SUSTAINABILITY MANAGEMENT AT FARM SCALE –
CONCEPT, OPERATIONALIZATION AND APPLICATION

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3 Topics

- Discussion about sustainable agriculture (deficits)
- Introduction and explanation framenwork „sustainability management“
- Example for application

+ Endless definitions for sustainability and sustainable agriculture

+ > 70 approaches / models “sustainable agriculture” (EMAS, RISE, INDIGO, KUL, REPRO…)

+ Several projects for development of sustainable land use concepts

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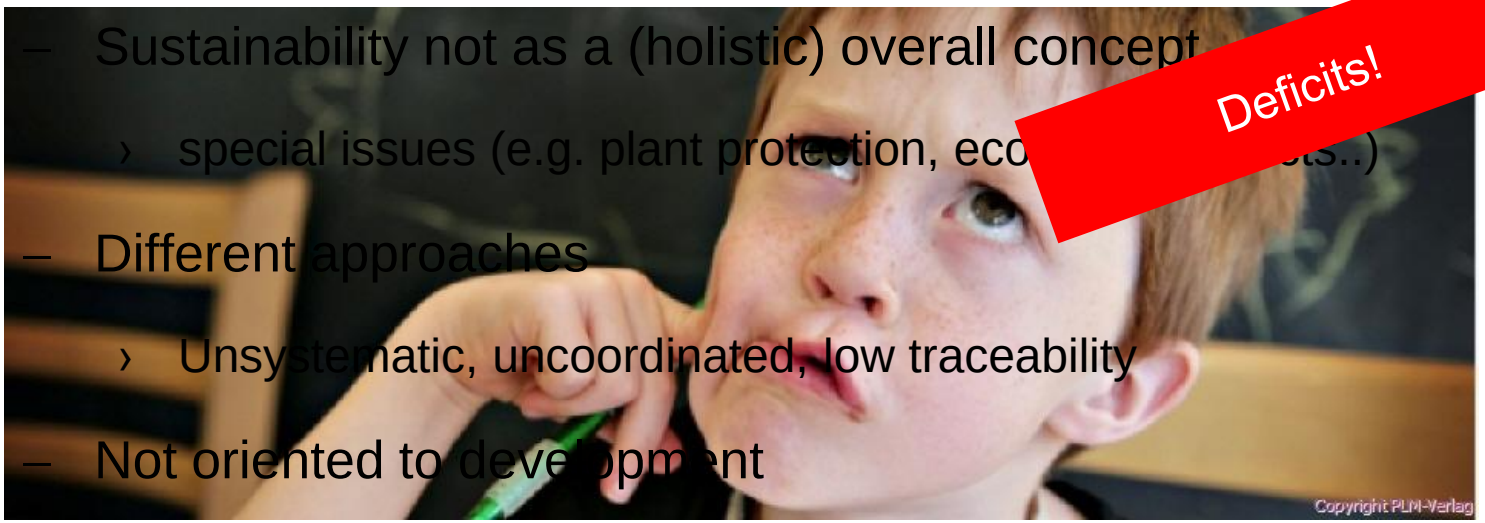
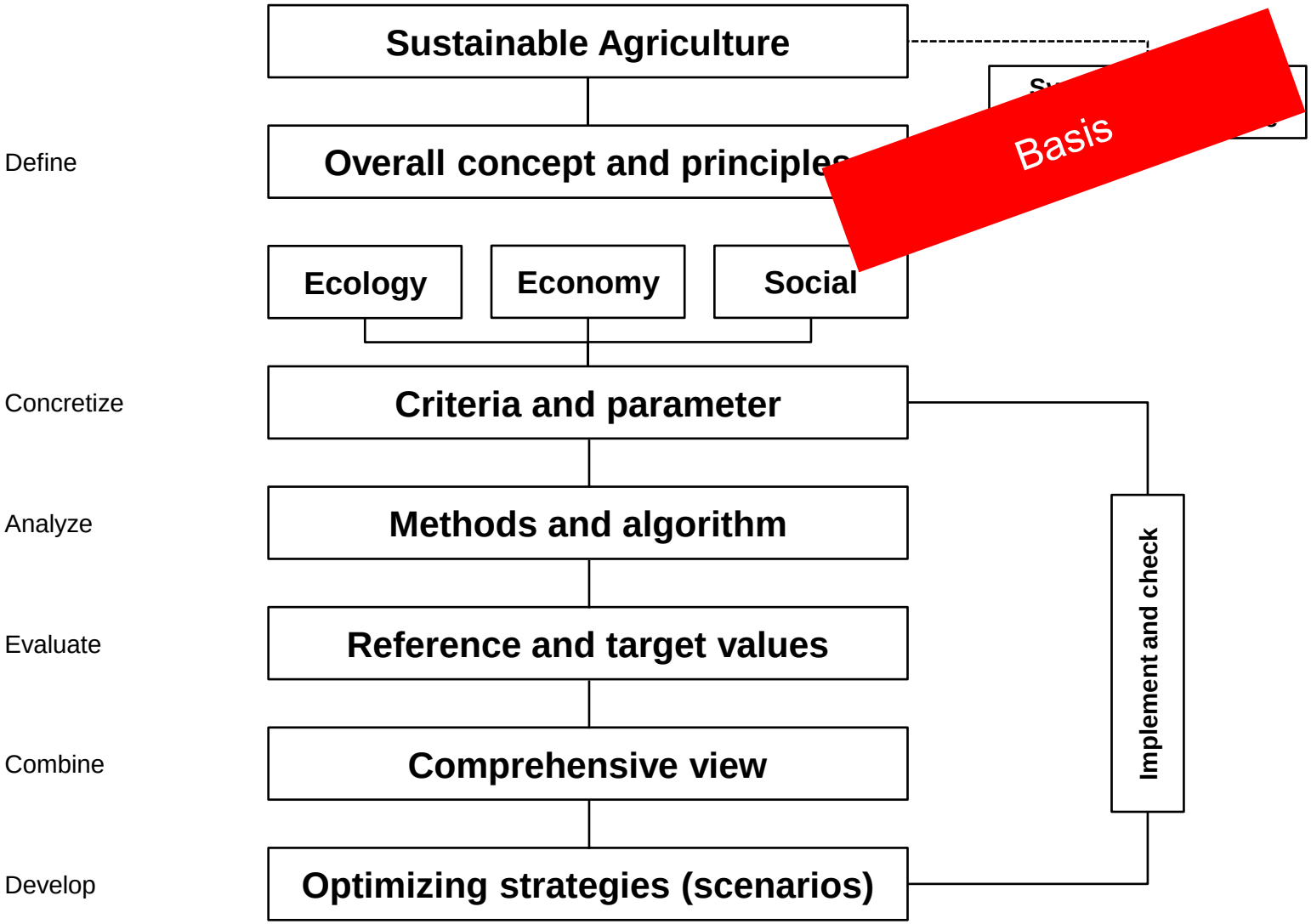
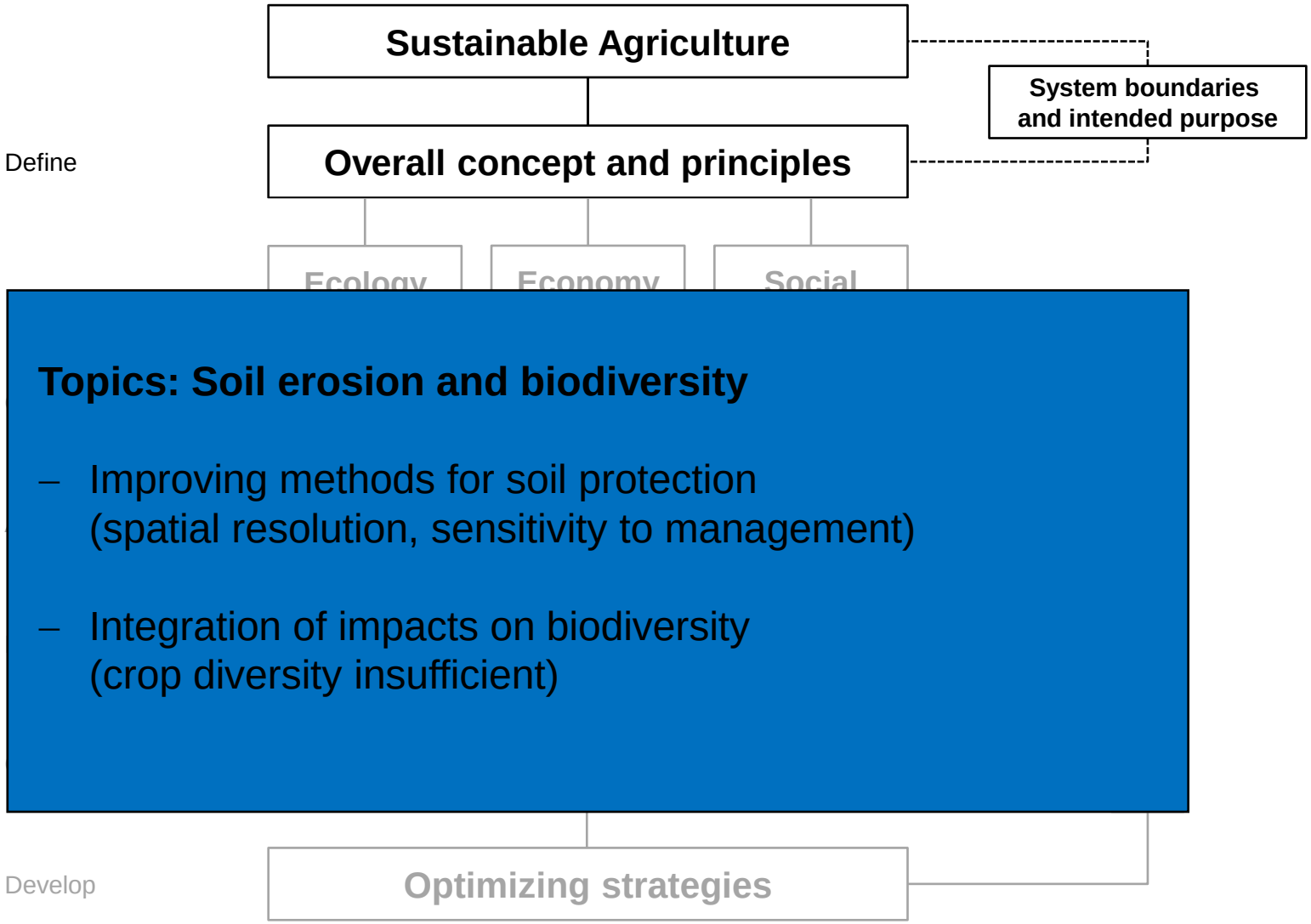
- Todays agriculture ≠ sustainable!



- Sustainability not as a (holistic) overall concept
  - › special issues (e.g. plant protection, eco ... ts..)
- Different approaches
  - › Unsystematic, uncoordinated, low traceability
- Not oriented to development
  - › “Only analyses”
- System under investigation
  - › E.g. abstract unit “region” → no development


Sustainable Agriculture
Define
Overall concept and principles
Basis
Ecology
Economy
Social
Concretize
Criteria and parameter
Analyze
Methods and algorithm
Evaluate
Reference and target values
Combine
Comprehensive view
Develop
Optimizing strategies (scenarios)
Implement and check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System boundaries and intended purpose
Define
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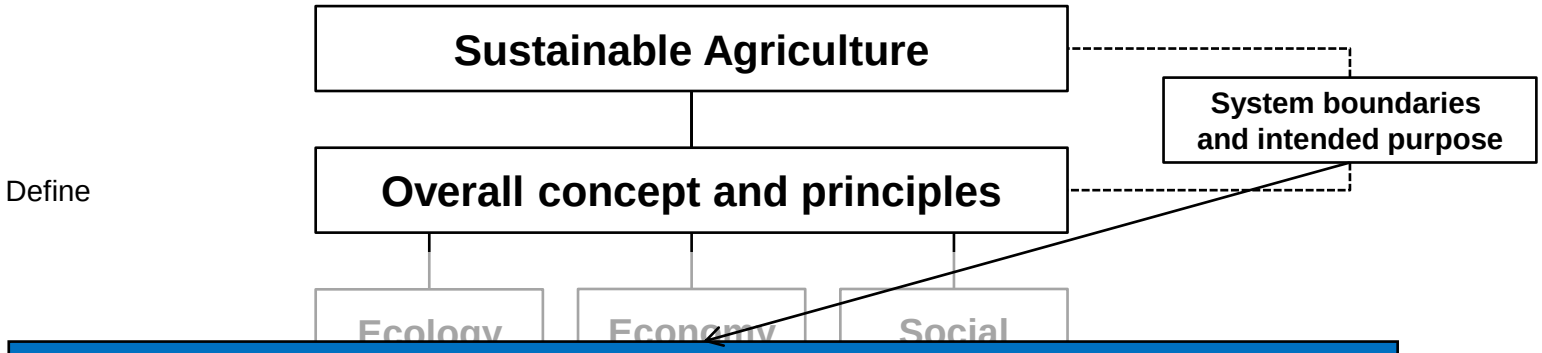
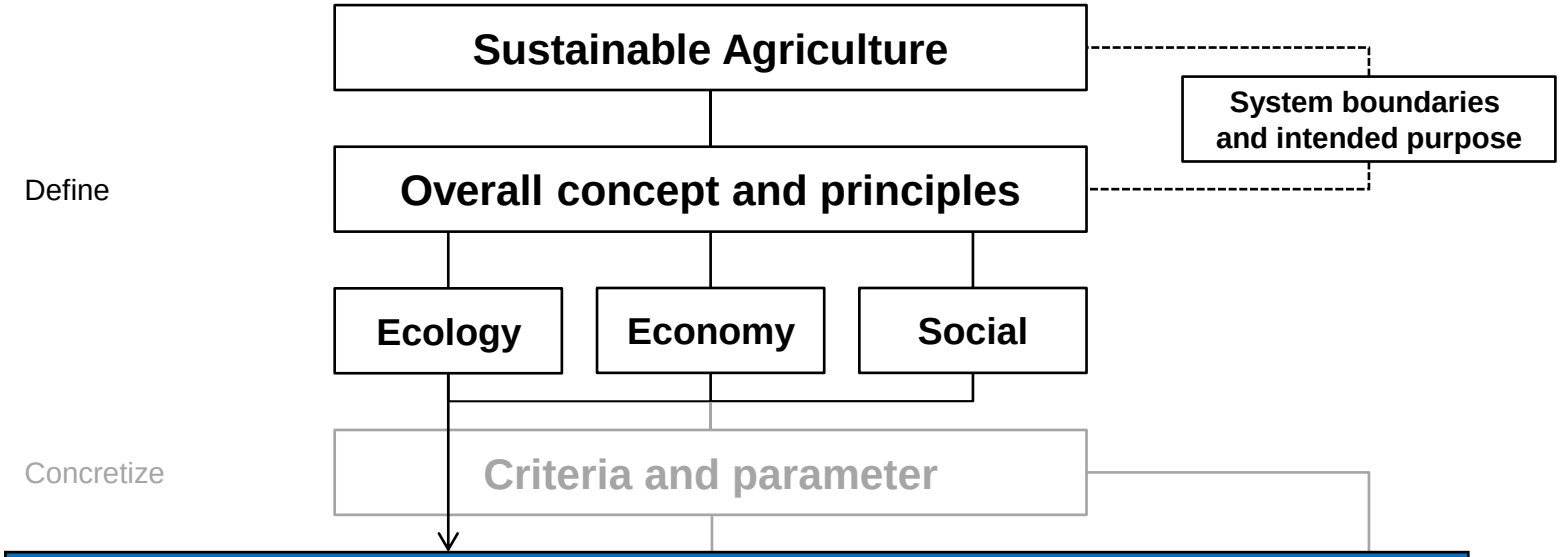
Topics: Soil erosion and biodiversity
– Improving methods for soil protection (spatial resolution, sensitivity to management)
– Integration of impacts on biodiversity (crop diversity insufficient)
Develop
Optimizing strategies

Application of the framework “Sustainable Management”

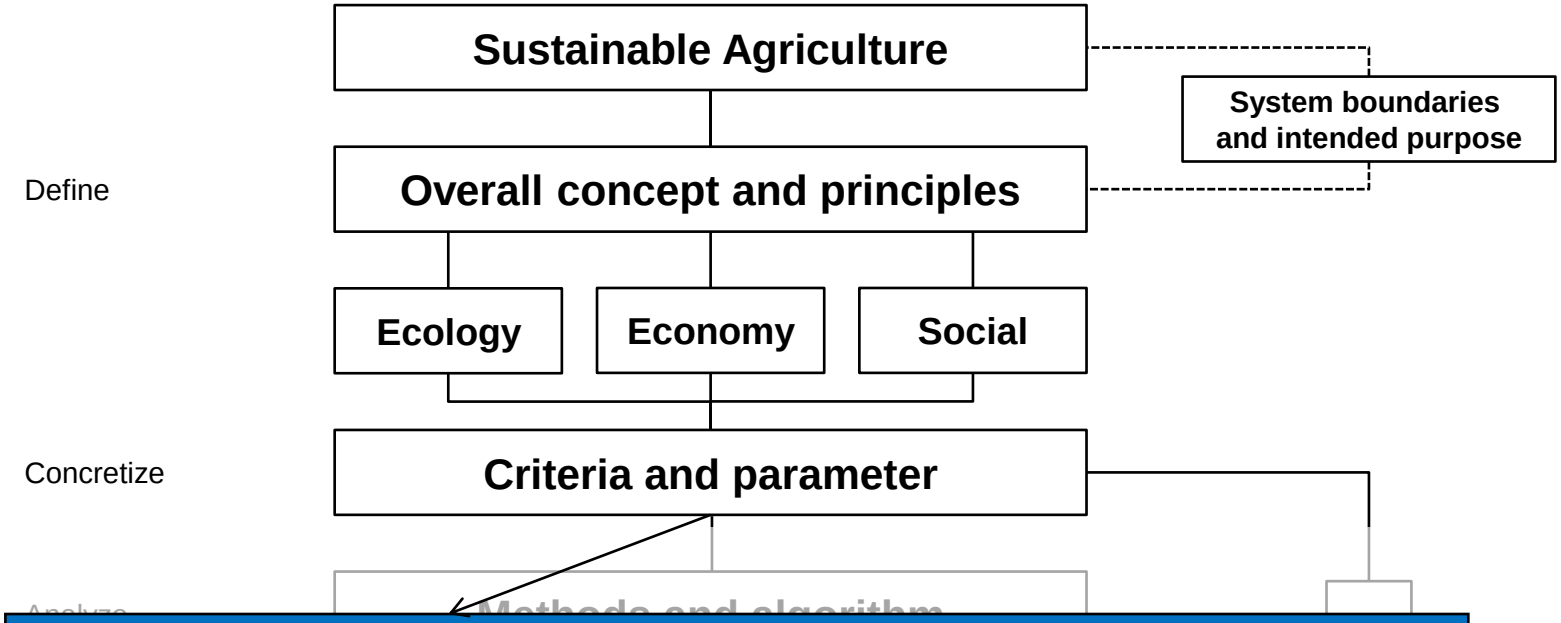


- **Farms scale, production system**
- **Supporting development of sustainable production systems**
- **Overall and holistic view of sustainability**
- **Realize analyses and evaluation of sustainability**
- **Identify weaknesses and derive management options**



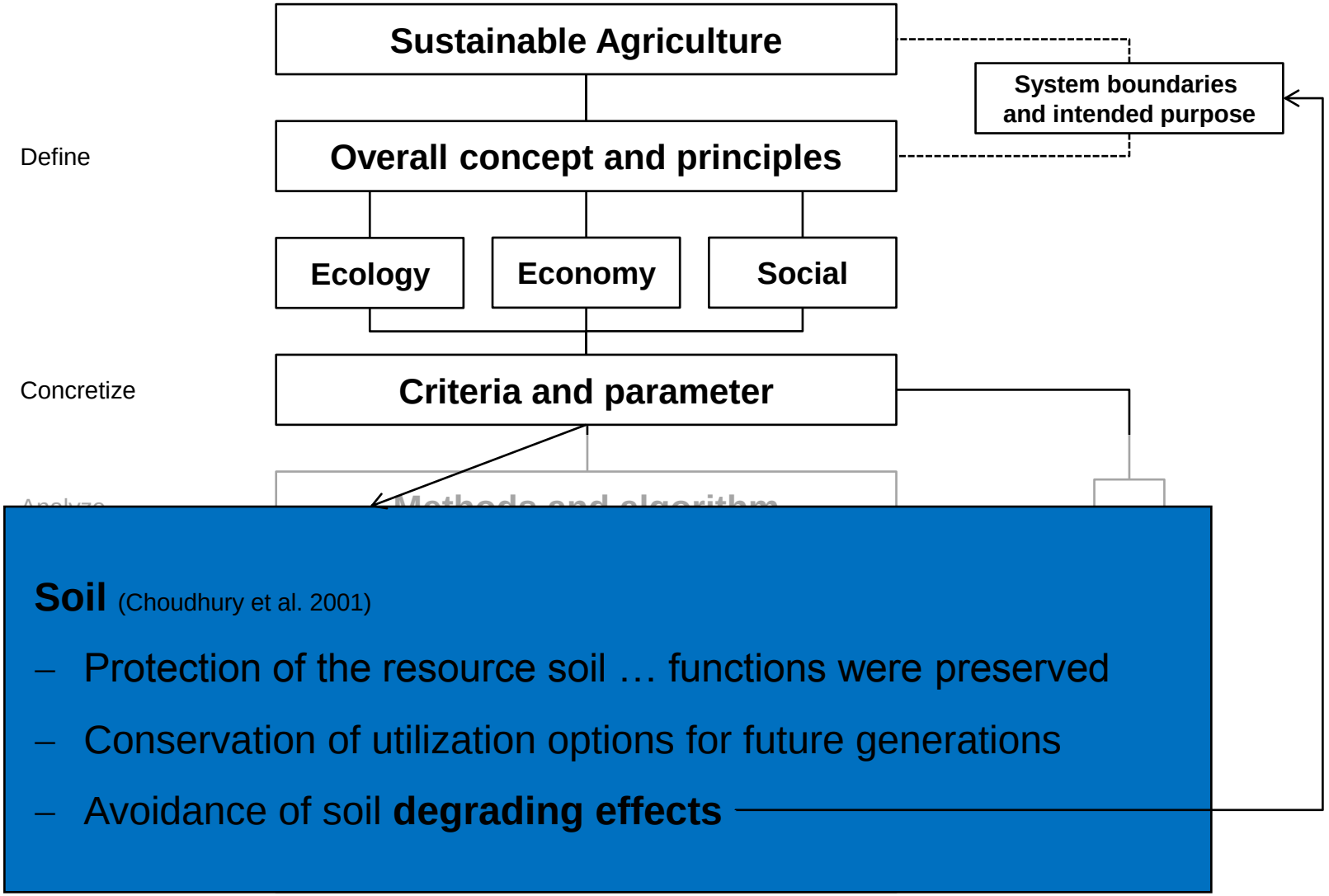
General principles

- Production as main aim (food, fiber or biomass)
- Conservation of resources (water, soil, air, …)
- Avoidance of negative influences on adjacent ecosystems
- Protection of ecosystem functions (e.g. regulation, pollination)
- Protection and development of biodiversity



Soil (Choudhury et al. 2001)

- Protection of the resource soil … functions were preserved
- Conservation of utilization options for future generations
- Avoidance of soil degrading effects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Soil degradation processes

Global Assessment of Human-Induced Soil Degradation

E. M. BRIDGES
L. R. OLDEMAN

International Soil Reference and Information Centre
Wageningen, Netherlands

	World	Asia	N. Africa and W. Asia[a]	Africa	South America	Central America	North America	Europe	Oceania
Degradation type								%	
Water	1094	440	84.1	227	123	46	60	**52**	83
Wind	548	222	145.2	187	42	5	35	**19**	16
Nutrient decline	135	14	6.3	45	68	4	–	1	+
Salinization	76	53	46.9	15	2	2	–	2	1
Pollution	22	2	0.3	+	–	+	–	9	–
Acidification	6	4	–	2	–	–	+	0,0	–
Compaction	68	10	3.6	18	4	+	1	**15**	2
Waterlogging	11	+	0.1	+	4	5	–	0,0	–
Subsidence organic soils	5	2	–	–		–	–	1	–
Total	1965	747	286.5	494	243	63	96	218	102

Bridges & Oldeman 1999

Model	APES [1]	DIALECTE [2]	EAQ [3]	EMA [4]	EP [5]	ESI [6]	FSI [7]	IDEA [8]	INDIGO [9]	IRENA [10]	KUL [11]	LCAA [12]	MODAM [13]	RAUMIS [14]	REPRO [15]	RISE [16]	SAFE [17]	SALCA [18]	SEC [19]

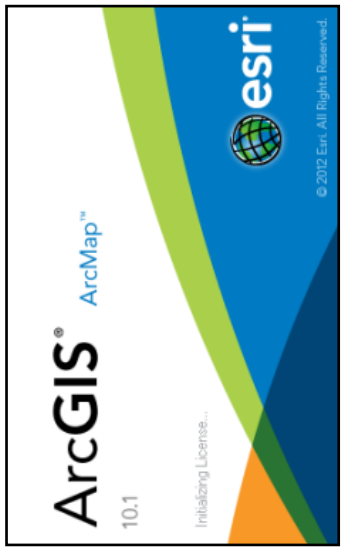
Publications: [1] Donatelli et al. 2007, Van Ittersum et al. 2008; [2] Pointereau et al. 1999, Solagro 2000; [3] Paccini et al. 2000; [4] Lewis & Tzilivakis 2000, Lewis et al. 2003; [5] Mayrhofer 1997; [6] Sands & Podmore 2000; [7] Taylor et al. 1993, Bonny & Vijayaragavan 2001; [8] Vilain 1999, Vilain 2003; [9] Weinstoerffer & Girardin 2000, Girardin & Bockstaller 2002; [10] EEA 2005; [11] Breitschuh et al. 2001, Eckert et al. 2002; [12] Audsley et al. 1997; [13] Sattler & Zander 2004; [14] Cypris 2000, Henrichsmeyer et al. 1996; [15] Hülsbergen 2003; [16] Fischer et al. 2004, Boller et al. 2004; [17] Peeters & Van Bol 2000, Van Cauwenbergh et al. 2007; [18] Nemecek et al. 2004, Jeanneret et al. 2006; [19] Marjoleine et al. 1998, Biewinga & Van der Bijl 1996

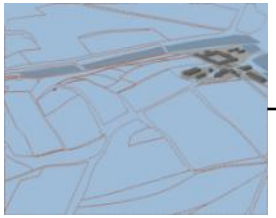
- Version of Universal Soil Loss Equation

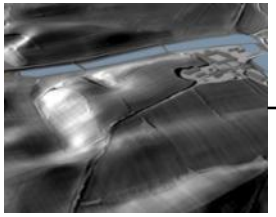
  (USLE = ABAG, Schwertmann et al. 1987)

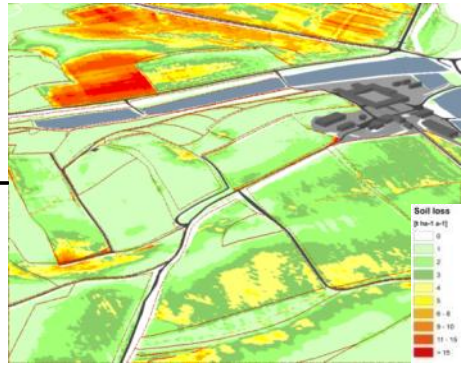
  - Adapted and validated
  - High sensitivity, required input data available
  - Results easy to interpret
- Simple equation – 6 factors

  $$A = R * K * L * S * C * P$$
- Modified with new algorithm (RUSLE, DIN 19708)
- GIS-based version → spatial heterogenity

Inputs	***Description***	**Result**
	Amount and intensity of rain	Calculates Soil losses
	Texture, SOM, Permeability, Aggregate stability	
	Slope length and inclination	
	Crops, soil management, erosion protection	E.g. 5 t ha^{-1} a^{-1}







Experimental Farm Scheyern

- 1991 and 2005 for long term research project
- Development of a **sustainable land use concept** for agriculture compatible with environmental protection
- **Impacts** of two cropping systems
  - **integrated managed** farm system (conventional) (**SI**)
  - **ecological managed** farm system (**SO**)

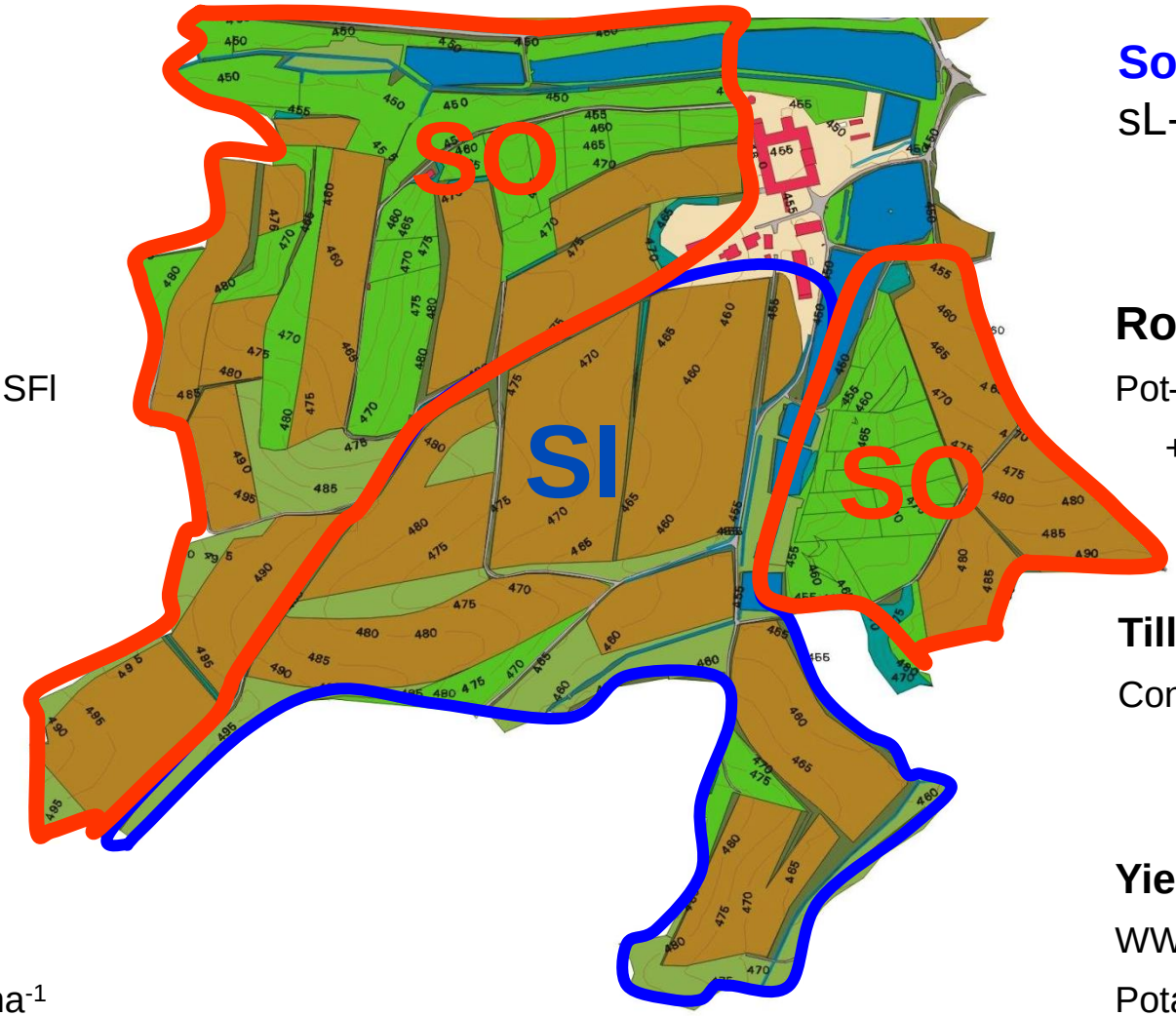
Experimental Farm Scheyern

Soil
lS-tL, 48 BP

Rotation
LCG– Pot– WW – SFl
LCG– WW – WR

Tillage system
Plough, 25 cm

Yields
WW: 40 dt ha^{-1}
Potatoes: 260 dt ha^{-1}



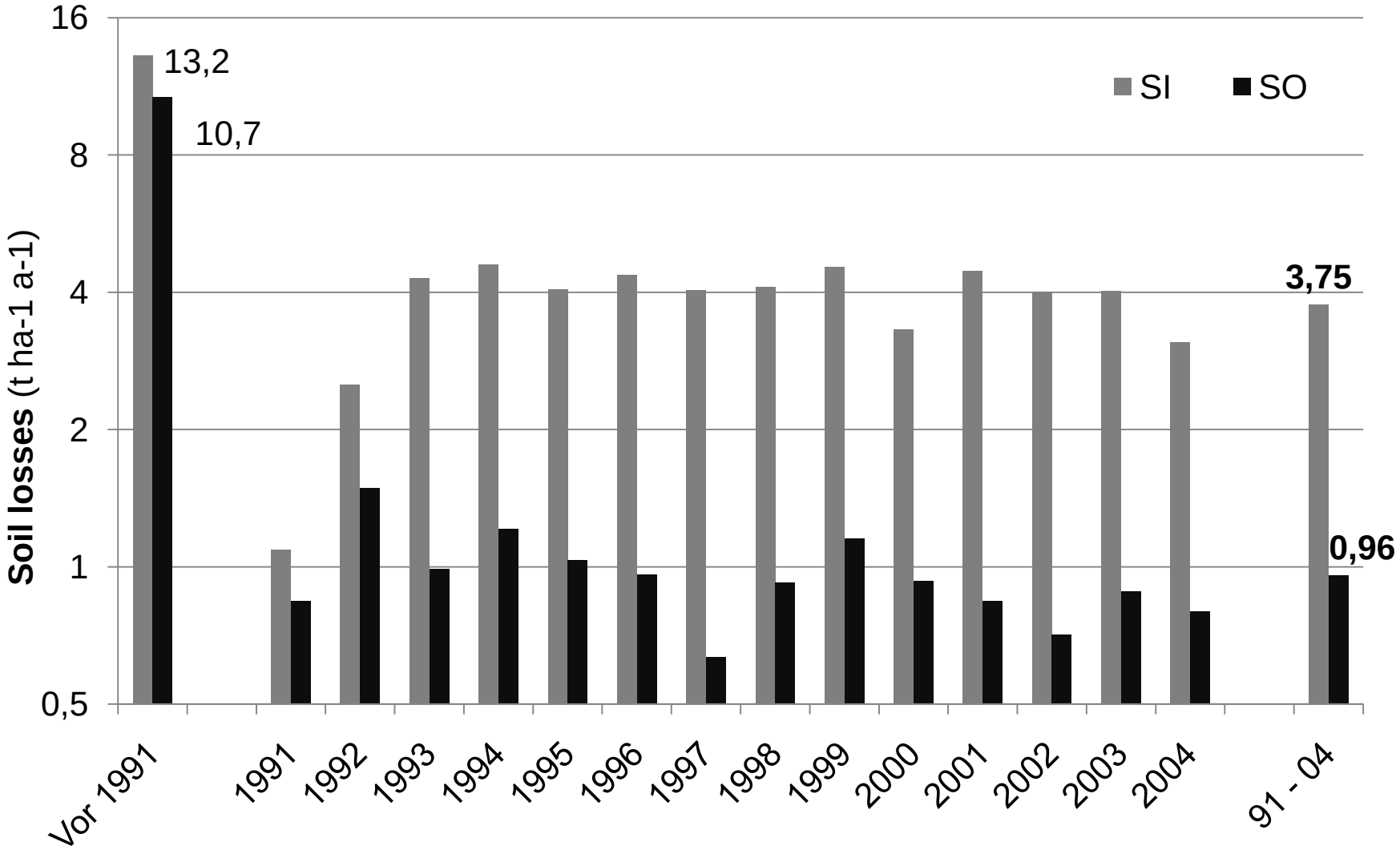
Soil
sL-utL, 52 BP

Rotation
Pot– WW – SM– WW
+ Mustard

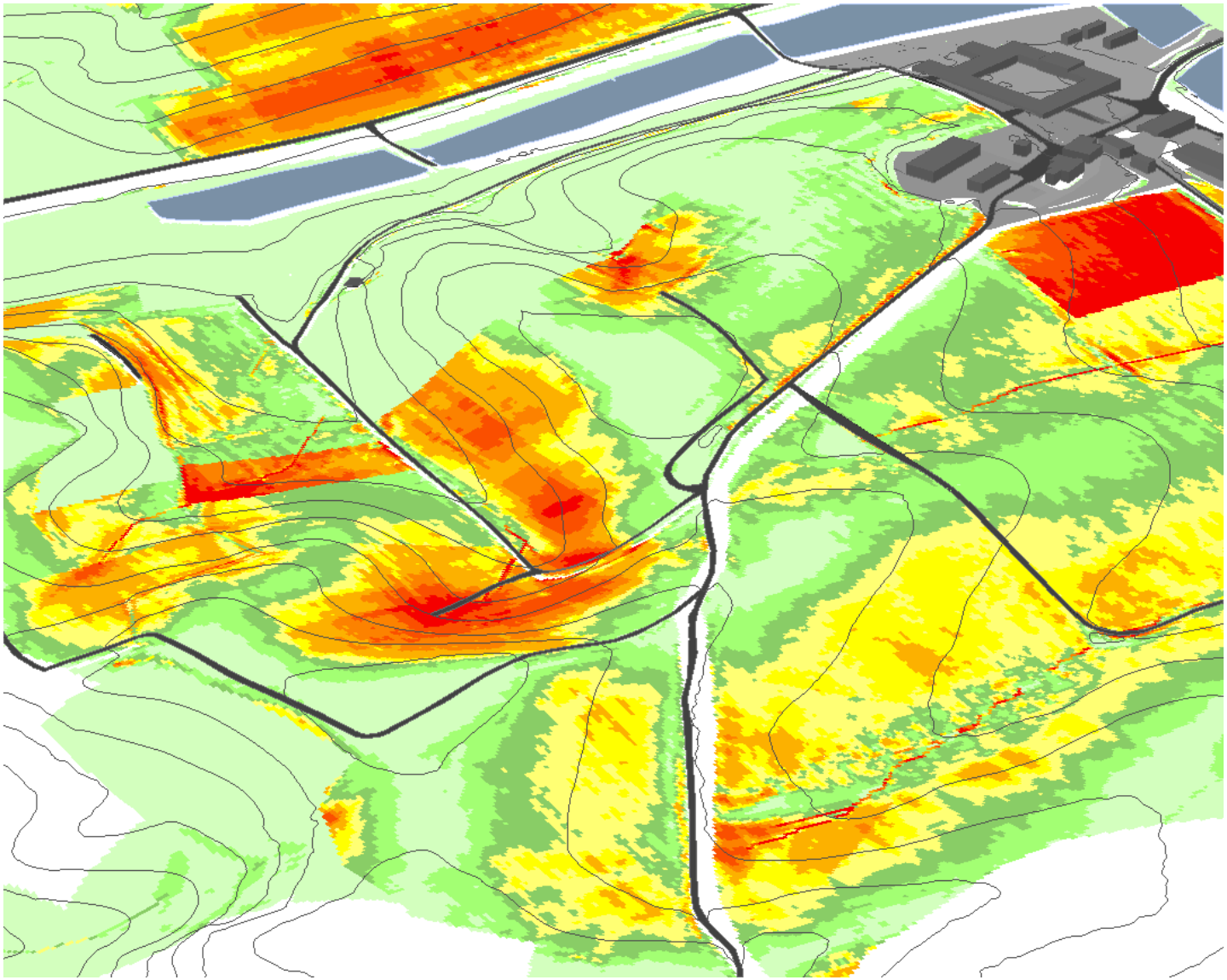
Tillage system
Conservation, 10 cm

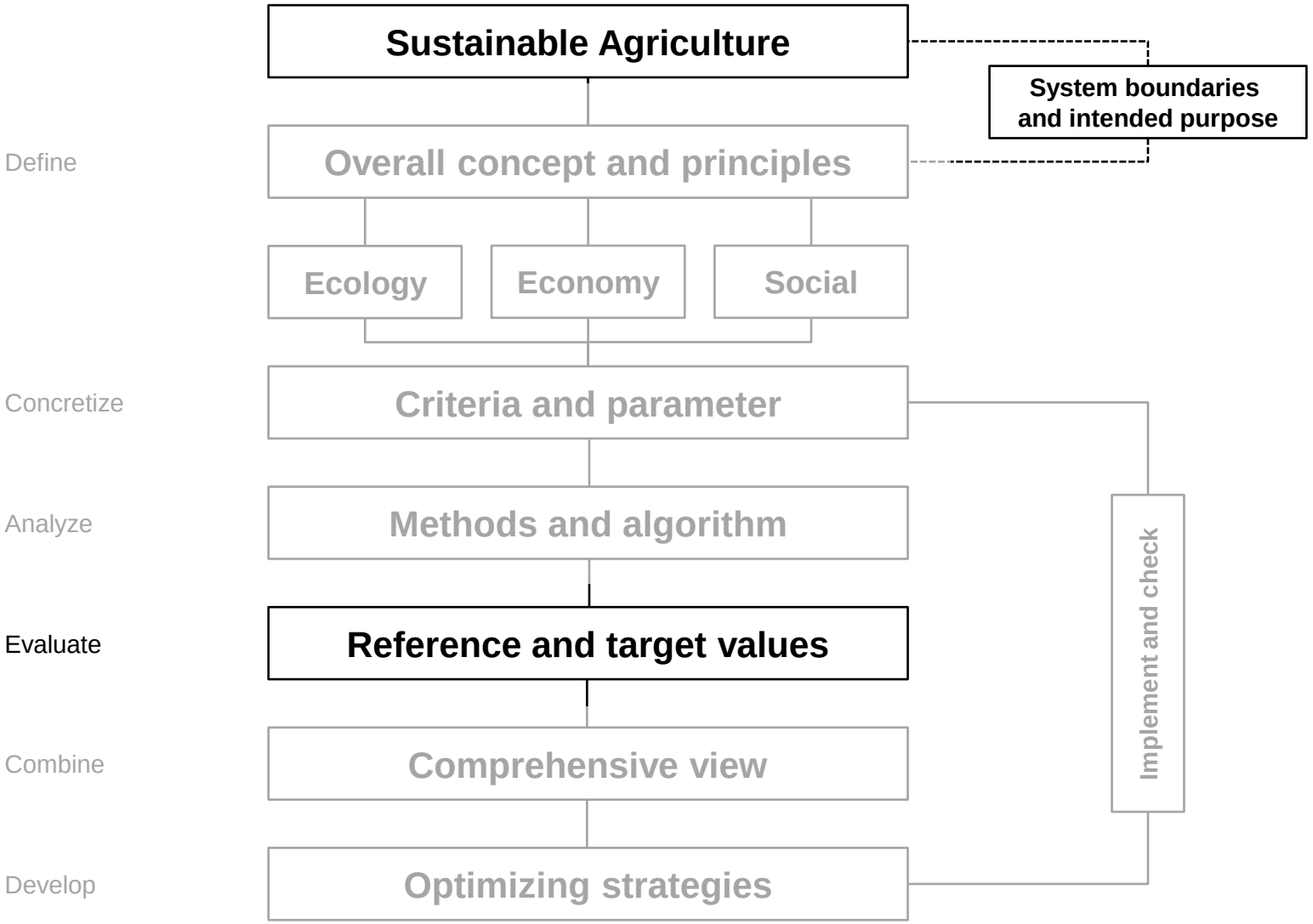
Yields
WW: 70 dt ha^{-1}
Potatoes: 370 dt ha^{-1}

Soil losses of both farming systems



Results - Experimental Farm Scheyern

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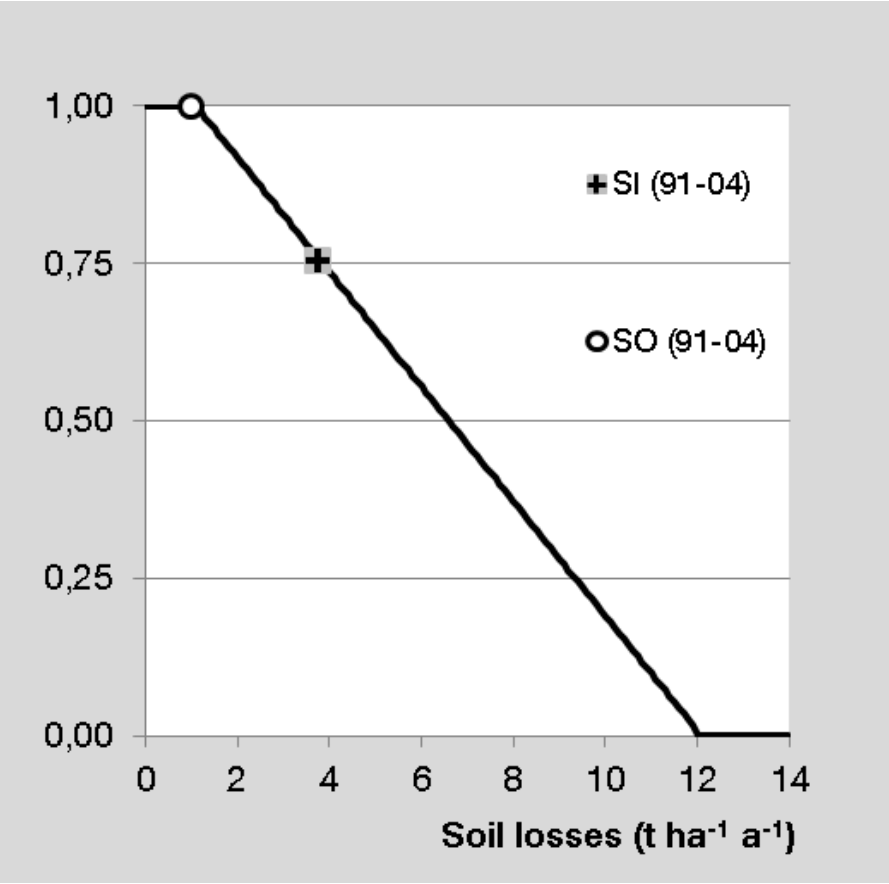
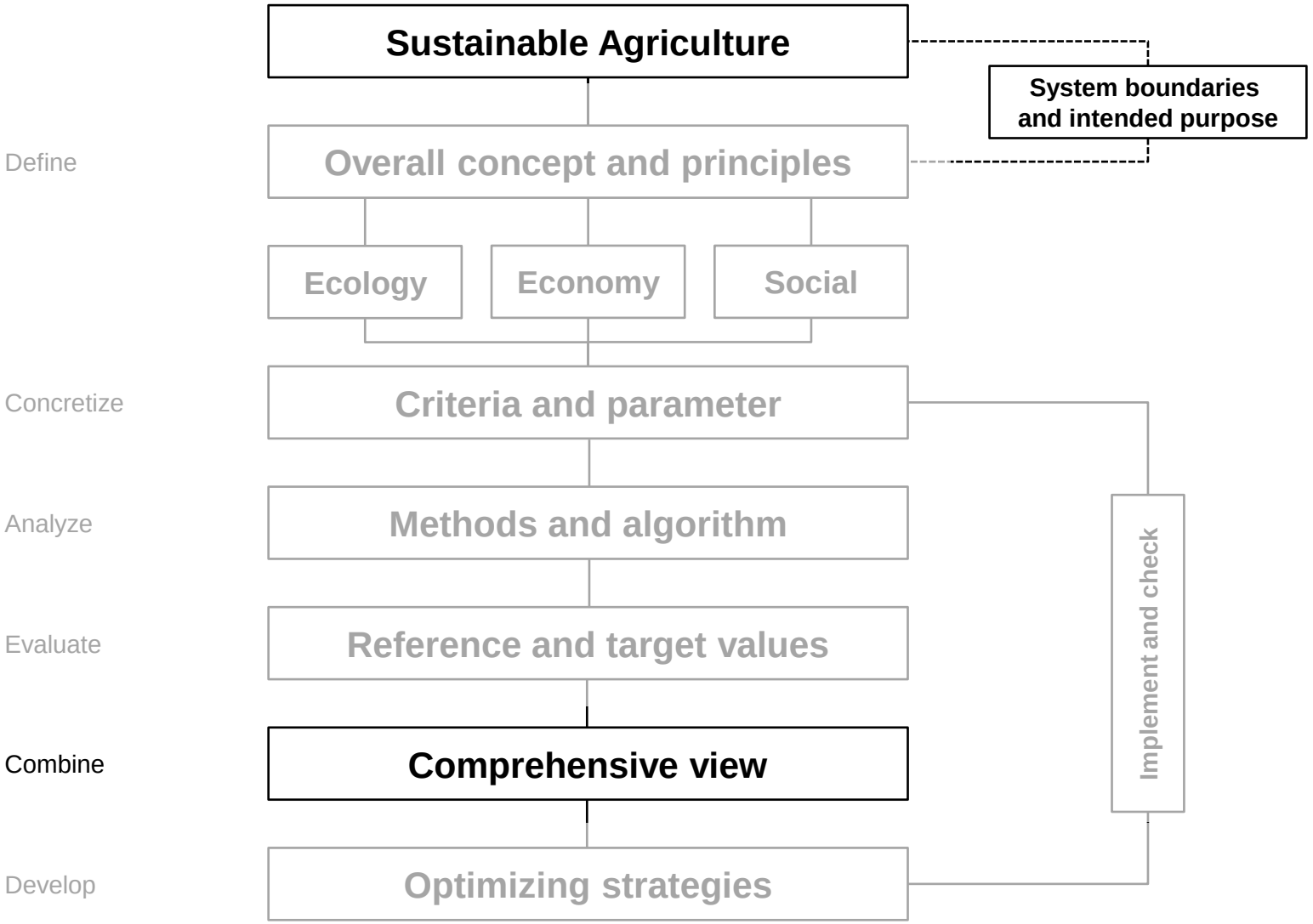
Water erosion – Evaluation function

Evaluation and normalization

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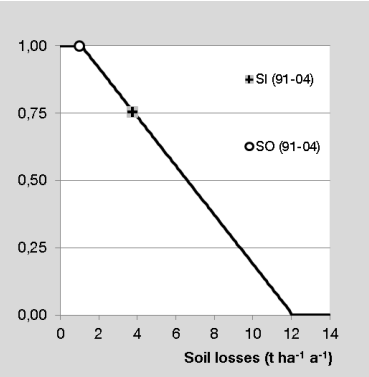
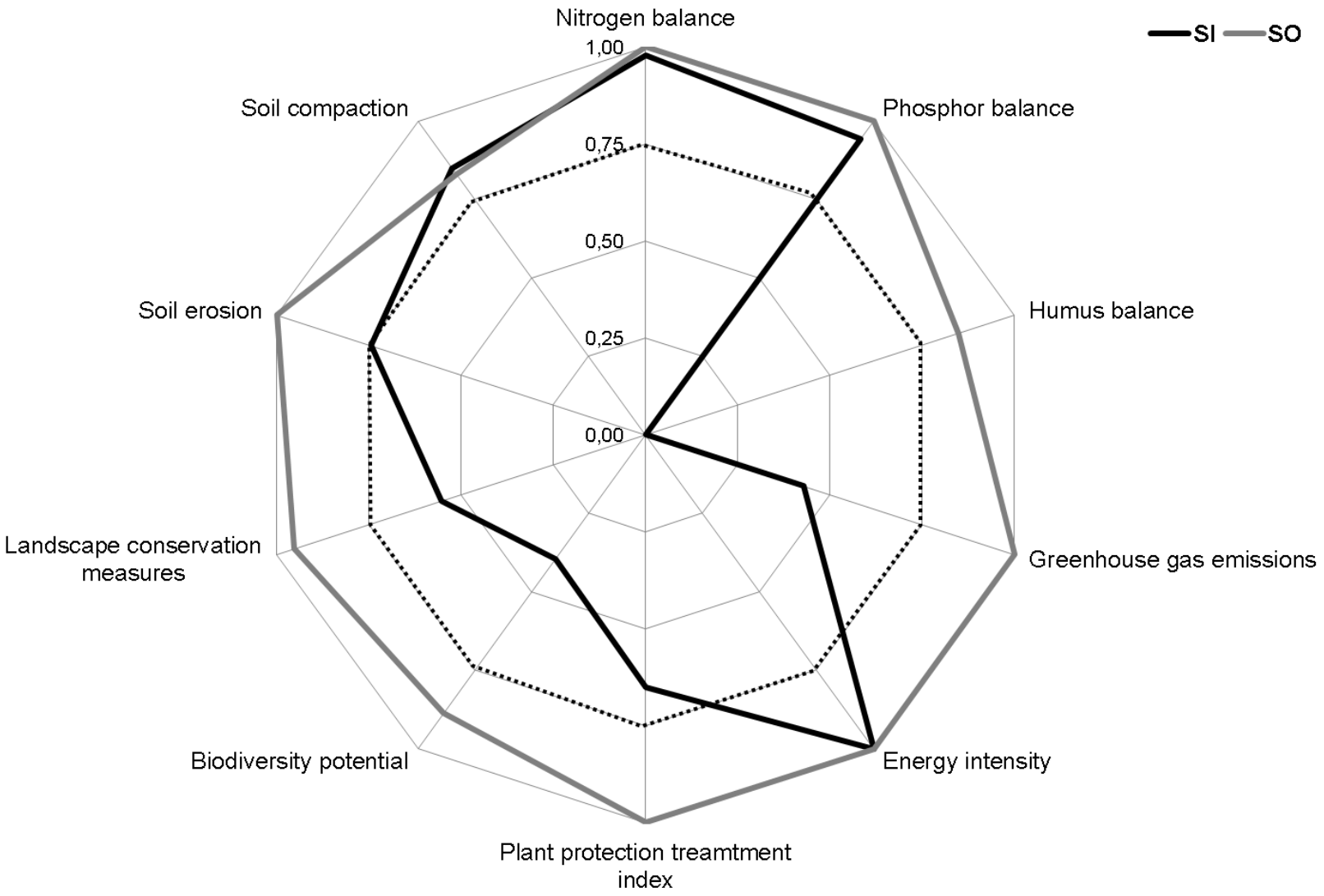
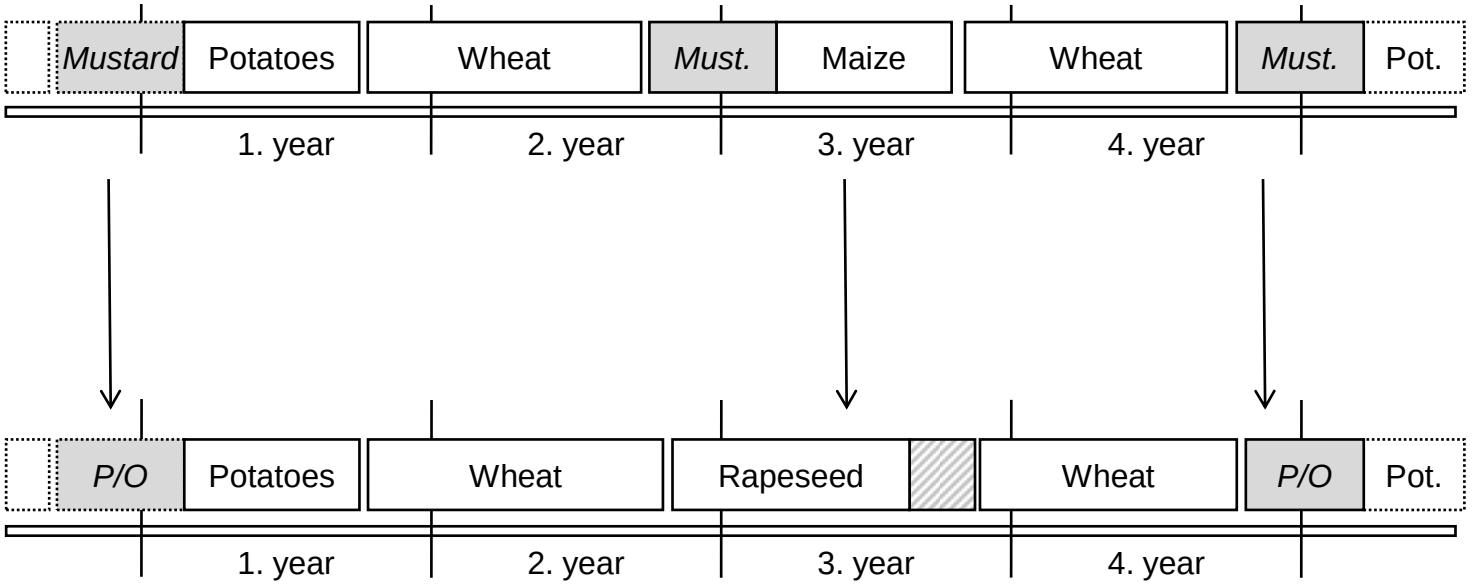
Indicator	Unit	Indicator value	
		SI	SO
N-Balance	kg N/ha	52,08	20,98
P-Balance	kg P/ha	-20,71	-1,26
Humus-Balance	kg C/ha	-297,25	130,50
Green house gas emiss.	kg $CO_{2\ eq}$/GJ	19,66	8,26
Energy intensity	MJ/GE	161,90	182,39
Plant protection treatm.	Index	0,65	1,00
Biodiversitäty potential	Index	-	-
Landscape conserv.	Index	0,55	0,95
Soil erosion	**t/ha**	**3,90**	**0,81**
Soil compaction	Index	0,00	0,00



Overall view of indicators

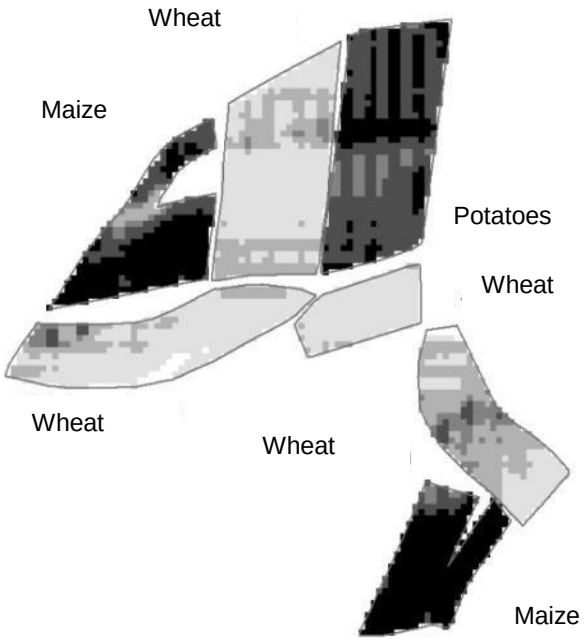


– IS-rotation



– Scenario-rotation

Is-Rotation

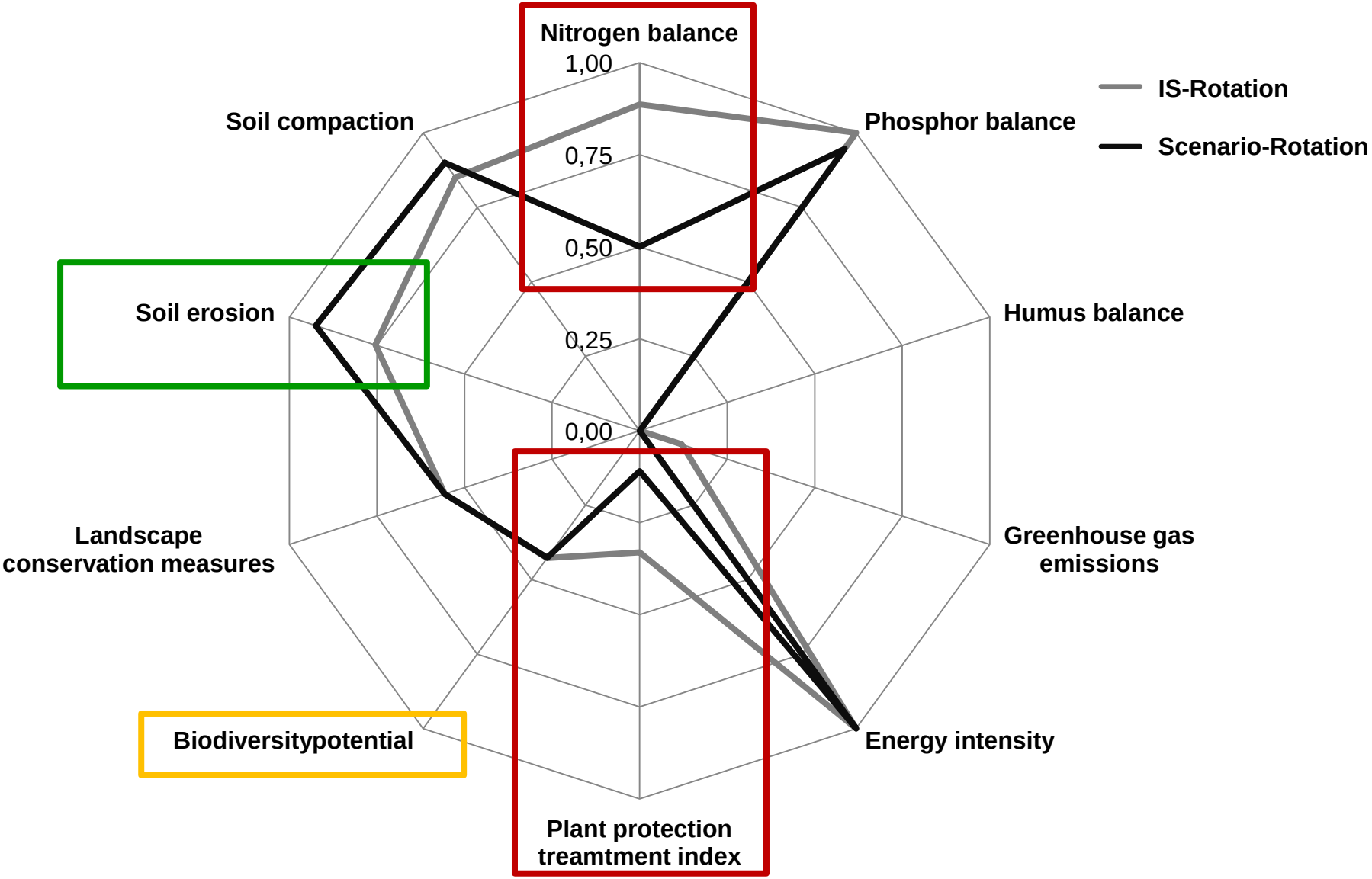


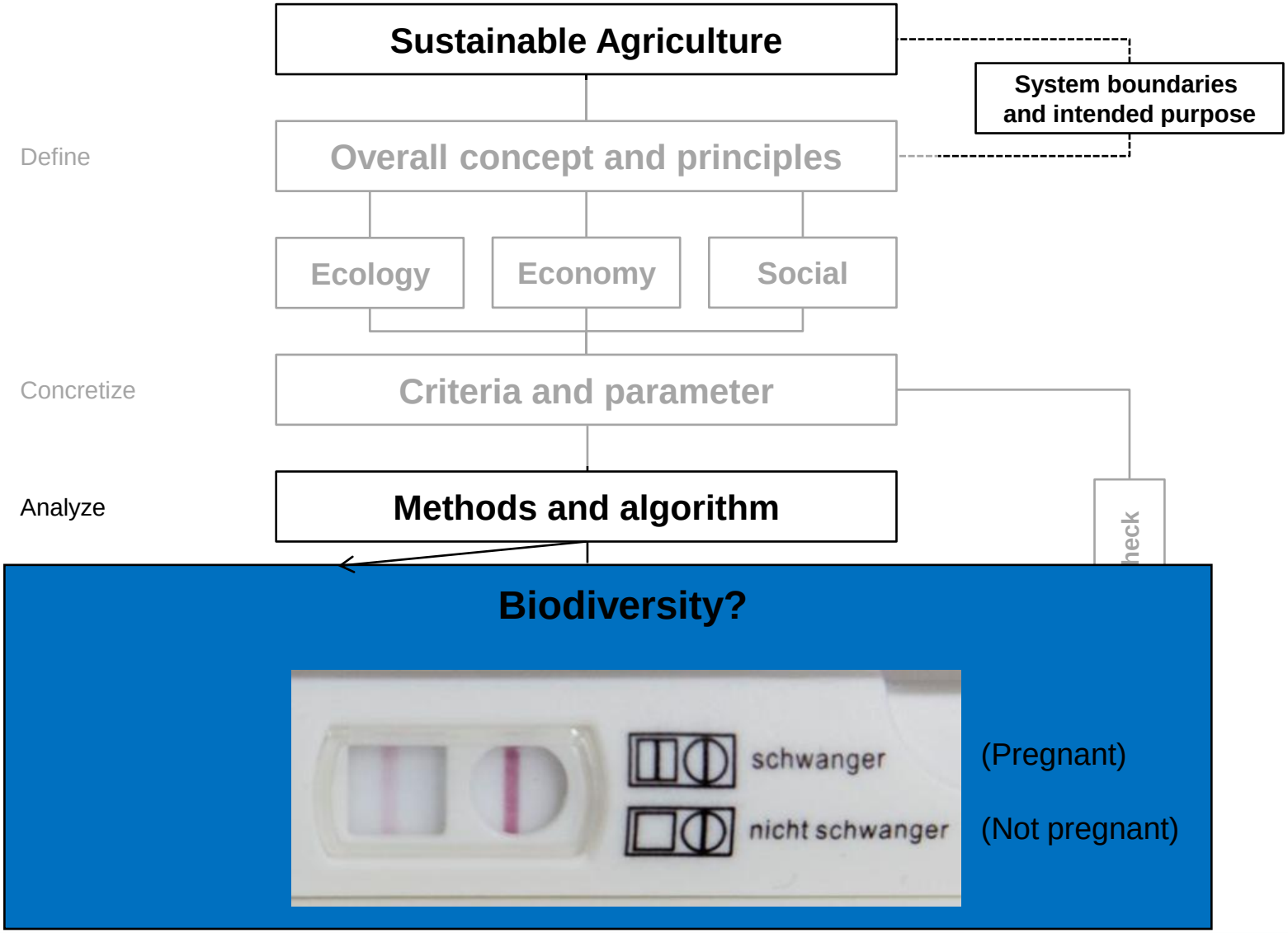
Soil losses (t ha^{-1} a^{-1})

- < 0,2
- 0,2 - 1,0
- 1,0 - 2,0
- 2,0 - 3,0
- 3,0 - 6,0
- > 6,0

ø 3,8 t ha^{-1} a^{-1}

0 0,25 0,5 1 Km


Nitrogen balance
1,00
0,75
0,50
0,25
0,00
Phosphor balance
Humus balance
Greenhouse gas emissions
Energy intensity
Plant protection treamtment index
Biodiversitypotential
Landscape conservation measures
Soil erosion
Soil compaction
IS-Rotation
Scenario-Rotation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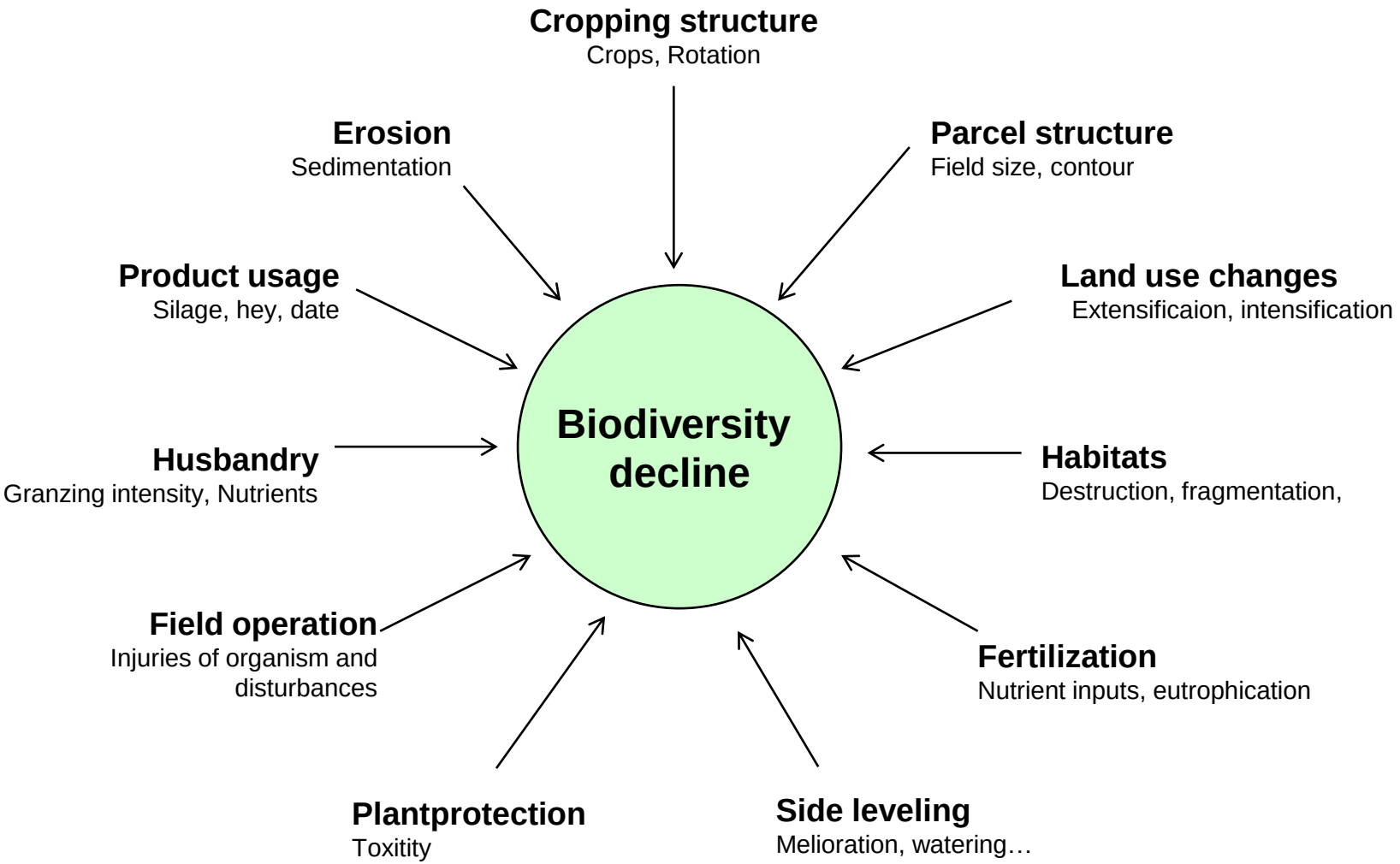
Biodiversity?
schwanger
nicht schwanger
(Pregnant)
(Not pregnant)

Causes for the biodiversity decline in agroecosystems

(Siebrecht 2010*)



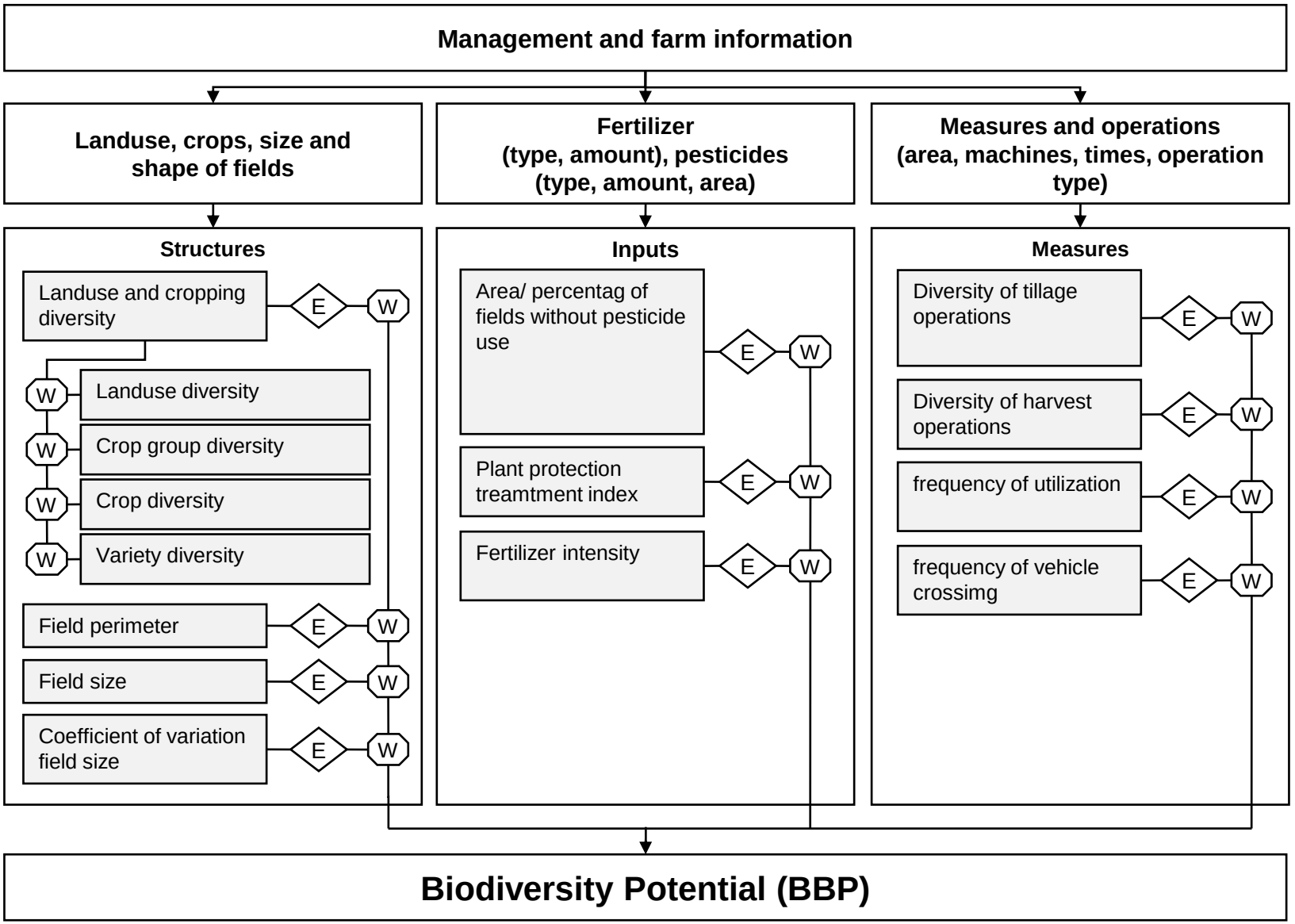
* Busch & Fahning (1992 in: Jessel & Tobias 2002), Girardin et al. (1996), Kraut (1997), Bastian & Schreiber (1999), Krebs et al. (1999), Srivasta et al. (1999), Bosch & Partner (2000), Geier & Köpke (2000), Freels et al. (2001), Jarfe (2002), Jessel & Tobias (2002), Oppermann (2002), Haber (2002), Fuller et al. (2005), Green et al. (2005), Bastian & Lütz (2006), Swinton et al. (2007)

Impact of the farming system

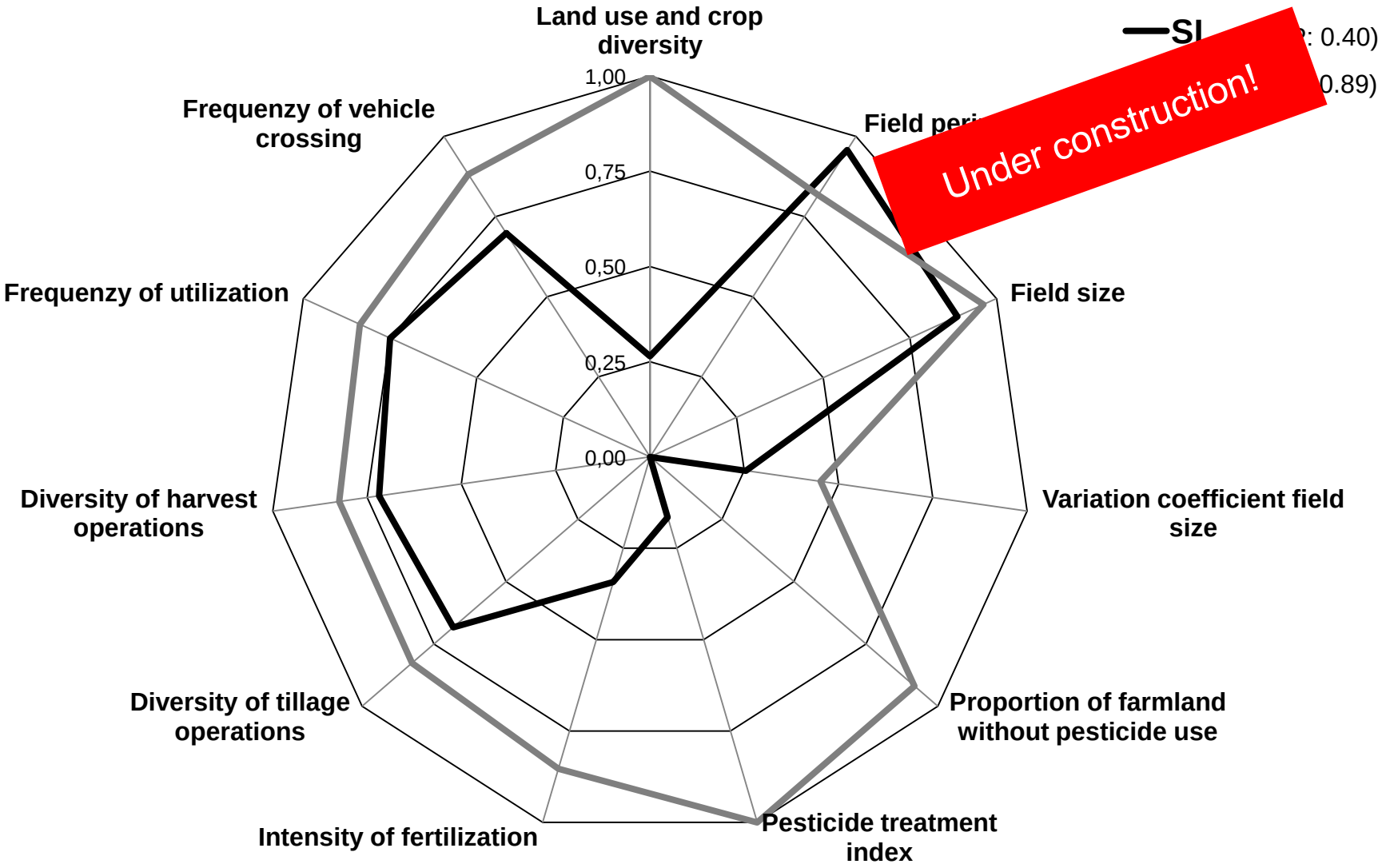
Biodiversity Potential	**Landscape Cons. Measures**
Depending from farm organization and mangement Considering only the farming practice – cultivation complex indicator	Depending from special measures and activities for enhancing biodiversity → adapted practices based on environmental programs for agriculture

Effects caused by …

structures	inputs	operations / measures
Farm structure	**Chemical effects**	**Mechanic-physical effects and disturbances**


Management and farm information
Landuse, crops, size and shape of fields
Fertilizer (type, amount), pesticides (type, amount, area)
Measures and operations (area, machines, times, operation type)
Structures
Landuse and cropping diversity
E
W
W
Landuse diversity
W
Crop group diversity
W
Crop diversity
W
Variety diversity
Field perimeter
E
W
Field size
E
W
Coefficient of variation field size
E
W
Inputs
Area/ percentag of fields without pesticide use
E
W
Plant protection treamtment index
E
W
Fertilizer intensity
E
W
Measures
Diversity of tillage operations
E
W
Diversity of harvest operations
E
W
frequency of utilization
E
W
frequency of vehicle crossimg
E
W
Biodiversity Potential (BBP)

Indicators	standardized value
land use and cropping diversity	0,68
field size	0,85
field perimeter	0,86
coefficient of variation field size	0,45
percentage of area without pesticide use	1,00
plant protection treatment index	0,94
fertilizer intensity	1,00
diversity of tillage operations	0,90
diversity of harvest operations	0,83
frequency of utilization	0,81
frequency of vehicle crossing	0,82
biodiversity potential	


Land use and crop diversity
Field peri
Field size
Variation coefficient field size
Proportion of farmland without pesticide use
Pesticide treatment index
Intensity of fertilization
Diversity of tillage operations
Diversity of harvest operations
Frequenzy of utilization
Frequenzy of vehicle crossing
1,00
0,75
0,50
0,25
0,00
SI
: 0.40)
0.89)
Under construction!

- **Potential** for sustainable development (basis for **discussions!**)
- Approach with **high applicability** (farm management data) and **sensitivity**
- **Distinguish between** systems and **intensities**
- **Further development – not finished**