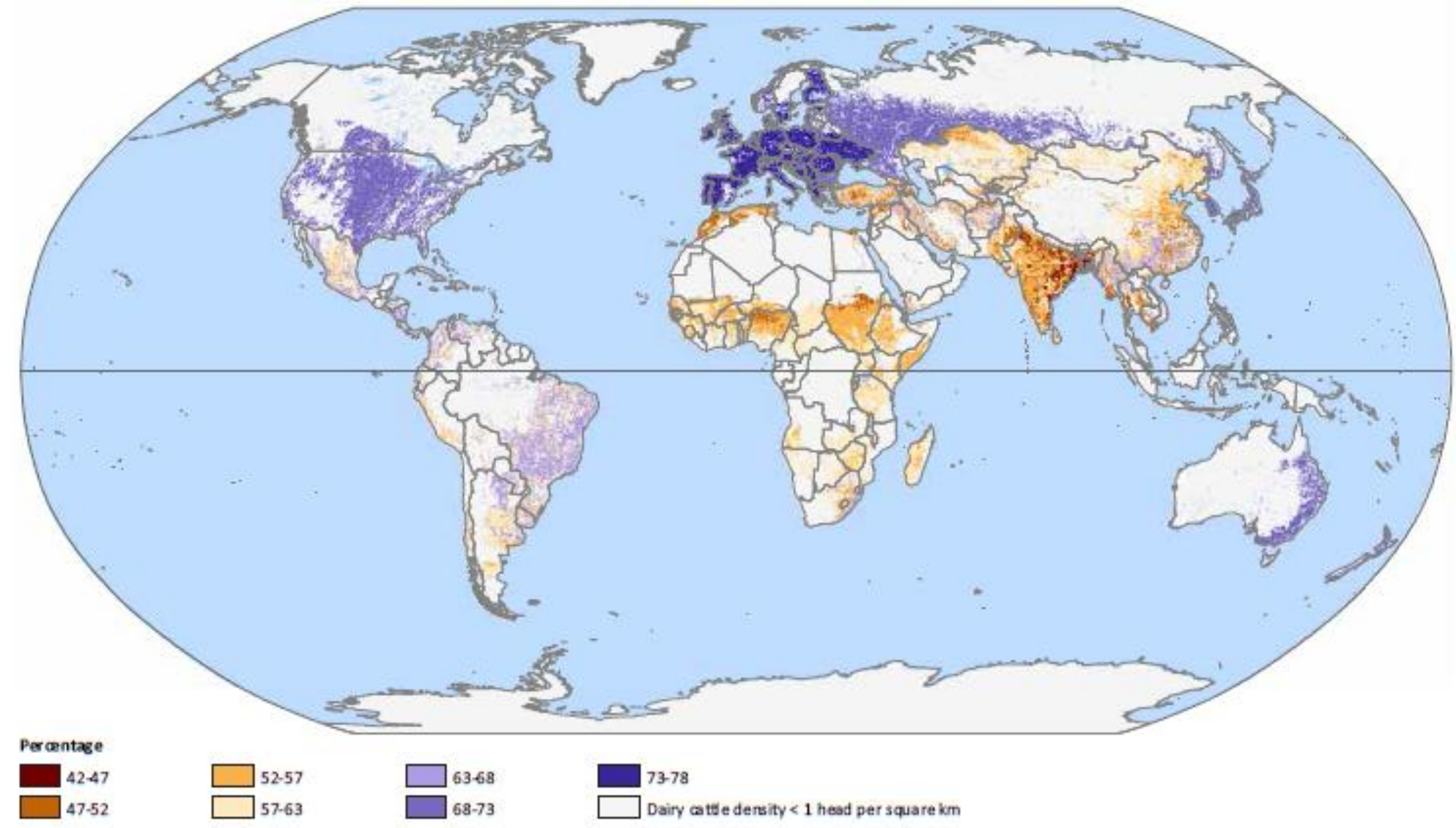
On-farm emissions: UK conventional pig farm (kgCO_2e/head/year)				
Sows	Sow replacements	Boars	Boar replacements	Pigs reared for meat
2,298	1,993	1,859	2,129	1,501

On-farm emissions: UK dairy farm (kgCO_2e/head/year)					
Cow	Cow replacements	Bull	Bull replacements	Surplus calves (F)	Surplus calves (M)
11,207	3,671	4,999	4,128	3,100	3,093

GLEAM INPUT DATA

- Specific feed baskets are defined for cohorts, production systems and regions
- 2 methods OECD/non OECD countries
- Data sources: Result of intermediate calculations in GLEAM (animal number/cohort), literature search, surveys and expert knowledge e.g. Proportion of feed materials in ration
- Dry-matter yield per hectare, net energy content and nitrogen content

AVERAGE FEED DIGESTIBILITY



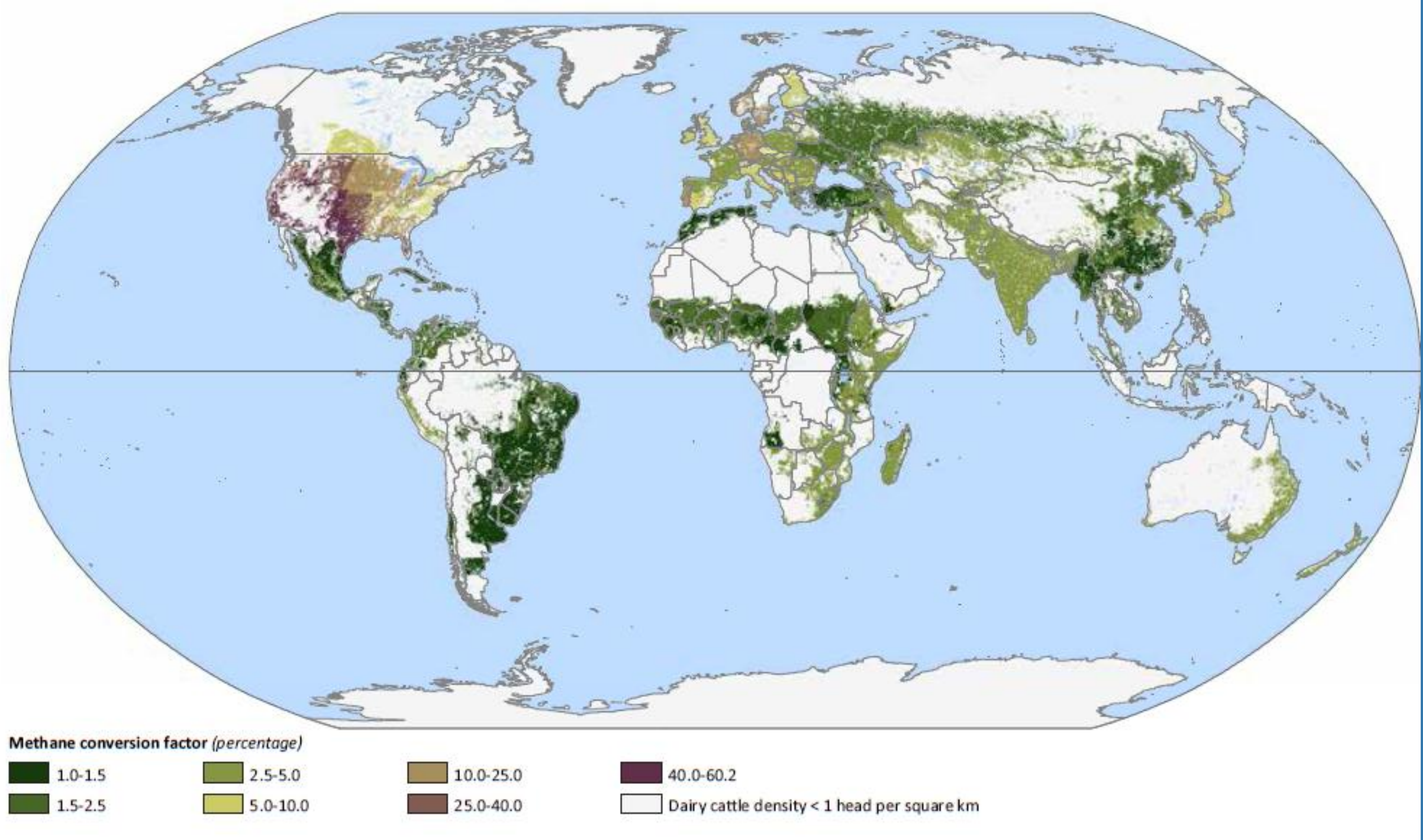
GLEAM INPUT DATA

- Types of MMS used in GLEAM are based on IPCC categories defined by IPCC (2006) guidelines
- Proportion of manure managed in different systems: Data taken from National inventories reports of MMS, expert knowledge and literature reviews
- Cross MMS and climatic conditions

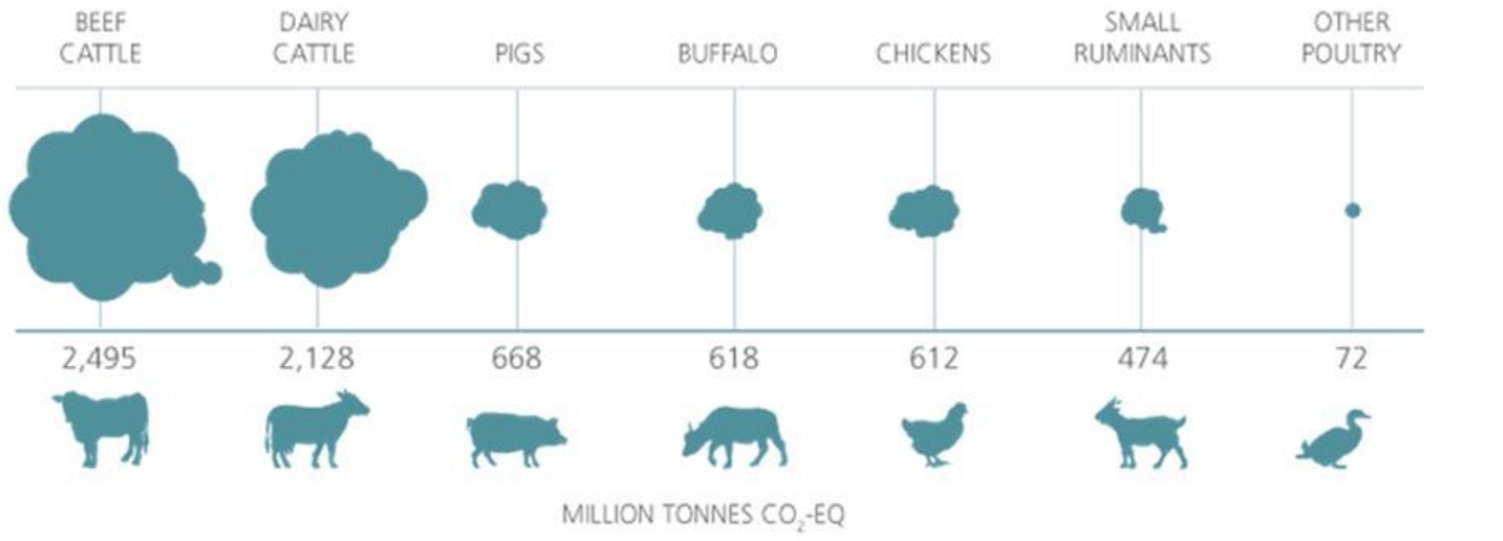
MMS DAIRY CATTLE SYSTEMS

MMS	Burned for fuel	Daily spread	Drylot	Uncovered anaerobic Lagoon	Liquid slurry	Pasture, range, pad-dock	Solid storage
				percentage			
N. America	-	9.5	-	27.2	26.3	11.8	25.2
Russian Fed.	-	-	-	-	-	22.5	77.5
W. Europe	-	2.3	-	0.1	41.6	26.6	29.5
E. Europe	-	1.4	-	-	10.2	17.0	71.3
NENA	3.6	-	39.4	-	-	46.1	10.9
E & SE Asia	1.5	-	29.1	-	3.1	30.7	35.7
Oceania	-	1.2	-	4.6	0.1	94.2	-
South Asia	20.0	-	54.4	-	-	23.5	2.0
LAC	0.4	-	41.5	-	-	53.5	4.7
SSA	6.9	-	34.8	-	-	39.7	18.5

MANURE METHANE CONVERSION FACTORS - DAIRY



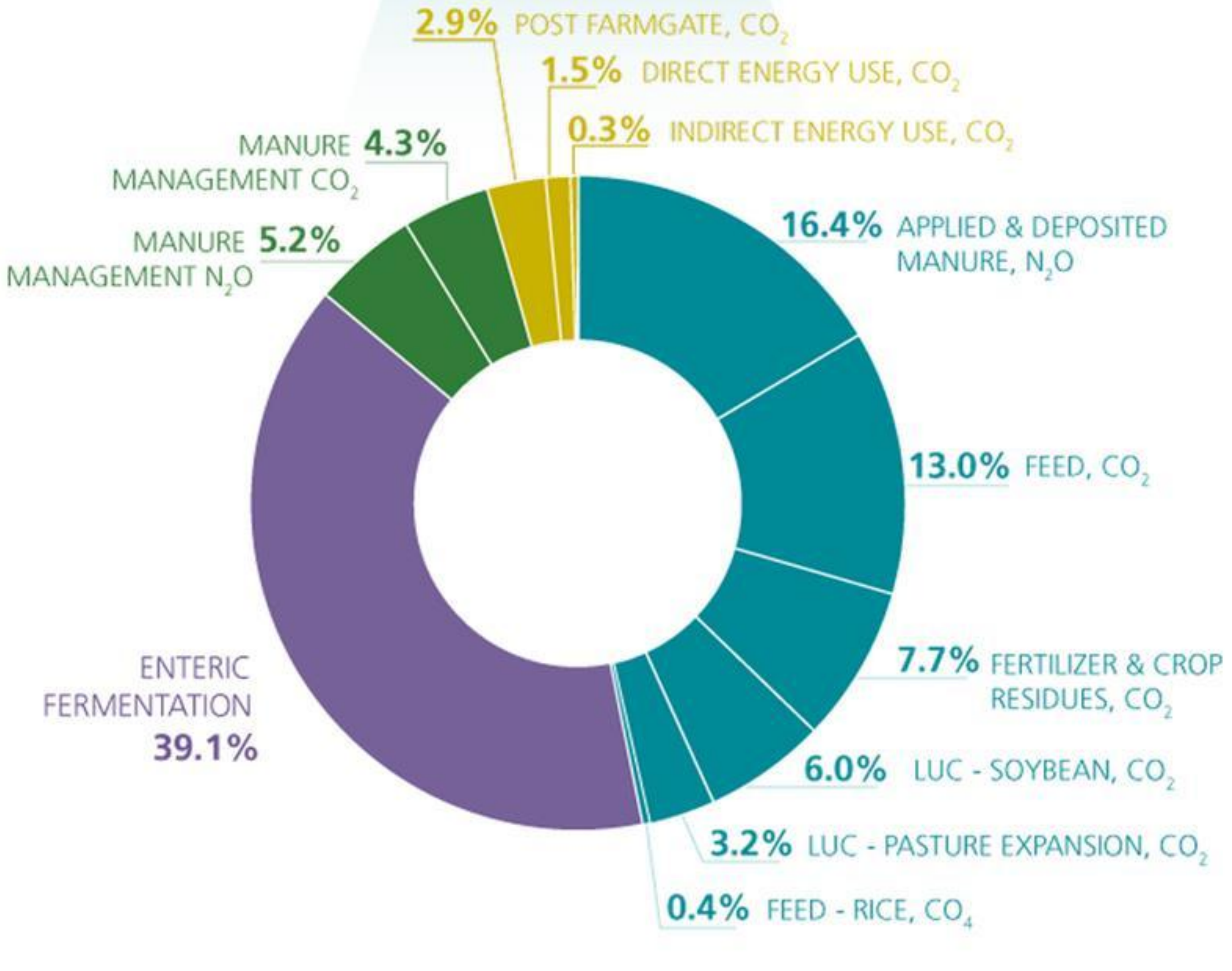
RESULTS: CONTRIBUTION BY SPECIES AT AGGREGATE LEVEL



Global estimates of emissions by species. *It includes emissions attributed to edible products and to other goods and services, such as draught power and wool. Beef cattle produce meat and non-edible outputs. Dairy cattle produce milk and meat as well as non-edible outputs.*

FAO, 2013

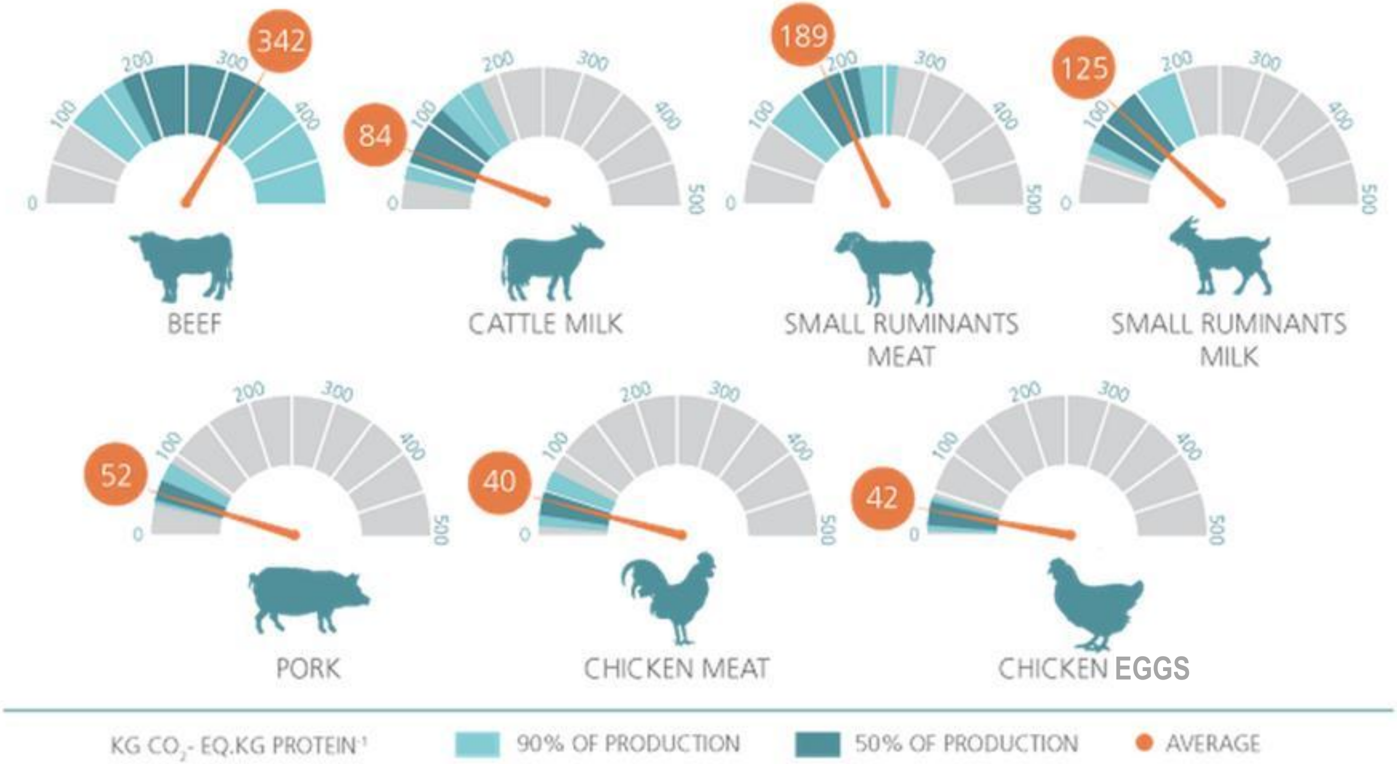
>45% OF EMISSIONS FROM FEED



Global emissions by source. Relative contribution of main sources of emissions from global livestock supply chains.

FAO, 2013

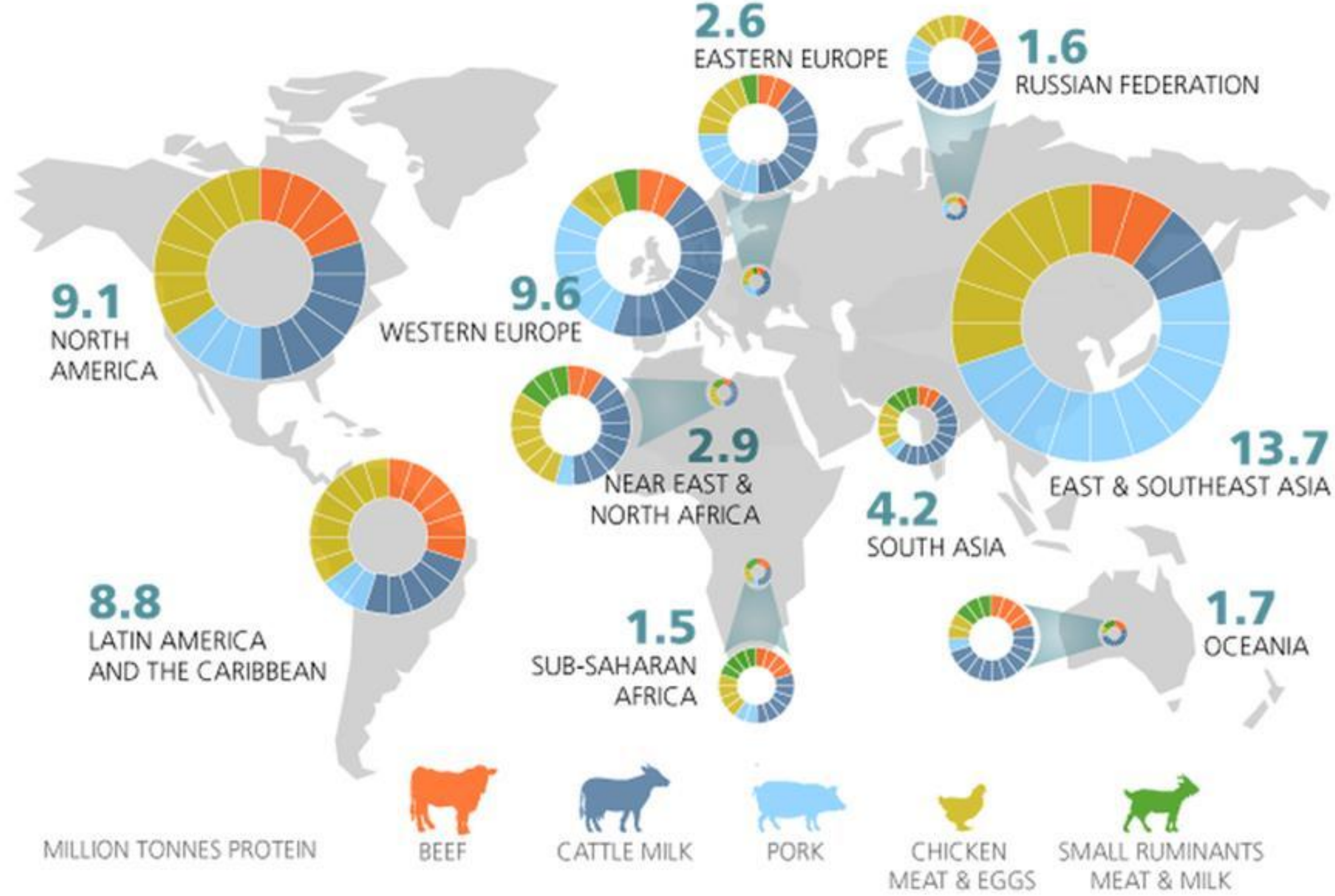
EMISSION INTENSITIES AND VARIABILITY IN EI



Global emission intensities by commodity*. All commodities are expressed in a per protein basis. Averages are calculated at global scale and represent an aggregated value across different production systems and agro-ecological zones.*

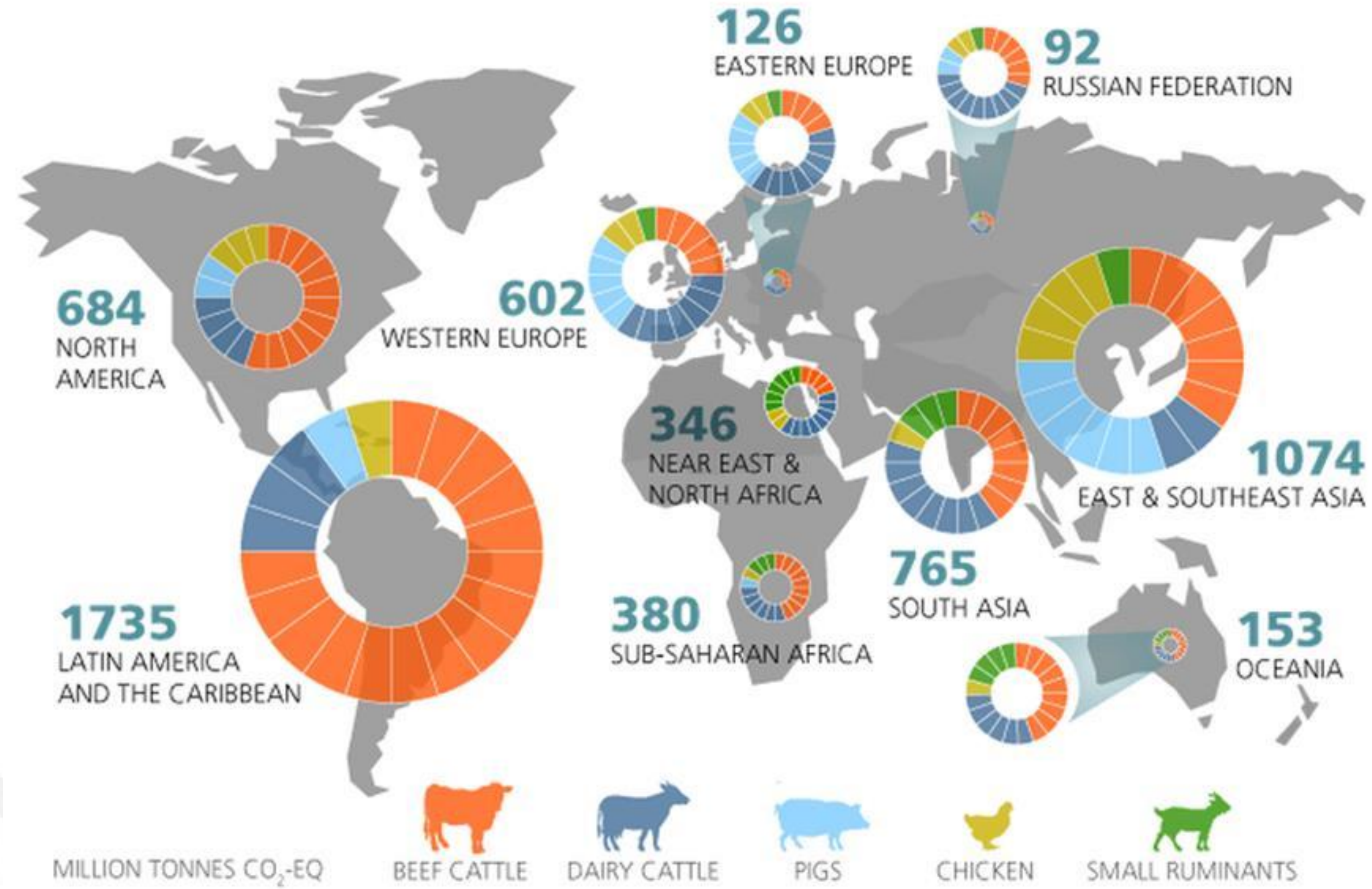
FAO, 2013

LIVESTOCK PRODUCTION



***Regional production**. Regional total production and their profile by commodity are shown. Meat production in protein basis was calculated by using data on dressing percentages, carcass to bone-free meat and average bone-free meat protein content. Milk from all species was converted into fat and protein corrected milk. Eggs production is also expressed in protein terms.*

LIVESTOCK EMISSIONS

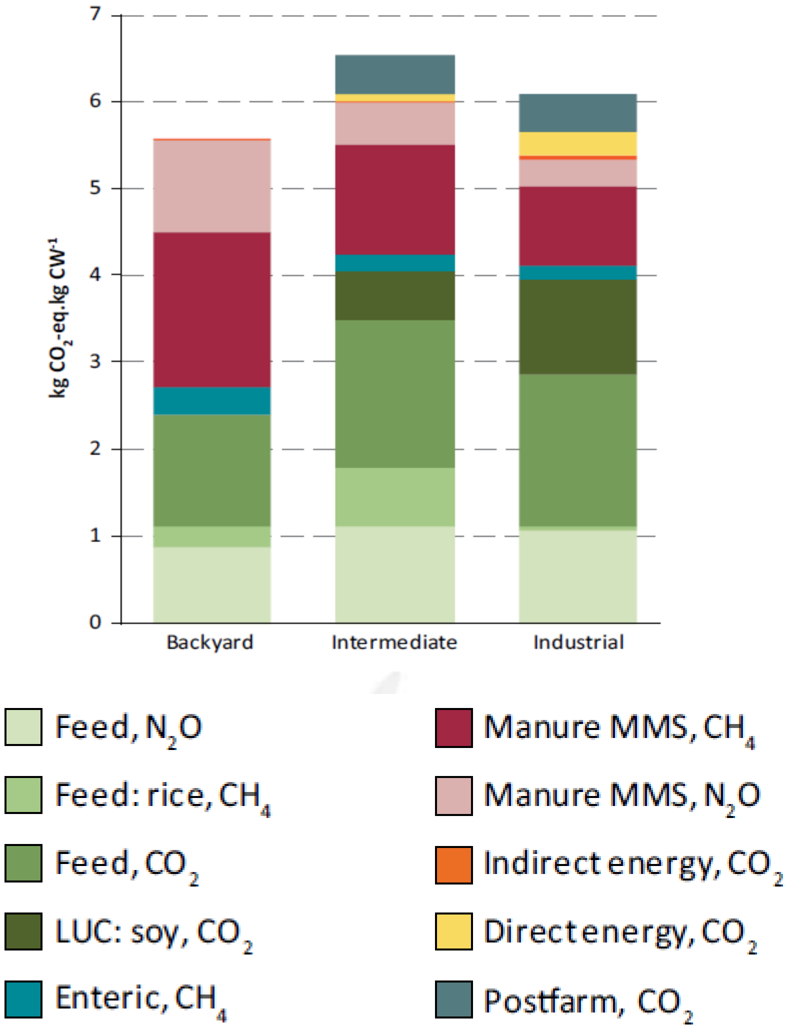


Regional emissions. Regional total emissions and their profile by animal species are shown. Results do not include emissions allocated to non-edible products and other services.

FAO, 2013

Comparison of systems

PORK: EMISSION INTENSITY BY MAIN SYSTEM



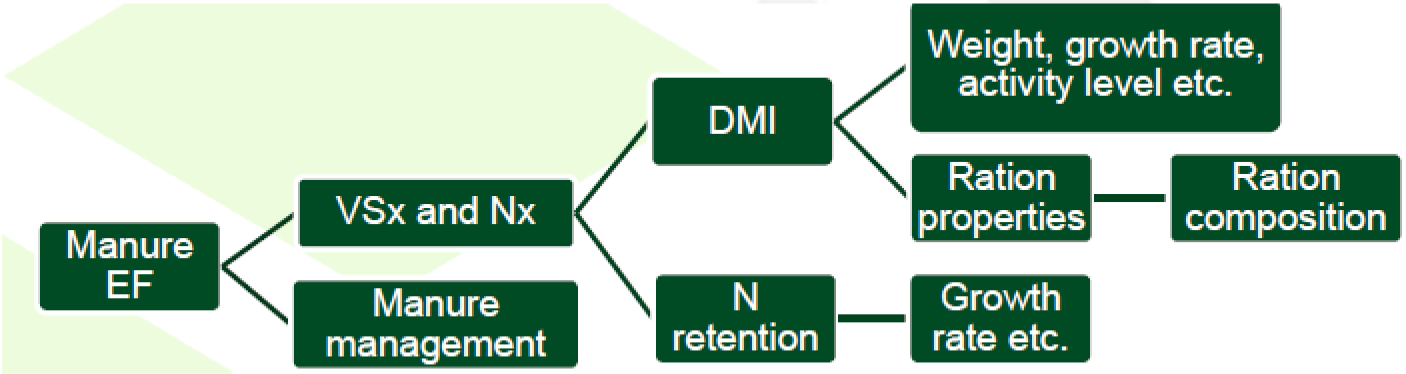
- **key drivers of emissions**: feed production and manure management dominate in all 3 systems
- **explain the differences**
- Backyard – highest on-farm emissions, but lowest overall EI - why?
  - Low FCR, low digestibility of the ration>high Volatile solids and N excretion
  - Feed CO2eq. low due to: no LUC associated with feed
  - Negligible emissions from post-farm, direct or embedded energy, and greater use of swill and waste crops

- Why is intermediate higher than industrial?
  - lower Feed conversion ratios
  - lower digestibility ration
  - Rice a large share of feed ration; high CH4 emissions from rice production

TIER 1 VS TIER 2

	Manure methane EFs for pigs (kgCH4/hd/year)			
	Sow		Market swine	
	Tier 1	Tier 2*	Tier 1	Tier 2*
Denmark	9.0	7.1	6.0	4.9
UK	9.0	3.0	6.0	2.0

* Calculated from GLEAM
Tier 1 – Default EF for Western Europe
Tier 2 – specific EF calculated for pig cohort

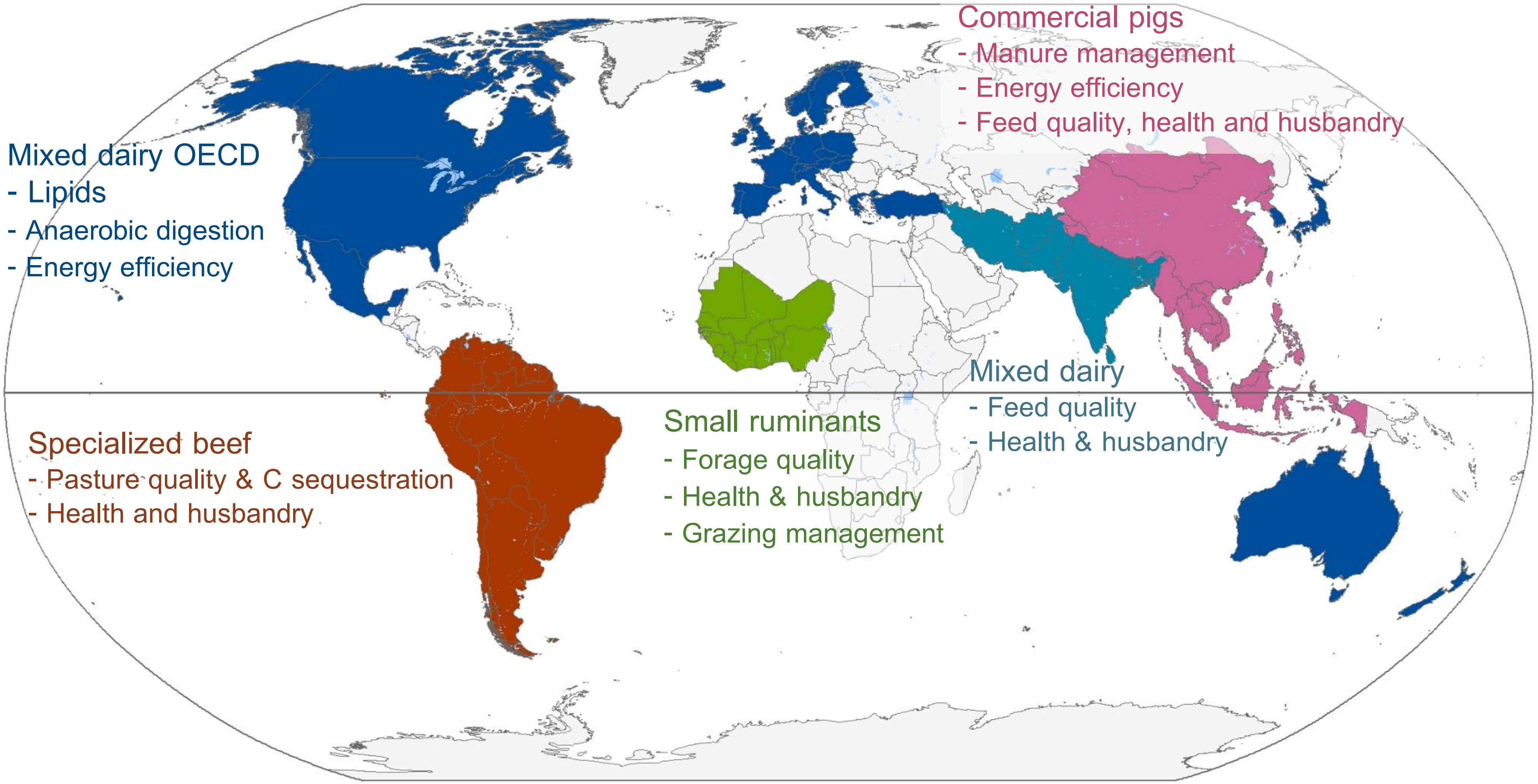


MITIGATION POTENTIAL

- **<u>Statistical analysis</u>**: mitigation potential of ca. 30% Potential of bridging the emission intensity gap without system change if producers with higher EI adopted practices of best- performing producers

- **<u>Case studies</u>**: designed on anticipated positive effects on producers income, food security, and broader environmental performance. Mitigation packages were selected on feasibility of adoption by farmers.
  Mitigation potential of 10 to 45 % for constant output

CASE STUDIES: MITIGATION PACKAGES



APPLICATIONS

- **The economics of resilience in the drylands of sub-Saharan Africa.** World Bank, FAO and other partners are collaborating to a flagship report on resilience in drylands in Africa. Livestock is the main user of land and a key support for livelihoods in those areas. *GLEAM was used to analyse the potential of livestock in drylands to meet the projected demand growth.*

- **AnimalChange.** International project with 25 partners from Europe, Africa and Latin America that aims to provide a sound basis for the future of livestock under climate change by improving the models, tools and policies used to address this topic. FAO leads the Component 4 of the project: the regional assessment and policy making support. *GLEAM was used to assess global and regional emissions and mitigation packages.*

- **Productivity and carbon credits in Kenyan dairy farms.** The FAO is involved in a project to improve the productivity of dairy farms in Kenya and to generate additional income for farmers based on carbon credits. *GLEAM supports the assessment of emissions and several technical options for smallholder dairy herds.*

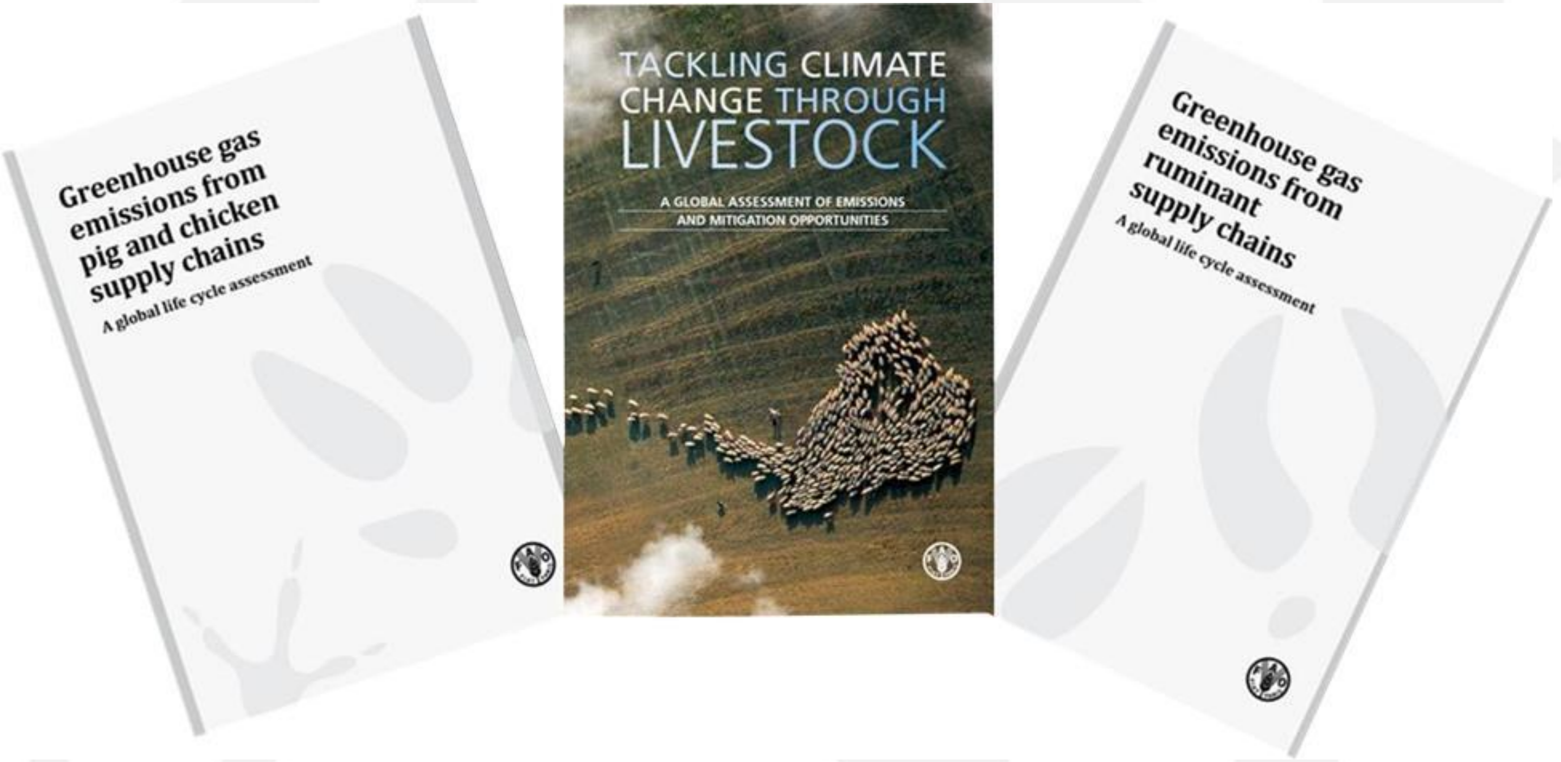
- **Climate Smart livestock investment proposals in Zambia.** The AGAL branch contributed to the Economics & Policy Innovations for Climate-Smart Agriculture (EPIC) programme regarding mitigation potential in Zambian livestock supply chains. The approach is currently being up-scaled for Southern Africa. *GLEAM was used to analyse emission profiles, mitigation options and productivity gains.*

- **Climate Smart Livestock in Ecuador.** Funded by the Global Environmental Facility, it aims at capacity development, adoption of better practices, access to new markets and diversification of livestock sector in Ecuador. The project is based on natural resource use efficiency and carbon sequestration. *GLEAM provides the analysis of emission profiles in livestock supply chains and the assessment of options to increase system resilience and productivity.*
- **Greenhouse gas mitigation potential of the world's grazing lands.** In collaboration with Colorado State University and together with the Century and Daycent models, *GLEAM was used to assess the global mitigation potential of different management practices of grasslands.*

NEXT STEPS

- Further investigate economics of mitigation
- Improve, update GLEAM to reduce uncertainty and measure progress: FAO-GRA project East Asia, South Asia, Cono-sur countries
- Progressively include more environmental categories in GLEAM
- Drive action on the ground >>>Support practice change
  - Test some of the options and related institutional frameworks on the ground
  - Support development of livestock NAMAs

THANK YOU



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