Food and Agriculture Organization of the United Nations

Global Livestock Environmental Assessment Model – Interactive (GLEAM-i)

Guidelines

Version 1.9

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GLOSSARY OF TERMS AND ABBREVIATIONS

Term or abbreviation	Explanation
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide-equivalent(s)
CSV	Comma-separated values (file)
DM	Dry matter
Emissions intensity	Emissions produced per unit of product (e.g. per kg protein)
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse gas
GLEAM	Global Livestock Environmental Assessment Model
GLEAM-*i*	Global Livestock Environmental Assessment Model – *interactive*
Guidelines (GLEAM-*i*)	This is the present document
IPCC	Intergovernmental Panel on Climate Change
LCA	Life cycle assessment
LUC	Land use change
Manual (GLEAM)	This is the pdf document of model description (version 2.0 with reference year 2010) and can be found using the link here
N_2O	Nitrous oxide

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ABOUT THIS DOCUMENT

These guidelines were prepared to provide the users with general guidance on how to use the tool GLEAM-*i*, and do not constitute professional advice. The default parameters that are currently embedded in the model are provided as national level average values derived from GLEAM 2.0, the second version of the spatially version of GLEAM. These default parameters were collected at different levels, sub-national, national, regional and global. They are provided as references and should systematically be reviewed and corrected by the user to use the most up-to-date and locally specific data. In particular, default parameters are not meant for country benchmarking or comparing the emission profiles of different countries and production systems.

GLEAM-*i* is continuously under development and improvement. FAO welcomes any feedback on the content of this document and encourages the users to check the GLEAM website (www.fao.org/gleam) regularly for any updates of the current version. This document may be seen complementary to three videos available on GLEAM website, providing the background information to the tool and the greenhouse gas emissions from the livestock sector (video part 1); explaining in the detail the main features of the tool (video part 2); and finally demonstrating two practice exercises on cattle and pig production systems (video part 3 and part 4).

ABOUT GLEAM-*i*

GLEAM-*i* is a publicly available and free tool specific to estimating the greenhouse gas (GHG) emissions from different livestock species and production systems from all countries in the world. The livestock species covered in GLEAM-*i* are four ruminant species (cattle, buffalo, sheep and goat); and two monogastric species (chicken and pigs). The production systems embedded in the tool are grassland-based and mixed for ruminants; backyard, broiler and layers for chicken; and backyard, intermediate and industrial for pigs (FAO, 2017; MacLeod et al., 2017).

The sources of emissions (Table 1), and the details regarding the background calculations in GLEAM-*i* can be found in GLEAM manual (i.e. model description) (FAO, 2017) using the link here.

TABLE 1. Sources of GHG emissions covered in GLEAM-*i*

SOURCES OF EMISSIONS	DESCRIPTION	
Feed CO_2[1]	field operations	CO_2 emissions arising from the use of fossil fuels during field operations
	fertilizer production	CO_2 emissions from the manufacture and transport of synthetic nitrogenous, phosphate and potash fertilizers
	pesticide production	CO_2 emissions from the manufacture, transport and application of pesticides
	processing and transport	CO_2 generated during the processing of crops for feed and the transport by land and/or sea
	blending and pelleting	CO_2 arising from the blending of concentrate feed
Feed LUC[2] CO_2	soybean cultivation	CO_2 emission due to LUC associated with the expansion of soybean
	palm kernel cake	CO_2 emission due to LUC associated with the expansion of palm oil plantations
	pasture expansion	CO_2 emission due to LUC associated with the expansion of pastures
Feed N_2O[3]	applied and deposited manure	Direct and indirect N_2O emissions from manure deposited on the fields and used as organic fertilizer
	fertilizer and crop residues	Direct and indirect N_2O emissions from applied synthetic nitrogenous fertilizer and crop residues decomposition
Feed CH_4[4]	Rice production	CH_4 emissions arising from the cultivation of rice used as feed
Enteric fermentation CH_4		CH_4 emissions caused by enteric fermentation
Manure management CH_4		CH_4 emissions caused by manure management
Manure management N_2O		N_2O emissions arising from manure storage and management
Direct energy use CO_2		CO_2 emissions arising from energy use on-farm for ventilation, heating, etc.
Embedded energy use CO_2		CO_2 emissions arising from energy use during the construction of farm buildings and equipment

[1] Carbon dioxide; [2] Land use change; [3] Nitrous oxide; [4] Methane

GLEAM-*i*'S PORTFOLIO

GLEAM-*i* has been designed to support governments, project formulators and investment officers from International Financing Institutions and national development banks, but also producers, private sector companies and civil society organisations to calculate GHG emissions from the livestock sector. It can be used in preparation of national inventories, and in project- or investment evaluation of intervention scenarios targeting herd-, feed-, and manure management. It can also be consulted as a monitoring and evaluation tool. The following table provides some examples of the range of applications of GLEAM-*i* (Table 2).

TABLE 2. Some projects in the FAO GLEAM-*i*'s portfolio

PROJECT/INITIATIVE	COUNTRY	YEAR	USEFUL LINKS/INFORMATION
IAMZ-CIHEAM Advanced course on livestock and climate change: Assessment of emissions, mitigation options and adaptation Strategies	Global (about 50 participants from over 15 countries)	2020 (online) 2019 (Spain)	Course webpage
AgrInvest initiative to strengthen the Uganda Development Bank's capacity on digital finance, pipeline building, environmental, climate and social risk management and impact assessment	Uganda	2020-2024	AgrInvest training course "Greening the Uganda Development Bank's agricultural lending portfolio"
Technical assistance to the Livestock Development Project (PRODEL) for assessing climate co-benefits	Cameroon	2020-2022	PRODEL website
Climate-proofing the livestock sector, funded by the European Bank for Reconstruction and Development (EBRD)	Kazakhstan	2020-2022	GLEAM-*i* will be used to assess baseline and ex-ante emissions
Technical assistance to the International Fund for Agricultural Development (IFAD) for low carbon and resilient livestock investments	Kenya, Lesotho, Ethiopia, Kyrgyzstan, Tajikistan	2020-2022	Monitoring and evaluation of livestock projects NDC revision in Kyrgyzstan Low carbon livestock development in Kyrgyzstan
Technical assistance to the International Finance Corporation (IFC) for estimating GHG emissions from livestock projects	Argentina, Nicaragua, Colombia	2019-2020	Example: Climate smart beef production in Oronoquia
Green Carbon Fund (GCF) Readiness program in Kyrgyzstan	Kyrgyzstan	2018-2022	Project website
FAO Investment days with the Investment Centre (CFI)	Global	2019 2017	Short training on GLEAM-*i* and low carbon livestock Investing in climate smart food systems (2019) Invest in sharing (2017)
Regional Sahel Pastoralism Support Program (PRAPS) 2	Mauritania, Senegal, Mali, Burkina Faso, Niger, Chad	2022-2028	GLEAM-*i* is proposed to assess baseline and ex-ante emissions

STEP BY STEP GUIDANCE TO USING THE TOOL

1. ACCESS

GLEAM-*i* can be accessed from the following link:

https://gleami.apps.fao.org/

2. SELECTION OF REGION AND COUNTRY

Select region and country from the drop-down menu. Click 'start simulation' (Figure 1).

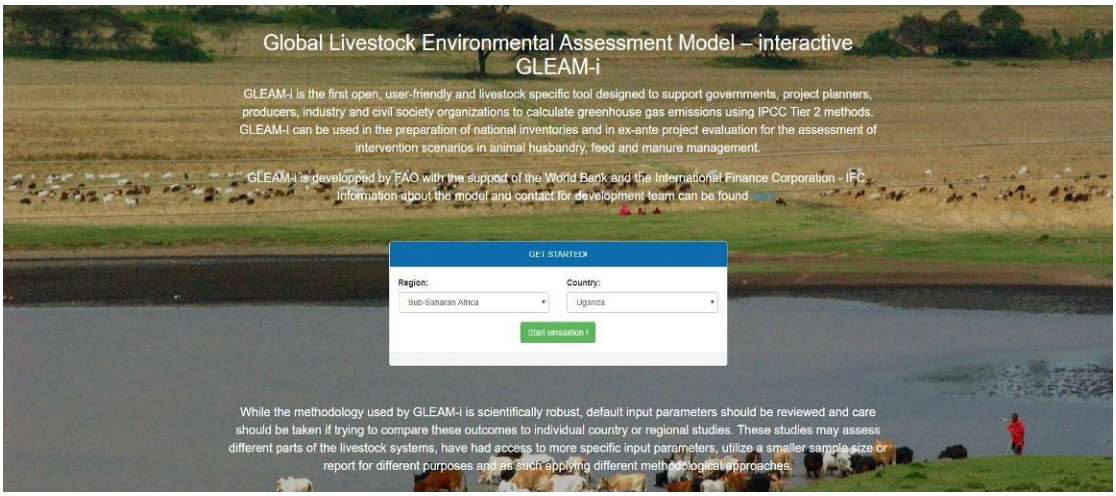

FIGURE 1. Selection of region and country

3. SELECTION OF ANIMAL SPECIES, PRODUCTION SYSTEMS AND ORIENTATIONS

Click on animal species, production systems and orientations you would like to conduct the assessment for (Figure 2). Consult the manual for the definition of production systems and orientations. Click 'next'.

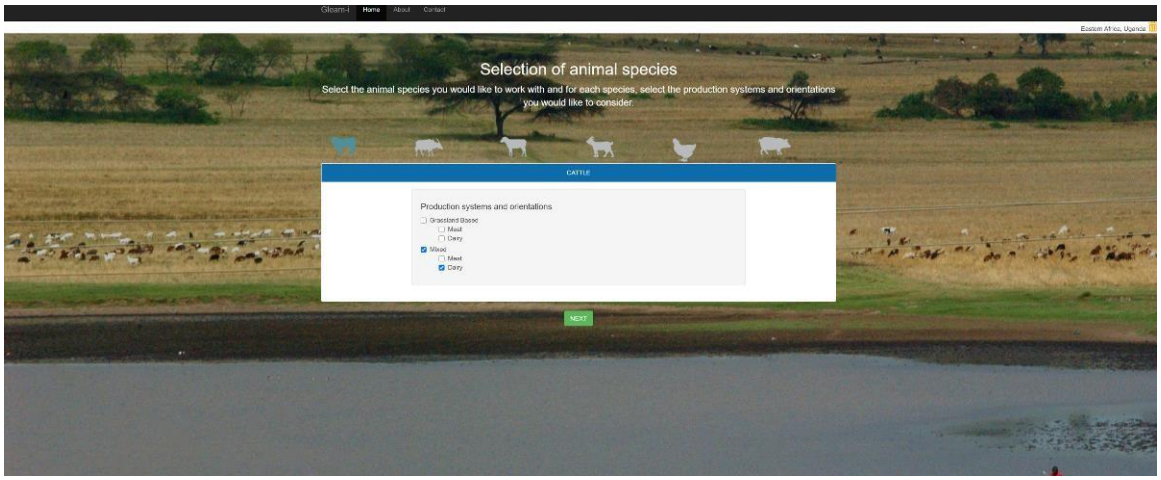

FIGURE 2. Selection of species, production systems and orientations

4. MODULES

There are three main modules in GLEAM-*i*: herd, feed and manure management.

5. SELECTION OF PARAMETER CATEGORIES

Select each of the three modules at a time and tick the boxes of parameter categories for which you want to enter data in the next step. For herd (Figure 3), feedlot must be clicked only for feedlot cattle; and production category is only valid for cattle production system with dairy orientation. For feed (Figure 4), tick the boxes relevant for the production system you are working with. Note that in the next step you will be asked to enter data for all parameter categories you have selected in this step. For manure (Figure 5), tick the only box provided. Click 'next'.

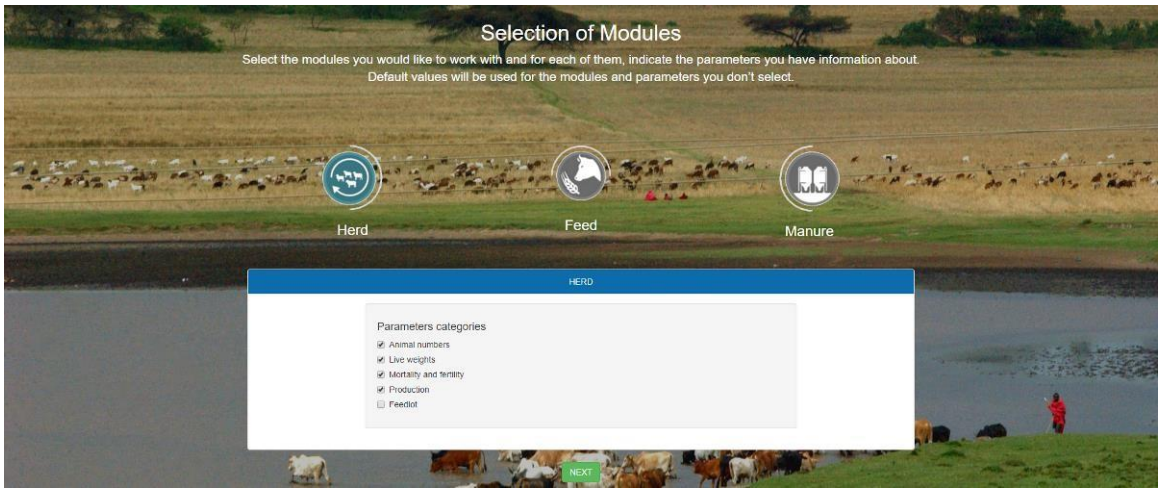

FIGURE 3. Selection of parameter categories in the herd module

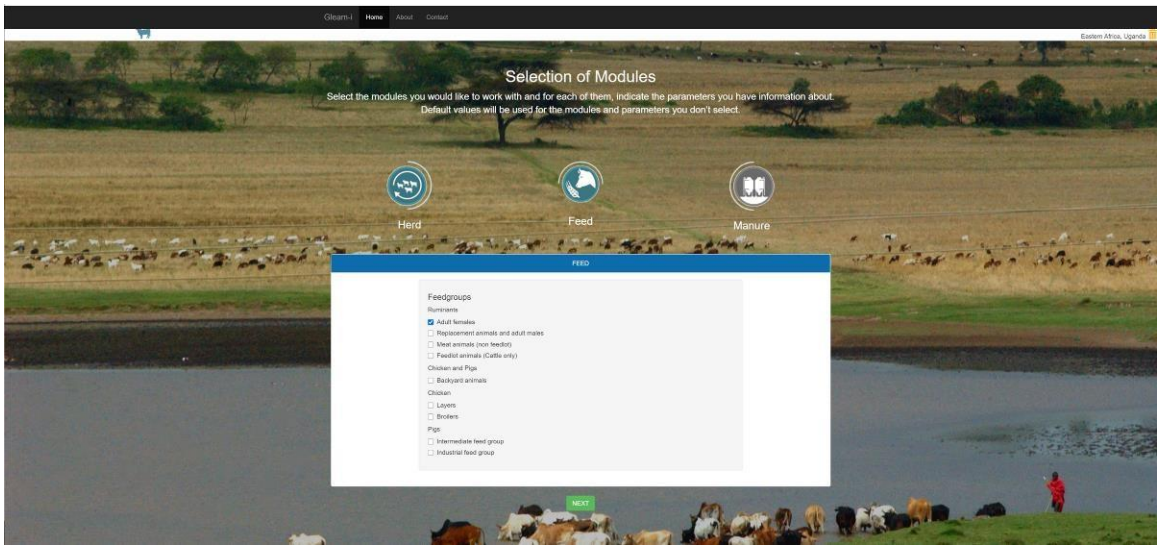

FIGURE 4. Selection of parameter categories in the feed module

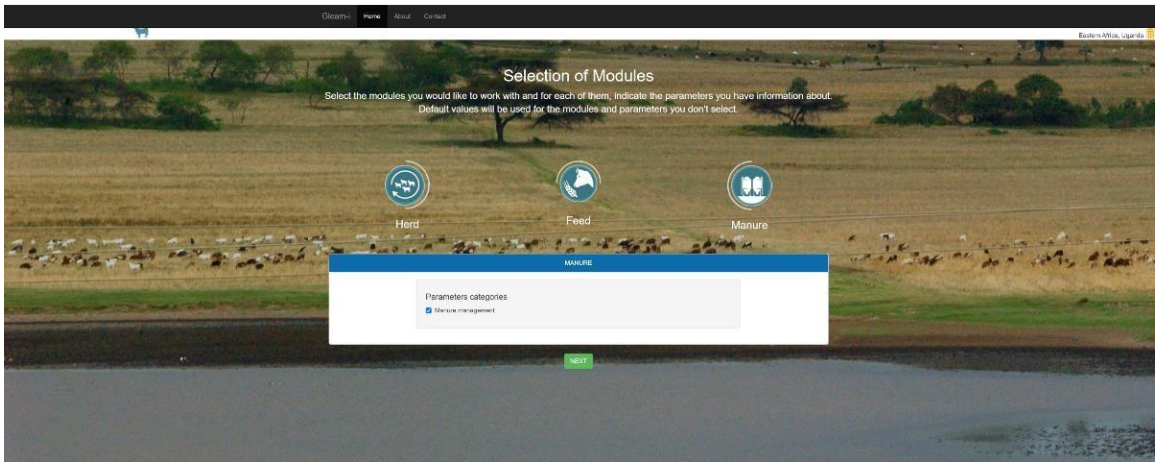

FIGURE 5. Selection of parameter categories in the manure module

6. BASELINE

Baseline refers to the system state to which the scenarios are compared. In this step, either select and existing baseline from the drop-down menu (if you are familiar with the existing baselines) or create a new one by typing it in one word and avoiding special characters (Figure 6). Click 'next'.

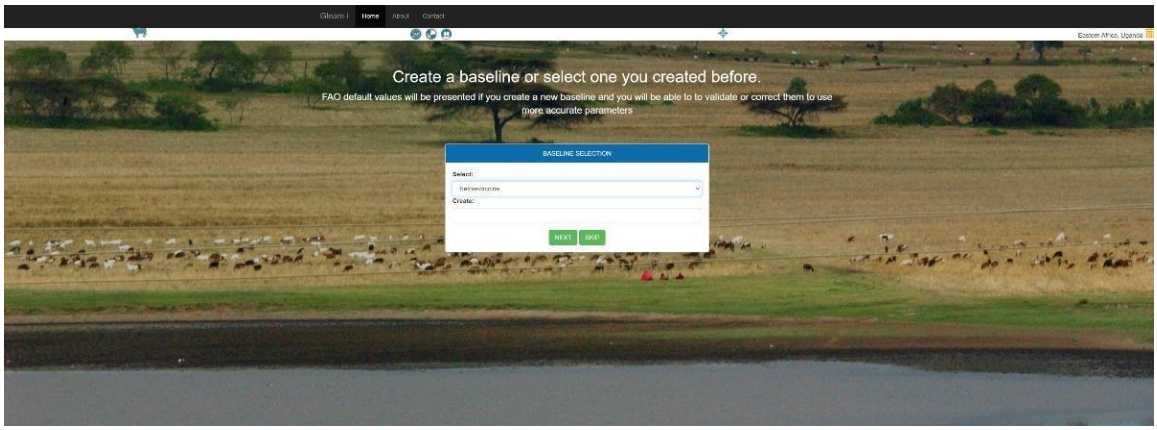

FIGURE 6. Baseline selection

7. SCENARIOS

Scenarios are specific cases the user wants to compare to the baseline. A scenario can be an intervention (e.g. a vaccination program), can represent different activities of a project, different herds or farms, or different seasons for the same herd. More details on what interventions may exist for different livestock production systems, and their impacts on GHG emissions can be found in Gerber et al. (2013). Type in the box the name of scenario and use one box for each scenario (Figure 7). Click 'next'.

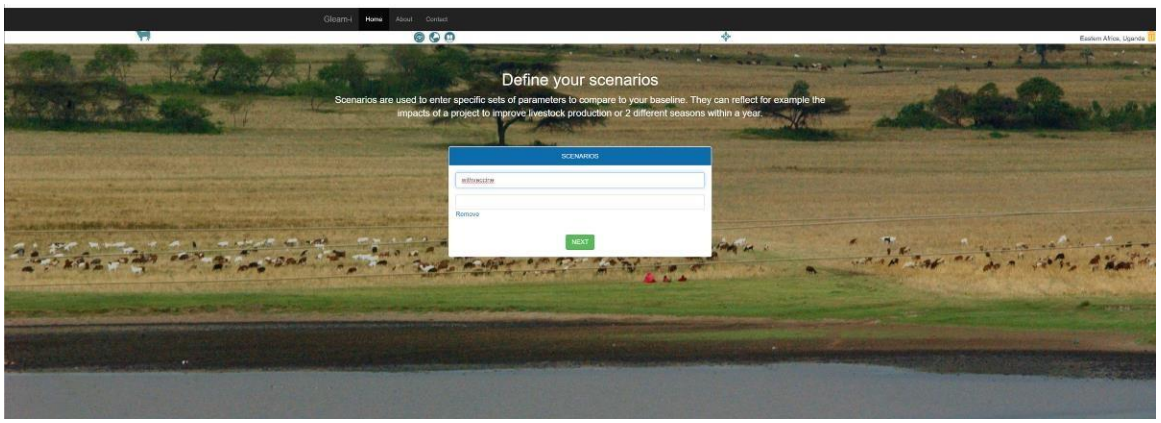

FIGURE 7. Scenario definition

8. DATA ENTRY

Herd module

Enter the required data in the herd module both for baseline and the scenario(s) (Figure 8). Click 'feed module'.

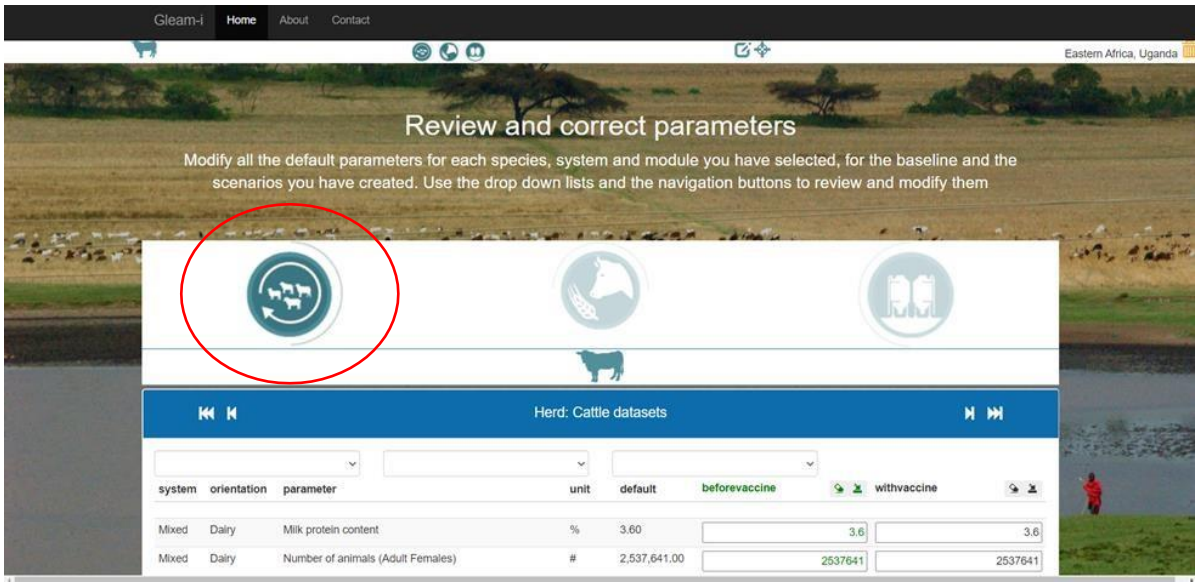

FIGURE 8. Data entry in the herd module

The following tables show the parameters in the herd module for non-fattening cattle (Table 3), pigs (Table 4) and chicken (Table 5).

TABLE 3. Herd parameters for cattle (non-fattening)

PARAMETER	UNIT
Age at the first parturition[1]	months
Average annual milk yield	kg/cow
Death rate of adult animals[2]	%
Death rate of young females[3]	%
Death rate of young males[3]	%
Fertility rate of adult females[4]	%
Live weight of adult females	kg
Live weight of adult males	kg
Live weight of meat females at slaughter	kg
Live weight of meat males at slaughter	kg
Milk fat content	%
Milk protein content	%

Number of adult reproductive females	heads
Number of adult reproductive males	heads
Replacement rate of adult females[5]	%
Weight at birth[6]	kg

[1] Average age at which reproductive females have the first offspring
[2] Annual average rate of non-intended adult animals deaths after reaching maturity
[3] Annual average rate of non-intended young female/male deaths before reaching maturity
[4] Average percentage of successful adult female parturitions, including young animals that die before reaching maturity
[5] Annual average rate of reproductive adult females replacement
[6] Average live weight of offspring at birth

TABLE 4. Herd parameters for pigs

PARAMETER	UNIT
Daily weight gain of fattening animals	kg
Days between parturition and next pregnancy	days
Death rate of adult animals	%
Death rate of young females	%
Fertility rate of adult females	number
Gestation period duration	days
Lactation period duration	days
Litter size[1]	number
Live weight of adult females	kg
Live weight of adult males	kg
Live weight of animals at slaughter	kg
Mortality of fattening animals	%
Mortality rate of weaned piglets	%
Number of adult reproductive females	heads
Number of adult reproductive males	heads
Replacement rate of adult females	%
Replacement rate of adult males	%
Weaning age	days
Weight at birth	kg
Weight of weaned piglets	kg

[1] Average number of piglets born in each parturition, including the ones that die before reaching maturity

TABLE 5. Herd parameters for chicken

PARAMETER	UNIT	APPLICABLE SYSTEM		
		Backyard	Broiler	Layer
Number of adult reproductive females	heads	x	x	x
Number of adult reproductive males	heads	x	x	x
Age at the first parturition (or laying age)	weeks	x	x	x
Hatchability[1]	%	x	x	x
Death rate of adult animals[2]	%	x	x	
Death rate during laying period	%		x	x
Death rate of young females[3]	%	x	x	x
Weight of pullets at birth	g	x	x	x
Average number of eggs laid per year	number	x	x	x
Average weight of whole eggs	g	x	x	x
Slaughter weight of fattening adult females	kg	x		
Slaughter weight of fattening adult males	kg	x	x	
Average duration of laying period[4]	weeks		x	x
Initial weight of laying hens	kg		x	x
Final weight of laying hens	kg		x	x
Is molting done?	yes/no			x

[1] Average share of eggs that successfully hatch a pullet
[2] Pullets after 16 weeks
[3] Pullets before 16 weeks
[4] Average length of the (first, if more than one) laying period of egg producing hens

Feed module

Enter the required data in the feed module for the % share of each feed ingredient in both for baseline and the scenario(s) (Figure 9). Note that the total should be 100%. Click 'manure management'.

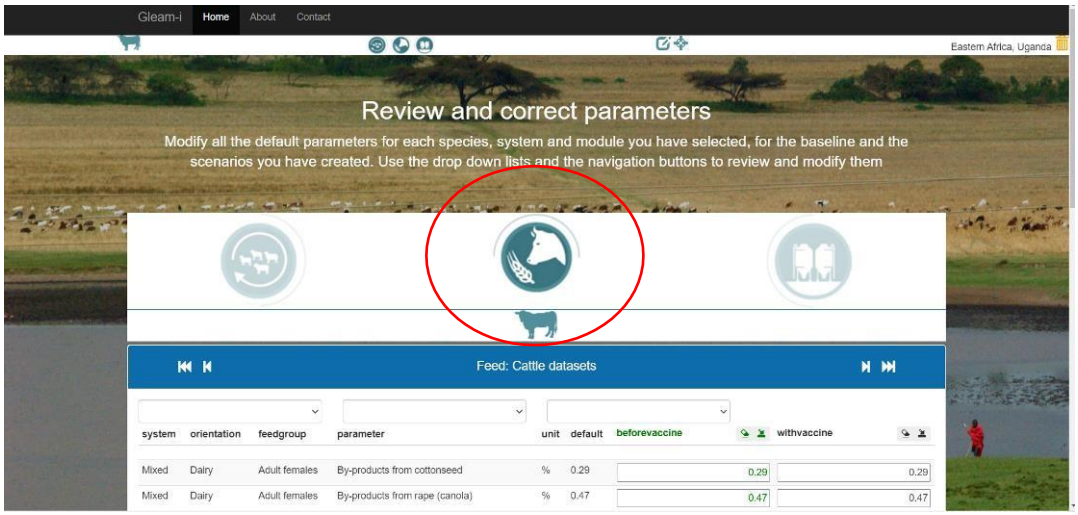

FIGURE 9. Data entry in the feed module

Table 6 below shows the feed ingredients available in the tool. Note that the total should be 100%. Description of feed materials can be found in Table 3.2 for ruminants and Table 3.14 for monogastrics in the manual (FAO, 2017).

TABLE 6. List of feed ingredients for ruminants and monogastrics

FEED INGREDIENTS	
Ruminants	**Monogastrics**
Roughages	***Swill and scavenging***
Grass i.e. any type of natural or cultivated fresh grass grazed or fed to the animals	Swill
Hay (i.e. grass is cut, dried and stored) or silage (i.e. grass is cut and fermented) from any natural or cultivated grass	***Locally-produced feed materials***
Hay from adjacent areas	Grass i.e. any type of natural or cultivated fresh grass grazed or fed to the animals
Fresh mixture of any type of grass and leguminous plants fed to the animals	Leguminous beans
Hay or silage from alfalfa (*Medicago sativa*)	Fibrous residual plant material e.g. straw from leguminous plant cultivation
Silage from whole barley (*Hordeum vulgare*), oat (*Avena sativa*), buckwheat (*Fagopyrum esculentum*) and fonio (*Digitaria spp.*) plants	Pellets from cassava (*Manihot esculenta*) roots
Silage from whole maize (*Zea mays*) plants	Grains from wheat (*Triticum aestivum*)
Fibrous residual plant material such as straw, brans, leaves, etc. from rice (*Oryza spp.*) cultivation	Grains from maize (*Zea mays*)
Fibrous residual plant material such as straw, brans, leaves, etc. from wheat (*Triticum spp.*) cultivation	Grains from barley (*H. vulgare*)
Fibrous residual plant material such as straw, brans, leaves, etc. from barley (*H. vulgare*), rye (*Secale cereale*) or oat (*Avena sativa*) cultivation	Grains from millet (e.g. *P. glaucum*, *E. coracana* and *P. miliaceum*)
Fibrous residual plant material such as straw, brans, leaves, etc. from maize (*Zea mays*) cultivation	Grains from rice (*Oryza sp.*)
Fibrous residual plant material such as straw, brans, leaves, etc. from millet (*Pennisetum glaucum*, *Eleusine coracana*, *Panicum miliaceum*, etc) cultivation	Grains from sorghum (*Sorghum sp.*)
Fibrous residual plant material such as straw, brans, leaves, etc. from sorghum (*Sorghum spp.*) cultivation	Beans from soy (*Glicyne max*)
Top portion of sugarcane (*Saccharum spp.*) plants, consisting of green leaves, bundle sheath and variable proportions of immature cane	Fibrous residual plant material from sugarcane (*Saccharum spp.*) cultivation
Leaves from natural, uncultivated vegetation found in trees, forest, lanes etc.	Leaves from natural, uncultivated vegetation found in trees, forest, lanes etc.
Fodder beet (*Beta vulgaris*), also known as mangel beet or field beet, used as animal feed	Fruit from banana trees (*Musa sp.*)
Cereals	Residual plant material such as stems from banana (*Musa sp.*) cultivation
Grains from barley (*H. vulgare*), oat (*A. sativa*), buckwheat (*F. esculentum*) and fonio (*Digitaria spp.*) plants	By-product from soy (*Glycine max*) oil production, commonly referred to as 'soy cakes' or 'soybean meal'
Grains from maize (*Zea mays*) plant	By-product from cottonseeds (*Gossypium sp.*) oil production, commonly referred to as 'cottonseeds cakes'
By-products	By-product (cakes, meals) from oil production other than soy, cottonseed or palm oil
By-product from soy (*Glycine max*) oil production, commonly referred to as 'soy cakes' or 'soybean meal'	Dry' by-products of grain industries such as brans, middlings, etc.
By-product from rape (*Brassica napus*) oil production, commonly referred to as 'rape cakes' or 'rapeseed meal'	***Non-local feed materials***
By-product from cottonseed (*Gossypium spp.*) oil production, commonly referred to as 'cottonseed meal'	Leguminous beans

By-products from the production of kernel palm oil (*Elaeis guineensis*), commonly referred to as 'kernel cake'	Pellets from cassava (*M. esculenta*) roots
By-product from maize processing (i.e. protein-rich feed with about 65% crude protein content)	Grains from wheat (*T. aestivum*)
By-product from maize processing. Unlike the gluten meal, its protein content is lower, of about 25% crude protein content	Grains from maize (*Zea mays*)
Also known as 'beet pulp', is the remaining material after the juice extraction for sugar production from the sugar beet (*Beta vulgaris*)	Grains from barley (*H. vulgare*)
By-product from the sugarcane sugar extraction	Grains from millet (e.g. *P. glaucum*, *E. coracana* and *P. miliaceum*)
'Dry' by-products of grain industries such as brans, middlings, etc.	Grains from rice (*Oryza sp.*)
Wet' by-products of grain industries such as biofuels, distilleries, breweries, etc.	Grains from sorghum (*Sorghum sp.*)
Concentrates	Beans from soy (*Glicyne max*)
Concentrate feed from feed mills	Seeds from rape (*B. napus*)
	Oil extracted from soybeans (*Glicyne max*)
	By-product from soy (*Glycine max*) oil production, commonly referred to as 'soy cakes' or 'soybean meal'
	By-product from cottonseeds (*Gossypium sp.*) oil production, commonly referred to as 'cottonseeds cakes
	By-products from rape oil production, commonly referred to as 'canola cakes'
	By-products from the production of kernel palm oil (*E. guineensis*), commonly referred to as 'kernel cake'
	By-product (cakes, meals) from oil production other than soy, cottonseed, rapeseed or palm oil
	By-products from the fish industries e.g. fishmeal
	By-product from the sugarcane sugar extraction e.g. molasses
	'Dry' by-products of grain industries such as brans, middlings, etc.
	'Wet' by-products of grain industries such as biofuels, distilleries, breweries, etc.
	Synthetic additives such as amino-acids or minerals
	Limestone used as source of calcium (laying hens)

Manure management module

Enter the required data in the manure module for their % share in the total both for baseline and the scenario(s). Note that the total should be 100% (Figure 10). Click 'next' to display the results.

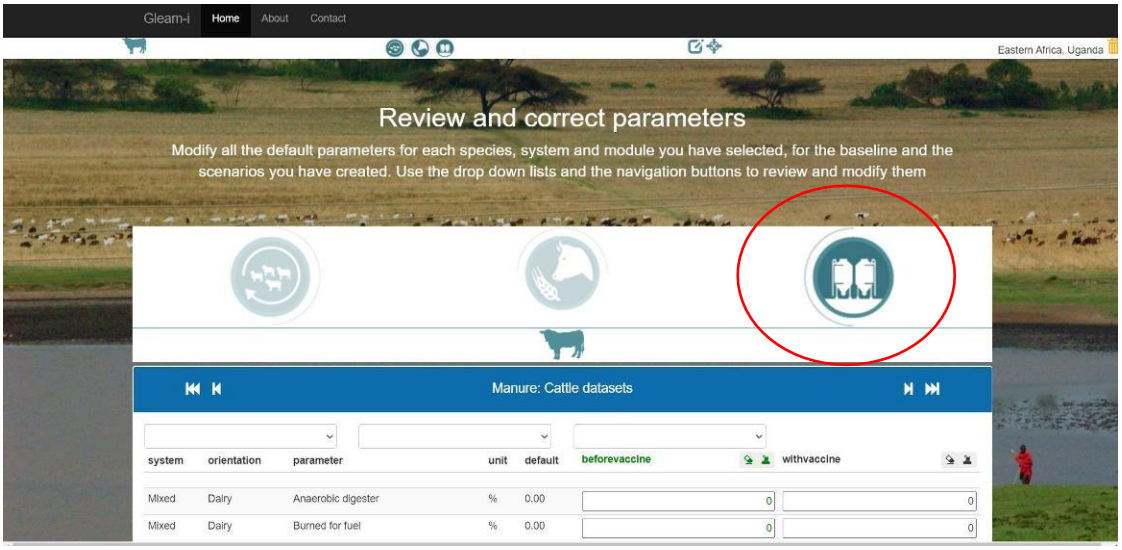

FIGURE 10. Data entry in the manure management module

Table 7 below shows the manure management systems in the tool, following the Intergovernmental Panel on Climate Change (IPCC) guidelines (IPCC, 2006).

TABLE 7. Manure management systems

SYSTEM	IPCC DEFINITION
Anaerobic digester	Animal excreta with or without straw collected and anaerobically digested in a large containment vessel or covered lagoon
Burned for fuel (*in cattle*)	The dung and urine are excreted in the field. The sun-dried dung cakes are burned for fuel
Composting (*in cattle*)	Composting in an enclosed channel with forced aeration and continuous mixing (in vessel), in piles with forced aeration but no mixing (static pile), in windrows with regular (at least daily) turning for mixing and aeration (intensive windrow), and in windrows with infrequent turning for mixing and aeration (passive windrow)
Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically
Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year
Pasture/Range/Paddock	The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed
Pit storage (*in pigs and chicken*)	Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year
Short pit storage (less than 1 month) (*in pigs*)	Pit storage – less than one month
Poultry manure with litter (*in chicken*)	Similar to cattle and swine deep bedding except usually not combined with a dry lot or pasture
Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks
Uncovered anaerobic lagoon	A type of liquid storage system designed and operated to combine waste stabilization and storage

9. RESULTS

Results are reported in three main sections. First section displays total figures on (i) Absolute GHG emissions; (ii) protein production; and (iii) feed intake (Figure 11).

FIGURE 11. Results section showing the total figures

Second part is where the main graphs are shows. The first three bar charts report the emissions intensity, protein production and total emissions. It is important to note here that the scale of baseline and scenario may be different to that of the default. The box representing the default may be clicked to remove it from the comparisons. The next two bar charts illustrate the breakdown of emissions by GHG. Finally, the last two bar charts show the breakdown of emissions by source and the sources of feed, respectively (Figure 12).

FIGURE 12. Results section showing the main graphs

Finally, the raw results display the breakdown of emissions, emissions intensity (i.e. emissions per kg protein), as well as the sources of emissions more in detail. The changes in the scenario(s) compared to the baseline are shown in the column called "delta" where orange colour refers to a position change (i.e. an increase in the scenario compared to the baseline); and blue colour refers to a negative change (i.e. a reduction in the scenario compared to the baseline). Note that the raw results can be saved as CSV file, which can be used with most spreadsheet programs or copied directly using the 'copy' function and pasted in a desired type of document (Figure 13).

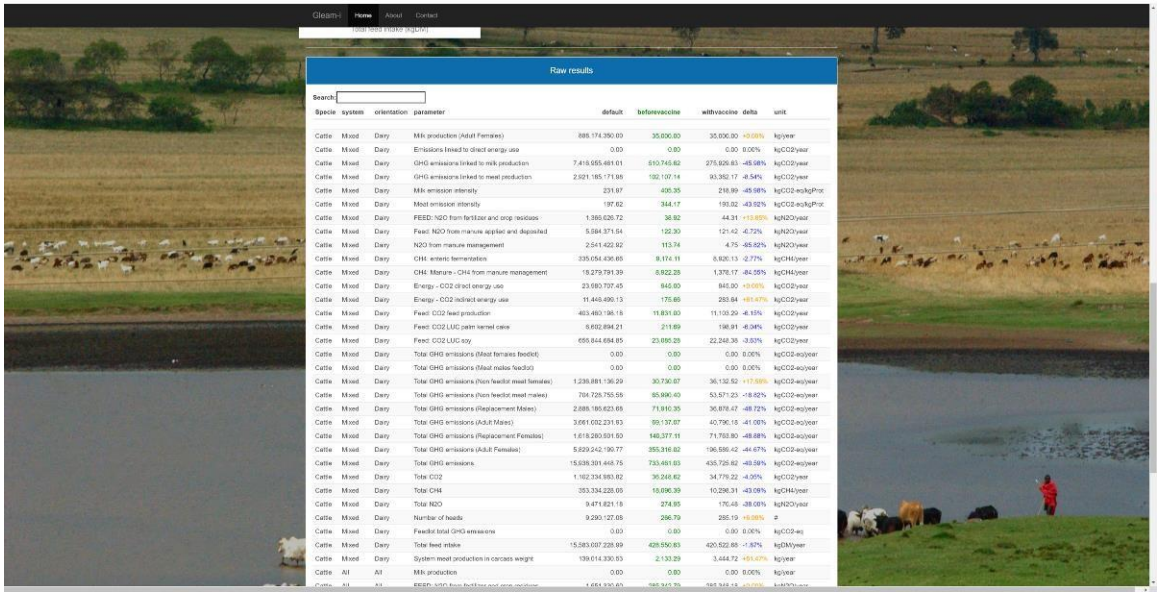

FIGURE 13. Results section showing the raw results

10. ICONS

The icons below appear (in an order) in the navigation bar and the top part of the screen and additional icons elsewhere in the tool. See Figure 14 and Figure 15 for their meaning. Note that the three boxes above the column headings in Figure 15 are useful when there is more than one production system (the box on the left), orientation (the box in the middle), and animal cohort (the box on the right).

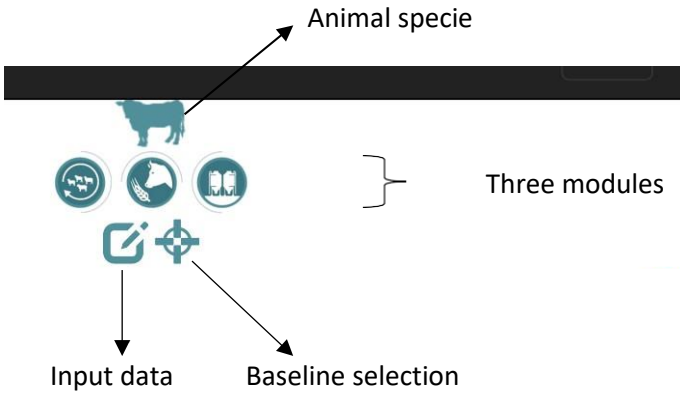

FIGURE 14. Icons on the navigation bar

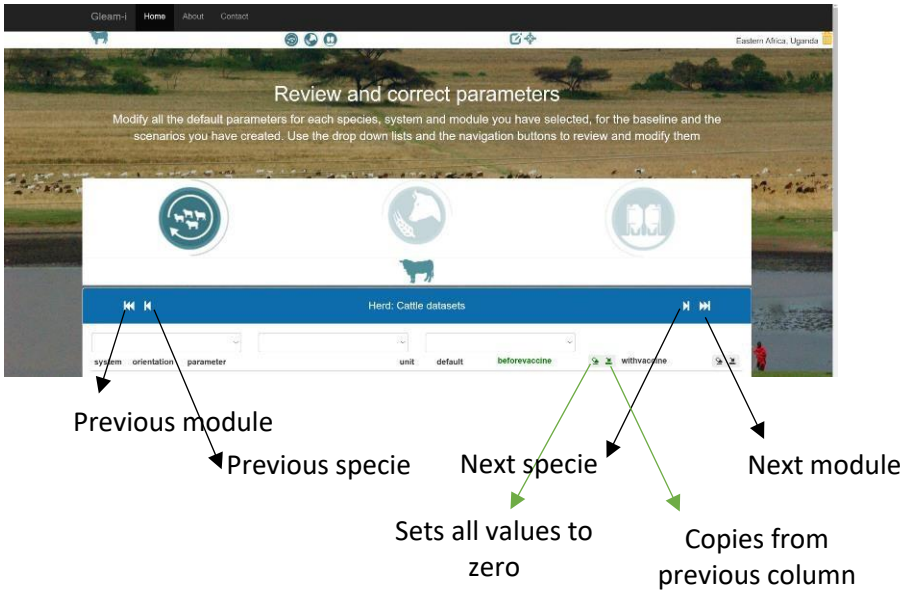

FIGURE 15. Additional icons

In the next two sections, the users are provided with the data required to run the tool for a grassland-based cattle production system with meat orientation in Brazil, and for an industrial pig production system with meat orientation in Germany.

DATA FOR PRACTICE EXERCISE WITH CATTLE

Region: Latin America and the Caribbean
Country: Brazil
Animal specie: Cattle
Production system: Grassland
Orientation: Meat
Selection of parameters: All parameters except for production and feedlot (herd), adult females and meat animals (feed), manure management (manure)
Baseline name: BRbaseline
Scenario names: management, breeding

The following tables present the data that should be inputted by the users in the herd (Table 8), feed (Table 9) and manure (Table 10) modules, respectively. See the supplementary material for the results.

TABLE 8. Herd data for practice exercise with cattle

PARAMETER	UNIT	BRBASELINE	MANAGEMENT	BREEDING
Age at first parturition	month	40	35	32
Death rate of adult animals	%	15	10	10
Death rate of young females and males	%	12	5	5
Fertility rate of adult females	%	70	75	80
Live weight of adult females	kg	400	500	550
Live weight of adult males	kg	600	700	750
Live weight of meat females at slaughter	kg	380	450	470
Live weight at of meat males at slaughter	kg	400	500	550
Number of adult reproductive females	number	2000	1500	1200
Number of adult reproductive males	number	70	30	10
Replacement rate of adult females	%	20	15	15
Weight at birth	kg	30	35	38

TABLE 9. Feed data for practice exercise with cattle

PARAMETER	UNIT	BRBASELINE	MANAGEMENT	BREEDING
By products from soy (adult females)	%	20	10	5
By products from soy (meat animals)	%	15	10	2
Crop residues from maize (adult females)	%	30	20	15
Crop residues from maize (meat animals)	%	45	15	10
Fresh grass (adult females)	%	10	50	50
Fresh grass (meat animals)	%	10	40	60
Grains (adult females)	%	5	15	20
Grains (meat animals)	%	2	10	15
Hay or silage from cultivated grass (adult females)	%	25	2	0
Hay or silage from cultivated grass (meat animals)	%	20	5	3
Wet byproducts grain industries (adult females)	%	10	3	10
Wet byproducts grain industries (meat animals)	%	8	20	10

TABLE 10. Manure data for practice exercise with cattle

PARAMETER	UNIT	BRBASELINE	MANAGEMENT	BREEDING
Anaerobic digester	%	0	50	0
Dry lot	%	0	0	50
Liquid/slurry	%	80	0	0
Pasture/range/paddock	%	20	50	0
Solid storage	%	0	0	50

DATA FOR PRACTICE EXERCISE WITH PIGS

Region: Western Europe
Country: Germany
Animal specie: Pigs
Production system: Industrial
Orientation: Meat
Selection of parameters: All parameters except for production and feedlot (herd), pigs industrial feed group (feed), manure management (manure)
Baseline name: GEbaseline
Scenario name: improved

The following tables present the data that should be inputted by the users in the herd (Table 11), feed (Table 12) and manure (Table 13) modules, respectively. See the supplementary material for the results.

TABLE 11. Herd data for practice exercise with pigs

PARAMETER	UNIT	GEBASELINE	IMPROVED
Daily weight gain of fattening animals	kg/day	0.7	0.9
Days between parturition and next pregnancy	day	30	20
Death rate of adult animals	%	7	2
Death rate of young females	%	12	5
Fertility rate of adult females	number/year	2	2.8
Litter size	number	10	12
Live weight of adult females	kg	190	230
Live weight of adult males	kg	230	280
Live weight of animals at slaughter	kg	110	130
Mortality of fattening animals	%	5	3
Mortality rate of weaned piglets	%	5	2
Number of adult reproductive females	number	1200	1000
Number of adult reproductive males	number	40	20
Replacement rate of adult females	%	50	30
Replacement rate of adult males	%	80	80
Weaning age	day	30	25
Weight at birth	kg	1.3	1.5
Weight of weaned piglets	kg	7	9

TABLE 12. Feed data for practice exercise with pigs

PARAMETER	UNIT	GEBASELINE	IMPROVED
By-products from oil production other than soy, cottonseed	%	15	10
By-products from soy	%	30	10
Dry by-products from grain industries	%	15	10
Grains from maize	%	20	40
Grains from wheat	%	10	15
Wet by-products from grain industries	%	10	15

TABLE 13. Manure data for practice exercise with pigs

PARAMETER	UNIT	GEBASELINE	IMPROVED
Anaerobic digester	%	0	50
Pit storage	%	100	0
Short pit storage	%	0	50

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SUPPLEMENTARY MATERIAL: RESULTS OF THE PRACTICE EXERCISES

Tables below present the results (selected and refined for brevity) of the two practice exercises with cattle (Table S1) and pigs (Table S2). Blue colour refers to a positive change and orange colour refers to a negative change in the scenario(s) compared to the baseline.

TABLE S1. Results of the exercise with cattle (grassland-based)

PARAMETER	BRBASELINE	MANAGEMENT	DELTA	BREEDING	DELTA	UNIT
CH_4 from enteric fermentation	226,721	210,315	-7.24%	157,762	-30.42%	kg CH_4/year
CH_4 from manure management	151,776	14,154	-90.67%	6,256	-95.88%	kg CH_4/year
Energy - CO_2 direct energy use	16,651	25,765	54.73%	24,440	46.77%	kg CO_2/year
Energy - CO_2 indirect energy use	17,502	27,082	54.73%	25,690	46.78%	kg CO_2/year
Feed: CO_2 feed production	1,972,431	1,846,010	-6.41%	1,382,393	-29.91%	kg CO_2/year
Feed: CO_2 LUC palm kernel cake	0.32	0.18	-43.43%	0.12	-61.36%	kg CO_2/year
Feed: CO_2 LUC soy	4,607,779	2,879,015	-37.52%	823,896	-82.12%	kg CO_2/year
Feed: N_2O from fertilizer and crop residues	1,752	1,665	-4.95%	1,226	-30.02%	kg N_2O/year
Feed: N_2O from manure applied and deposited	2,643	5,968	125.83%	5,122	93.80%	kg N_2O/year
Feedlot total GHG emissions	72,895	86,889	19.20%	66,964	-8.14%	kg CO_2e
GHG emissions linked to meat production	21,631,413	14,623,143	-32.40%	10,723,092	-50.43%	kg CO_2/year
Meat emission intensity	1,082	469	-56.64%	362	-66.53%	kg CO_2e/kg protein
N_2O from manure management	3,058	84	-97.23%	3,574	16.88%	kg N_2O/year
Number of heads	5,257	4,031	-23.31%	3,146	-40.15%	number
System meat production in carcass weight	126,148	198,871	57.65%	188,946	49.78%	kg/year
Total CH_4	378,498	224,470	-40.69%	164,018	-56.67%	kg CH_4/year
Total CO_2	6,614,365	4,777,874	-27.77%	2,256,419	-65.89%	kg CO_2/year
Total feed intake	10,484,734	9,845,978	-6.09%	7,397,049	-29.45%	kg DM/year
Total GHG emissions	21,704,396	14,710,062	-32.23%	10,790,067	-50.29%	kg CO_2e/year
Total GHG emissions (Adult females)	11,023,836	7,114,667	-35.46%	5,117,050	-53.58%	kg CO_2e/year
Total GHG emissions (Adult males)	367,011	132,284	-63.96%	42,751	-88.35%	kg CO_2e/year
Total GHG emissions (Meat males feedlot)	72,895	57,445	-21.19%	44,307	-39.22%	kg CO_2e/year
Total GHG emissions (Non-feedlot meat males)	4,417,384	3,375,716	-23.58%	2,548,451	-42.31%	kg CO_2e/year
Total GHG emissions (Replacement Females)	5,450,954	2,134,846	-60.84%	1,661,589	-69.52%	kg CO_2e/year
Total GHG emissions (Replacement Males)	372,314	119,314	-67.95%	39,989	-89.26%	kg CO_2e/year
Total N_2O	7,453	7,718	3.56%	9,922	33.13%	kg N_2O/year

TABLE S2. Results of the exercise with pigs (industrial)

PARAMETER	GEBASELINE	IMPROVED	DELTA	UNIT
CH_4 from enteric fermentation	14,023	18,847	34.40%	kg CH_4/year
CH_4 from manure management	109,870	56,773	-48.33%	kg CH_4/year
Feed: CO_2 feed production	3,473,559	3,584,290	3.19%	kg CO_2/year
FEED: N_2O from fertilizer and crop residues	6,063	5,973	-1.47%	kg N_2O/year
Feed: N_2O from manure applied and deposited	861	848	-1.47%	kg N_2O/year
GHG emissions linked to meat production	10,195,070	7,917,764	-22.34%	kg CO_2/year
Meat emission intensity	37	17	-52.96%	kg CO_2e/kg protein
N_2O from manure management	3,096	1,243	-59.86%	kg N_2O/year
Number of heads	11,486	13,873	20.78%	number
System meat production in carcass weight	2,104,011	3,473,846	65.11%	kg/year
Total CH_4	109,870	56,773	-48.33%	kg CH_4/year
Total CO_2	3,473,559	3,584,290	3.19%	kg CO_2/year
Total feed intake	8,640,871	12,290,942	42.24%	kg DM/year
Total GHG emissions	10,195,070	7,917,764	-22.34%	kg CO_2e/year
Total N_2O	10,020	8,064	-19.52%	kg N_2O/year