# Quantis

# IMPLEMENTATION OF LAND USE CHANGE IN ECOINVENT

## LCA DISCUSSION FORUM
3. NOVEMBER 2017

Jürgen Reinhard
juergen.reinhard@quantis-intl.com

In collaboration with    ecoinvent Centre

LAND USE CHANGE:
WHY IS IT RELEVANT?
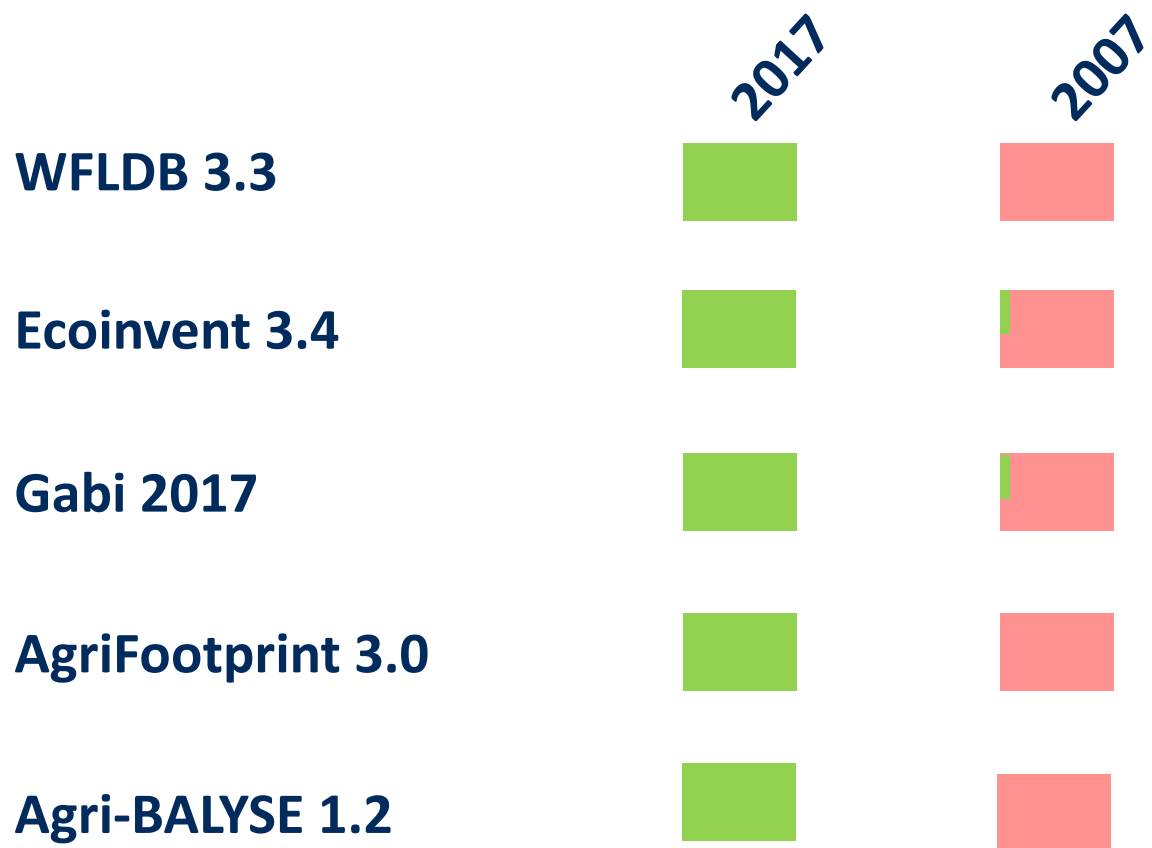
01

# Land use change

$CO_2$

$CO_2$

$CO_2$

$CO_2$

Land use change,
accounts for
**nearly 20% of GHG emissions**
(IPCC, 2007).

# LUC consideration in existing databases – today and 10 years ago

2017

2007

**WFLDB 3.3**

**Ecoinvent 3.4**

**Gabi 2017**

**AgriFootprint 3.0**

**Agri-BALYSE 1.2**

# Implementation of LUC in ecoinvent

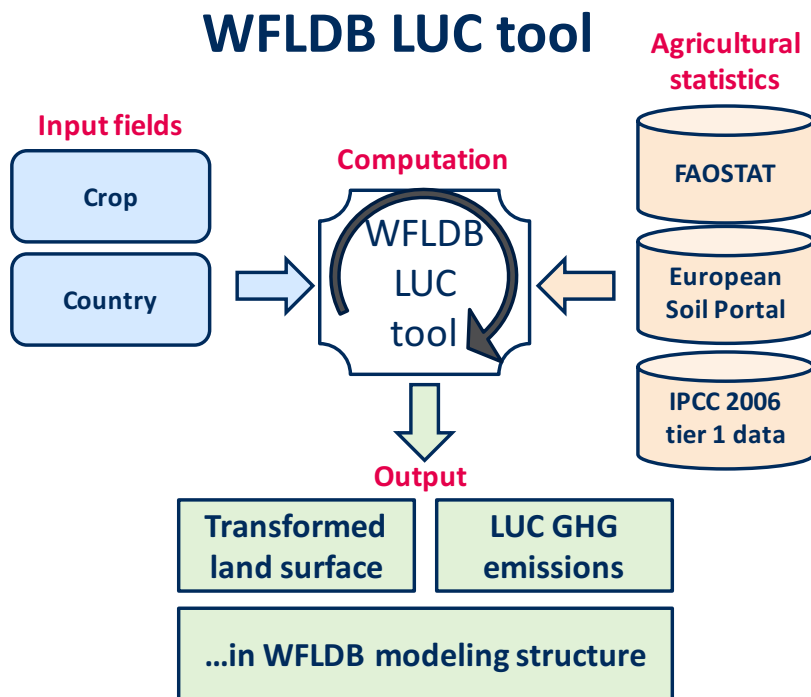| | V2.2 - 2007 | V3.2 - 2013 | V3.3 - 2016 |
|---|---|---|---|
| **Scope** | Soybean (BR)<br><br>Palm fruit bunch (MY) | Soybean (BR),<br><br>Sugarcane (BR)<br><br>Palm fruit bunch (MY) | **All crops** with a non-Swiss geography. |
| **Method** | No consistent methodology | Consistent methodology – Nemecek et al (2016) | Consistent methodology –WFLDB Method (Quantis adapted version of the Blonk tool) |
| **Carbon pools considered** | Above Ground Biomass (AGB) | AGB, BGB, DOM, SOC (in mineral and organic (peat) soils) | AGB, BGB, DOM, SOC in mineral and organic (peat) soils |
| **Land transformations from** | Primary (rain) forest to arable land | Primary forest, secondary forest, shrubland and grassland to arable land. | Primary forest, secondary forest, grassland and perennial land to arable land (annual crop and perennial crop) |

➔ **Improvement in consistency and completeness**

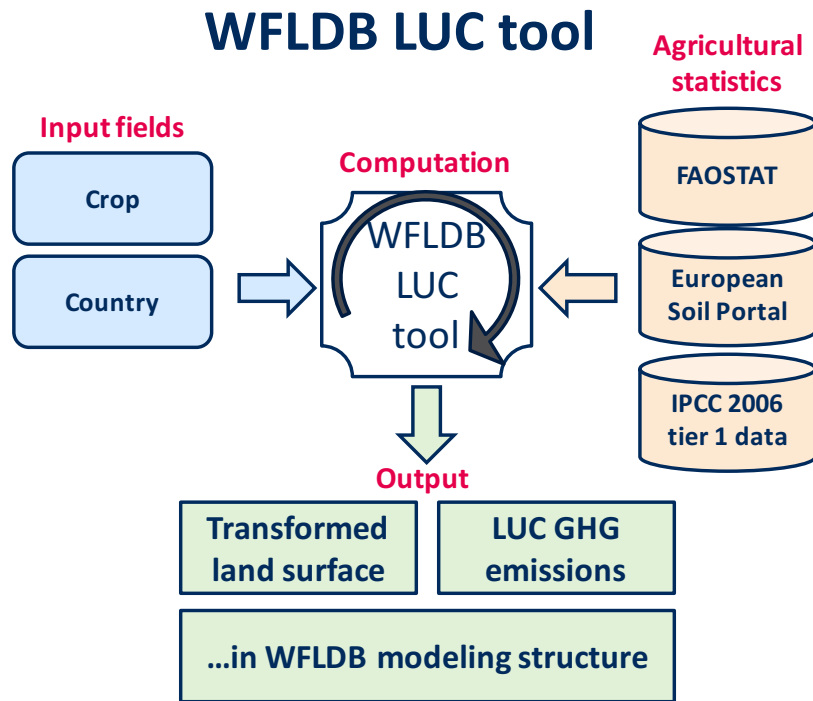LAND USE CHANGE:
MODELING PRINCIPLES

02

# WFLDB LUC tool (Quantis modified version of the Blonk tool)



**WFLDB LUC tool**

Input fields
- Crop
- Country

Computation: WFLDB LUC tool

Agricultural statistics
- FAOSTAT
- European Soil Portal
- IPCC 2006 tier 1 data

Output
- Transformed land surface
- LUC GHG emissions
- …in WFLDB modeling structure

- Excel-based tool
- Provides a predefined way of calculating country-centric GHG emissions from LUC.
- Applicable for PAS 2050-1, GHG Protocol, ENVIFOOD protocol, EU-PEF guide, and FAO LEAP guidelines.

# Capabilities (Quantis modified version)

**WFLDB LUC tool**

**Input fields**

**Crop**

**Country**

**Computation**

WFLDB LUC tool

**Agricultural statistics**

FAOSTAT

European Soil Portal

IPCC 2006 tier 1 data

**Output**

**Transformed land surface**

**LUC GHG emissions**

**…in WFLDB modeling structure**

1. How much of which type of LUC is attributed to a given crop in any country?
   (crop specific or shared responsibility)

2. Carbon inventory for:
   - Transformation (VEG)
   - Occupation (SOC)

# Two approaches to allocated LUC
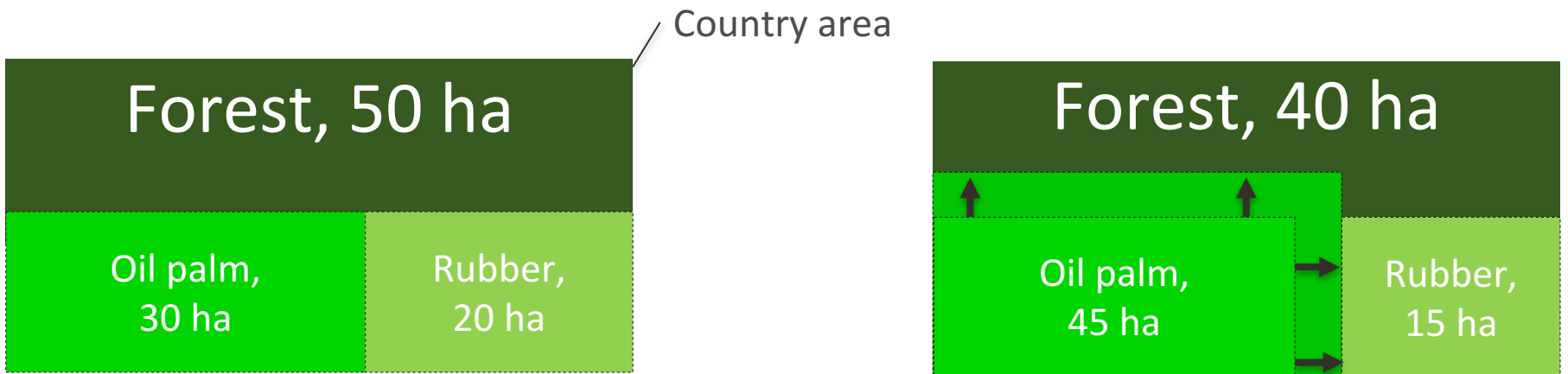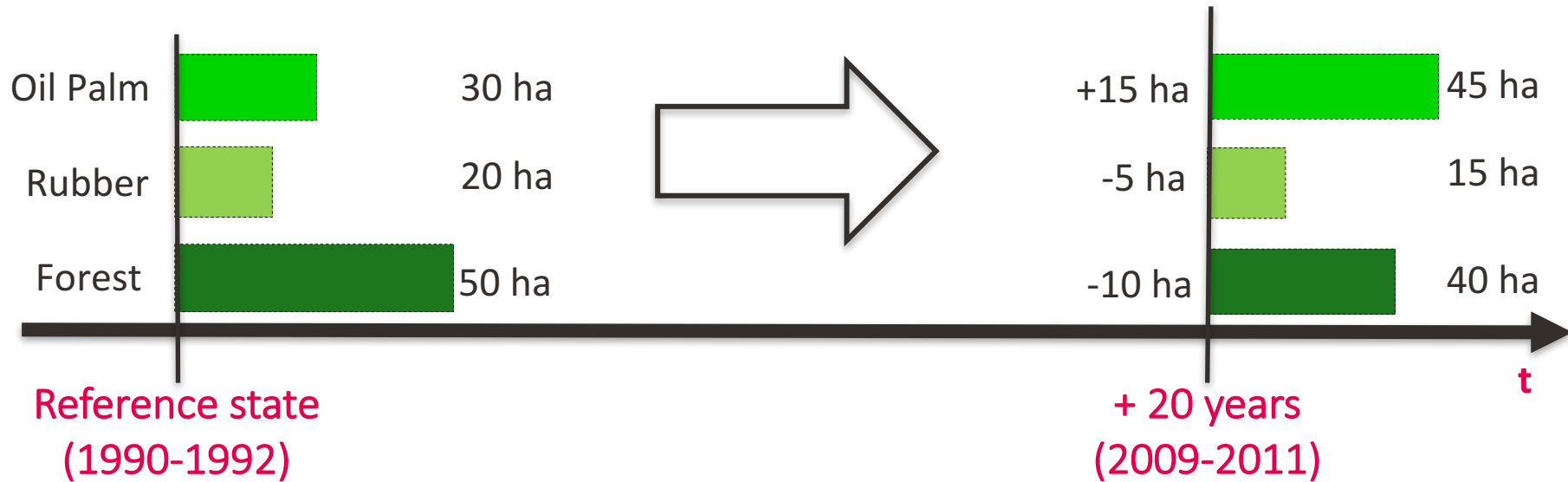
## Crop-specific approach

Land use change is allocated to all crops which **increased their area**
➔ only the crops with increasing area carry the burden of land use change.
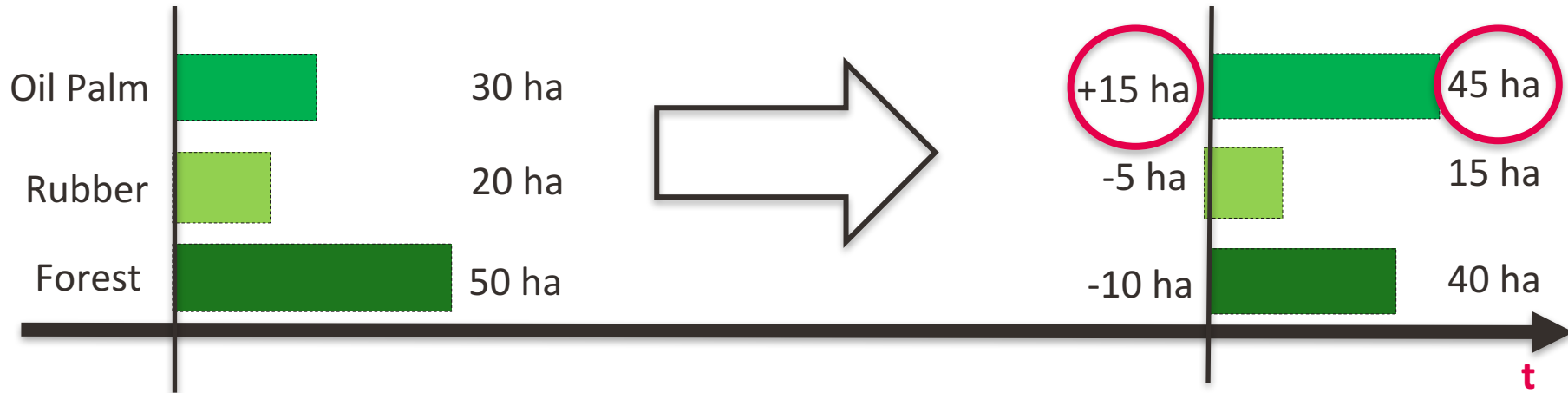
## Shared-responsibility approach

Land use change is allocated to all **crops which occupy area**
➔ all crops which occupy area carry the burden of land use change, even when decreasing.

# Crop-specific approach



Reference state
(1990-1992)

+ 20 years
(2009-2011)

| | | |
|---|---|---|
| Oil Palm | 30 ha | +15 ha · 45 ha |
| Rubber | 20 ha | -5 ha · 15 ha |
| Forest | 50 ha | -10 ha · 40 ha |

Country area

Forest, 50 ha

Oil palm, 30 ha

Rubber, 20 ha

Forest, 40 ha

Oil palm, 45 ha

Rubber, 15 ha

# Crop-specific approach



| | | | |
|---|---|---|---|
| Oil Palm | 30 ha | +15 ha | 45 ha |
| Rubber | 20 ha | -5 ha | 15 ha |
| Forest | 50 ha | -10 ha | 40 ha |

**LUC patterns of the expanded area**

Perennial crop → Perennial crop: **1/3**

Primary forest → Perennial crop: **2/3**
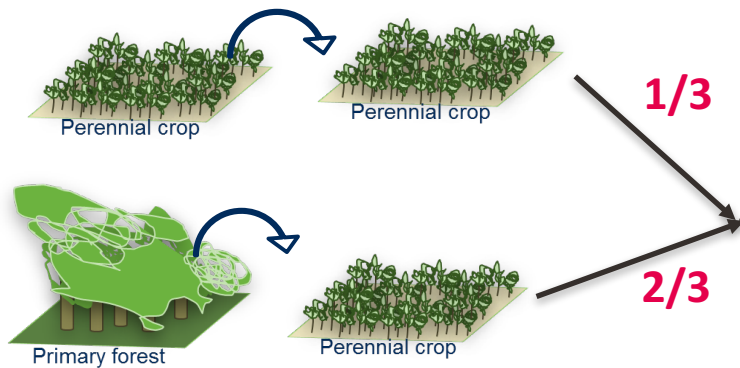
**Proportion of palm oil area which expanded during time period**

**15/45 = 1/3**

**Oil palm**

# We distinguish between two LUC effects

| Land transformation | Land occupation |
|---|---|

**Emissions**

$CO_2$   $N_2O$   $CH_4$   PM   ....   |   $CO_2$   $N_2O$   $CH_4$
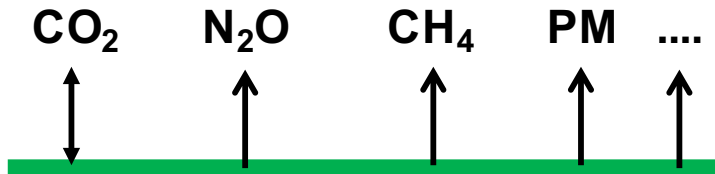
Land transformations are considered for **5 types of land:**

Primary forest
Annual crop
Secondary forest
Perennial crop
Grassland
Annual crop
Perennial crop

**Carbon pools considered**
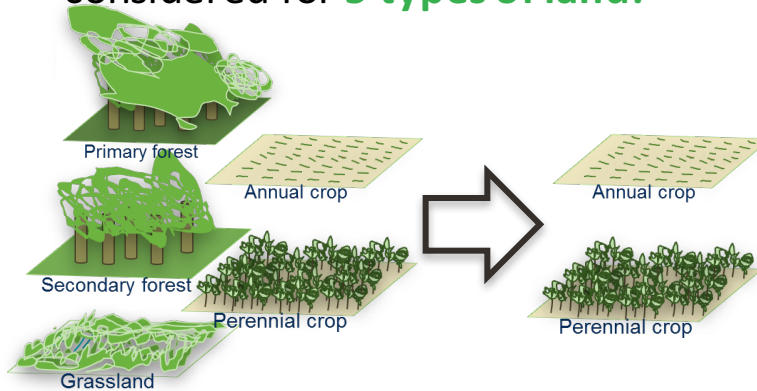
Changes in **above ground biomass, below ground biomass and dead organic matter** are considered.
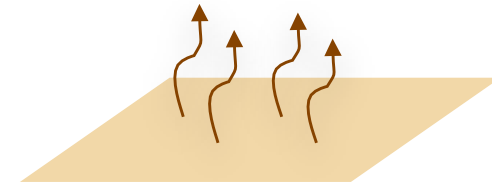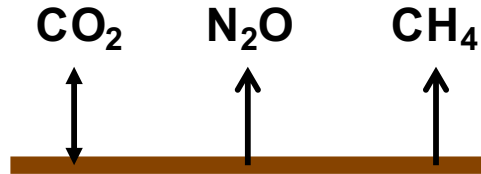
Changes in the **soil organic carbon in mineral and organic (peat)** soils are considered.
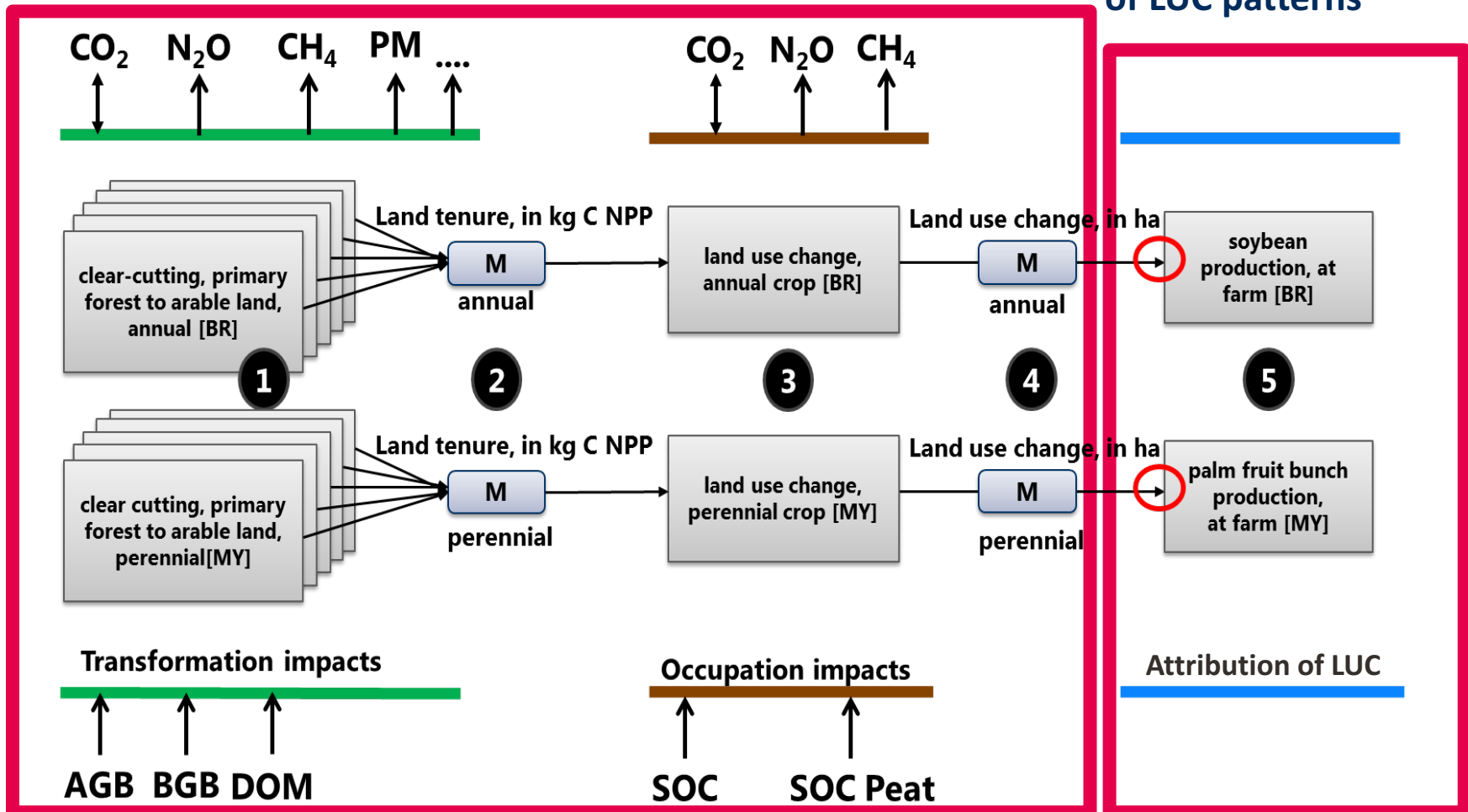
# LAND USE CHANGE IMPLEMENTATION IN ECOINVENT 3.4

03

# Structure



**Country-specific LUC pattern per crop type**

**Crop-specific attribution of LUC patterns**

$CO_2$  $N_2O$  $CH_4$  PM ....

$CO_2$  $N_2O$  $CH_4$

clear-cutting, primary forest to arable land, annual [BR]

Land tenure, in kg C NPP

M annual

land use change, annual crop [BR]

Land use change, in ha

M annual

soybean production, at farm [BR]

**1**  **2**  **3**  **4**  **5**

clear cutting, primary forest to arable land, perennial[MY]

Land tenure, in kg C NPP

M perennial

land use change, perennial crop [MY]

Land use change, in ha

M perennial

palm fruit bunch production, at farm [MY]

**Transformation impacts**

AGB  BGB  DOM

**Occupation impacts**

SOC    SOC Peat
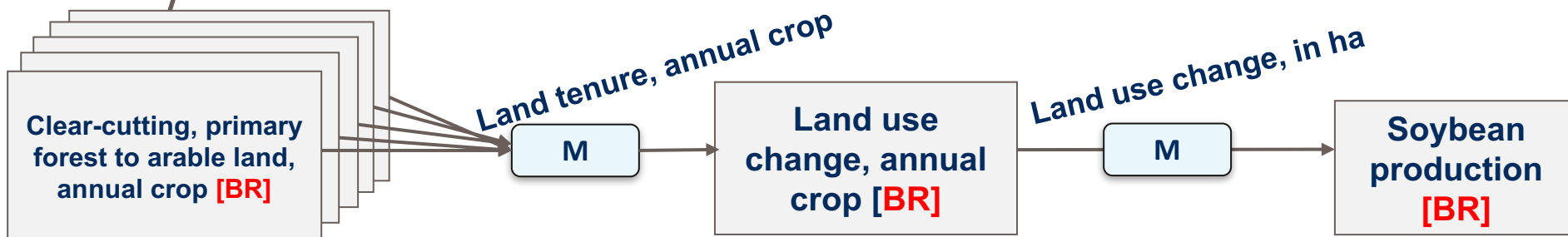
**Attribution of LUC**

# Land transforming activities produce land tenure

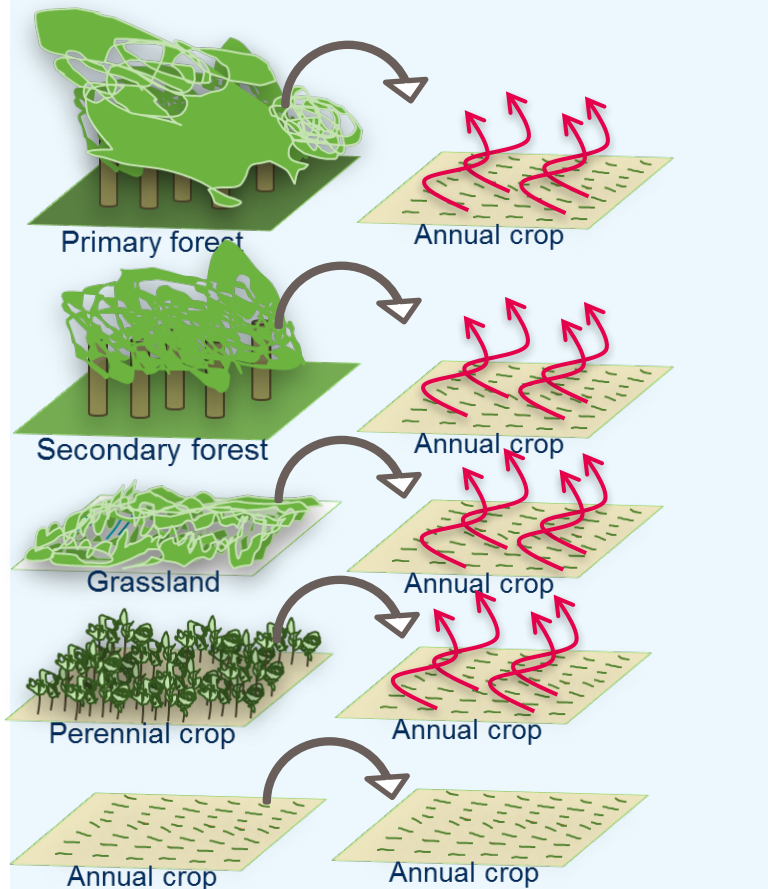- Land transforming activities
  - models the interventions associated with and caused by the transformation of land
  - **produce land tenure** (the common currency to account for the productivity of land)
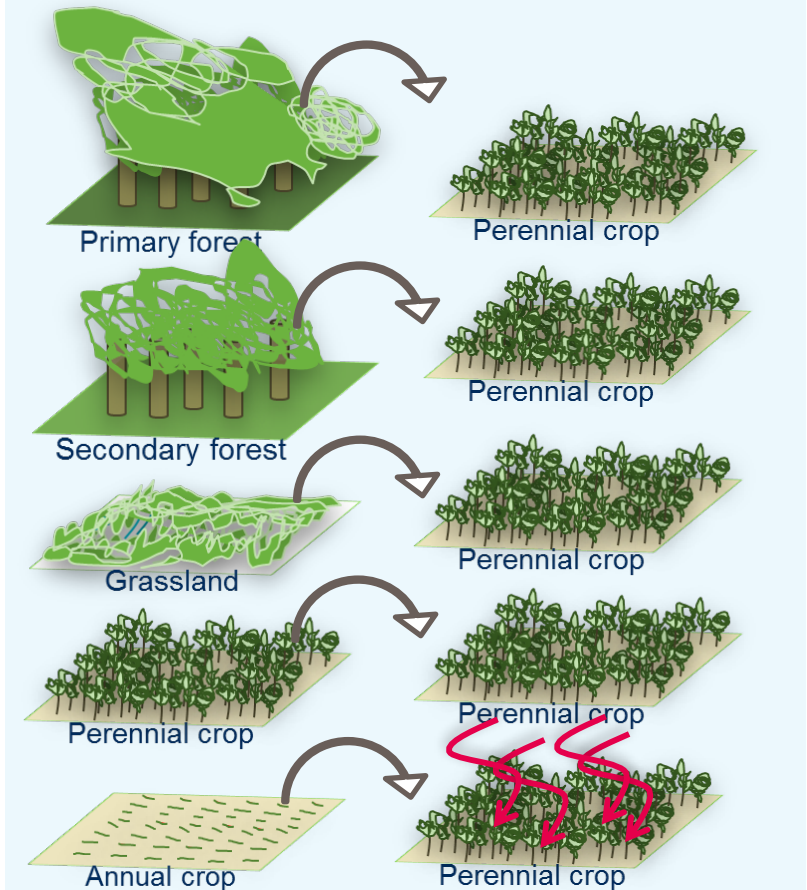
**Clear-cutting, primary forest to arable land, annual crop [BR]**

Land tenure, annual crop

**M**

**Land use change, annual crop [BR]**

Land use change, in ha

**M**

**Soybean production [BR]**

# Land transformation inventories

# Land transformation inventories – annual crop



**From…**     **…to annual**

Primary forest → Annual crop
Secondary forest → Annual crop
Grassland → Annual crop
Perennial crop → Annual crop
Annual crop → Annual crop
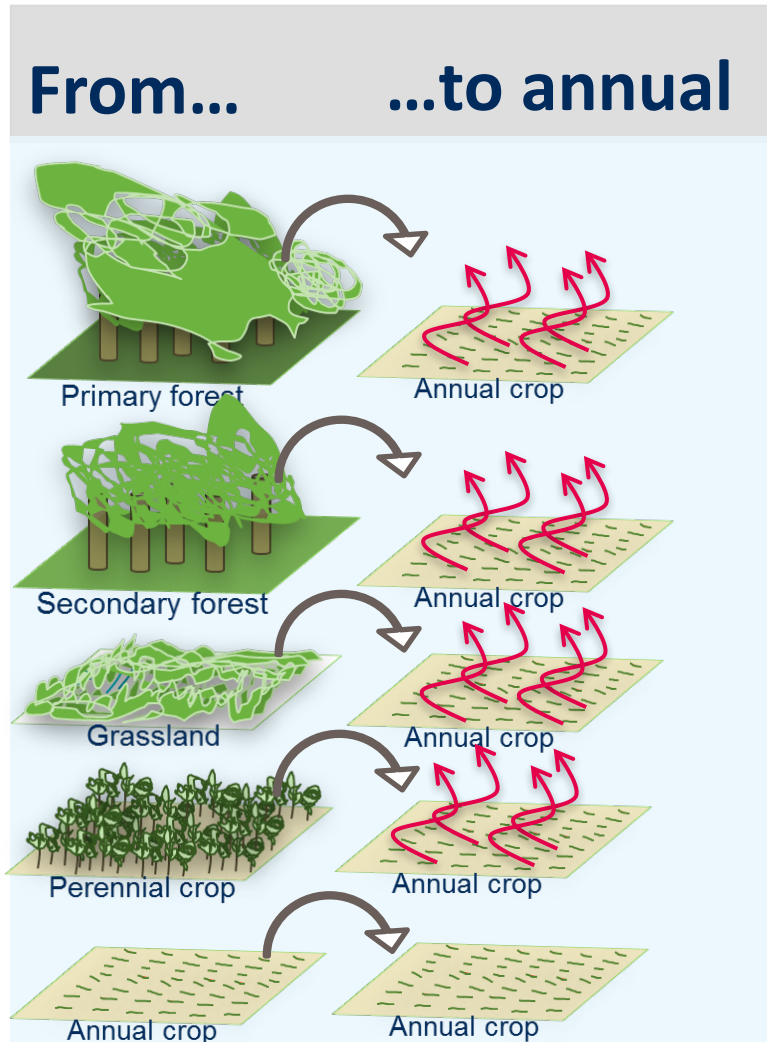
- Clear-cutting of primary and secondary forest,
  - 80% of AGB, BGB and DOM is assumed to decay.
  - 20% of the vegetation is assumed to be burned.
  - interventions required for the clearing of the area—chainsaw and building machines.
- Grassland
  - 100% of the carbon in vegetation to atmosphere as $CO_2$.
- Perennial crop:
  - 100% of the carbon in vegetation to atmosphere as $CO_2$.
- Annual crop:
  - Zero

# Land tenure market model the country- specific LUC mix

- **Local** market for land tenure
  - **mixes** land tenure flows according to their **relevance**
  - generates a **country-specific** land tenure **mix**

Clear-cutting, primary forest to arable land, annual crop **[BR]**

*Land tenure, annual crop*

**M**

Land use change, annual crop **[BR]**
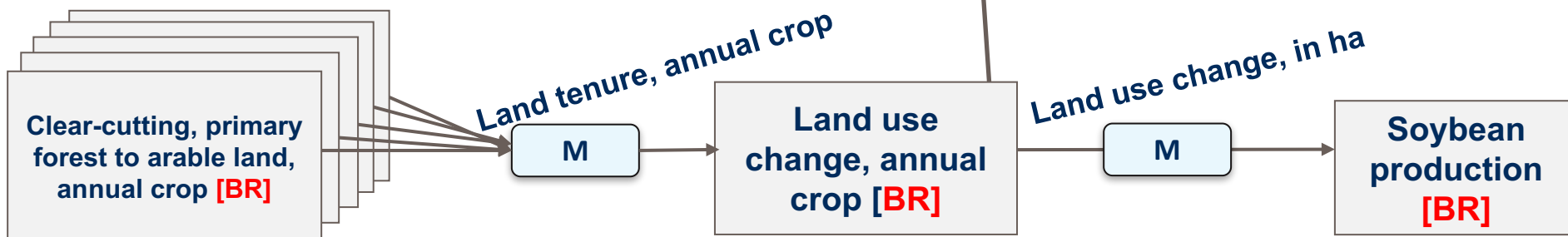
*Land use change, in ha*

**M**

Soybean production **[BR]**
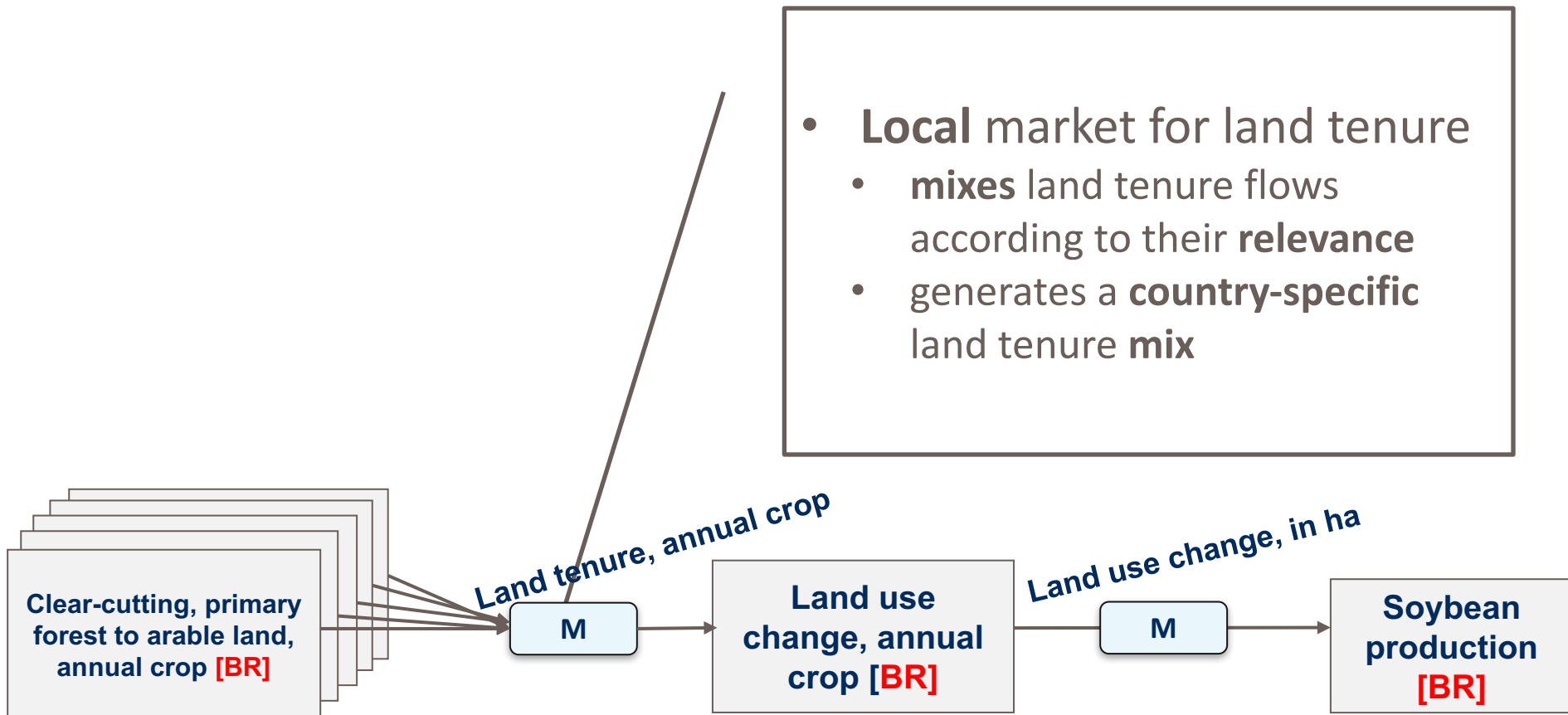
# Land use change adds occupation impacts

- Land use change activity
  - **input** is the country-specific **land tenure** market mix ➜ **amortization** happens here
  - **adds occupation impacts** ➜ loss in SOC and SOC peat
  - **output** represents **country-specific** land use change on a **per hectare basis**

**Clear-cutting, primary forest to arable land, annual crop [BR]**

Land tenure, annual crop

**M**

**Land use change, annual crop [BR]**

Land use change, in ha

**M**

**Soybean production [BR]**

# Local market for land use change

- **Local** market for land use change
  - link to integrate LUC to all crops of relevance

**Clear-cutting, primary forest to arable land, annual crop [BR]**

Land tenure, annual crop

M

**Land use change, annual crop [BR]**

Land use change, in ha

M

**Soybean production [BR]**
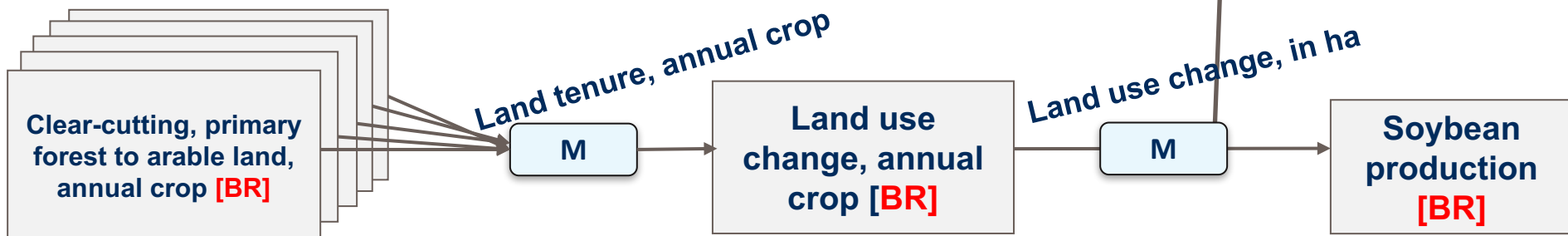
# Expansion of crop activity determines attribution

**Attribution of land use change**

- What was the expansion of the crop during the time period under consideration?
- Expansion / Current area
  - 12 million ha / 23 million ha = **52%**



Clear-cutting, primary forest to arable land, annual crop **[BR]**

Land tenure, annual crop

**M**

Land use change, annual crop **[BR]**

Land use change, in ha

**M**

Soybean production **[BR]**
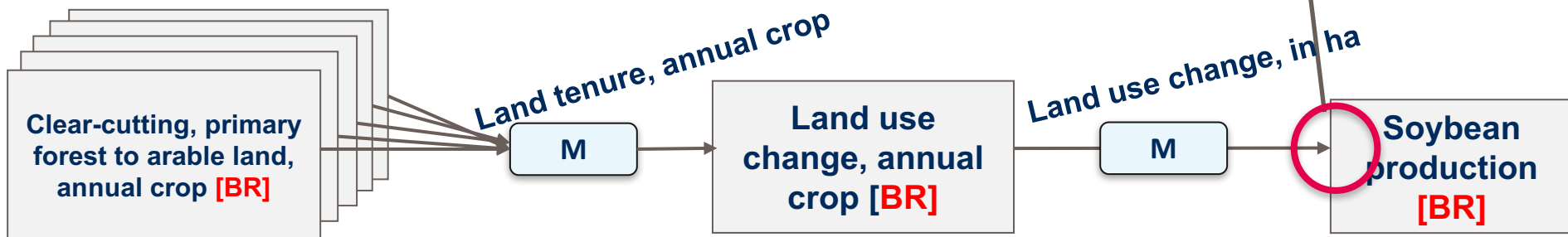
# LUC modeling in ecoinvent

- Consistent consideration of LUC for all crops on a global scale
  - all crops link to their country specific "Market for land use change" (if they cause any LUC according to Quantis Blonk tool)
  - more specific data can be considered ➔ Oil palm MY
- Country-centric
  - propagation of LUC throughout different countries are not considered
  - more rape seed in Switzerland ➔ less barley ➔ more demand for Barley in Canada?
- Modular: easy to
  - add new transforming activities
  - trace LCIA contributions to the causing LUC activities
  - exclude from the calculations or
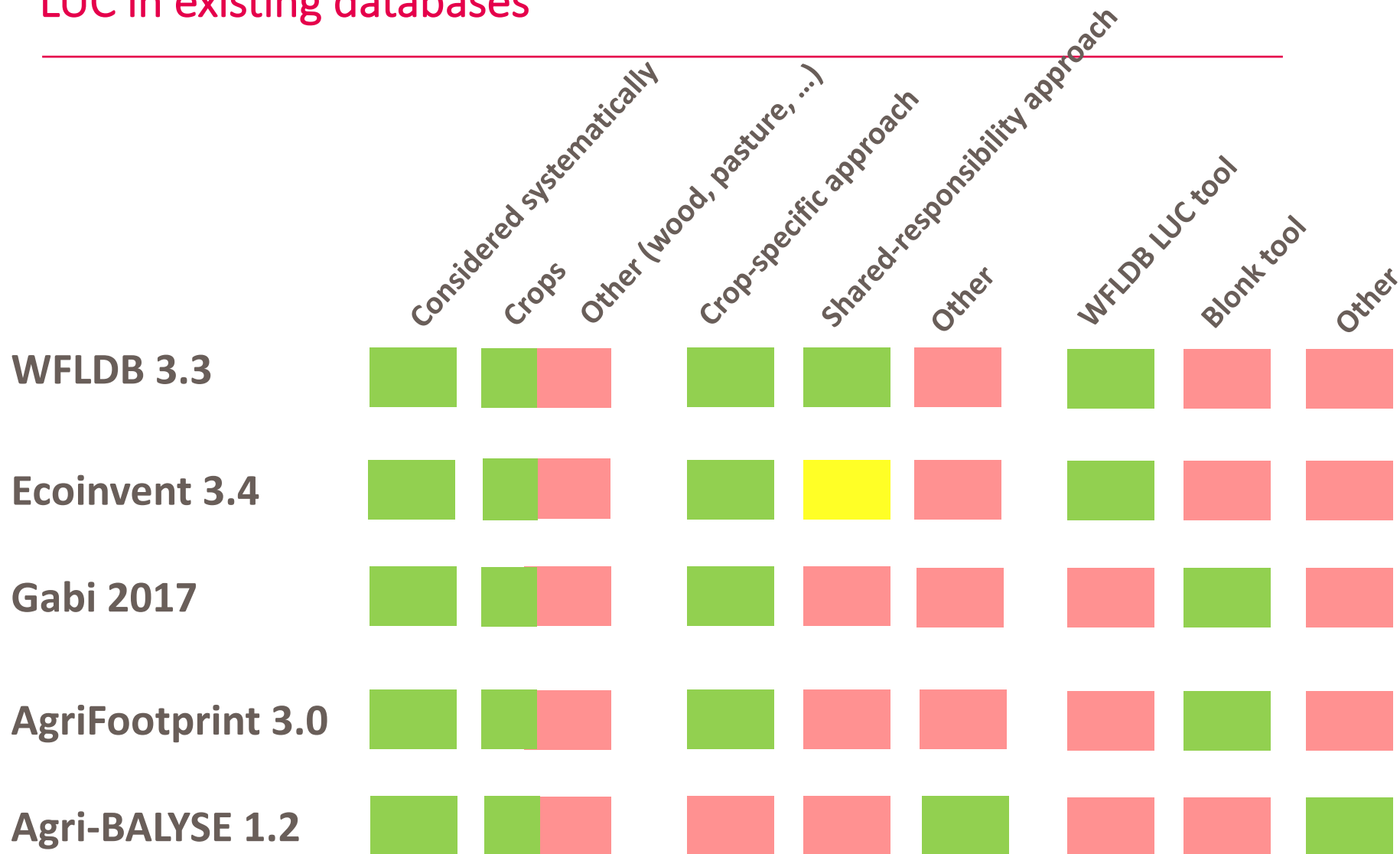  - adapt to own needs

# LAND USE CHANGE CONSIDERATION IN EXISTING LCI DATABASES

04

# LUC in existing databases

| | Considered systematically | Crops | Other (wood, pasture, ...) | Crop-specific approach | Shared-responsibility approach | Other | WFLDB LUC tool | Blonk tool | Other |
|---|---|---|---|---|---|---|---|---|---|
| **WFLDB 3.3** | 🟩 | 🟩 | 🟥 | 🟩 | 🟩 | 🟥 | 🟩 | 🟥 | 🟥 |
| **Ecoinvent 3.4** | 🟩 | 🟩 | 🟥 | 🟩 | 🟨 | 🟥 | 🟩 | 🟥 | 🟥 |
| **Gabi 2017** | 🟩 | 🟩 | 🟥 | 🟩 | 🟥 | 🟥 | 🟥 | 🟩 | 🟥 |
| **AgriFootprint 3.0** | 🟩 | 🟩 | 🟥 | 🟩 | 🟥 | 🟥 | 🟥 | 🟩 | 🟥 |
| **Agri-BALYSE 1.2** | 🟩 | 🟩 | 🟥 | 🟥 | 🟥 | 🟩 | 🟥 | 🟥 | 🟩 |

CONCLUSIONS

05

# Conclusion

- LUC is a key issue ➔ highly relevant, highly uncertain!
- Many value choices
  - time period under consideration (20y) and amortization (20y)
  - distribution of emission through time
  - focus on crops and ignore other drivers
  - focus on the past
- Further refinement and extension is needed
  - integration of forest degradation and country-specific land management
  - integration of other drivers (soil depletion, forestry, cattle farming, etc.)
  - no propagation of LUC across country boundaries ➔ iLUC
- …and already ongoing!
  - SRI project, Brazil ➔ regional disaggregation (to state-level) and consideration of cattle farming a driver
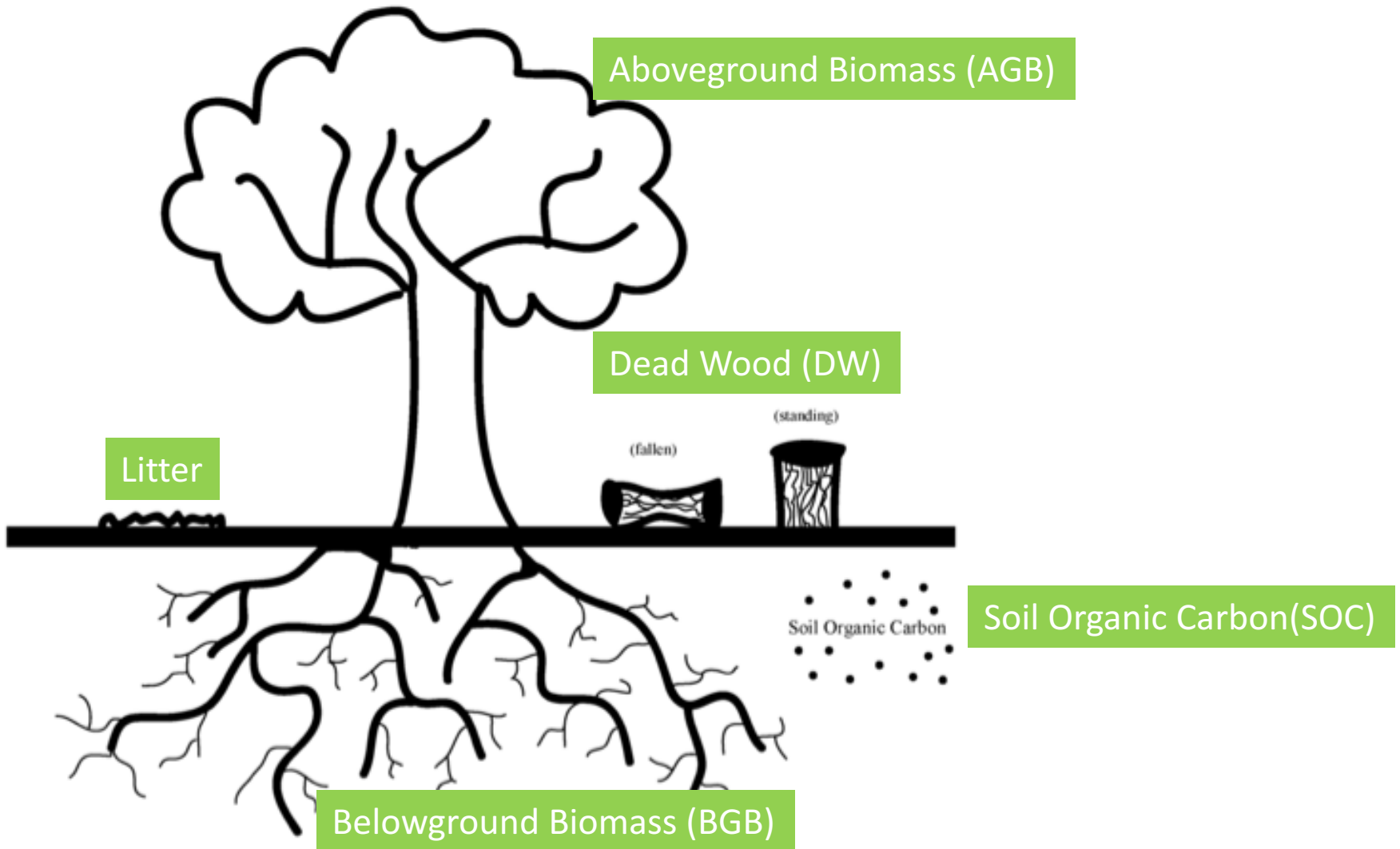
Quantis

THANKS A LOT
FOR YOUR
ATTENTION!

QUESTIONS?

# Considered carbon pools



Aboveground Biomass (AGB)

Dead Wood (DW)

(standing)

(fallen)

Litter

Soil Organic Carbon

Soil Organic Carbon(SOC)

Belowground Biomass (BGB)

Quantis

# General concept: Examples with real land tenure flows

406/0.811=
**500 [m2]** → **Land transformation, primary forest to arable land, [BR]** → **406 [kg C NPP]** → **M**

Land tenure, in kg C NPP

→ **8'110/20=406 [kg C NPP]** → **Land use change, [BR]** → **1 [ha]**

511/1.022=
**500 [m2]** → **Land transformation, primary forest to arable land, [MY]** → **511 [kg C NPP]** → **M**

Land tenure, in kg C NPP

→ **10'220/20=511 [kg C NPP]** → **Land use change, [MY]** → **1 [ha]**

276/0.551=
**500 [m2]** → **Land transformation, grassland to arable land, [DE]** → **276 [kg C NPP]** → **M**

Land tenure, in kg C NPP

→ **5'510/20=276 [kg C NPP]** → **Land use change, [DE]** → **1 [ha]**