The advantages of generic LCA tools for agriculture: examples SALCAcrop and SALCAfarm

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Overview

- Introduction
- SALCA concept
- Estimating direct field emissions
- Impact assessment
- Principles of SALCA tools implementation
- SALCAcrop
- SALCAfarm
- Embedding into IT architecture
- Conclusions

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Introduction

- LCA is a data intensive method
  → need for efficient data management
- High variability and complexity of agricultural production
  \+ small production units (farms)
  → environmental models and data adapted to agriculture
  → many LCA calculations needed for representative results
  → efficient LCA calculation procedures required
- Various demands from stakeholders (environmental management of farms, environmental product declaration, selection of raw materials, research, etc.)
  → need for integrative concept as a basis for manifold uses

SALCA: An integrated concept for agricultural environmental assessment

SALCA = **S**wiss **A**gricultural **L**ife **C**ycle **A**ssessment

SALCA consists of the following elements:

- **Database for life cycle inventories** for agriculture (in collaboration with ecoinvent)
- Models for the calculation of **direct emissions from field and farm**
- A selection of **impact assessment methods (midpoints)**
- Methods for the assessment of impacts on **biodiversity** and **soil quality**
- **Calculation tools** for agricultural systems (farm, crop)
- **Interpretation scheme** for agricultural LCA
- **Communication concept** for the environmental management of farms

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Estimating direct field and farm emissions

Ideal emission models should

- Reflect the underlying environmental mechanisms
- Be site and time dependent
- Consider the effect of soil and climate
- Consider the effect of management
- Be applicable under a wide range of different situations
- The different models should have a similar level of detail
- But also be usable:
  - Parameters are measurable
  - Data can be collected in a reasonable time
  - Calculation is feasible

A compromise is needed!

SALCA emission models

Emission	Description	Reference
Ammonia (NH_3)	Considers type of fertiliser, climate, time and technique of application	Menzi *et al.* (1997)
Nitrous oxide (N_2O)	Direct and indirect emissions	IPCC (2006)
Nitrate (NO_3^-)	Monthly balance, considering crop, sowing and harvest dates, soil tillage, timing and quantity of N fertilisation	Richner *et al.* (2006)
Phosphorus (P, PO_4^{3-})	Includes erosion, run-off and leaching, considers P fertilisation, 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)
Methane (CH_4)	Enteric fermentation and manure management	IPCC (2006)

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SALCA impact assessment methods

Impact category	Reference	Remarks
Non-renewable energy demand	Ecoinvent (2007)	Fossil und nuclear energy resources
Global warming potential	IPCC (2007)	
Ozone formation potential	EDIP (2003)	With regionalisation
Eutrophication potential	EDIP (2003)	With regionalisation
Acidification potential	EDIP (2003)	With regionalisation
Aquatic and terrestrial ecotoxicity Human toxicity	CML (2001)	Complemented with characterisation factor for ca. 400 pesticide active ingredients
Biodiversity	Jeanneret et al. (2006)	11 indicator organism groups 2 characteristics
Soil quality	Oberholzer et al. (2006)	9 indicators for physical, chemical and biological soil properties

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Principles of SALCA tools: Organisational structure

- **Generic LCA systems** to cover all types of farms (SALCAfarm) or crops (SALCAcrop) within the validity range
  - → wide range of applications
  - → applicable for multiple purposes
- **Standardised LCA calculation**
  - → ensures consistency
  - → avoids redundancy
- **Parameterisation**
  - → inputs and processes defined by variables
  - → non-existing inputs and processes set to 0
  - → hundreds to thousands of parameters
- **Modular structure**
  - → each module has clearly defined interfaces
  - → modules can also be used/tested independently
  - → complexity can be managed
- Illustrated by the example of **SALCAcrop**

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SALCAcrop

- System boundary: 1 crop per growing season
  - By multiple calculations it can represent also crop rotations and permanent crops
- 140 arable/permanent crops and vegetables covered
- Valid for Central Europe

	C	D	F	G	H	I	J	K	L	M	N	O
1			Crop rotation without GL					Crop rotation with GL				
2												
3		VARIABLE	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT
4	MODULES	NAME	Saxony_1_OSR	Saxony_2_WW1	Saxony_3_WW2	Saxony_4_WW3	Saxony_5_WB	Saxony_GL_1_OSR	Saxony_GL_2_WW1	Saxony_GL_3_pea	Saxony_GL_4_WW1	Saxony_GL_5_WB
557	N-Dünger Total	N Kalk-Ammoniumnitrat (kg N)	51.30	159.30	186.30	99.90	135.00	51.30	159.30	0.00	156.60	135.00
558	N-Dünger Total	N Ammoniumsulfat (kg N)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
566	P-Dünger Total	P Triple-Superphos. (kg P2O5)	53.67	53.67	53.67	46.00	46.00	46.00	46.00	53.67	53.67	53.67
567	P-Dünger Total	P Superphosphat (kg P2O5)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
568	P-Dünger Total	P Monoammoniumphosphat (MAP, kg P2O5)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
569	P-Dünger Total	P Diammoniumphosphat (DAP, kg P2O5)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
570	P-Dünger Total	P AN-Phosphat (kg P2O5)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
571	P-Dünger Total	P Hyperphosphat (Rohphosphat, kg P2O5)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
572	P-Dünger Total	P Thomasmehl (kg P2O5)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
576	K-Dünger	K Kalisalz (KCl, kg K2O)	29.33	29.33	29.33	57.00	57.00	44.00	44.00	0.00	0.00	0.00
577	K-Dünger	K Kaliumsulfat (K2SO4, kg K2O)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
578	K-Dünger	K Patentkali (kg K2O)	15.77	15.77	15.77	0.00	0.00	8.25	8.25	44.00	44.00	44.00
584	Andere Total	Ca Kalk (kg Ca)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
585	Andere Total	Ca Karbonationskalk (kg Ca)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
586	Andere Total	Ca Meeresalgenkalk (kg Ca)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
587	Andere Total	Mg Magnesium (kg Mg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
588	Andere Total	Steinmehl (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
589												
590	Weitere Hilfsstoffe Total	Wasser (Leitung, Alloc)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
591	Weitere Hilfsstoffe Total	Wasser (Quelle/Bach, Alloc)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

PI | Tabelle2 | Tabelle3

Production inventory
Example: 2 crop rotations in Germany

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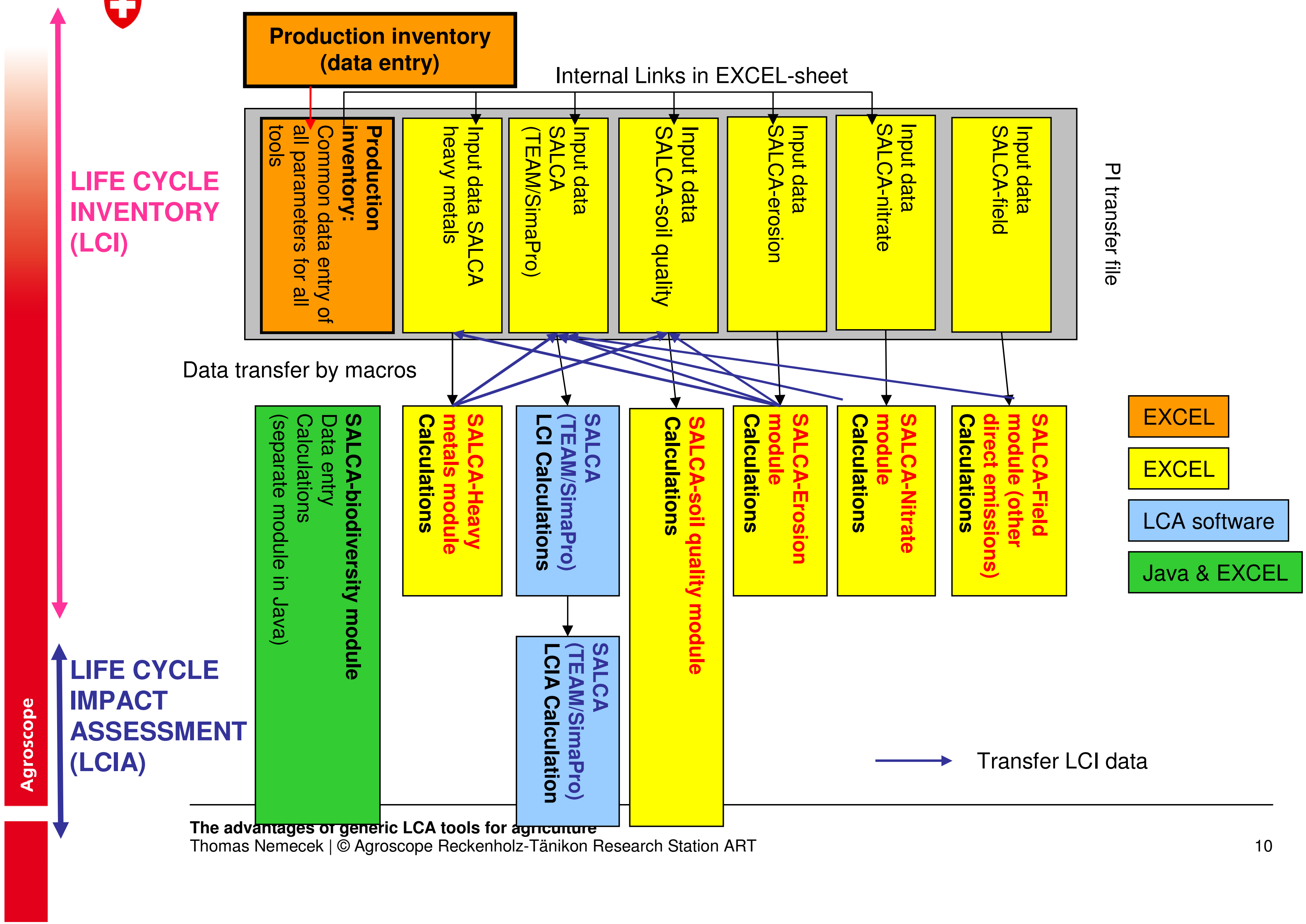
Modular architecture of the SALCA-crop V3.1



Principles of SALCA tools: Software implementation

- **Automated workflow**
  → efficient calculation procedure
- **Batch processing**
  → mass calculation
  → many farms or crops can be calculated in one run
- **Core components** (SALCAcrop, SALCAfarm)
  → own programming
- **Peripheral components**
  → IT service provider, parametrisable tools
- Illustrated by the example of **SALCAfarm**

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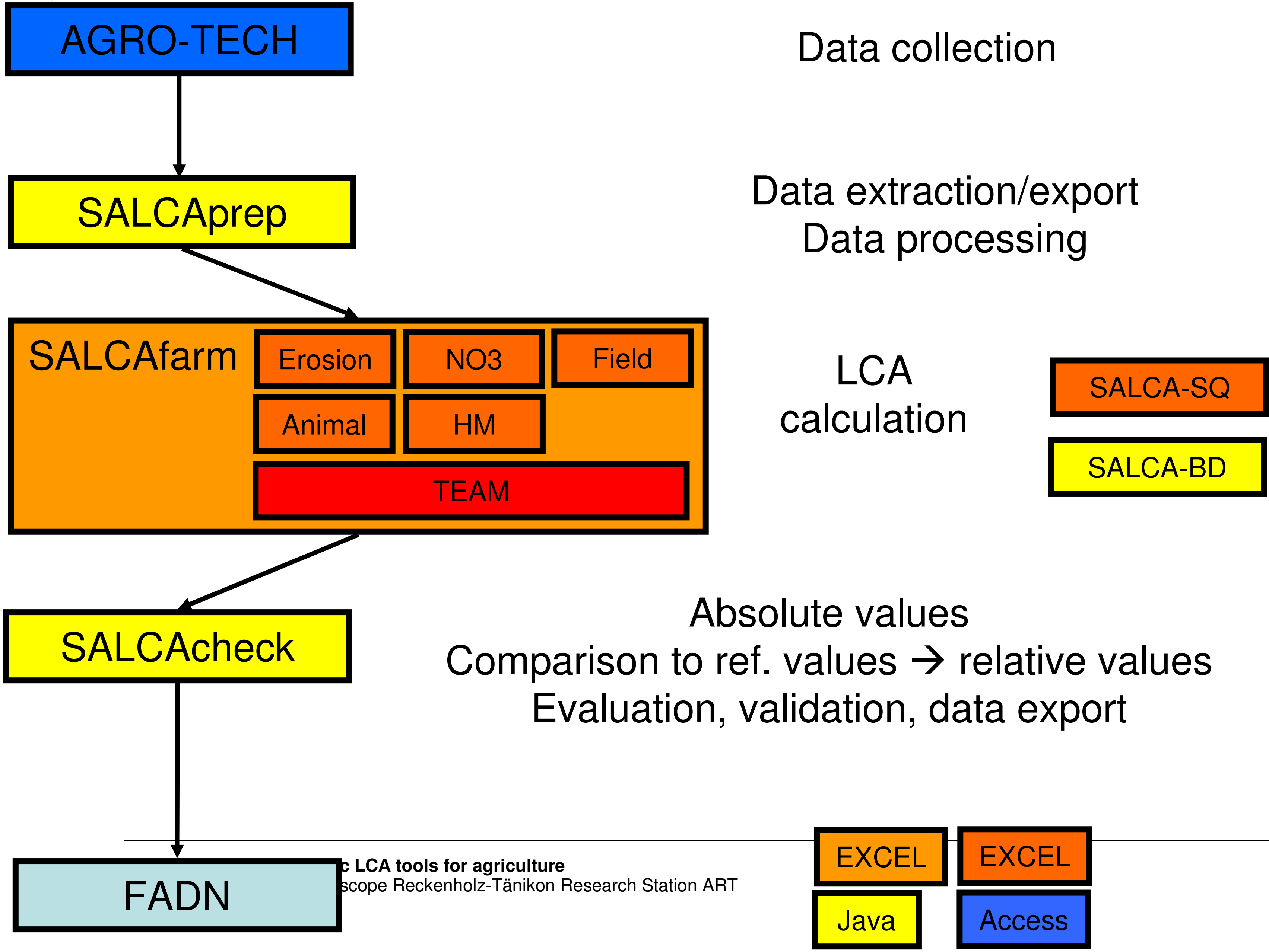
SALCAfarm

- System boundary: farm / product group
  - Can also be used for animal production systems
- Applicable for Swiss conditions
- Four system levels:
  - **Farm**
  - **Product group** (up to 14 product groups)
  - **Field**
  - **Crop**
- Allocation of inputs and outputs to the product groups by a set of allocation rules (economic, area, arable area, livestock units)

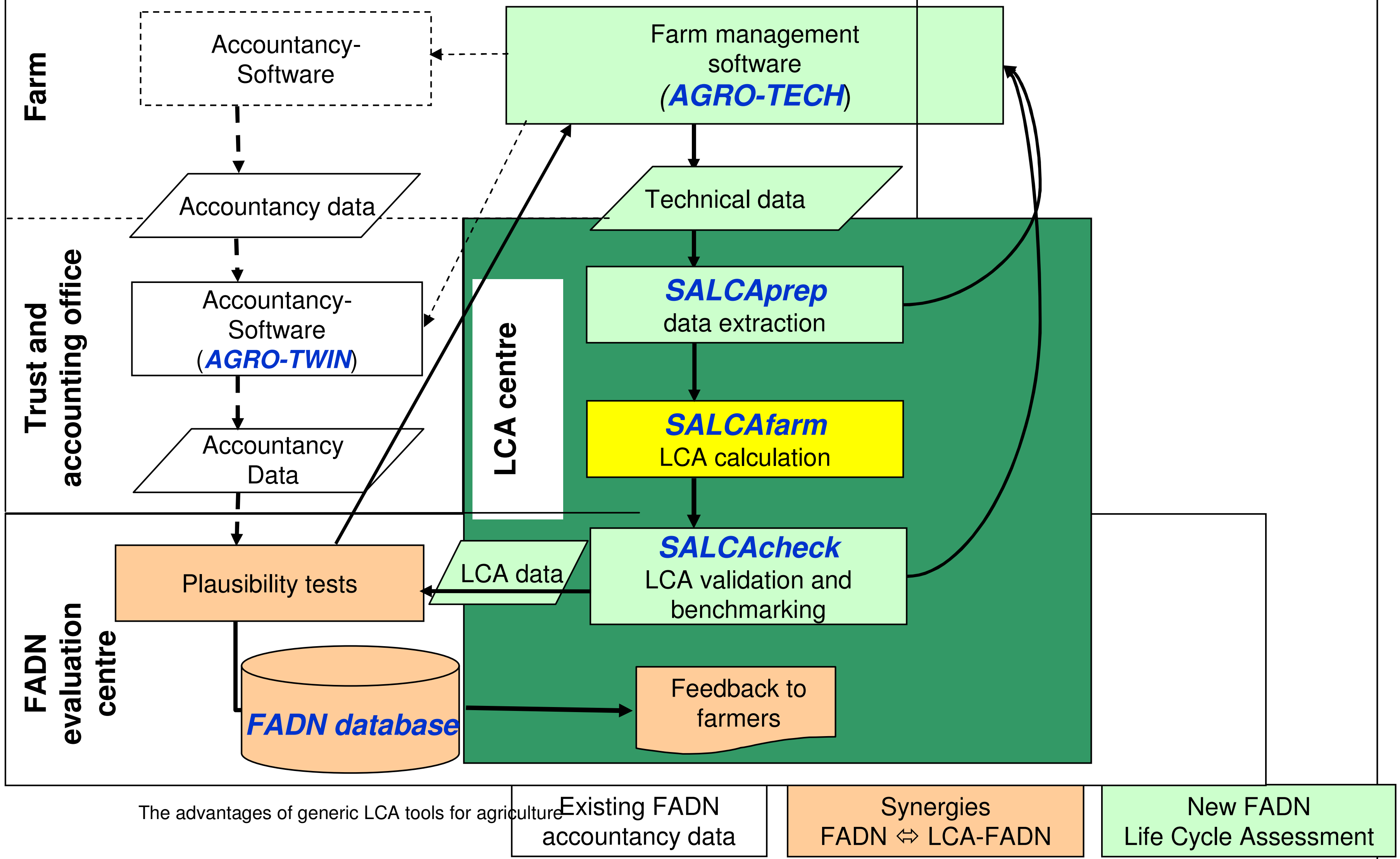
SALCAfarm:
Iterative calculation procedure at several levels

	Calculation level		
Module	**Crop**	**Field**	**Farm / product group**
SALCAerosion	↻	↻	
SALCAnitrate	↻	↻	
SALCAfield	↻	↻	
SALCAheavyMetals			↻
SALCAanimal			↻

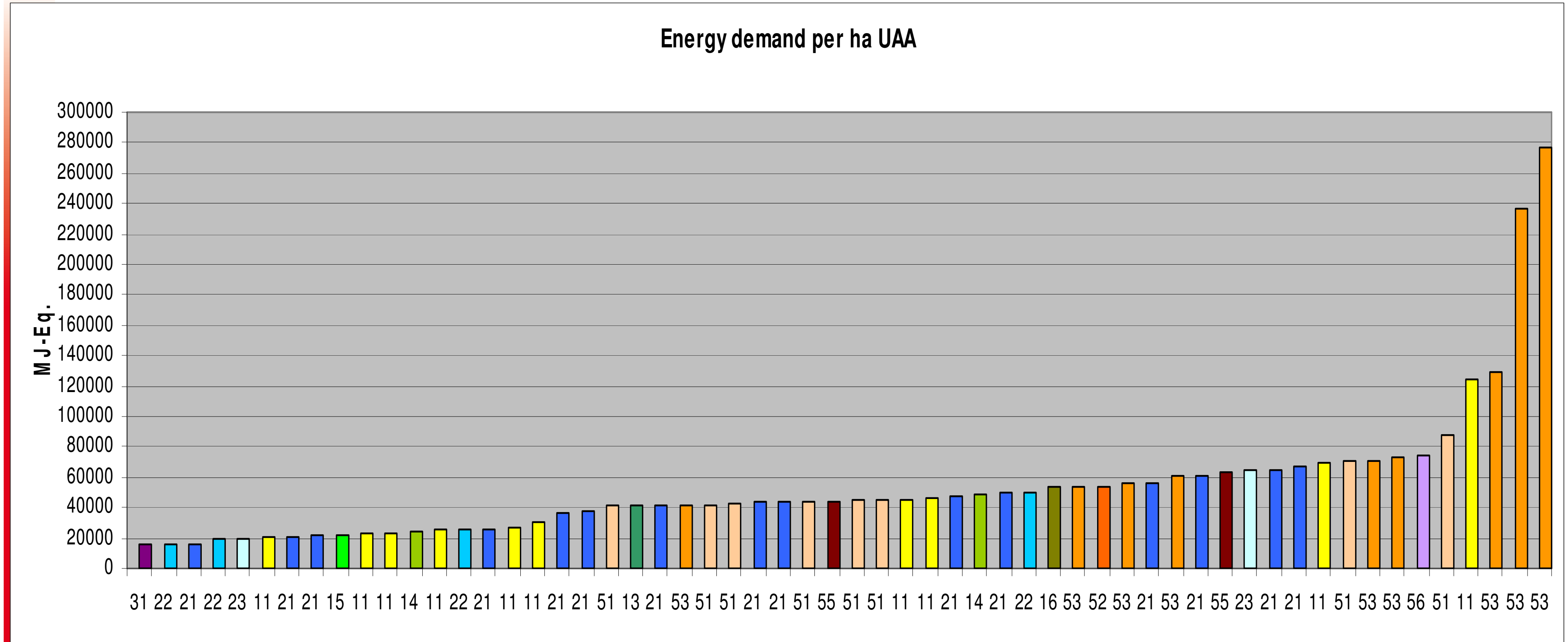
Automated workflow as used in LCA-FADN



Embedding into existing IT infrastructure
Workflow in the project LCA-FADN



Variability of environmental impacts: Energy demand per ha UAA (62 Swiss farms)



Farmtype	Description	Farmtype	Description
11	arable farming	23	other cattle
13	vegetable cultivation	31	horses/goats/sheep
14	fruit cultivation	51	dairy farm / arable farming combined
15	viticulture	52	suckler cows / arable farming combined
16	other cultures	53	pigs and poultry / arable farming combined
21	dairy farm	55	dairy farms / other combined
22	suckler cows	56	cattle / other combined

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Conclusions

- Advantages of generic LCA tools
  - Consistent, standardised calculation of a large number of LCAs
  - More efficient calculation → allows to assess variability better
  - Avoids redundancy → changes and improvements made only once
  - Flexibility by parameterisation
- Drawbacks of generic LCA tools
  - Time-consuming development
  - System gets more complex (need to consider all cases) → modular structure required
- Generic LCA tools are required
  - to handle large datasets
  - to assess variability
  - to foster agricultural LCA

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Thank you!

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