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SUPREMA GLOBIOM-MAGNET Training

December 4, 2020

GLOBIOM
Model structure, equations & variables

Center for Environmental Resources & Development, Presenter: Stefan Frank

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suprema

Model file structure

File structure model folder:

- 1_loaddata: Loading data
- 2_activesets: Data aggregation
- 3_precompute: Final data compilation
- 3b_calibtrade: Calibration of trade
- 4_model: Model & base year calibration
- 5_precompute_scen: Compilation scenario data
- 6_scenarios: Scenario implementation
- 7_output: Output reporting

```
***
* =====================
* GLOBIOM EXECUTION FILE
* =====================
* Top-level script of the GLOBIOM model. It executes the numbered stages of
* the model in-sequence, passing the output of a stage as input to the
* next stage via the filesystem (``.g00`` files in the ``Model/t`` directory).
*
* This allows the model to be re-run quickly after modifying a stage by
* commenting out the execute statements of prior stages: since these will not
* produce modified output, their existing output files can be re-used.
*
* After running this script, check that all files compiled and executed
* without error by opening ``0_executebatch.log`` and searching for occurrences
* of "error" and "infeasible". These should be absent.
****

$set env ide=%gams.ide% lo=%gams.lo% errorlog=%gams.errorlog% errmsg=1 pw=130 cerr=5

$setLocal X %system.dirSep%
execute "gams 1_loaddata.gms          %env%                        -s .%X%t%X%a1_v1                      ";
execute "gams 2_activesets.gms        %env% -r .%X%t%X%a1_v1       -s .%X%t%X%a2_v1  gdx=.%X%gdx%X%a2_v1 ";
execute "gams 3_precompute.gms        %env% -r .%X%t%X%a2_v1       -s .%X%t%X%a3_v1  gdx=.%X%gdx%X%a3_v1 ";
execute "gams 3b_calibtrade.gms       %env% -r .%X%t%X%a3_v1       -s .%X%t%X%a3b_v1 gdx=.%X%gdx%X%a3b_v1";
execute "gams 4_model.gms             %env% -r .%X%t%X%a3b_v1      -s .%X%t%X%a4_v1  gdx=.%X%gdx%X%a4_v1 ";

*execute "gams 5_precompute_scen.gms  %env% -r .%X%t%X%a4_v1       -s .%X%t%X%a5_v1  gdx=.%X%gdx%X%a5_v1";

* Identifier of the output file
$set output_name Baseline_may18_adj

execute "gams 6_scenarios.gms         %env% -r .%X%t%X%a4_v1       -s .%X%t%X%a6_v1_test  gdx=.%X%gdx%X%a6_v1_test";

*execute "gams 7_output.gms  %env%  -r .%X%t%X%a6_v1  //CSV=1 //lab=%output_name%";

***
* Arguments for ``7_output.gms``:
*   - ``//CSV=1`` for production of a CSV file using GDXVIEWER.

* Use this command to convert a .g00 into .gdx
*execute "gams blank.gms              %env% -r .%X%t%X%a6_v1 gdx=.%X%gdx%X%a6_v1  FW=1"
```

Overview of key GLOBIOM equations

Objective equation
- Maximizing global producer + consumer surplus for agriculture and forestry

Linearization and convexity equations:
- Stepwise linearization of non-linear functions e.g. demand functions
- Non-linear variable <= weighted sum of closest fixed points

Balance equations:
- Market balance: Supply >= demand
- Land balance: New land use >= previous land use + land expansion
- Resource constraints: Water available >= water use
- …

Inertia equations:
- Crop new >= crop area previous * maxcrop_coef
- Animal number >= animal number previous * lstick_coef
- …

Accounting equations:
- GHG Emissions = Activity Level * GHG Emissions Coefficient

Objective equation

Maximizing global consumer and producer surplus:

+ Demand function integral

- Costs crop production

- Costs dedicated energy crops

- Costs forest harvesting

- Forest industry investment cost

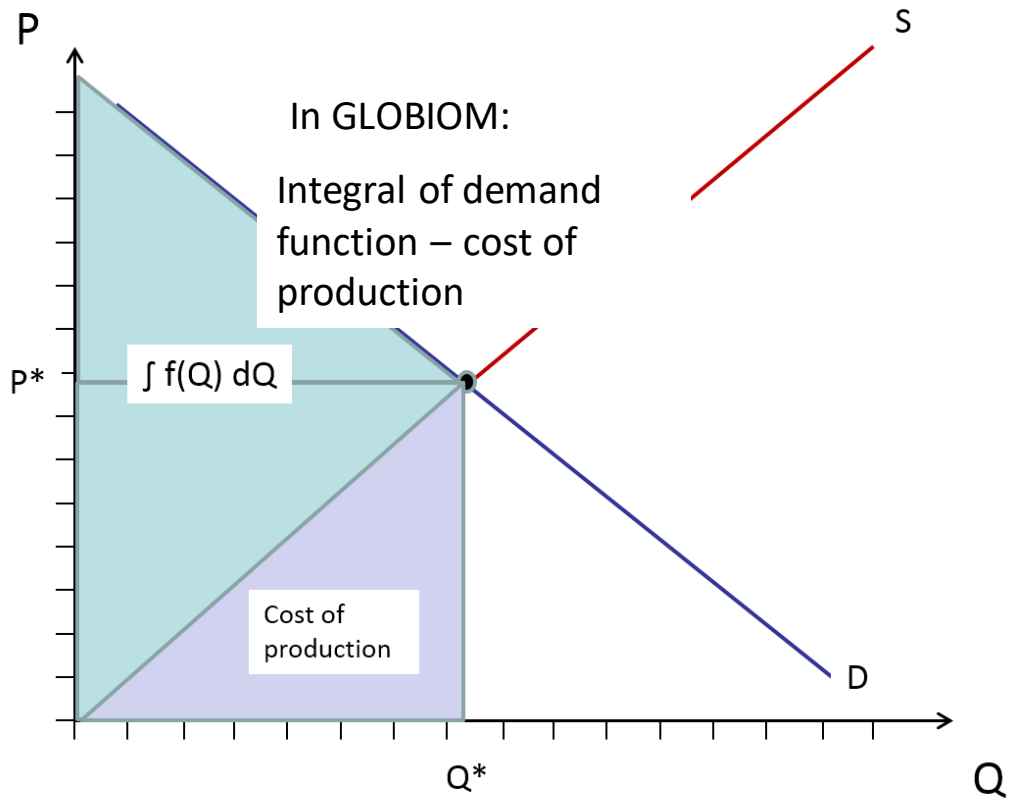
- Processing costs

- Land use change costs

- Resource supply costs

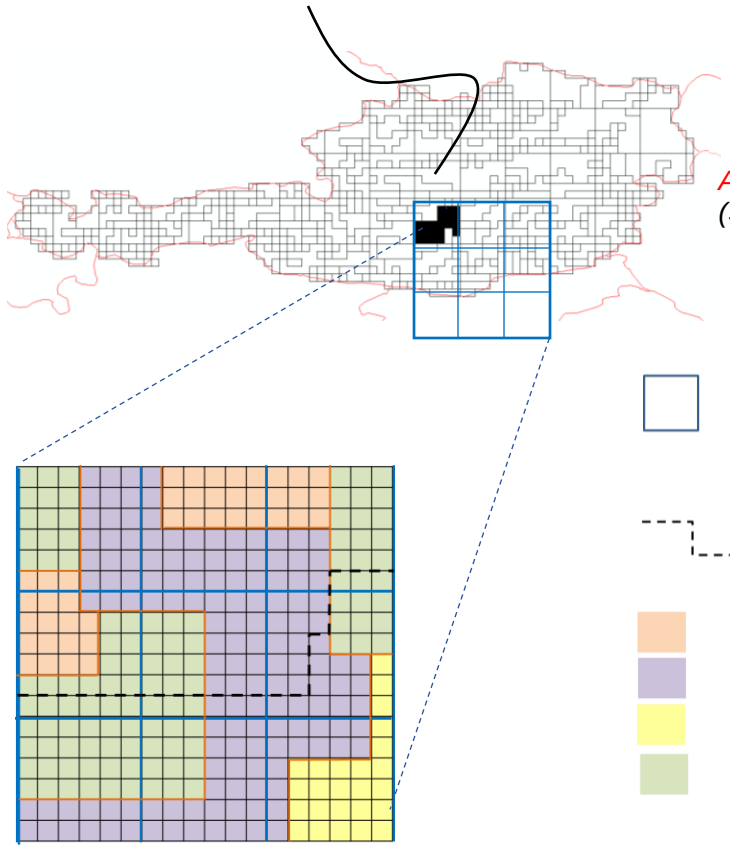
- Trade costs

-/+ Calibration costs/subsidies



Spatial resolution – Simulation Units

1 Simulation Unit (SimU)



Austria
(356 Simulation Units)

Gridded representation of world land use

Global scale
(> 200 k Simulation Units)

Simulation unit

=

A cluster of 5' pixels (contained within a 30' pixel) belonging to the same country and with similar altitude, slope and soil

Crop production

18 crops in 4 management systems

- Barl, BeaD, Cass, ChkP, Corn, Cott, Gnut, Mill, OPAL, Pota, Rape, Rice, Soya, Srgh, SugC, Sunf, SwPo, Whea
- SS - subsistence, LI – low input, HI – high input,
  IR – high input & irrigation (4 sub-systems: Basin, Furrow, Sprinkler and Drip)

Variables

- Crop area [1000 ha]

`CROP_VAR(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS,CROP,CROPTECH)`

Parameters

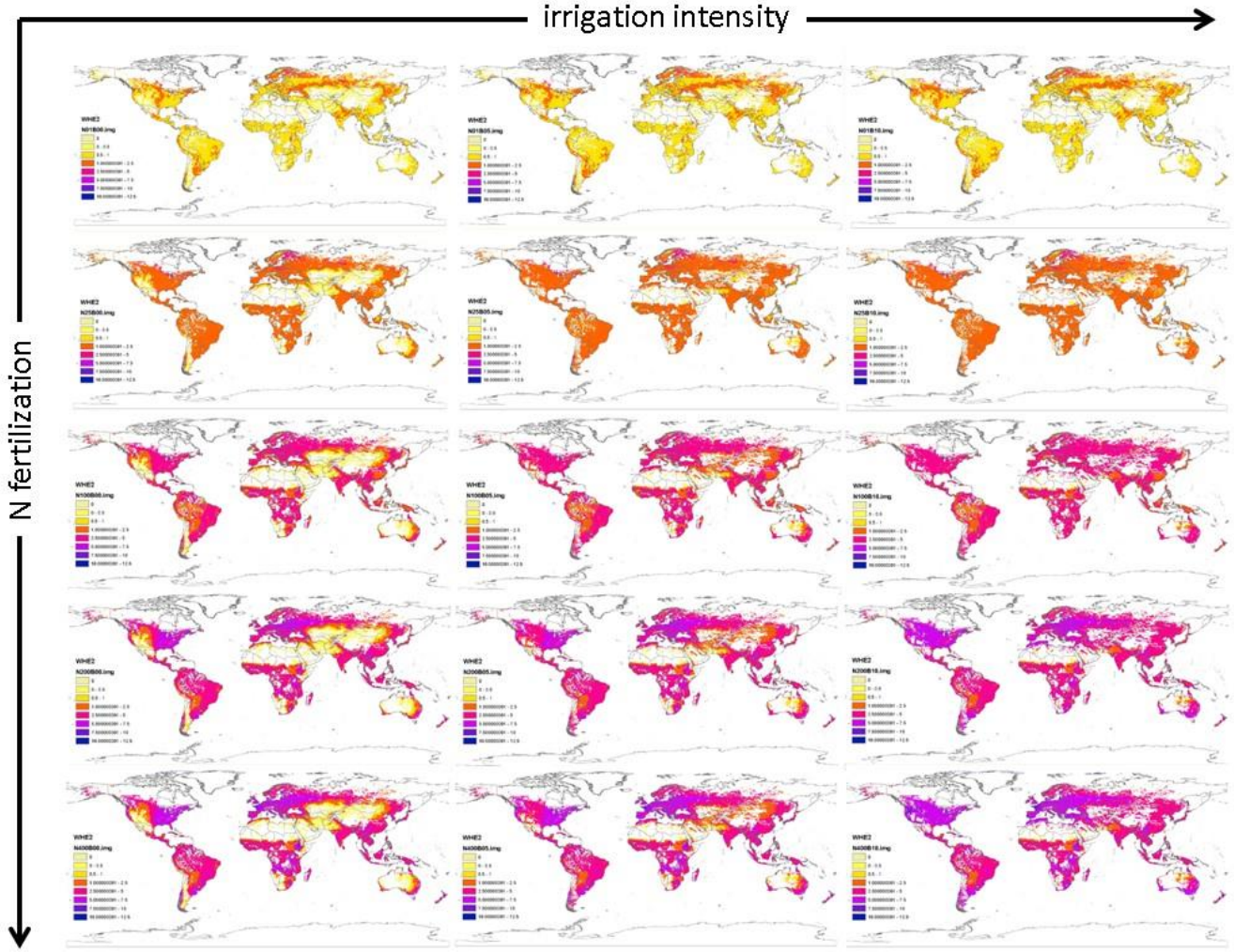
- Base area, yield, cost, N/P requirements, GHG coefficients

`CROP_DATA(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS,CROP,CROPTECH,ALLITEM)`

Equations

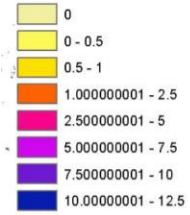
- Balance equations: matching physical crop areas with total available cropland
- Inertia equations: limiting maximum expansion of production systems or crops at SimU level

Crop production systems



Balkovic et al. (2014)

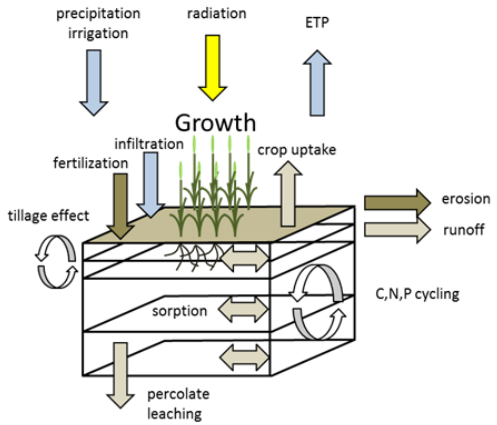
wheat yield [tDM/ha]



Spatially explicit production functions

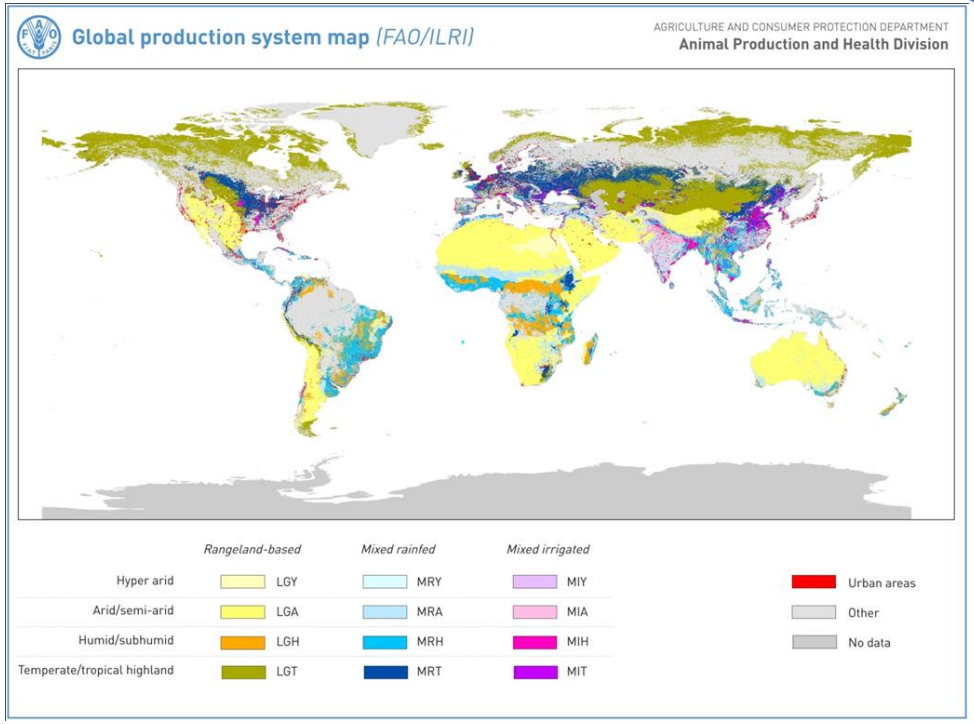
In every SimU:

- Up to 18 possible crops & 4 crop managements
- Parameters (yield, fertilizer and irrigation input requirement) estimated with biophysical models
  e.g., EPIC model (Izaurralde et al., 2006)



Livestock production systems

ANIMALS: 10 Animal types	LIVE_SYSTEM: 8 Production system
BOVO – Bovine meat herd BOVD – Bovine diary herd BOVF – Bovine followers SGTO – Sheep and goat meat herd SGTD – Sheep and goat dairy herd SGTF – Sheep and goat followers PIGS – Pigs PTRB – Broilers PTRH – Laying hens PTRX – Mixed	LGA – Grazing arid LGH – Grazing humid LGT – Grazing temperate MRA – Mixed arid MRH – Mixed humid MRT – Mixed temperate OTHER – Other system URBAN – Urban system



Variables

- Livestock numbers [1000 TLU]

`LIVE_VAR(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS,LIVE_SYSTEM,ANIMALS)`

Parameters

- Feed requirements, Milk and meat yield, GHG coefficients by production system and animal

`LIVE_DATA(COUNTRY,LIVE_SYSTEM,ANIMALS,AllITEM)`

Livestock production – Feed

Feed aggregates: Feed grains, Grass, Stover and Occasional

Feed grains: All 18 crops (9 different aggregates)

Variables

- Total livestock feed demand for grains at the regional level [1000 ton]

`FEEDQUANTITY(REGION,CROPS)`

- Utilized spatially explicit pasture area [1000 ha]

`GRAS_VAR(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS)`

Parameters

- Base area and productivities

`GRAS_DATA(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS,ALLITEM)`

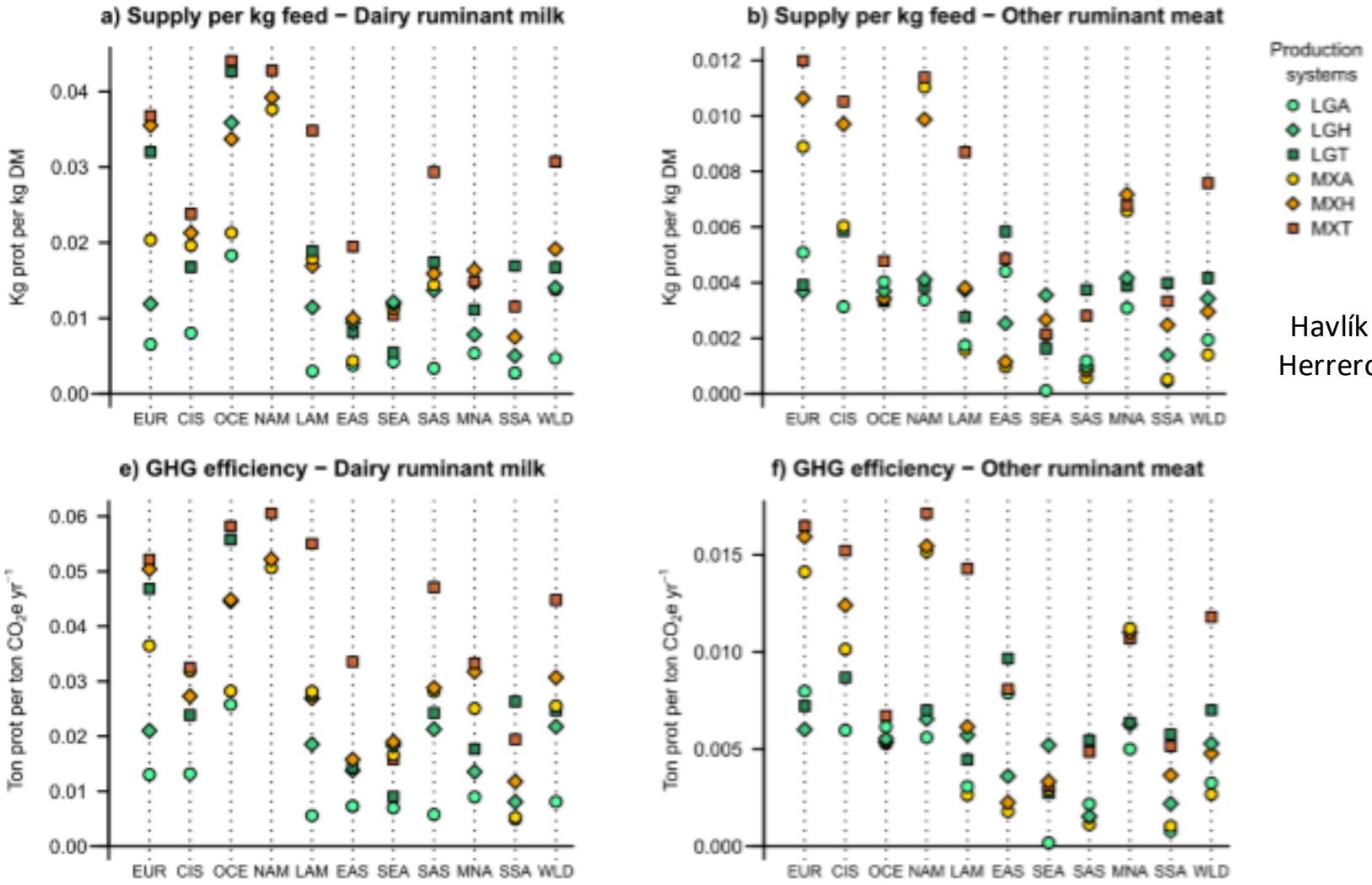
- Feed requirements, Milk and meat yield, GHG coefficients by production system and animal

`LIVE_DATA(COUNTRY,LIVE_SYSTEM,ANIMALS,AllITEM)`

Equations

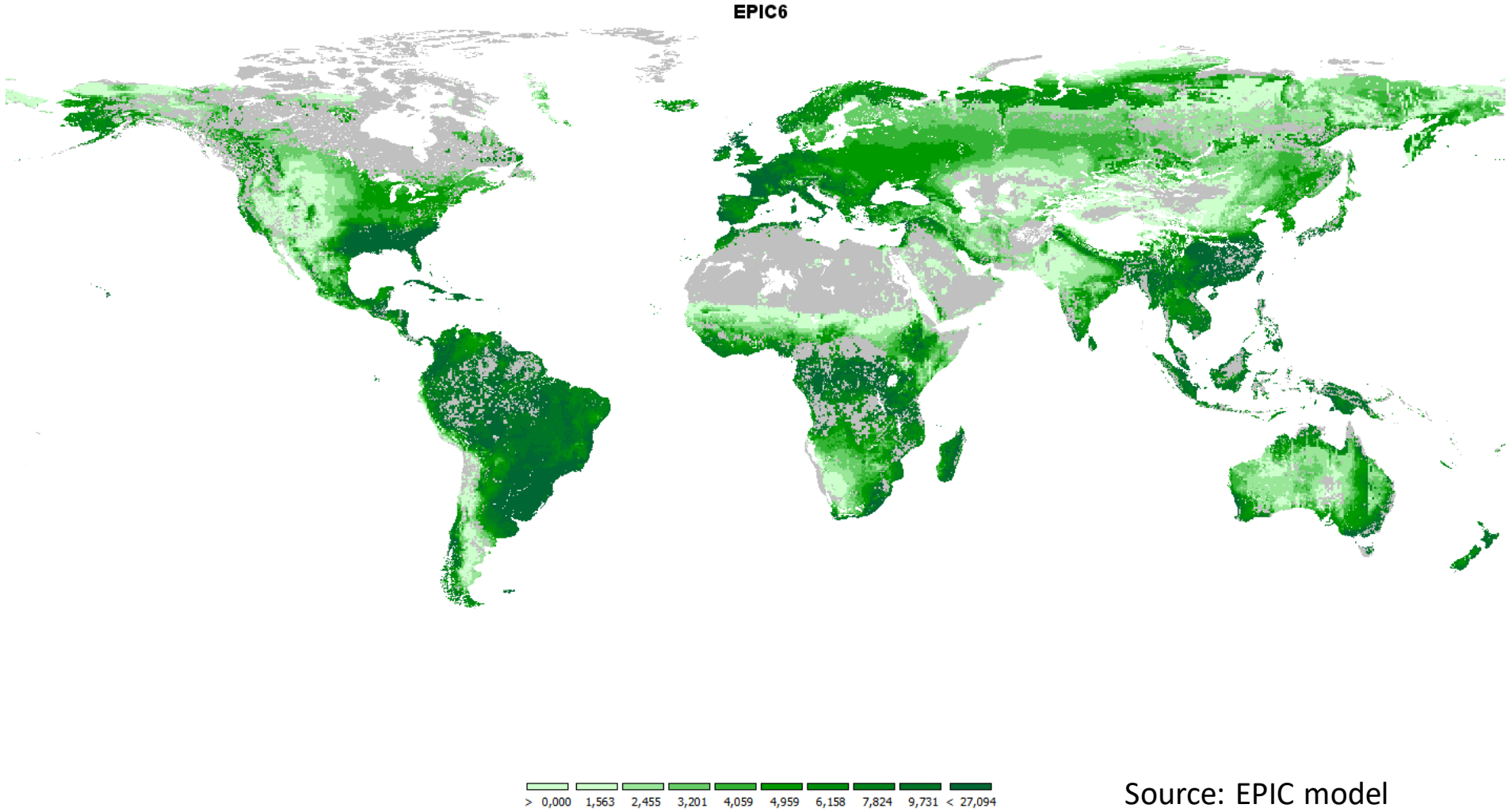
- Herd dynamics equations
- Feed equations
- Inertia equations

Livestock production systems



Havlík et al. 2014
Herrero et al. 2013

Grassland productivities



Source: EPIC model

Forest production – Biomass

Primary biomass types:

- Stemwood: sawlogs, pulplogs, other industrial round wood, fuelwood
- Logging residues: branches, stumps, and harvest losses

Variables

- Area of forest harvested during the rotation time [1000 ha]

`HARVEST_VAR(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS,ForMngType)`

- Harvested quantity of a particular biomass grade [1000 m3]

`SQUANTITY_FOREST(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS,FORMNGTYPE,PRODUCT)`

Parameters

- Mean annual increment, proportion of different types of biomass, carbon balance, harvest cost

`FOREST_DATA(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS,FORMNGTYPE,ALLITEM)`

Forest production – Industry

Industry products:

- 8 final products: sawnwood, plywood, fiberboard, mechanical and chemical pulp, other industrial roundwood, fuelwood, energy wood
- 5 by-products: sawdust, woodchips, bark, black liquor, recycled wood

Variables

- Quantity of processed primary product [1000 m3]

`PQUANTITY(REGION,PROCESS)`

- Processing capacity of main final products [1000 m3 or 1000 t]

`CAPACITY_VAR(REGION,PRODUCT)`

Parameters

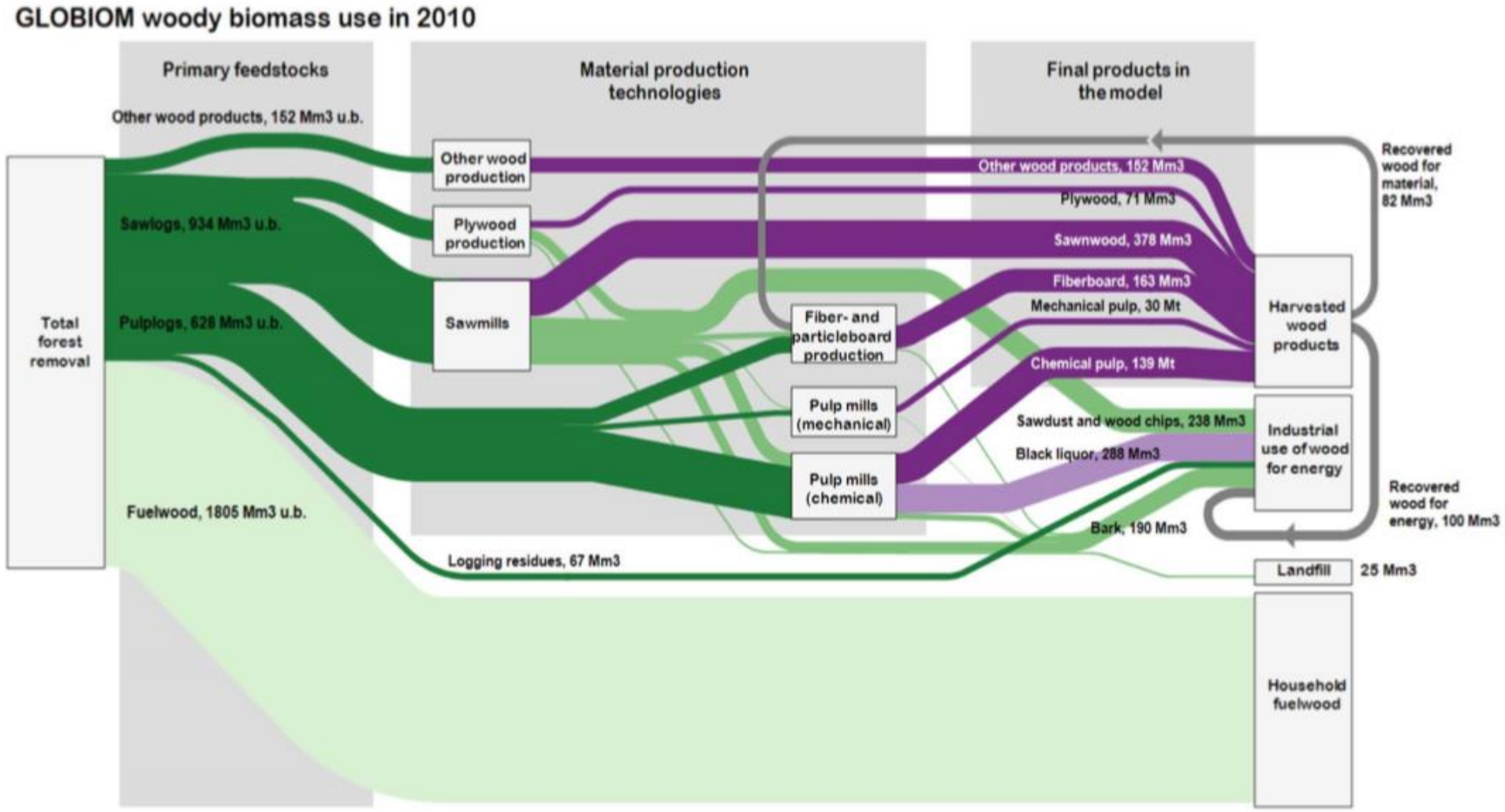
- Input-output relationships between primary and final products and processing cost

`PROCESSDATA(REGION,PROCESS,PRODUCT)`

Equations

- Harvesting equations: extraction of different biomass grades, logging residues, wood recycling etc.
- Forest industry equations: capacity constraints
- Land balance equation

Forest production and forest industries



Lauri et al. 2017

Natural resources – Land

Land cover types:

- Cropland, Grassland, Short rotation plantations, Managed forest, Unmanaged forest, Other natural vegetation

Variables

- Land cover/use area [1000 ha]

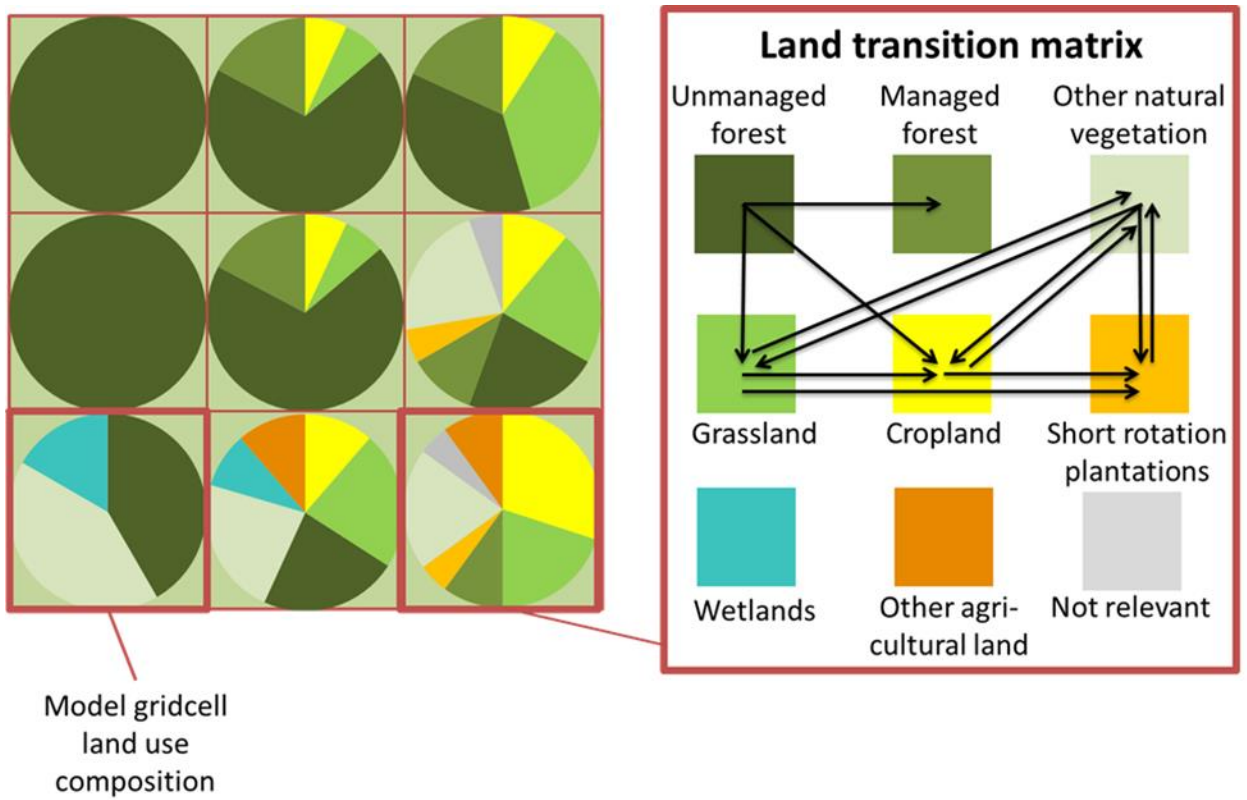
```
LANDAVAIL_VAR(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS,LC_TYPE)
```

- Land use change [1000 ha]

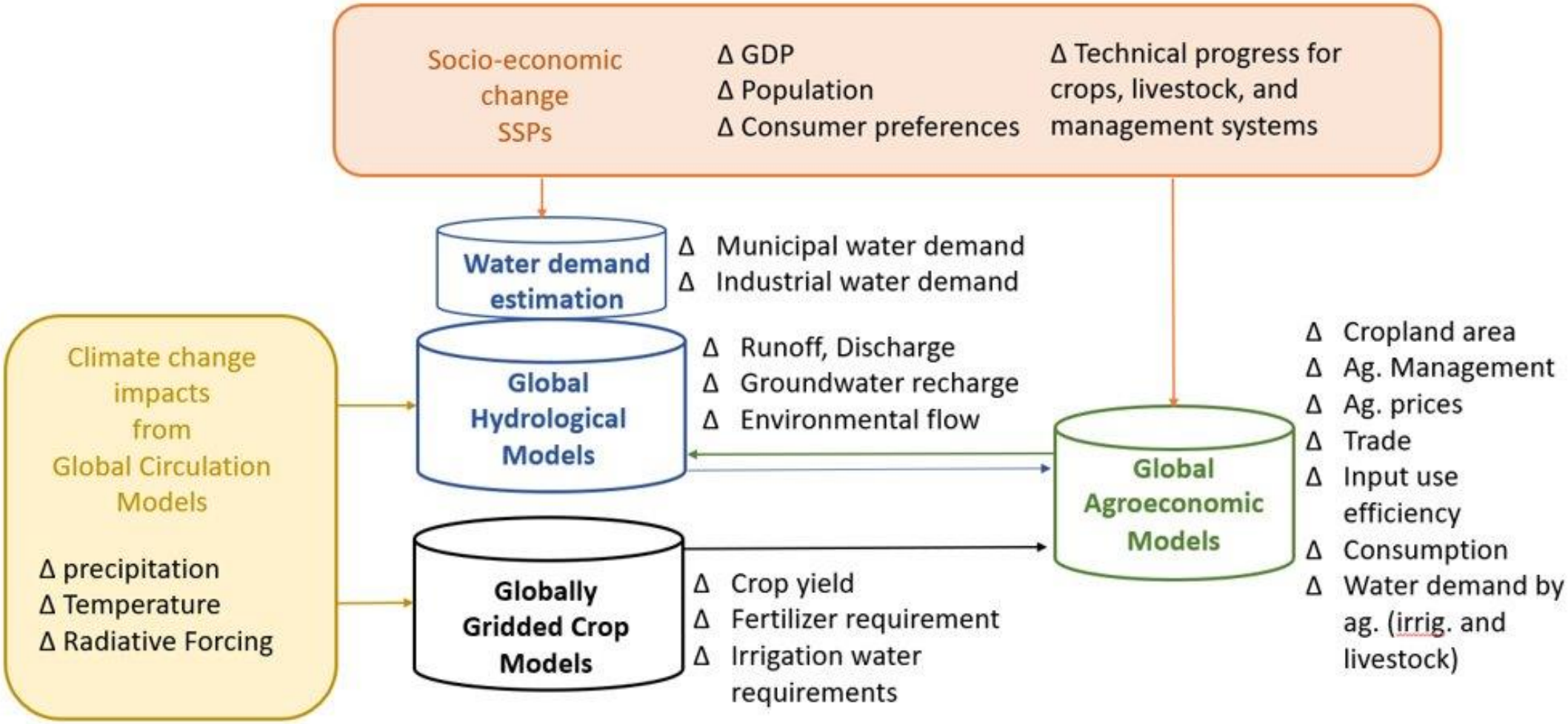
```
LUCDET_VAR(COUNTRY,ALLCOLROW,ALTICLASS,SLPCLASS,SOILCLASS,AEZCLASS,LC_INIT,LC_CRNT)
```

Land cover change

- Land cover change endogenous depending on profitability of different land use activities
- Conversion implies a conversion cost
- Max conversion rates can be capped to mimic policy/social constraints



Irrigation water use



Palazzo and Kahil (in preparation). Assessing global water resources embedded in agroeconomic systems.

GHG emissions accounting

Spatially explicit accounting of AFOLU GHG emissions at the SimU level. Link to G4M for detailed forest sector carbon dynamics

Variables

- AFOLU GHG emissions [Million tons CO2 equivalent]

`EMISSION_VAR(REGION,GHGACCOUNT)`

Sector	Source	GHG	Reference
Land use change	Deforestation	CO_2	Downscaled FRA 2005 (Kindermann et al. 2008)
	Conversion of other vegetation types	CO_2	Ruesch and Gibbs (2008)
	Soil carbon	CO_2	IPCC Tier 1 approach
Crops	Fertilizer use	N_2O	Requirements from EPIC/IFA, emission coefficients from IPCC
	Rice production	CH_4	IPCC Tier 1 approach
Livestock	Enteric fermentation	CH_4	RUMINANT model (Herrero et al. 2008)/IPCC
	Manure management	N_2O, CH_4	RUMINANT model (Herrero et al. 2008)/IPCC
	Manure dropped/applied	N_2O	RUMINANT model (Herrero et al. 2008)/IPCC

Additional GLOBIOM modules

- Food security and undernourishment
- Fisheries & aquaculture
- Nitrogen cycle
- Global water demand and link to hydrological models
- Biodiversity and link to ecosystem models
- Bioenergy and link to energy system models
- …

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For further information: www.globiom.org

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