GLOBIOM :
Vers une modélisation de l' élevage mondial par systèmes de production

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OUTLINE:

1. Model presentation

2. Illustrative application

X. Special features

Motivation

LIVESTOCK

   - complex sector itself

   - strongly connected to other sectors
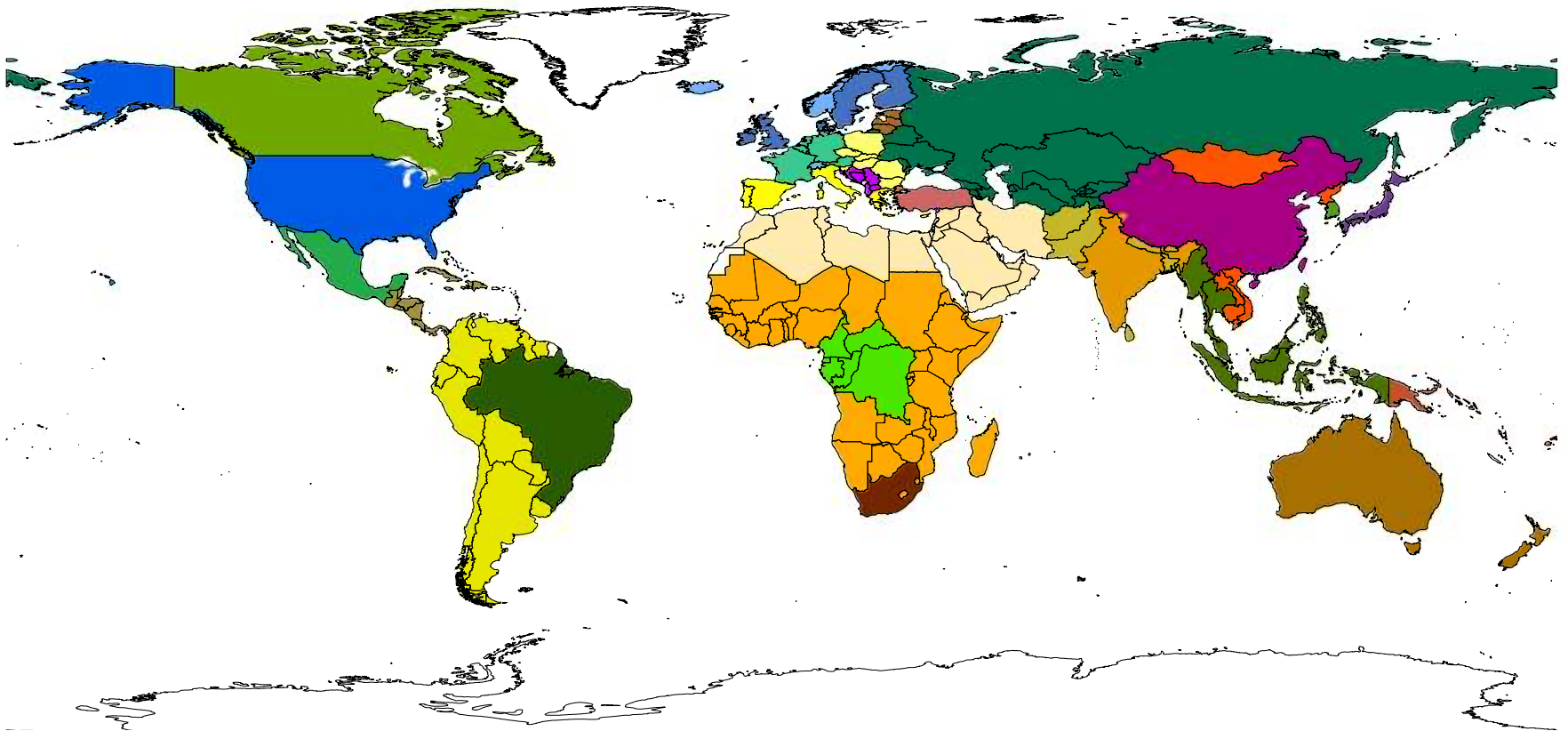
   and to the environment

An integrated modeling framework needed

   - detailed enough to capture local constraints

   and environmental effects

   - complete in sector and Earth coverage

   to capture "linkage and leakage"

I. GLOBIOM

Global Biosphere Management Model
Basic resolution: 28 regions

I. GLOBIOM

Partial equilibrium model (endogenous prices)

> **Agriculture:** major agricultural crops and livestock products

> **Forestry:** traditional forests for sawnwood, and pulp and paper production

> **Bioenergy:** conventional crops and dedicated forest plantations

Recursively dynamic (10 year periods)

Maximization of the social welfare (PS + CS)

Supply functions
> **implicit:**

> production system 1 (grass based) → productivity 1 + constant cost 1
> production system 2 (mixed) → productivity 2 + constant cost 2

Demand functions
> **explicit:** linearized non-linear functions $p = \hat{p} * (q / \hat{q})^{1/e}$

I. GLOBIOM

International trade:

Spatial equilibrium model
    Trade flows between individual regions (BACI database, CEPII)

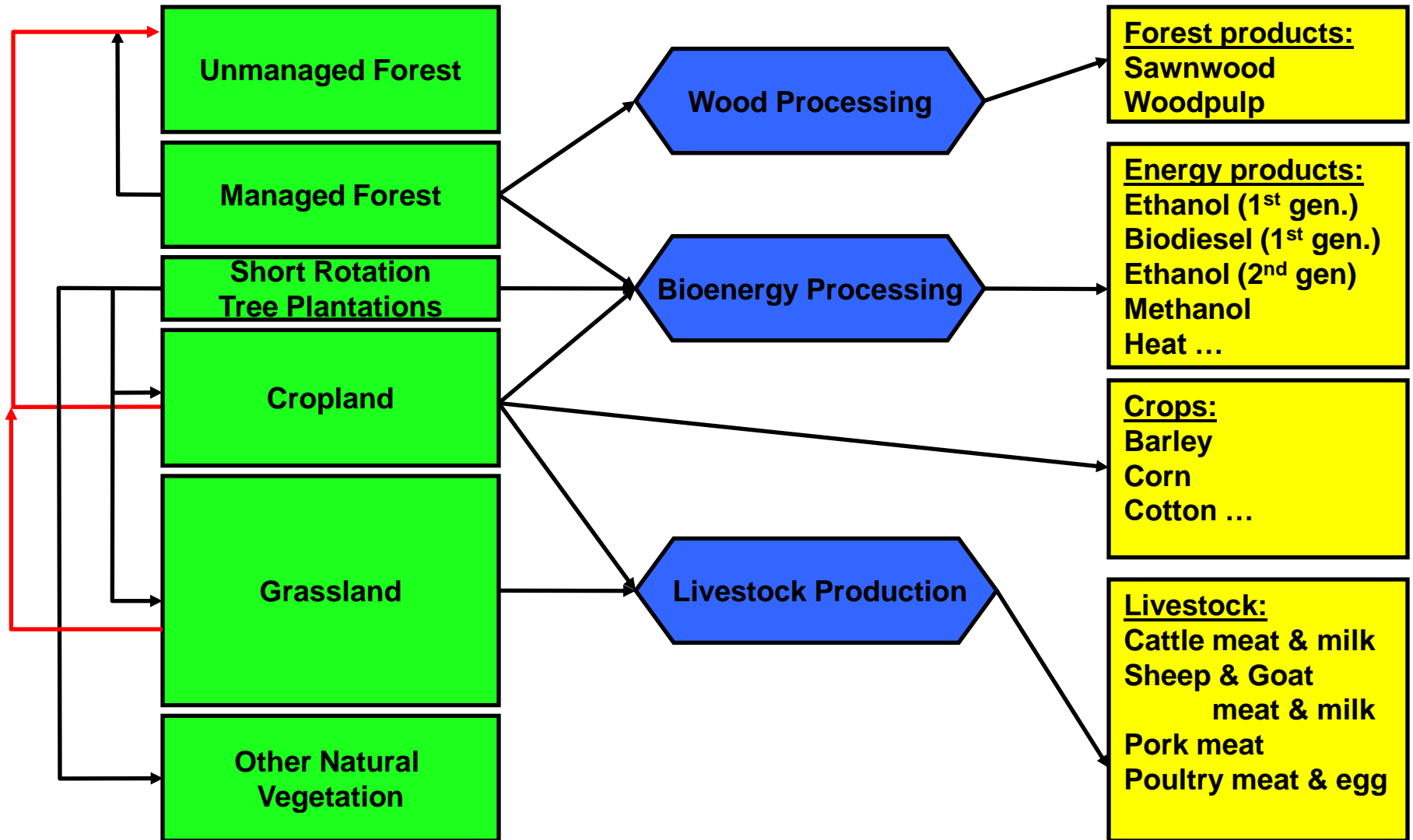**Homogeneous goods assumption**
    - Within a region imported and domestically produced goods are valued equally
         → no mutual trade
    - Differences in prices between regions are due to external trade costs

Trade costs
        Trade barriers (MacMap database, ITC/CEPII)
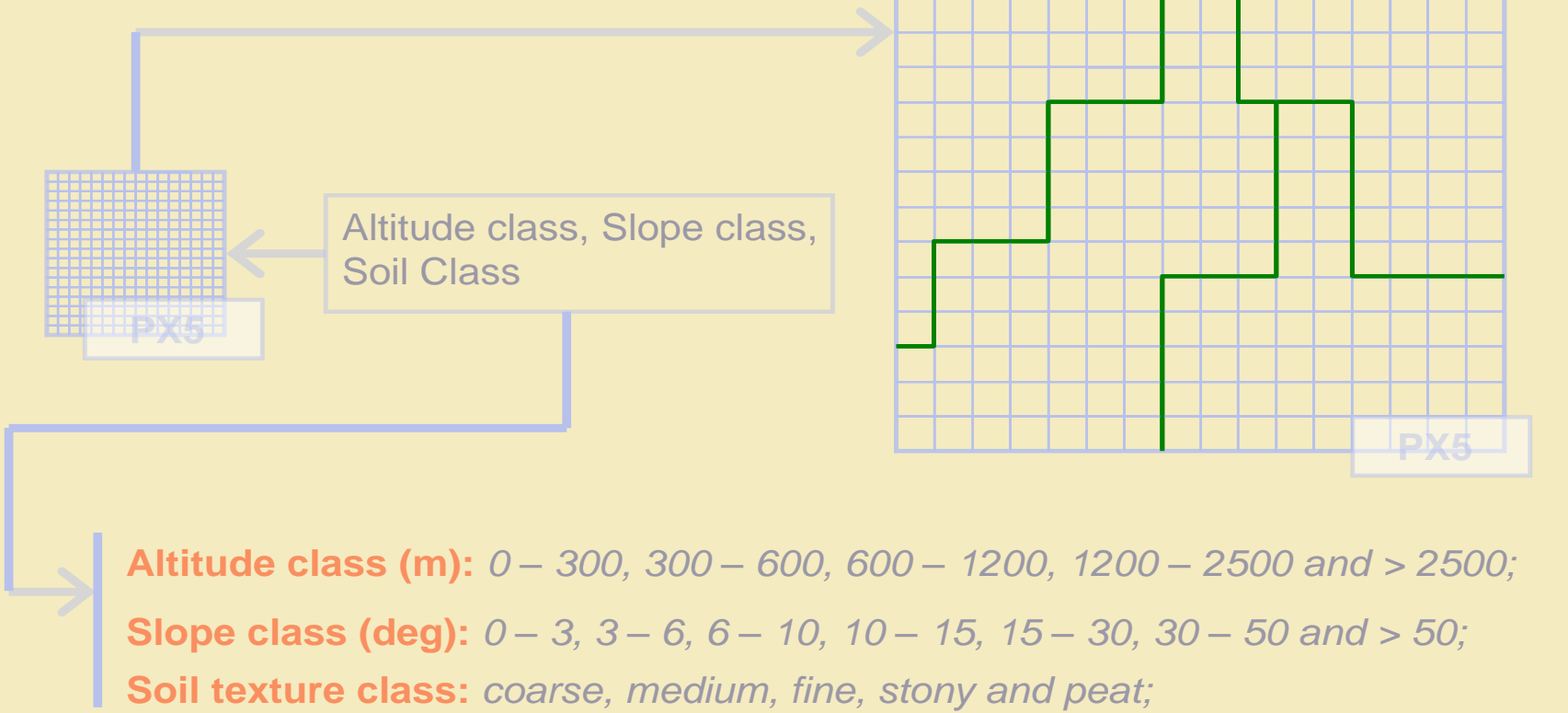   +   Transport cost (Hummels, 2001)
    +   Calibration

I. GLOBIOM: Supply chains

I. GLOBIOM: Land
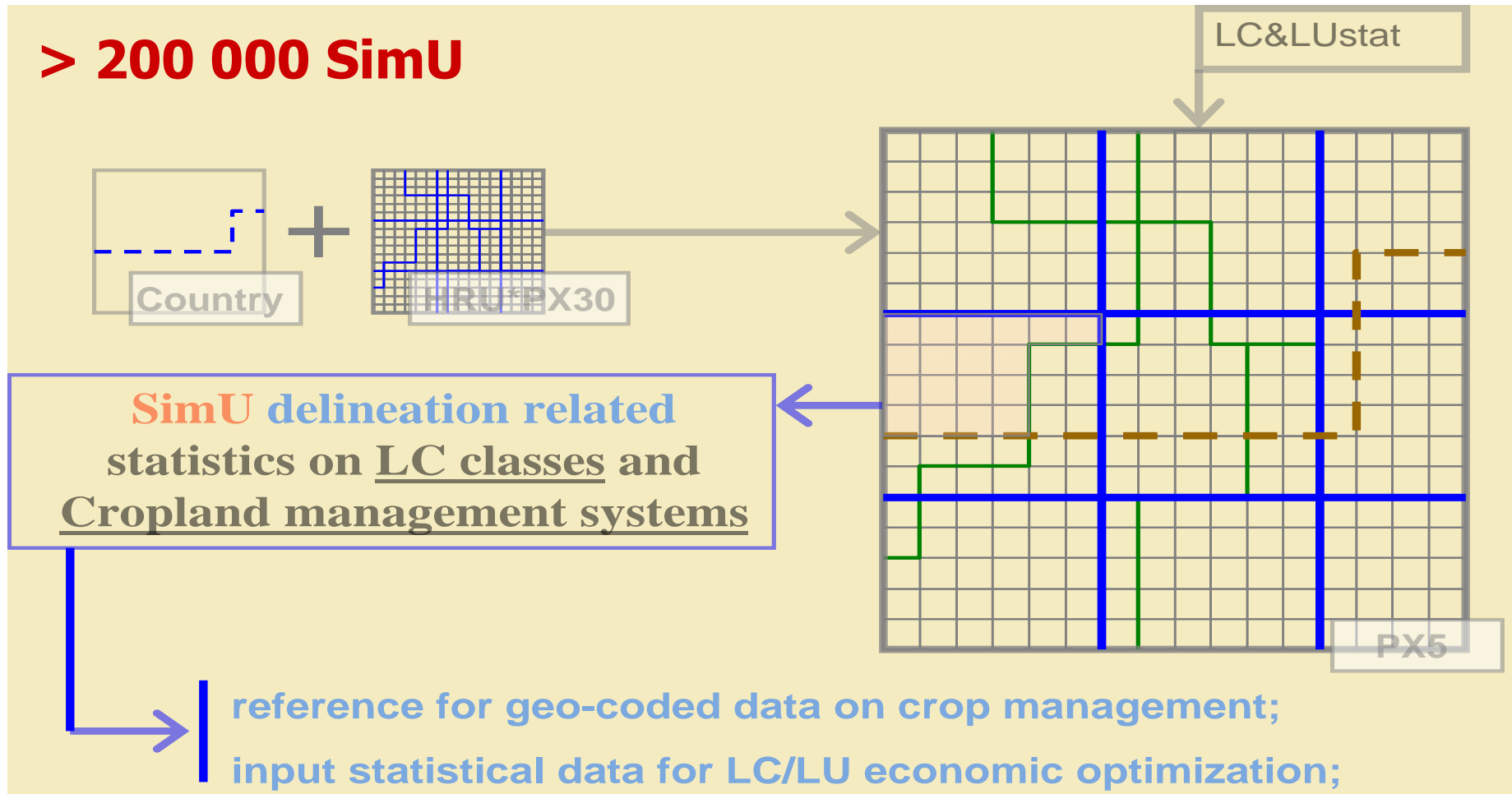
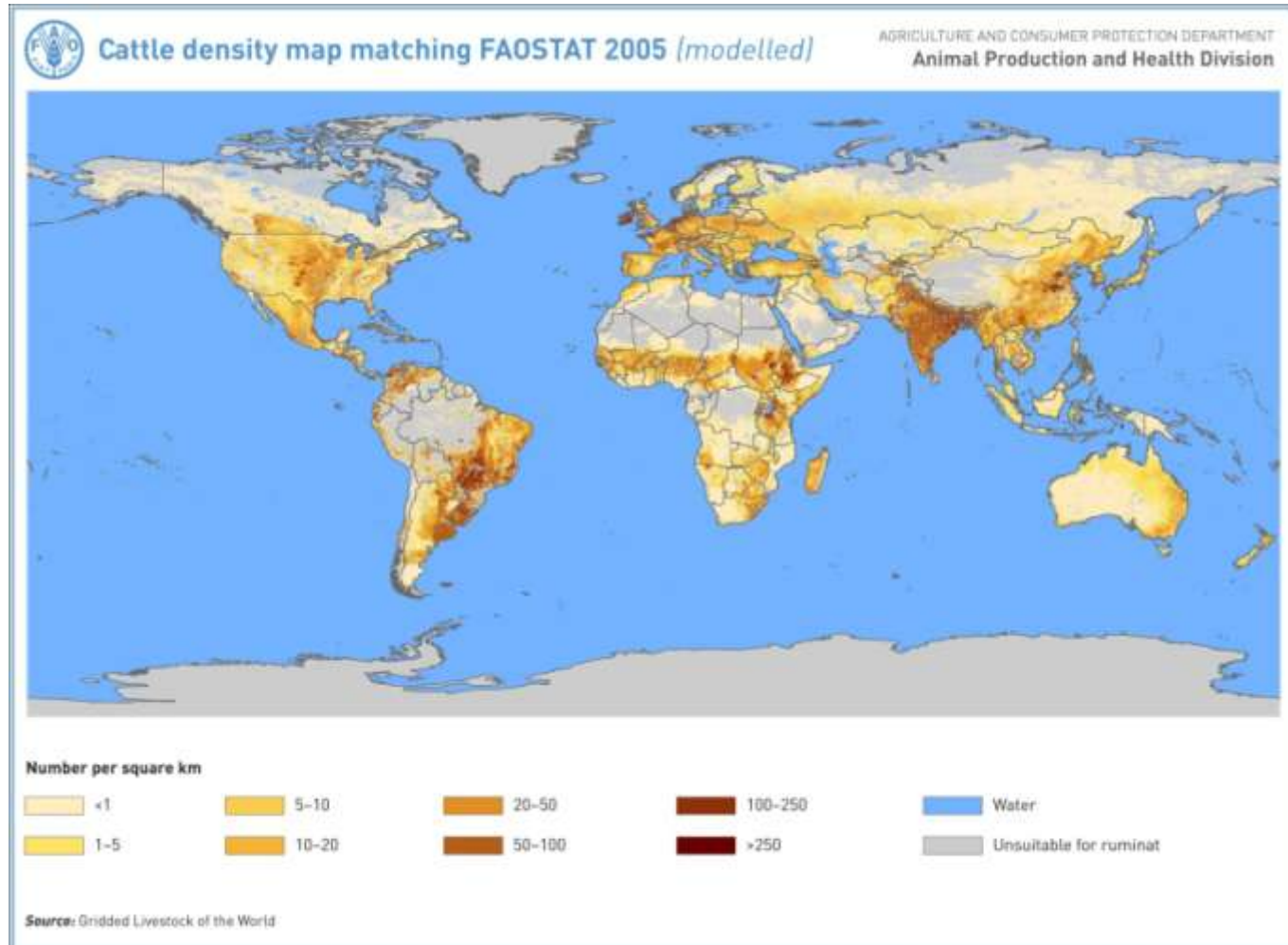## Homogeneous response units (HRU)

HRU = Altitude & Slope & Soil

Altitude class, Slope class, Soil Class

PX5

PX5

Altitude class (m): *0 – 300, 300 – 600, 600 – 1200, 1200 – 2500 and > 2500;*

Slope class (deg): *0 – 3, 3 – 6, 6 – 10, 10 – 15, 15 – 30, 30 – 50 and > 50;*

Soil texture class: *coarse, medium, fine, stony and peat;*

Source: Skalský et al. (2008)

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I. GLOBIOM: Land

Simulation Units (SimU) = HRU & PX30 & Country zone

> 200 000 SimU

LC&LUstat

Country + HRU*PX30

SimU *delineation related* statistics on LC classes and Cropland management systems

PX5

reference for geo-coded data on crop management;

input statistical data for LC/LU economic optimization;

Source: Skalský et al. (2008)

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I. GLOBIOM: Livestock

Spatially explicit representation

Cattle density map matching FAOSTAT 2005 [modelled]

AGRICULTURE AND CONSUMER PROTECTION DEPARTMENT
Animal Production and Health Division

Number per square km

<1	5–10	20–50	100–250	Water
1–5	10–20	50–100	>250	Unsuitable for ruminat

Source: Gridded Livestock of the World

I. GLOBIOM: Livestock

Livestock Production System Approach (8 systems)

Global production system map (FAO/ILRI)
AGRICULTURE AND CONSUMER PROTECTION DEPARTMENT
Animal Production and Health Division

	Rangeland-based	Mixed rainfed	Mixed irrigated	
Hyper arid	LGY	MRY	MIY	Urban areas
Arid/semi-arid	LGA	MRA	MIA	Other
Humid/subhumid	LGH	MRH	MIH	No data
Temperate/tropical highland	LGT	MRT	MIT	
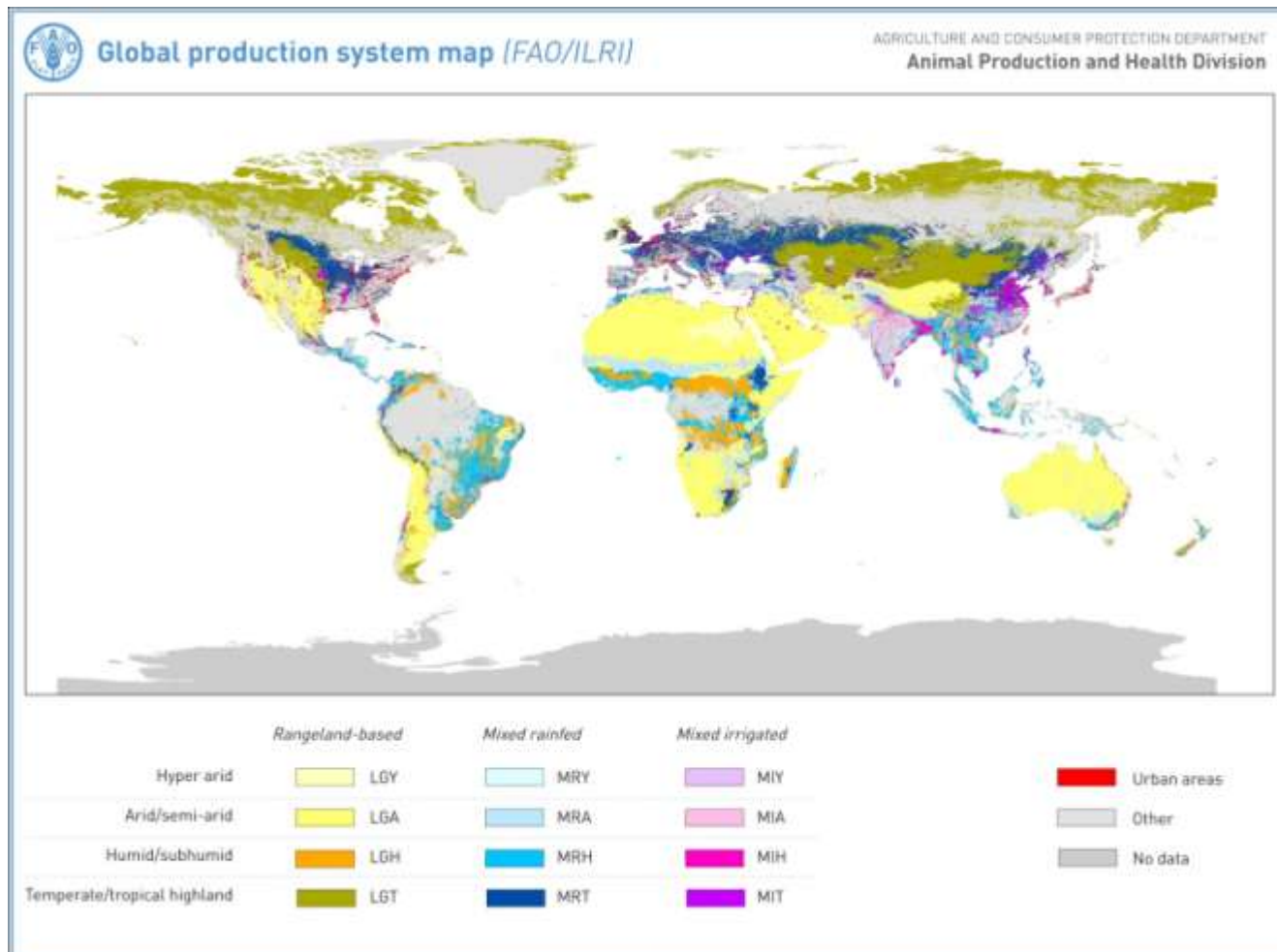
I. GLOBIOM : Livestock

Livestock Production System Parameters

Input parameters

- Stover
- Grains
- Cut&Carry
- Grazing
- Occasional

Bovines
Sheep & Goat
Pigs
Poultry

Output parameters

Bovine Milk & Meat
Shoat Milk & Meat
Pig Meat
Poultry Meat & Eggs

CH4
Manure
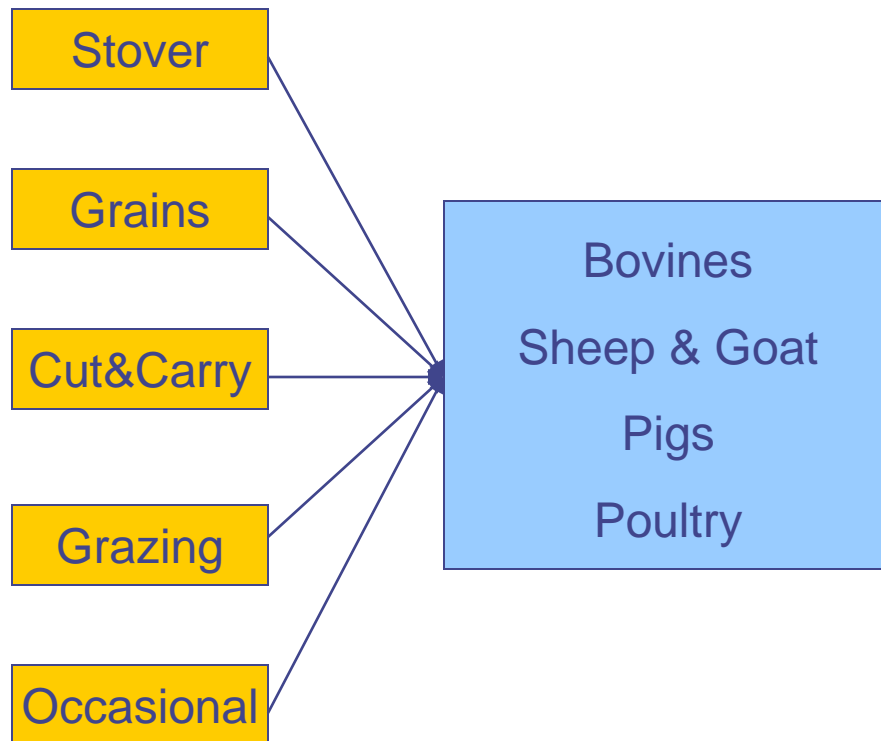
I. GLOBIOM : Livestock

The RUMINANT Simulation model

◆ **Dynamic simulation model of digestion in ruminants** (Herrero et al 2004) largely based on IPCC methods

◆ **Predicts intake, production (milk, meat), and excretion** (faeces and urine) using a dynamic model of digestion (Illius and Gordon 1991)

◆ **Predicts metabolism end products** (**METHANE**, Volatile fatty acids, etc)

Prediction of intake
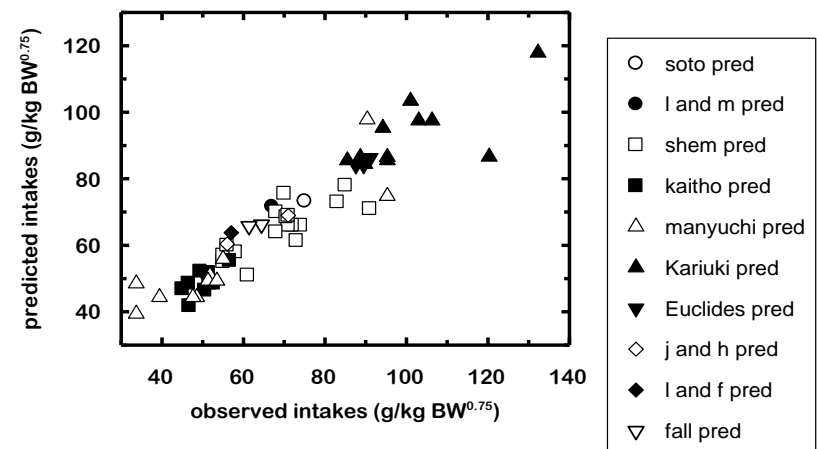
- CH4 coefficients have recently been approved by the IPCC GHG emissions taskforce (Herrero et al 2008, 2009)

I. GLOBIOM: Cropland - EPIC

Processes

- **Weather**
- **Hydrology**
- **Erosion**
- **Carbon sequestration**
- **Crop growth**
- **Crop rotations**
- **Fertilization**
- **Tillage**
- **Irrigation**
- **Drainage**
- **Pesticide**
- **Grazing**
- **Manure**

EPIC

Rain, Snow, Chemicals

Evaporation and Transpiration

Subsurface Flow

Surface Flow

Below Root Zone
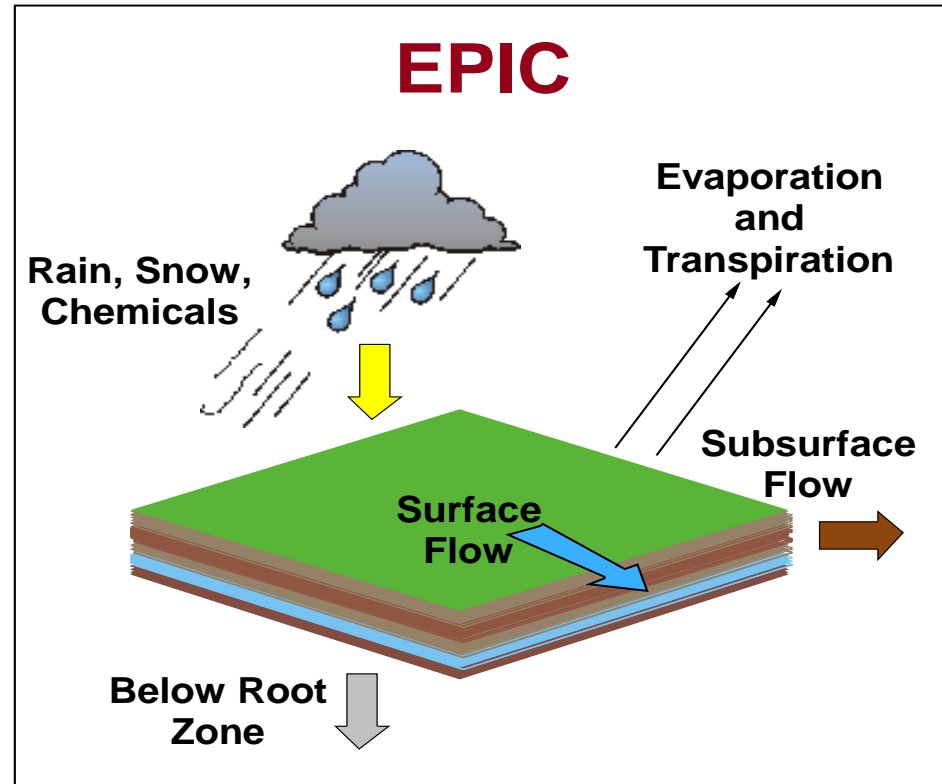
Major outputs:

Crop yields, Environmental effects (e.g. soil carbon,)

20 crops (>75% of harvested area)
4 management systems: High input, Low input, Irrigated, Subsistence
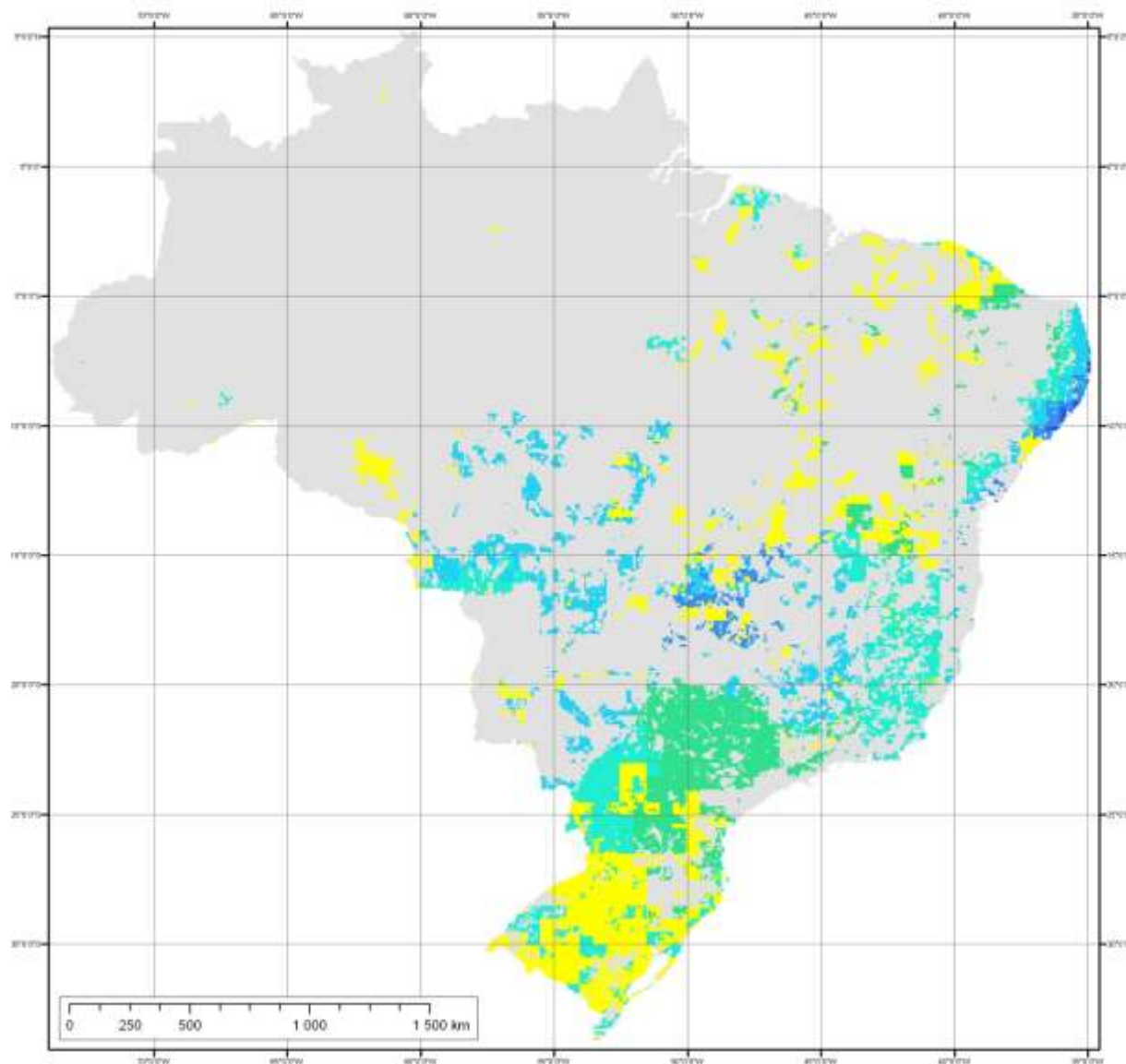
Brazil:

Sugar cane yield, IFPRI allocated area, high input system

Legend:

Sugar cane Yield (t/ha)

- 0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35

no cropland

other cropland (no sugar cane cultivated)

GEOBENE

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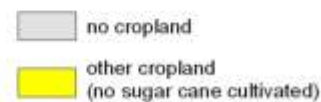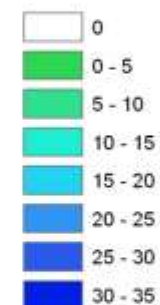
I. GLOBIOM: Forests – G4M

Step 1: Downscaling FAO country level information on above ground carbon in forests (FRA 2005) to 30 min grid

Source: Kindermann et al. (2008)
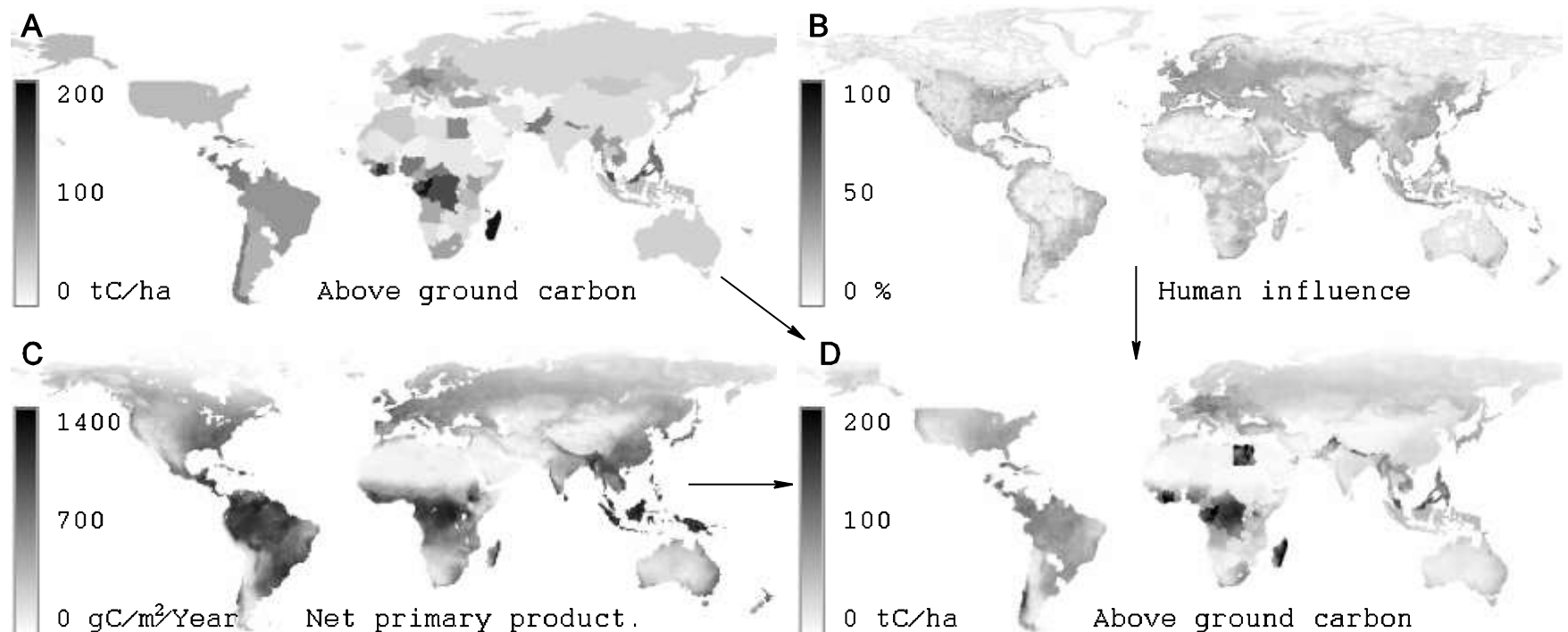
I. GLOBIOM: Forests – G4M

Step 2: Forest growth functions estimated from yield tables

Major outputs:

Mean annual increment

Tree size

Sawn wood suitability

Harvesting cost

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I. GLOBIOM: Scenario analysis

Main exogenous drivers:

Population

GDP

Technological change

Bio-energy demand (POLES team)

Diets (FAO, 2006)

Output: Production Q

- land use (change)

- water use

- GHG,

- other environment (nutrient cycle, biodiversity,…)

Consumption Q

Prices

Trade flows

II. Preliminary results: Livestock
(Havlík et al, 2009)

Livestock production system development:

STICKY livestock production systems

     - min 75% of LPS of 2000 still in the same place in 2020

FLEXIBLE livestock production systems

     - min 25% of LPS of 2000 still in the same place in 2020

POLES Macro Scenarios
(Population [Relative to 2000], poles_bas_sep10)
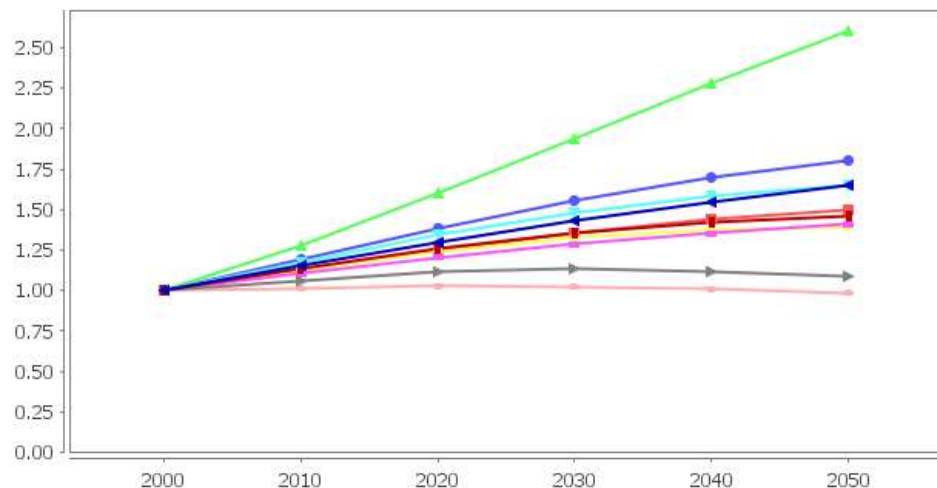
POLES Macro Scenarios
(GDP per Capita [Relative to 2000], poles_bas_sep10)
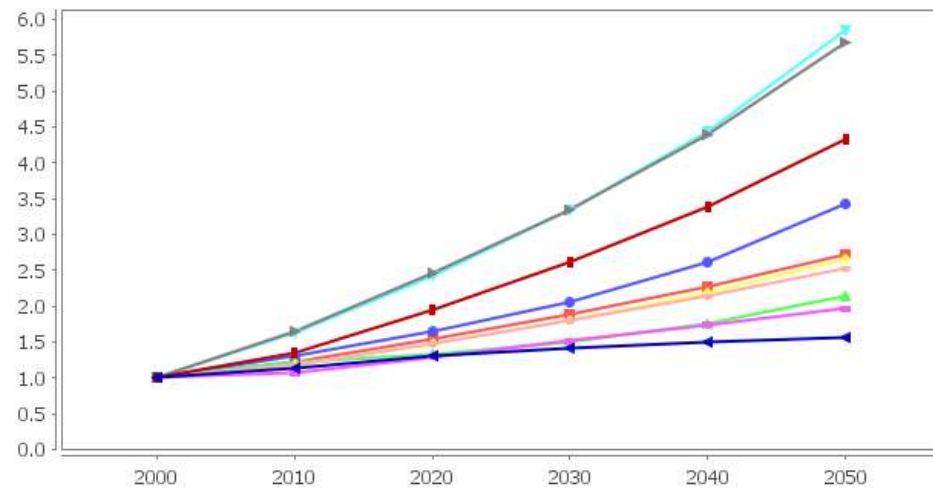
Calorie Consumption [kcal/cap/day]
(animal total, poles_bas_sep10, GHGPrice0, DETAILED)
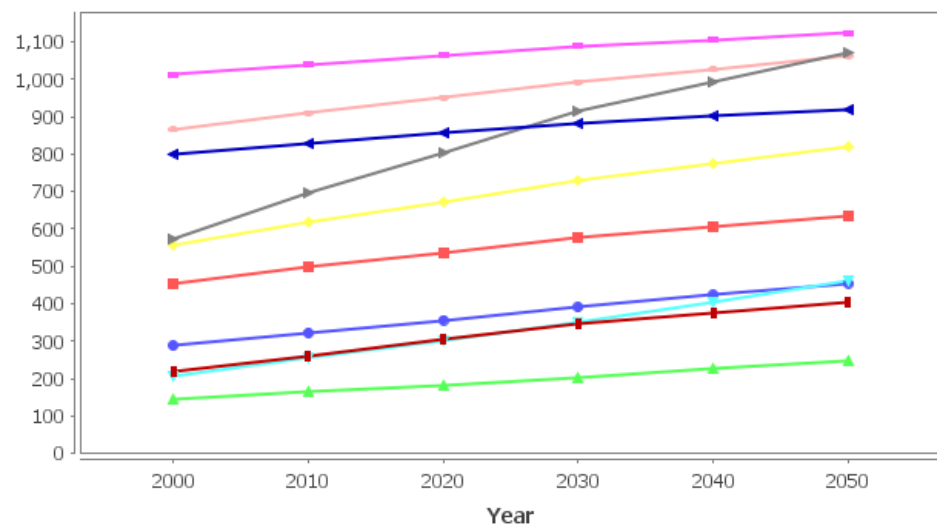
POLES Energy Production/Consumption [Mtoe]
(poles_bas_sep10, GHGPrice0, DETAILED)

Legend: World, MidEastNorthAfr, SubSaharanAfr, LatinAmericaCarib, NorthAmerica, SouthAsia, Europe, EasternAsia, SouthEastAsia, Oceania

Legend: BIOINEL, BIOINBIOD, BFP1, BFP2
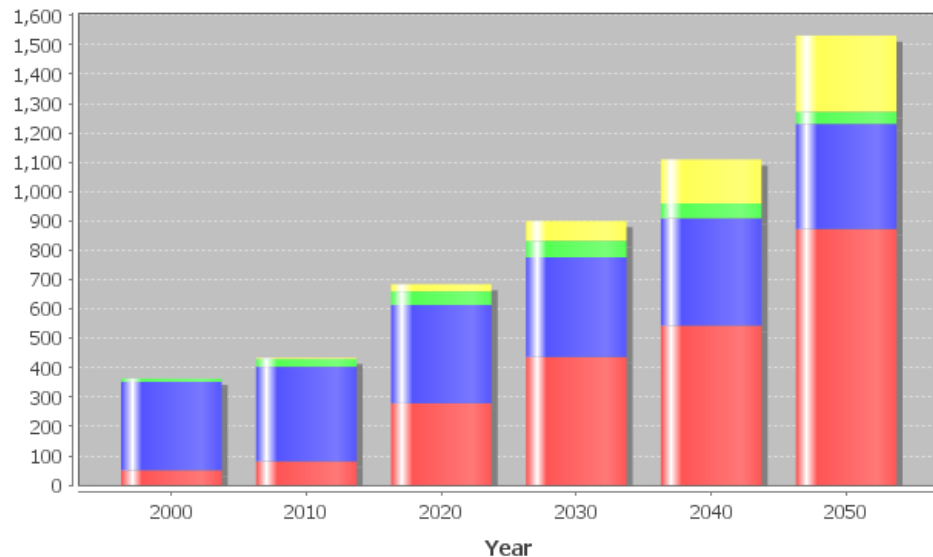
Calorie Consumption [billion kcal]
(ANIM, WRLD_YTRD_YDFR_NCHG)
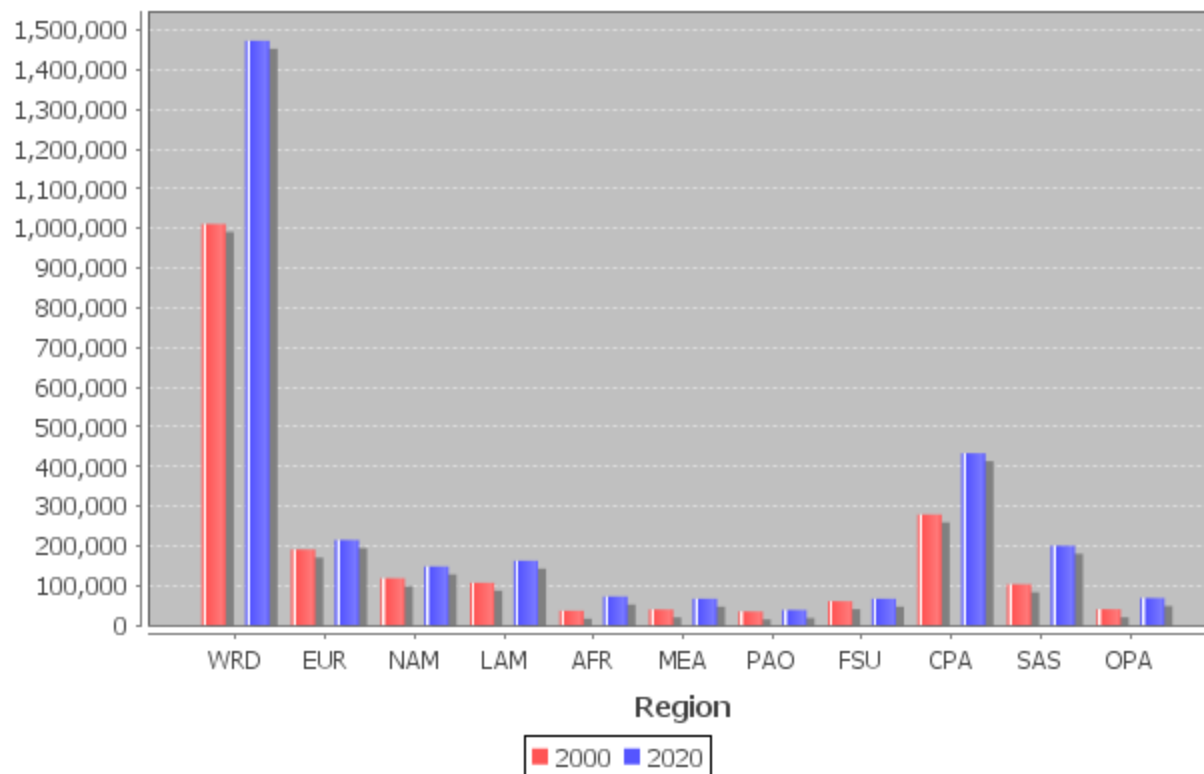
Important increase in absolute animal calorie consumption.

Animal Numbers [1000 TLU]
(CATL, 2020, WRD)
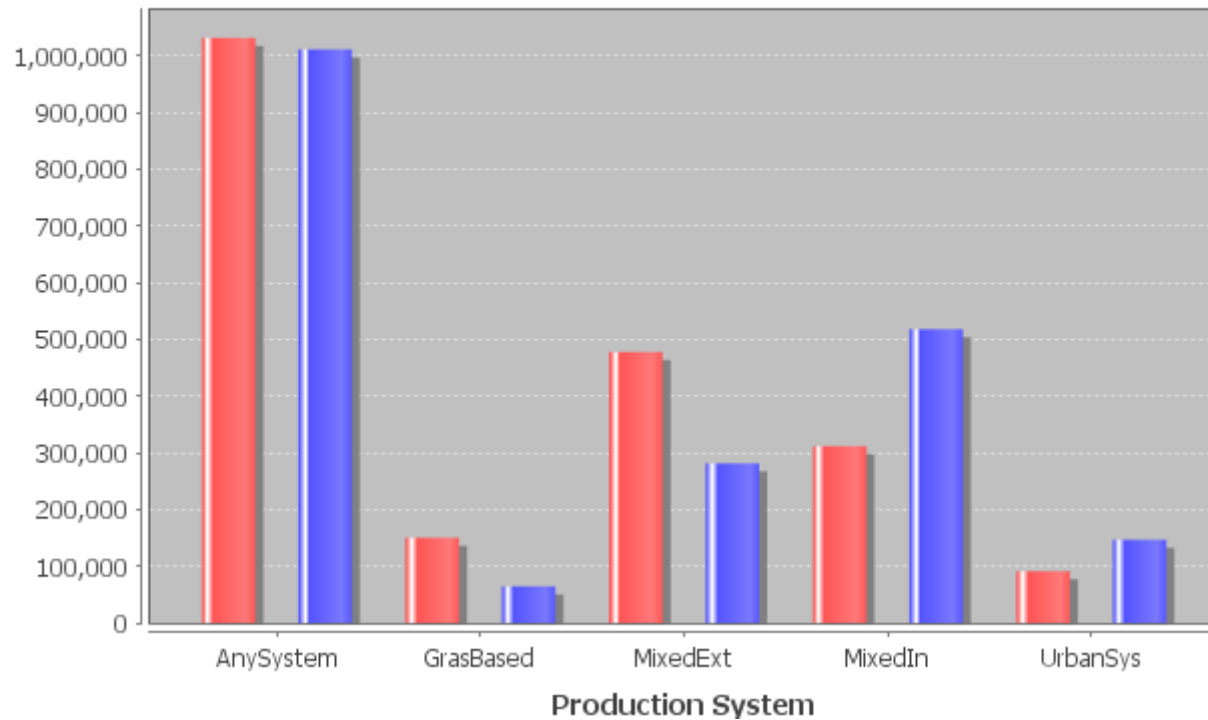
STICKY x FLEXIBLE

IF system change possible → shift to intensive production systems

Commodity Price Index
(2020, WORLD)
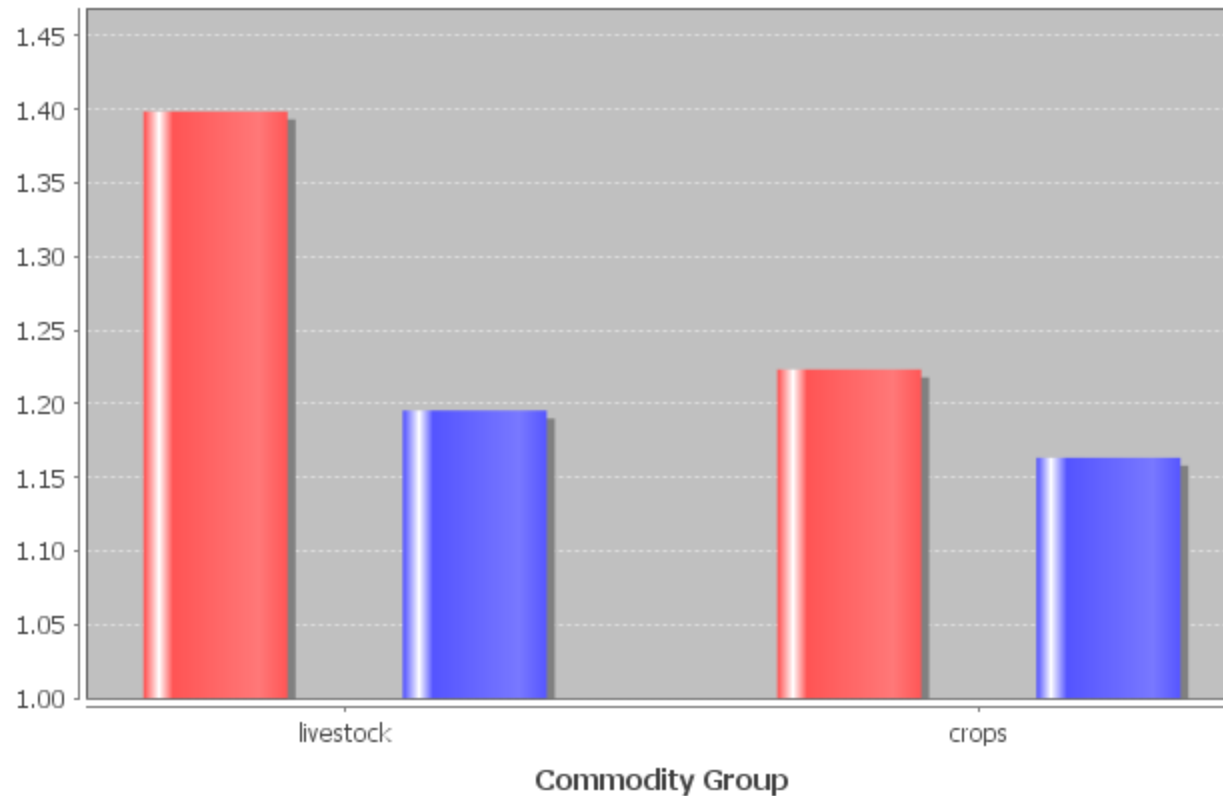
STICKY x FLEXIBLE

Adjustments in production systems help to keep commodity prices low

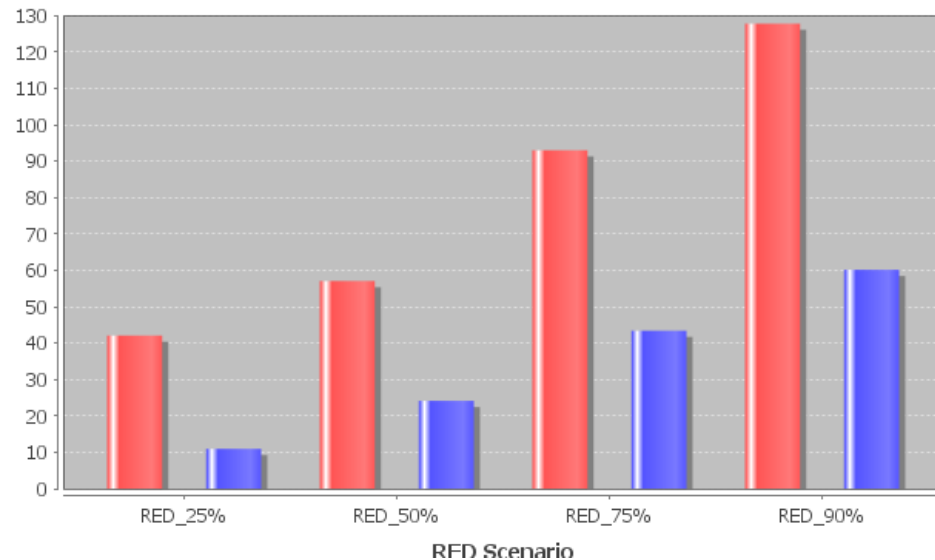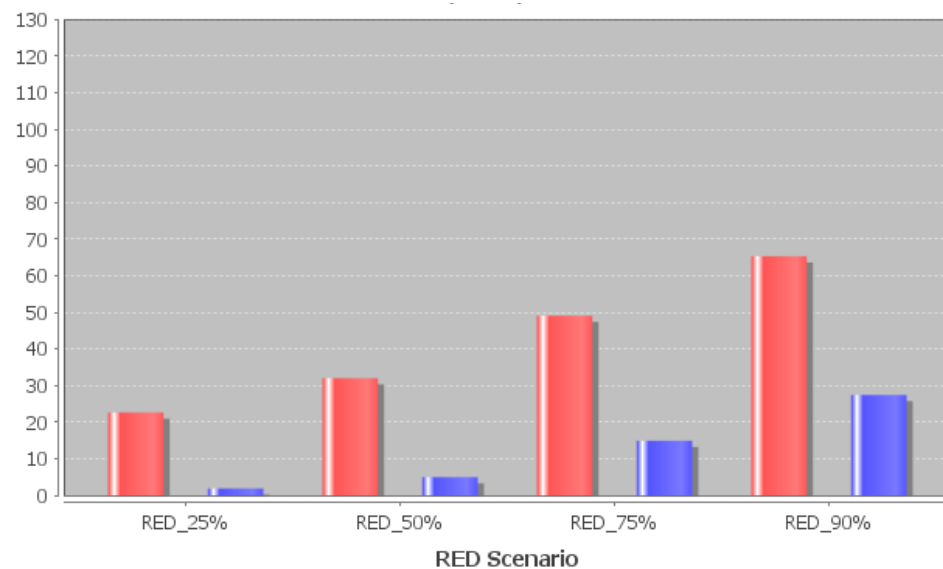**Deforested Area [Mha/year]**
(WORLD)
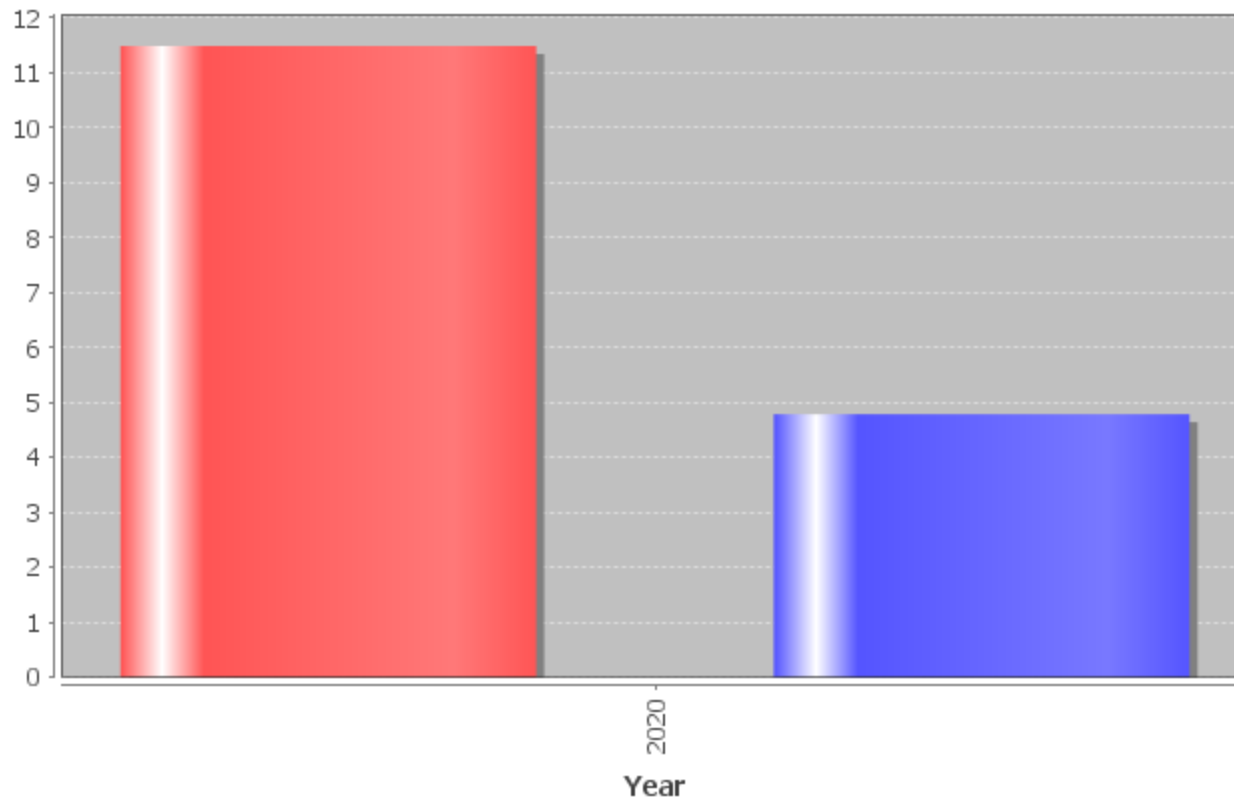
STICKY x FLEXIBLE

AND to reduce deforestation!

GHG Emissions [MtCO2/year]
(2020, WORLD)
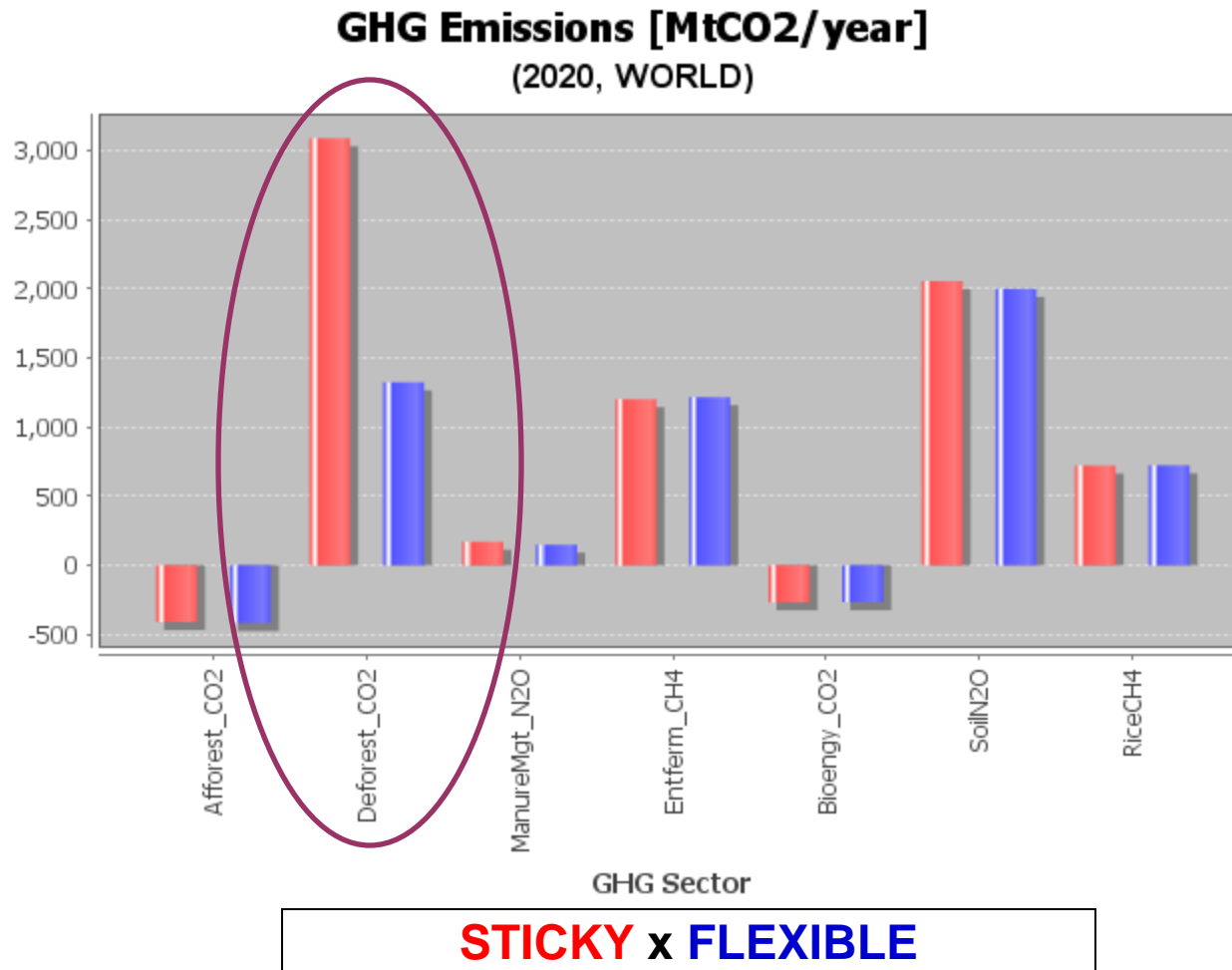
STICKY x FLEXIBLE

RED through livestock does not have negative effect on non-CO2 emissions.

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Marginal RED cost [USD/tCO2]

Baseline

2x biofuels

STICKY x FLEXIBLE

The cost of mitigation policies lower if systems can adapt

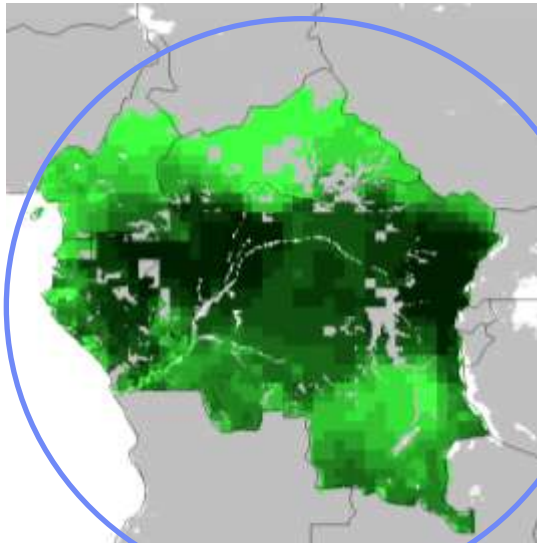# X. Special features

Xa. G4M-GLOBIOM link
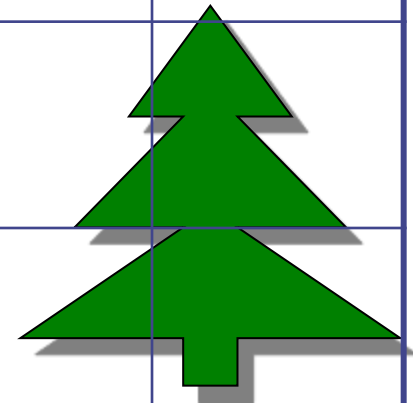
FM:

H=WD

0.5°x 0.5°

Xa. G4M: Spatially explicit results
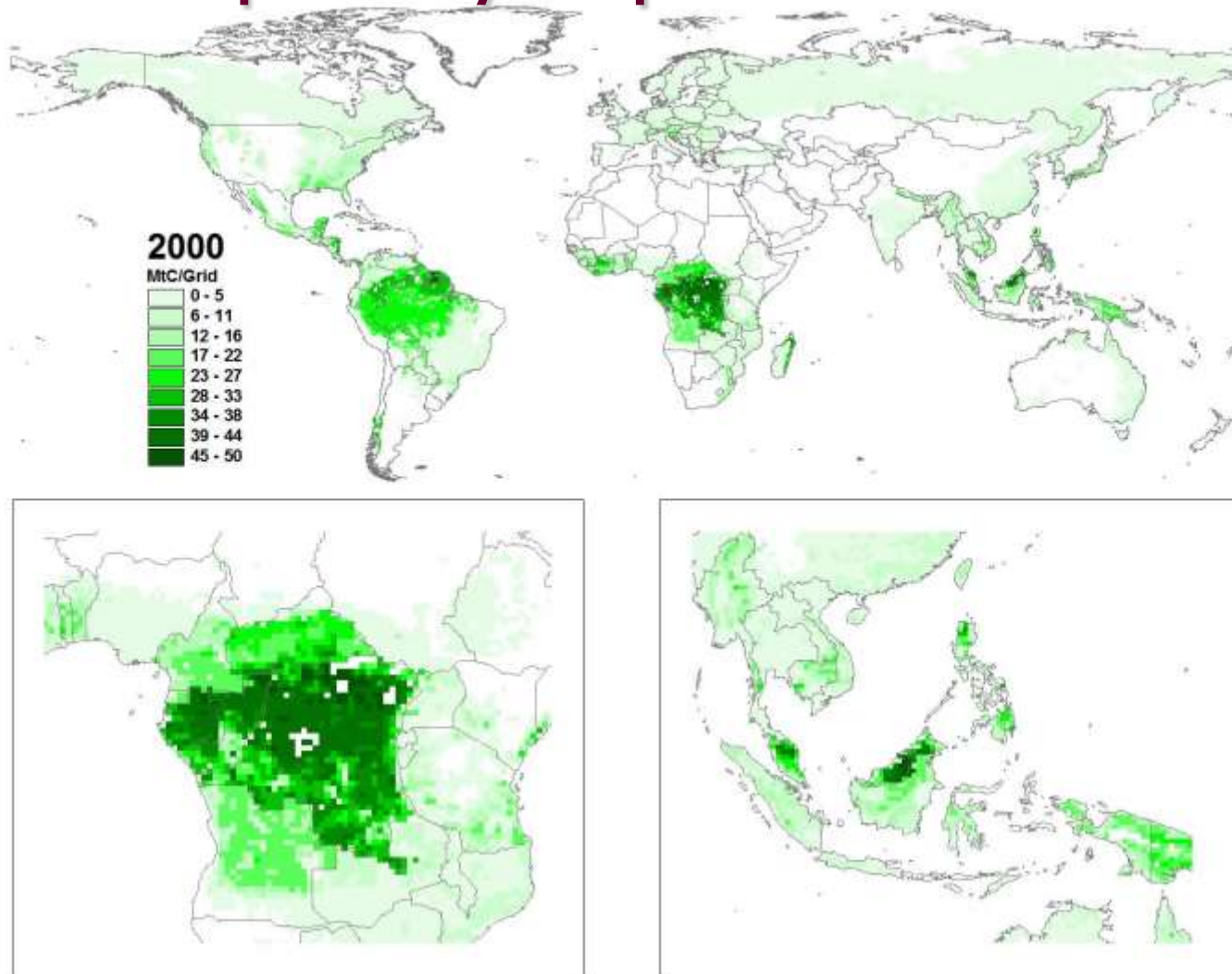
Xb: Regional zooming - CongoBIOM

Drivers of deforestation study for World Bank
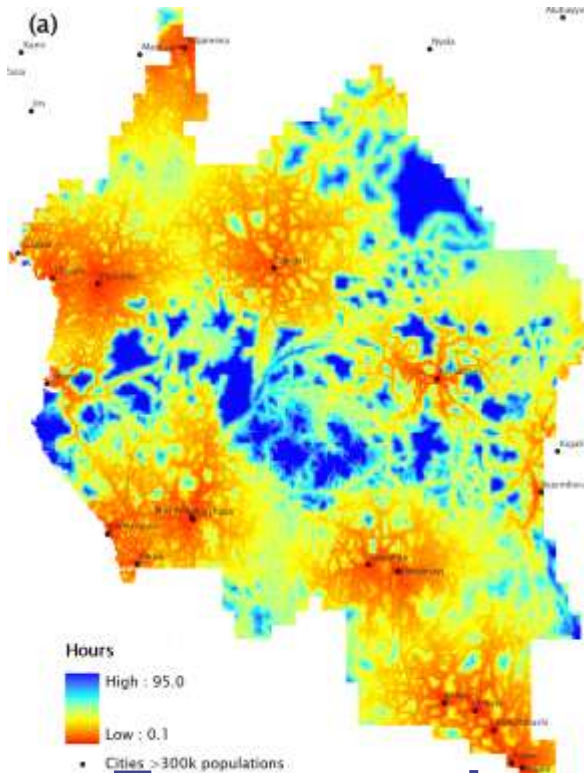
1550 Simulation Units from10*10km to 50*50 km

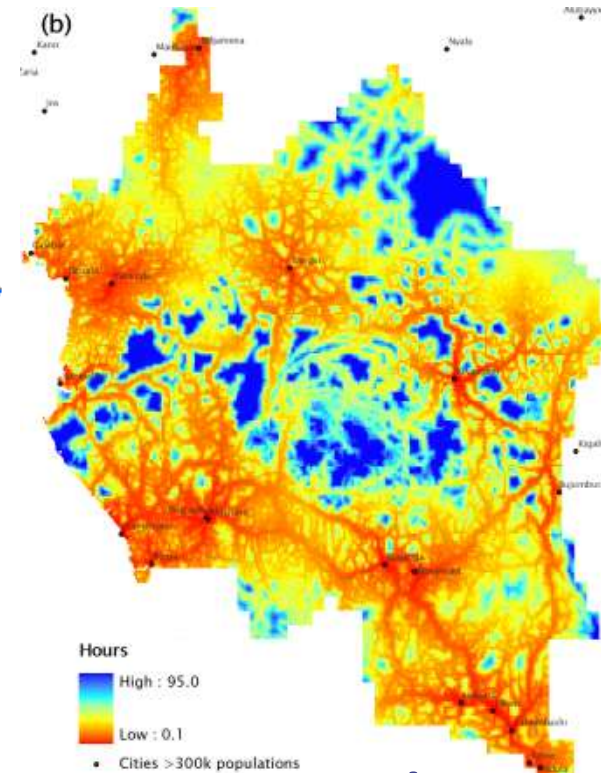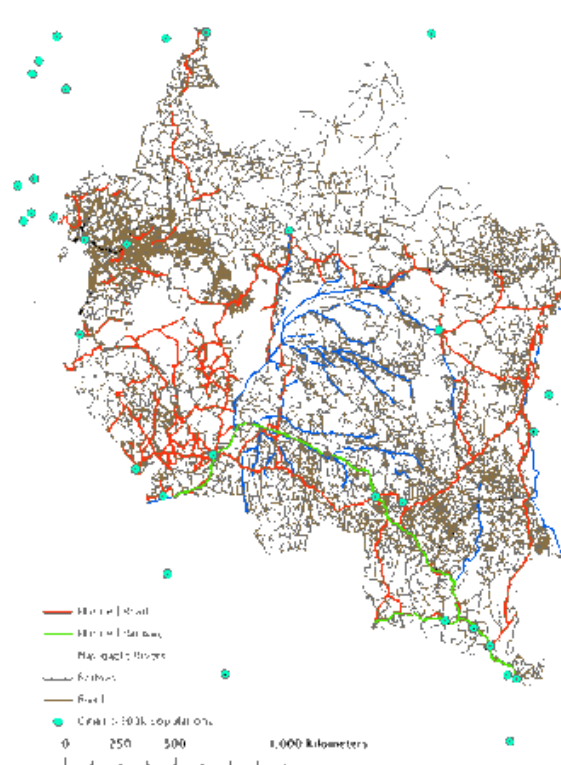**Spatially explicit aspects:**
- population
- infrastructure
→ **market access**

Xb: Regional zooming - CongoBIOM
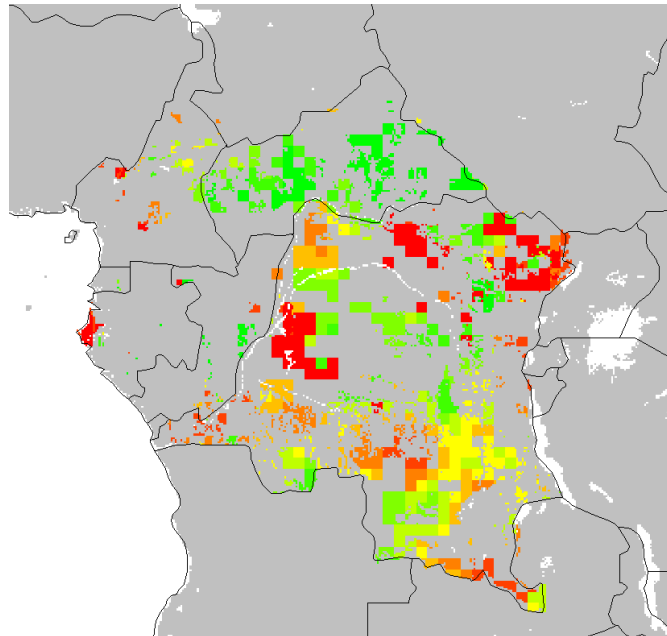

Transportation time – Existing infrastructures

Transportation time- New Infrastructures

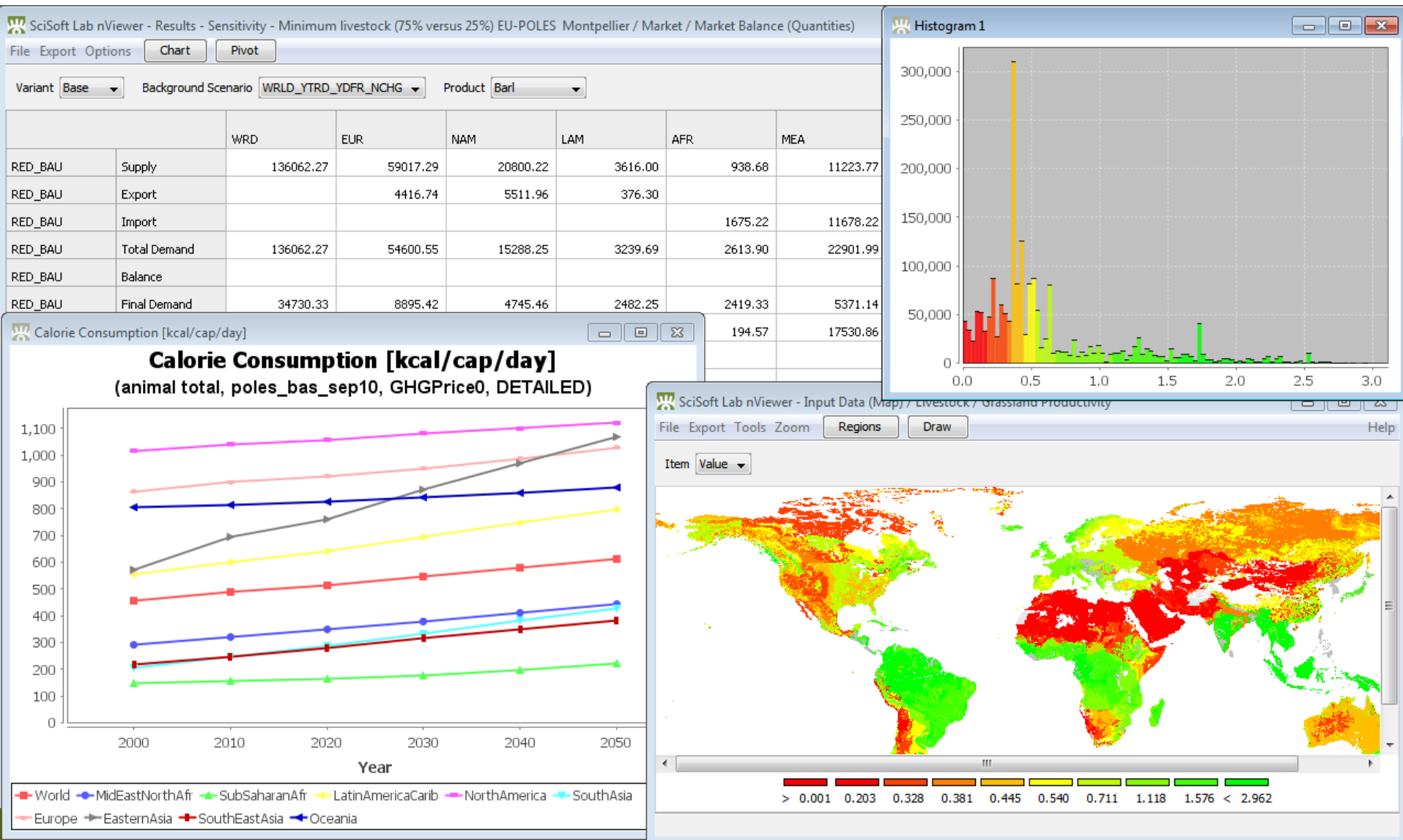(Circa 2000)

(National Statistics, World Bank)

Xb: Regional zooming - CongoBIOM

Deforestation after infrastructure improvement
[1000 ha/SimU/10 years]

Green = low   **Red = high**

Xc: Scenario exploration tool - GUI

Thank you !

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