FACCE SURPLUS
SUSTAINABLE AND RESILIENT AGRICULTURE FOR FOOD AND NON-FOOD SYSTEMS

SUSTAg

Assessing options for the SUSTainable intensification of Agriculture for integrated production of food and non-food products at different scales

SUSTAg modelling framework and scenarios

Conceptual and technical integration of the different models within and beyond SUSTAg
biewald@pik-potsdam.de; hwebber@uni-bonn.de; bodirsky@pik-potsdam.de

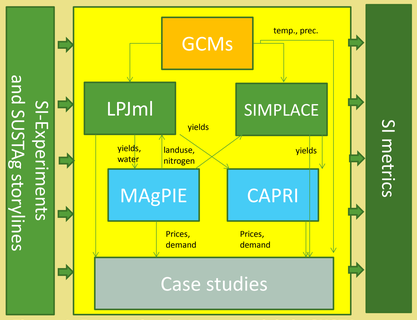

Figure 1. Interaction between models in SUSTAg. All models are embedded into the SUSTAg storylines.

SUSTAg storylines	1	2	3	4	5
Shared socioeconomic pathways (SSPs)	SSP1	SSP2	SSP3	SSP4	SSP5
Climate impacts	RCP 1.9	RCP 2.6	RCP 6.0	RCP 4.5	RCP 4.5
Climate target	1.5°	2°	3.3°	2.8°	2.8°
Ag-SSP	Ag-SSP1	Ag-SSP2	Ag-SSP3	Ag-SSP4	Ag-SSP5
N-SSP	N-SSP1	N-SSP2	N-SSP3	N-SSP4	N-SSP5
EU-RAPs	EU-RAP1	EU-RAP2	EU-RAP3	EU-RAP4	EU-RAP5
Diet-SSPs	Diet-SSP1	Diet-SSP2	Diet-SSP3	Diet-SSP4	Diet-SSP5

Table 1. The SUSTAg storylines integrate socio-economic, climate, management and policy narratives. The storylines built on scenarios that have been developed in a number of community efforts, such as the SSP narratives and the RCP scenarios developed for the IPCC, the Ag-SSP and EU-RAP storylines developed within the MACSUR community, and the N-SSP storylines developed within the INMS project.

Global and EU model assessment

LPJmL heinke@pik-potsdam.de
The new LPJmL version with nitrogen cycle will be used to estimate biogeochemical consequences of SI options.

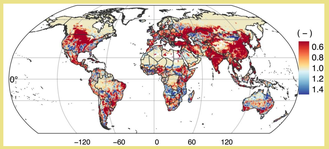

Figure 2. Change of nitrogen leaching due to land cover change and N application. Leaching from current agricultural lands divided by leaching under potential natural vegetation.

SIMPLACE hwebber@uni-bonn.de
SIMPLACE will be used to assess the impacts of climate change and SI options on crop yields and soil.

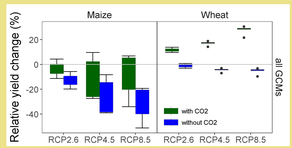

Figure 3. Relative grain yield changes for three climate change scenarios. Period 2040-2069 relative to 1980-2010, current European cropping patterns, sowing dates irrigation, and varieties. Uncertainty across 2 (RCP2.6) or 5 GCMs (RCPs 4.5 & 8.5).

MAgPIE & MADRAT bodirsky@pik-potsdam.de
The newly developed MAgPIE 4.0 will explore impacts of upscaled SI option implementation.

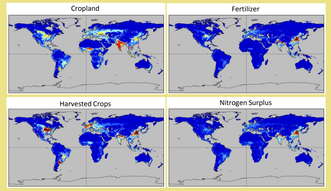

Figure 4. The newly developed global historical inventory MADRAT. It facilitates linkage to other models by providing data on historical cropland management.

CAPRI yinan.zhang@ilr.uni-bonn.de
The inclusion of SSP storylines into CAPRI allows impact analysis based on different scenarios.

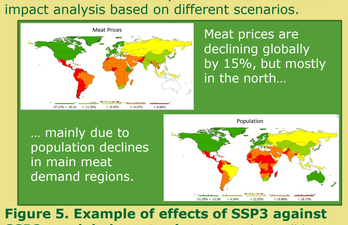

Figure 5. Example of effects of SSP3 against SSP2 on global meat prices. Price data will be utilised by the case studies.

European SI-experiment N°1: New substrates for bioenergy production
yinan.zhang@ilr.uni-bonn.de; bodirsky@pik-potsdam.de

In a first experiment, CAPRI and MAgPIE will be used to analyse the impacts of the **EU biofuel target**. In particular, we will compare the impact of **different bioenergy substrates**, including 1st and 2nd generation technologies. Results shall be groundchecked with expert knowledge of the case studies.

Substatrate	Reference scenario	EU biofuel Target Sc. 2020	2030	SUSTAg storyline
Oilseeds	0%	20%	27%	SUSTAg 1-3
Starch crops	0%	20%	27%	SUSTAg 1-3
Crop residues	0%	20%	27%	SUSTAg 1-3
Miscanthus	0%	20%	27%	SUSTAg 1-3
Manure	0%	20%	27%	SUSTAg 1-3
Cost-optimal	0%	20%	27%	SUSTAg 1-3

Table 2. Bioenergy scenario set-up.

Improved approaches for assessing SI options at regional scale

Evaluation and identification of stakeholder relevant SI options at different regions

North Savo, Finland: How to increase crop yields more sustainably and how to utilise manure for **biogas** production?
heikki.lehtonen@luke.fi; taru.palosuo@luke.fi; erika.winquist@luke.fi

Agriculture: dairy and beef (82% of value), grasslands, cereals
Sustainability challenges: low cereal yields, low profitability, N and P leaching, soil compaction

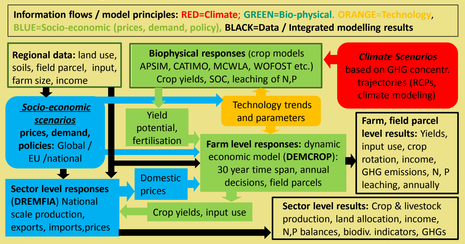

Figure 6. Integrated framework developed in Luke for the evaluation of SI options.

Options identified for yield increase based on stakeholder workshop outcomes (8th Nov 2016) with farmers, extension, input suppliers, food industry, researchers; 64 participants.
SI option 1: New cultivars of cereals, grass and oilseeds
SI option 2: Use of forage crop seed mix tailored for farms
SI option 3: Changes in fertilizer amounts and timing
SI option 4: Improved crop rotations and crop protection
SI option 5: Increased liming for better nutrient utilisation
SI option 6: Irrigation of high valued crops
SI option 7: Developing economically sound biogas concepts

Critical views on policy: Policies and weak markets do not support increased resource and input use for higher yields, under increased (climate, market) risks.
Early modeling results on yields: significant cereal yield and income gains are possible on cereal farms in North Savo, if adapted cultivars are adopted.
Biogas: provides energy self-sufficiency for dairy and beef farms based on manure and excess grass, replaces wood chips or fuel oil in energy production. There is a growing interest in biogas, synergies with increasing farm size.

North Rhine-Westphalia, Germany: How to use SI to maximize the potential of **crop residues** for emissions reduction and energy output, without jeopardizing other environmental objectives and other competing demands?
i.mouratiadou@uu.nl; tommaso.stella@zalf.de; tgaiser@uni-bonn.de

Agriculture: highly productive and intensive agricultural region
Sustainability challenges: N leaching, alternatives to maize

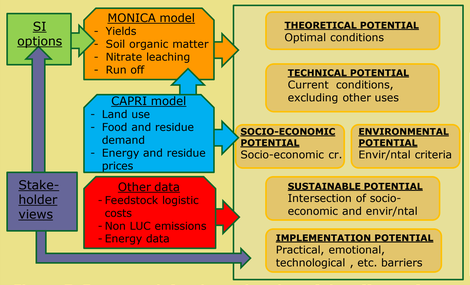

Figure 7. Framework for the estimation of the effects of SI on crop residue potentials.

Options for crop residue production identified during stakeholder interviews (Jan 2017) with farmers, farmer associations, NGOs, state environment and agricultural services, ministry, researchers.
SI option 1: New varieties with increased residue production
SI option 2: Improved soil organic matter practices
SI option 3: Changes in fertilizer amounts and timing
SI option 4: Full soil winter cover

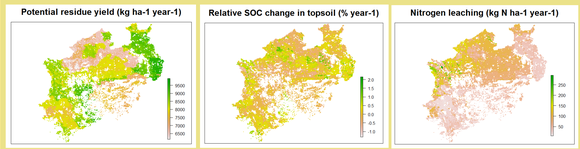

Figure 8. Averages of residue yield potential, change in topsoil soil organic carbon, and nitrogen leaching in the period 2006-2030 for RCP 2.6.

Andalusia, Spain: How to use SI to optimize **water management** while maintaining environmental and financial farm sustainability?
margarita.ruiz.ramos@upm.es; ignacioj.lorite@juntadeandalucia.es; alberto.garrido@upm.es

Agriculture: Modern irrigation scheme, highly productive region
Sustainability challenges: low profitability, water availability, innovative options

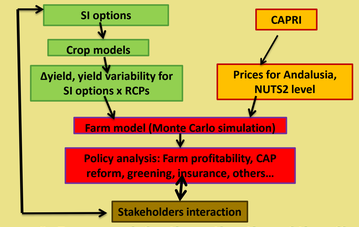

Figure 9. Framework for the estimation of the effects of SI combining crop and farm models.

Options for optimizing water and soil management in an irrigation scheme of 15000 ha and 840 farms.
SI Option 1: Extension of the irrigated area **with limited water allocation**
SI Option 2: Soil no-tillage practices and cover crops for dual use
SI Option 3: Diversification of the crop pattern at field scale
SI Option 4: Rearrangement of **irrigation allocations**
SI Option 5: Development of **local irrigation advisory services**
SI Option 6: Improving **irrigation water management** at farm scale
SI Option 7: Integrated crop management supported by **decision systems**
SI Option 8: Reductions in available irrigation water even on years without water limitations
SI Option 9: Improvement in the **irrigation infrastructure**

Early results: 3218 plots have been clustered in 5 cropping systems to assign SI options by cluster. Clusters: 1) Horticulture 2) Olive monoculture, 3) Other monoculture, 4) Multiculture with olive, 5) Multiculture without olive.

Generic and flexible SI metrics

Evaluation of SI options and measurement of SI
i.mouratiadou@uu.nl; catharina.latka@ilr.uni-bonn.de; r.berges@agrathaer.de

Aim: Enable informed discussion and trade-off evaluation, in combination with modelling, to support farm management and policy design with respect to
- economic profitability
- contribution to bio-based economy
- environmental and social impacts
- vulnerability to climate change

Approach: modular methodology of
- extensive indicator list including indicator classification into SI themes
- proposal of operationalisation approach for measuring and combining indicators

Figure 10. SUSTAg workshop on Sustainable Intensification metrics at the MACSUR Science Conference 2017.

Sustainability
→ all three dimensions: economic, social, env/tal. (UN)

Intensification
→ an increase in agricultural production per unit of inputs (FAO)

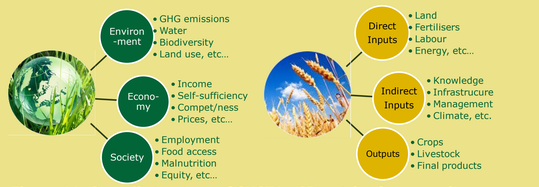

Figure 11. Overall structure of SUSTAg SI metrics framework.

Dissemination and valorisation

- **Stakeholder interviews** and **workshops** in Finland, Germany, and Spain.
- International **scientific workshop on SI metrics** at MACSUR Science Conference 2017
- Three **conference presentations** at MACSUR Science Conference 2017: SI metrics, work on North-Savo case study.
- Contributions to **science policy dialogue:** two project presentations to Dutch ministry of economic affairs and to Netherlands Organisation for Scientific Research, participation at FOOD 2030 conferences in 2016 and 2017, contribution to expert groups of the UNECE Convention on Long-range Transboundary Air Pollution on nitrogen-related emissions.
- **Web site**: http://faccesurplus.org/research-projects/sustag/
- Seven finalised **project deliverables.**
- Future outputs in preparation: **scientific articles**, **policy briefs, press releases, communications to farmers, educational material, further stakeholder events.**

CONTACT

Dr. Anne Biewald
Project coordinator
Germany
biewald@pik-potsdam.de

Dr. Ioanna Mouratiadou
Deputy project coordinator
Netherlands
i.mouratiadou@uu.nl

Prof. Frank Ewert
Germany
frank.ewert@uni-bonn.de

Res. Prof. Heikki Lehtonen
Finland
heikki.lehtonen@luke.fi

Mrs. Anita Beblek
Germany
beblek@agrathaer.de

Dr. Margarita Ruiz-Ramos
Spain
margarita.ruiz.ramos@upm.es

Dr. Ignacio Lorite-Torres
Spain
ignacio.lorite@juntadeandalucia.es

Dr. Claas Nendel
Germany
nendel@zalf.de

Prof. Reimund Rötter
Germany
reimund.roetter@uni-goettingen.de

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