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The SALCAfuture project: agroenvironmental expertise translated into LCA

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Introduction – agricultural LCA

- Agricultural systems are complex, stochastic systems with human, technical and environmental interactions
- High spatio-temporal variability of many parameters in these systems
- High importance of direct emissions for environmental impacts
- Different levels are relevant and need to be differentiated
  - Sector
  - Region
  - Farm
  - Field
  - Products (plant-based, animal-based)
- Different fields of knowledge need to be included in the development of methods and tools for agricultural LCAs
  - Scientific disciplines (biology, chemistry, toxicology, physics, agronomy, engineering, …)
  - IT
  - Practical agriculture
- A broad variety of in-depth technical competence is necesssary for LCI modelling (especially direct emission modelling)
- Interfaces between **data collection**, **modelling** and impact assessment need to ensure proper calculations

Data collection – example machinery

Challenges:

- Variety of machinery is used in practical agriculture even for the same working process
- Farmer expects to find "his" machine in the data collection sheet (right type of machine, size, etc.)
- Models need the information on a different level of aggregation

→ Variety of machinery necessary for data collection, not essentially for calculations

- Inventories in the background databases (such as ecoinvent) are again on a different level of aggregation resp. more generalized
- For a generic LCA tool, numerous of such lists for input data are needed (crop production/animal production, domestic/foreign, ...)

Data collection – (other) examples for challenges and solution for input data

- Machinery (variety, differentiation)
- Feedstuff (unit conversion; measured vs estimated amounts)
- Pesticides (different national regulations)
- Mineral fertilizers (variability, background data)
- Organic fertilizers (variability, differentiation and characterization)
- Seed (background data)
- Buildings (variety, differentiation)

We solved that by:

1) Provision of detailed lists for data collection for each of that groups of input data as detailed as available by practitioners

2) Mapping, conversion and aggregation for emission models and background data sets

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Emission modelling – main challenge

Challenge: Expertise from a wide range of disciplines is needed to model emissions in a well-founded way and needs to be translated into LCA context (data demand and precision)

Experience:

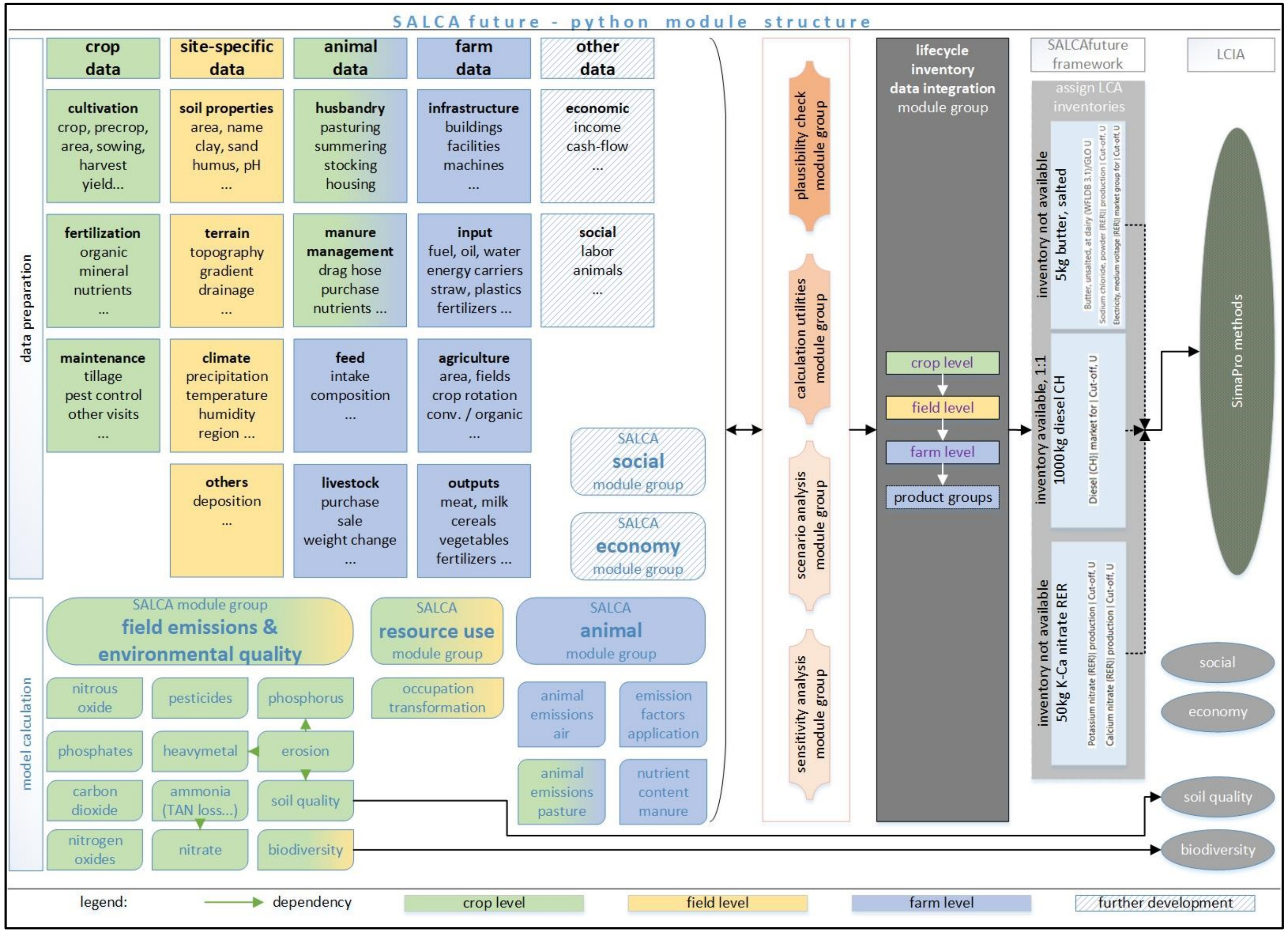
- We at Agroscope are fortunate to have many of these disciplines in-house and were able to built on existing emission models to a large extent for the most important emissions
- Close cooperation with specialists from other disciplines was necessary and possible
- Models were translated to fit the LCA context, e.g. in terms of data requirements and precision
- Mutual benefits have resulted from the fact that the knowledge of the specialists is now applicable in a broader context and the LCA team did not have to acquire it themselves (win-win situation)

→ Emission models presented are internationally recognised and are used by numerous actors and initiatives for databases and tools (Agroscope, ecoinvent, Agribalyse, Geofootprint, WFLDB, etc).

Emission modelling – most relevant emissions and overview emission models used by SALCAfuture

Emission	Description	Reference
Ammonia (NH_3)	Considers type of fertiliser, climate, time and technique of application	Agrammon (2013) EEA/EMEP (2019)
Nitrous oxide (N_2O)	Direct and indirect emissions from soil/ crops Emissions from livestock	IPCC (2019) Crop: Tier 1 Animal: Tier 2 (adapted)
Nitrate (NO_3^-)	Monthly balance, considering crop, sowing and harvest dates, soil tillage, timing and quantity of N fertilisation	Richner *et al.* (2014)
Phosphorus (P, PO_4^{3-})	Includes erosion, run-off and leaching, considers type of fertiliser, the quantity of P spread, soil characteristics, topography	Prasuhn (2006)
Heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn)	Field or farm level balance, considers inputs, harvest, leaching, erosion and change in soil concentration	Freiermuth (2006), updated
Methane (CH_4)	Enteric fermentation and manure management	IPCC (2019), Tier 2
Nitrogen oxides (NOx)	From application of N fertilisers and manure storage	EEA/EMEP (2019) Kirchgessner *et al.* (1993)

How to implement data collection and emission calculation conceptually in an LCA-framework?



- Modular approach
- Data preparation for
  - emission modules
  - background databases
- Differentiation of farm, field and product level
- Variety of applications possible (different types of research questions can be answered)

How to calculate if there are varieties of applications?

- Step 1: identify dependencies

	Abhängigkeit																								
Zielmodul	SALCAtables	SALCAprep_ls	SALCAprep_crop	SALCAprep_field	SALCAprep_farm	Agrammon	SALCAanimal_ls_prep	SALCAanimal_ls	SALCAanimal_farm	SALCAerosion_field_prep	SALCAerosion_field	SALCAphosphor_crop_prep	SALCAphosphor_crop	SALCAfield_field_prep	SALCAfield_field	SALCAheavymetal_crop_prep	SALCAheavymetal_crop	SALCAheavymetal_farm_prep	SALCAheavymetal_farm	SALCAnitrate_field_prep	SALCAnitrate_field	SALCAnitrate_farm	SALCAsoilquality_crop_prep	SALCAsoilquality_crop	SALCAsoilquality_farm
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SALCAerosion_field_prep	indirekt		direkt		direkt																				
SALCAerosion_field	indirekt		indirekt		indirekt					direkt															
SALCAphosphor_crop_prep	direkt		indirekt		indirekt	indirekt	indirekt	indirekt	direkt	indirekt	direkt														
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SALCAnitrate_farm	indirekt		indirekt		indirekt	indirekt	indirekt	indirekt	indirekt					indirekt	indirekt					indirekt	direkt				
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- Step 2: set up a calculation procedure that allows an adaptation of the calculations according to the selected emission models and application levels

Summary of main obstacles and challenges

- Highly complex (and stochastic) systems
  - Different levels (sector, region, farm, field, products)
  - Techno-environmental system with human interruptions
  - Different emissions and emission pathways
  - Variety of environmental impacts

  → Flexible calculation procedure needed
- Different levels of details (data collection vs modelling)
- High temporal and spatial variability
- Interactions of experts from different fields needed (IT, specific environmental impacts, farmers)
- Need to cover generic and primary data

Key learnings and recommendations

- Collect data at the level of detail it is available and translate it later (convert/map/aggregate)
- Modular approach to deal with the complexity (adapt to different levels of application) and variability
- Responsive/interactive calculation system (dependency graph)
- Create win-win situations in cooperations
- Be as precise as necessary, not as precise as possible
- Speak with people in their own language

Thank you for your attention

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