Modelling the effect of agricultural policy scenarios on soil ecosystem services at the continental level

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Introduction

- **Soil ecosystem services (SESs)**
  - Strongly linked to soil quality indicators (SQIs)
  - Affected by agricultural management practices (AMPs)

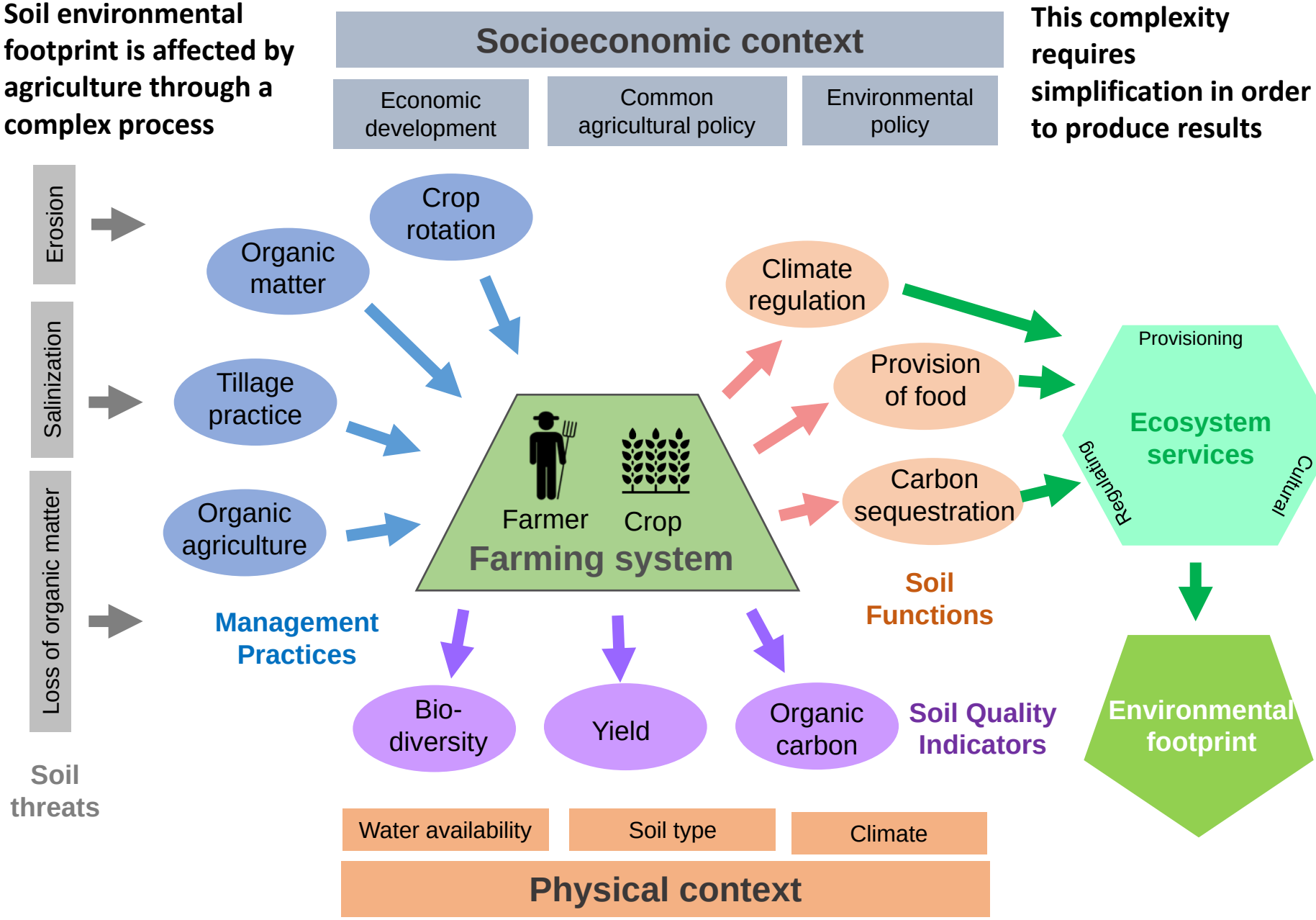
- **Projection of soil environmental footprint**
  - SESs determined through soil productivity, nutrients and biodiversity
  - SESs are evaluated as a function of SQIs

- **Geographically explicit model to link AMPs to SQIs**
  - AMPs are implemented by farmers in a policy context
  - Functional relations between AMPs and SQIs
  - Effectiveness depends on local conditions
  - Geographical assessment of SQIs as a result of AMPs

A complex system

Soil environmental footprint is affected by agriculture through a complex process

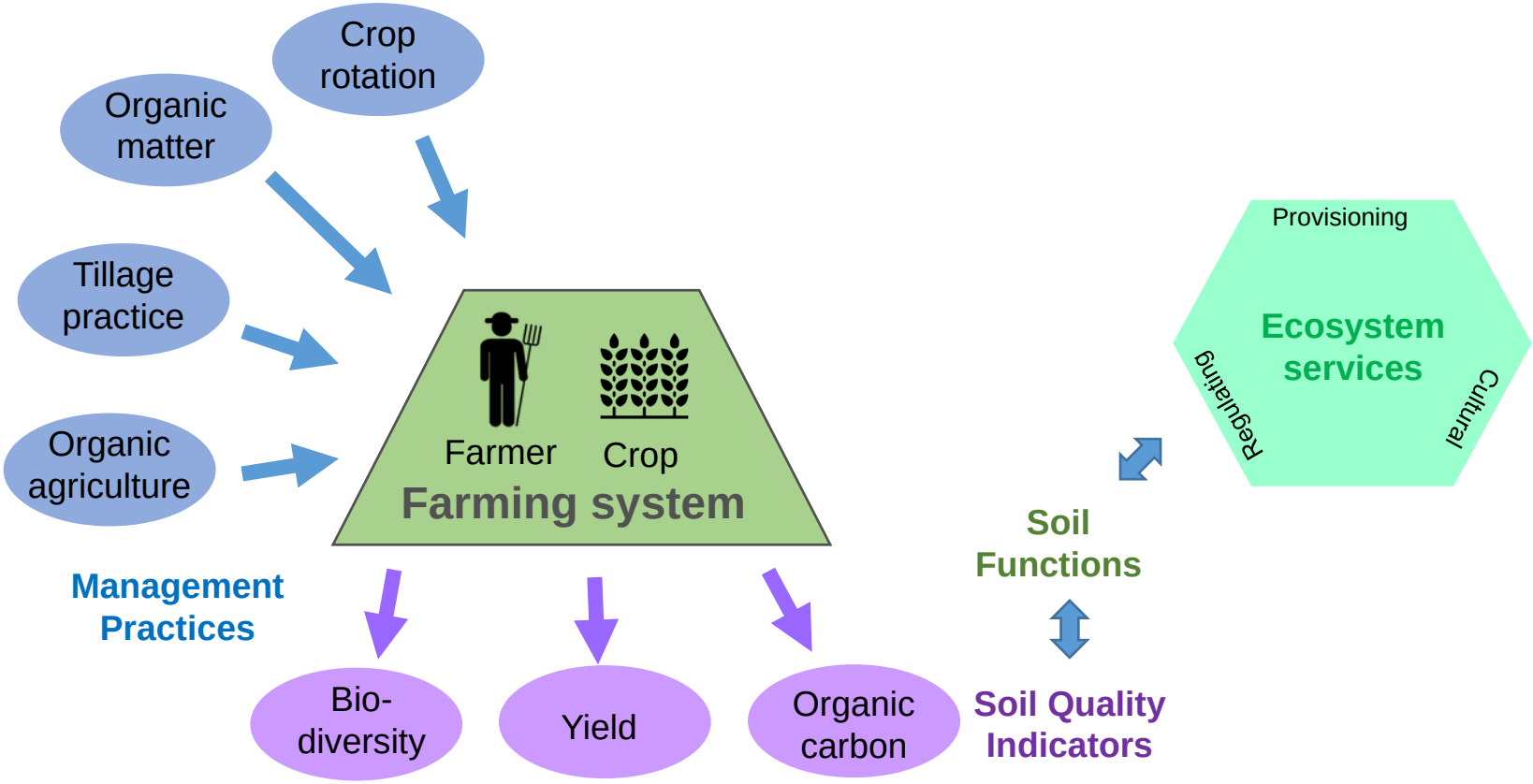
This complexity requires simplification in order to produce results



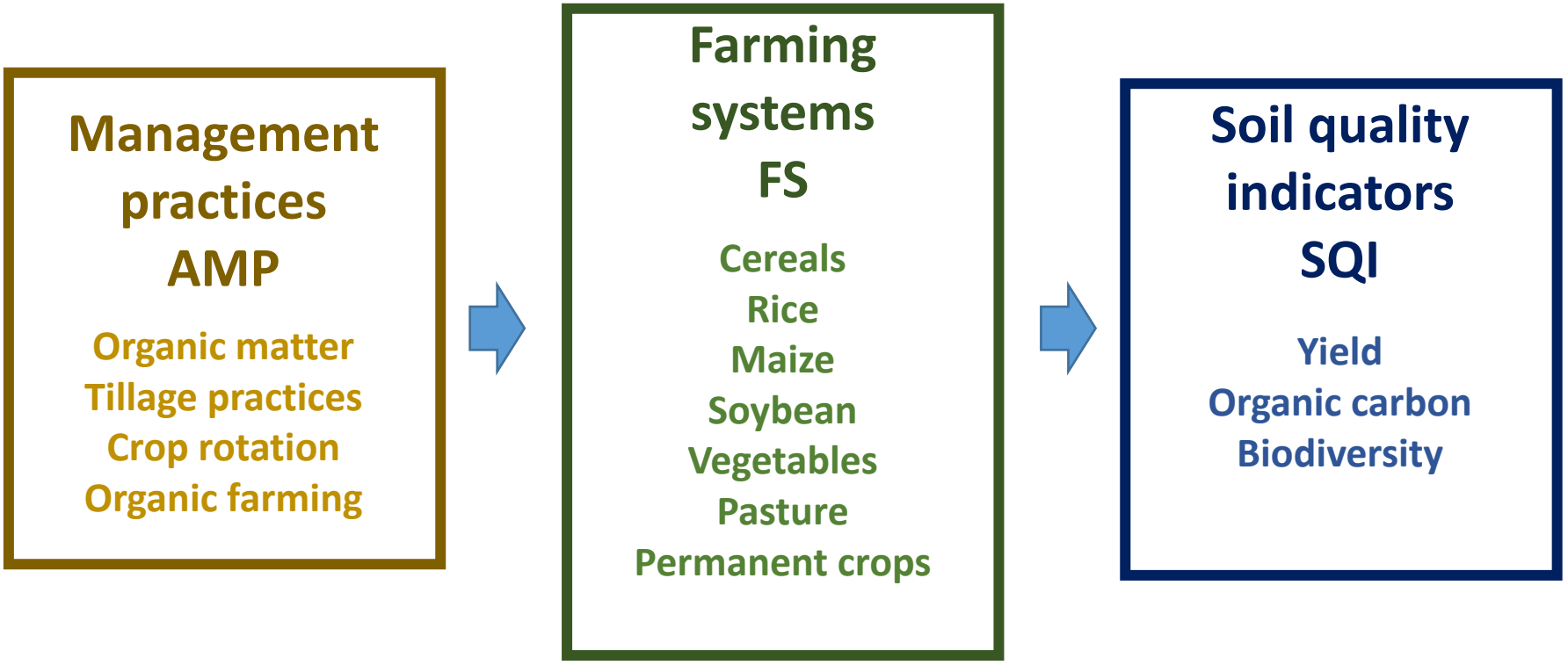
Model focus

The model retains the essential factors to relate AMPs to SQIs

SQIs are directly linked to Soil ecosystem services



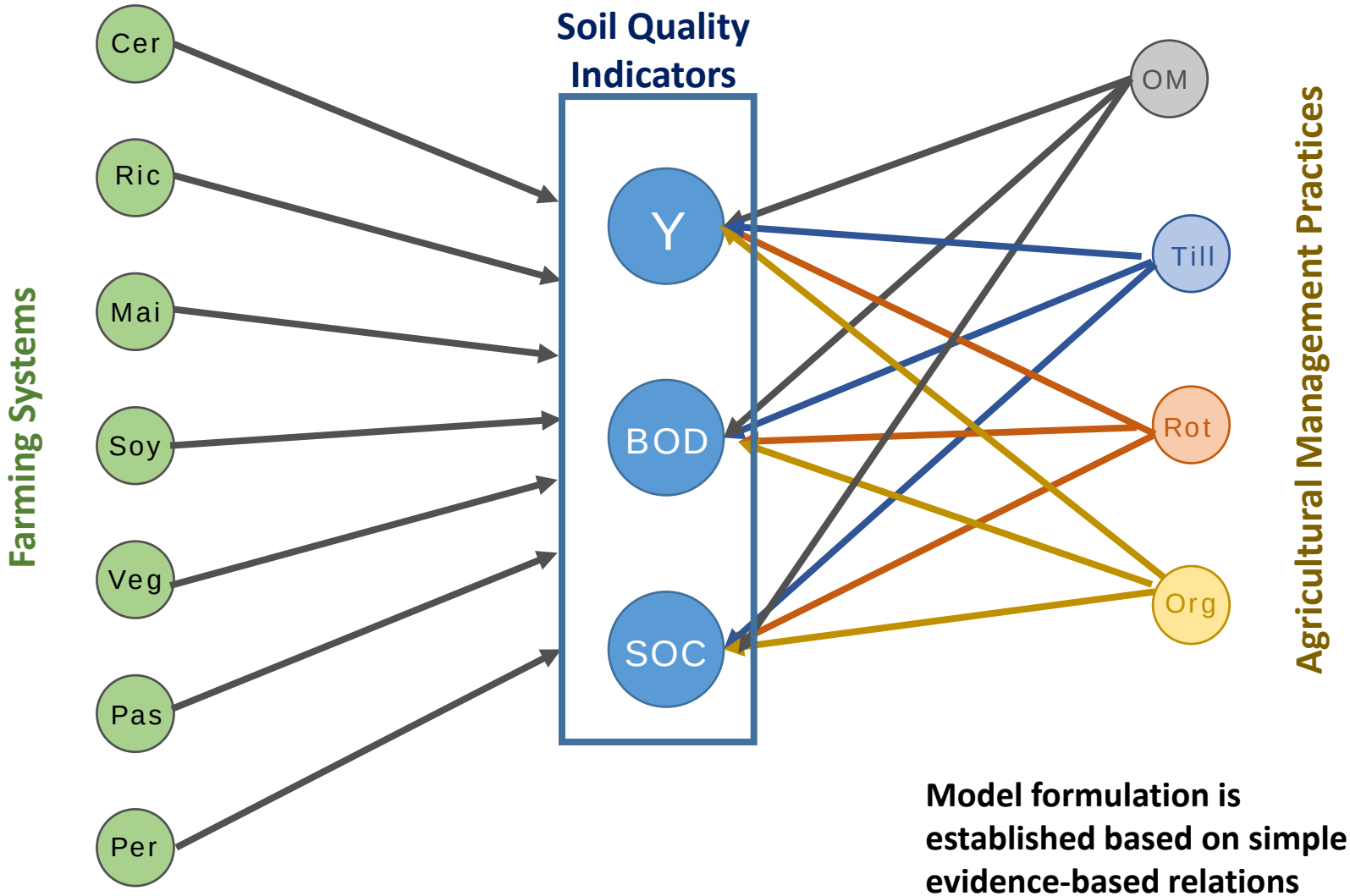
Model conceptualization



The model relates beneficial agricultural management practices to improved soil quality indicators

The linkage is established through field experiments where the management practice is applied to the soil during a long period

Formulation of functional relations



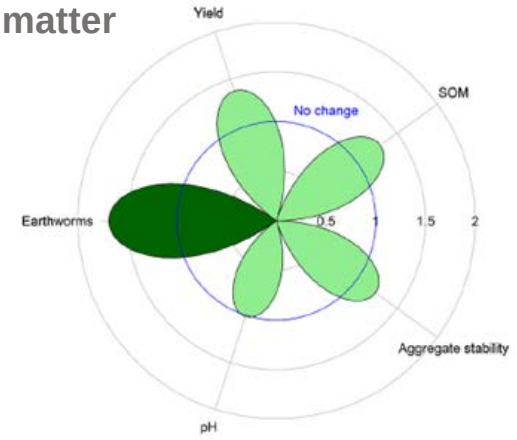
Model formulation is established based on simple evidence-based relations

Quantification of functional relations

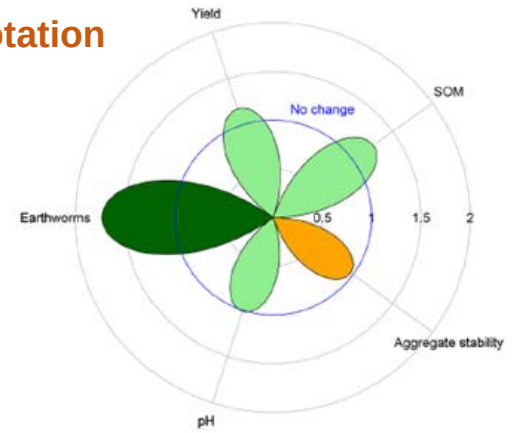
iSQAPER
Interactive Soil Quality Assessment

The quantification of functional relations is based on science developed within the iSQAPER project

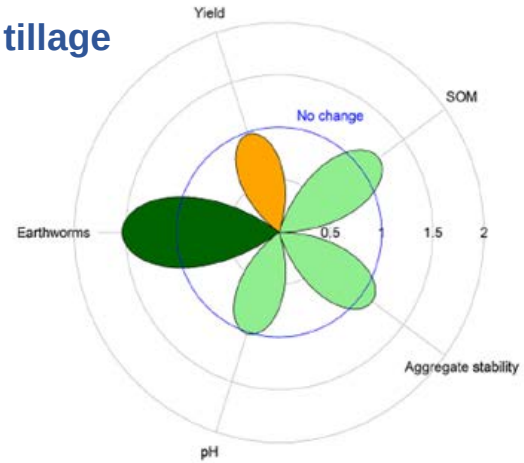
Org matter



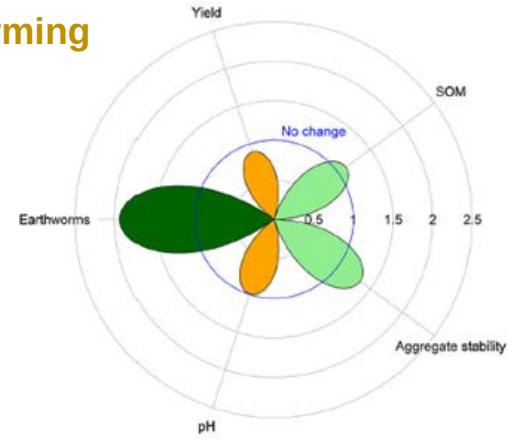
Rotation



No tillage



Org farming



Source: Bai et al., 2018: Effects of agricultural management practices on soil quality: A review of long-term experiments for Europe and China

Reference response ratios

- **Response ratio**: unit change in soil quality indicator as a response to long-term application of beneficial management practices
- Derived from results obtained in long term experiments

Response ratios of soil quality indicators

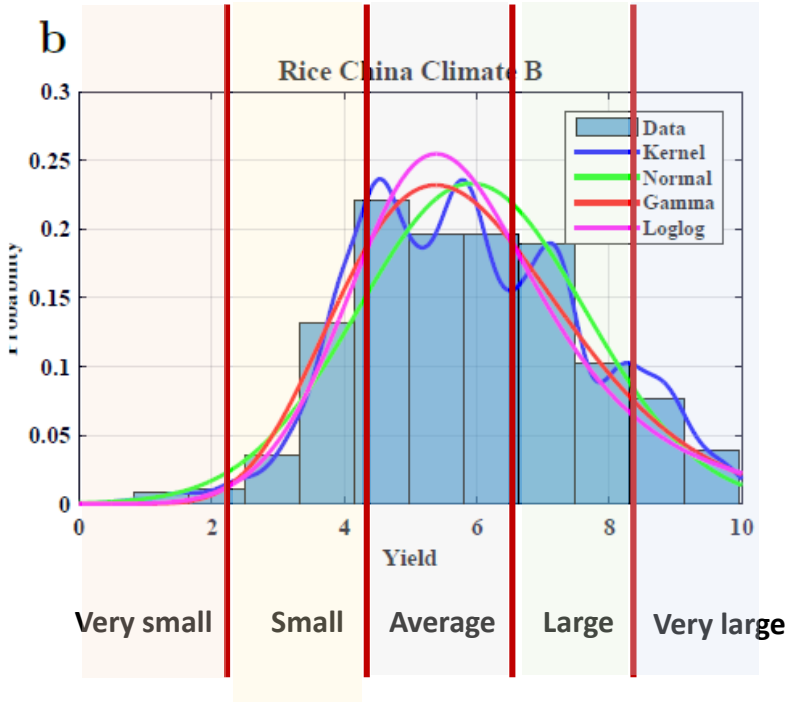
	Yield		Soil Organic Matter		Earthworms	
Mgmt. Practice	Median	Std Dev	Median	Std Dev	Median	Std Dev
Organic matter	1.37	1.19	1.29	0.33	1.69	1.67
No tillage	0.98	0.12	1.20	0.69	1.53	0.62
Crop rotation	1.17	0.40	1.25	0.61	1.73	1.55
Organic farming	0.89	0.30	1.12	0.56	1.93	0.37

Source: Bai et al., 2018: Effects of agricultural management practices on soil quality: A review of long-term experiments for Europe and China

Accounting for local conditions

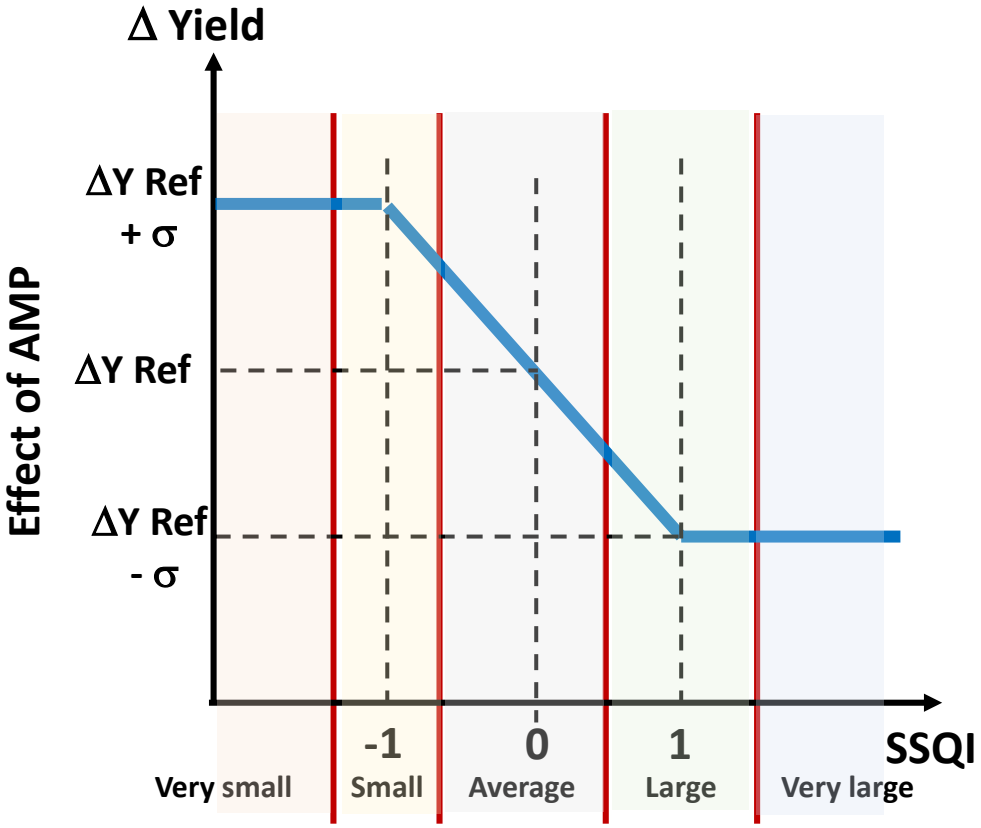
Standardized Soil Quality Indicators

$$SSQI = \frac{x - \mu}{\sigma}$$



Standardized SQIs compare SQIs with the distribution of values in similar regions, determined by climate, soil or biome zones

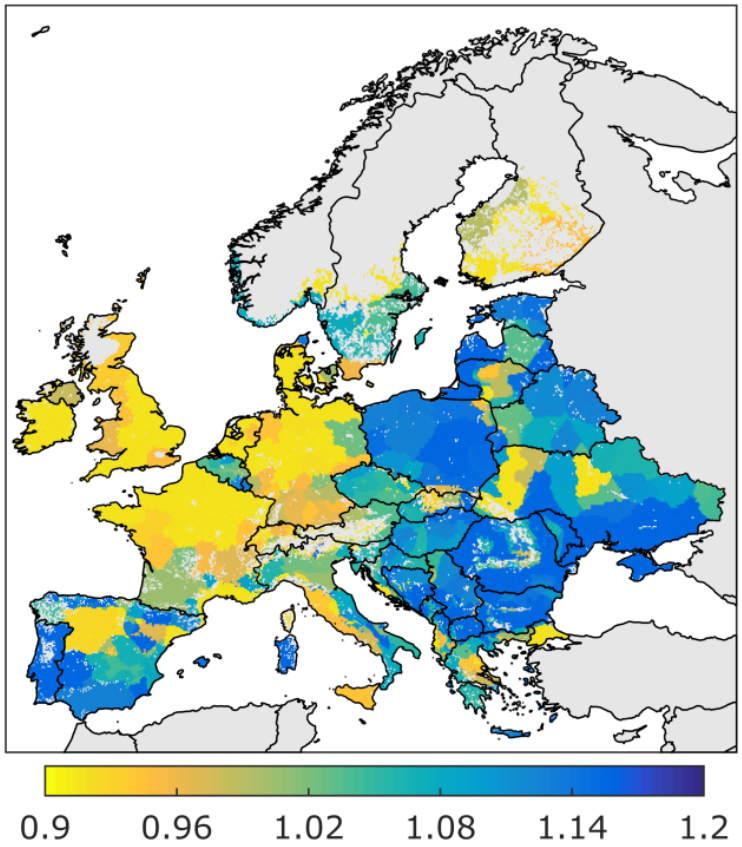
Response function

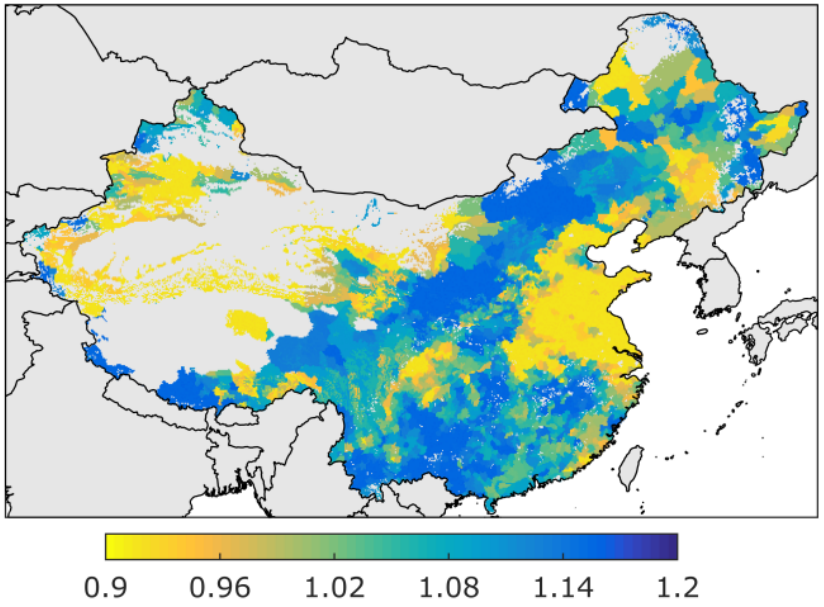


The effect of AMPs is assumed to be larger in zones where SSQI is lower

Sample model results

Basic model results are produced to obtain the estimated change of a soil quality indicator as a consequence of the application of an agricultural management practice on a farming system





Formulated in Standardized Soil Quality Indices

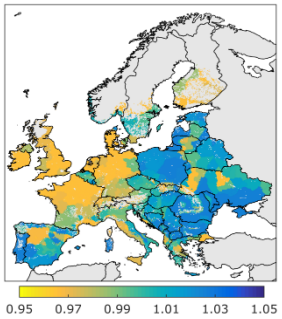
Projected effect of uniform 10% increase in implementation of **organic matter addition** on mean increase in **crop yield** for **cereal**

Integration of model results

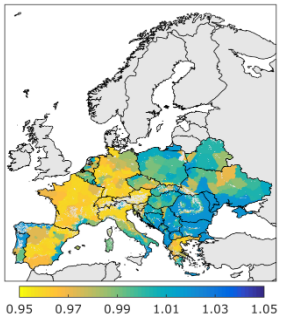
Results are integrated to obtain the effect across all farming systems

Results by farming system

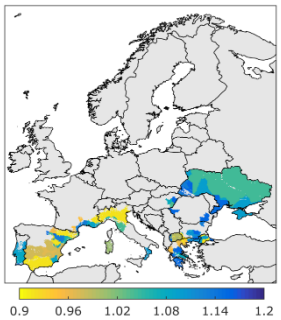
Cereal



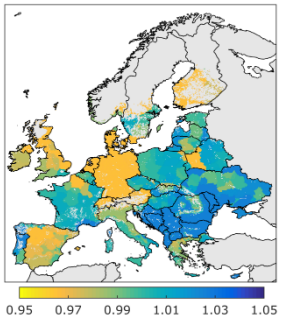
Maize



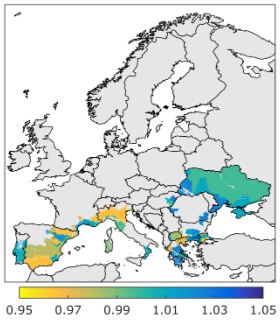
Soybean



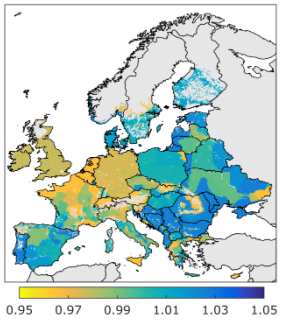
Vegetables



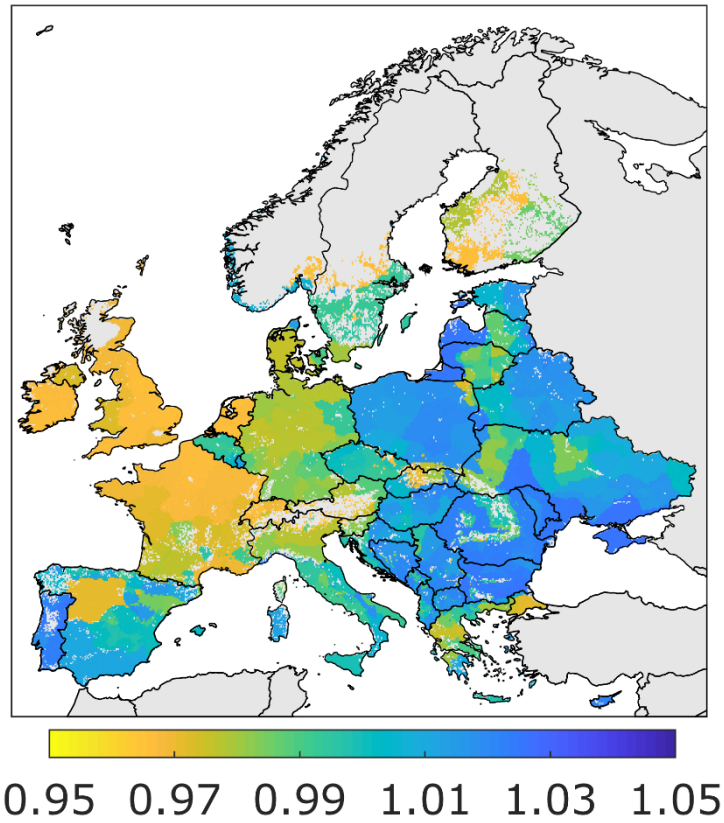
Rice



Permanent



Integrated results

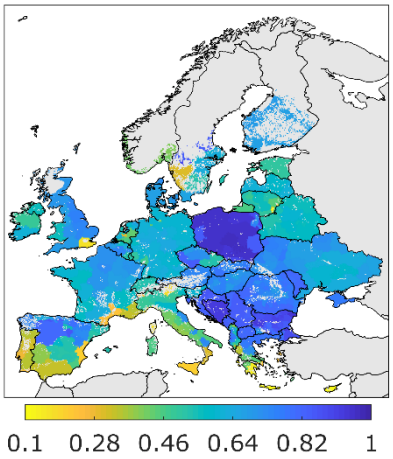


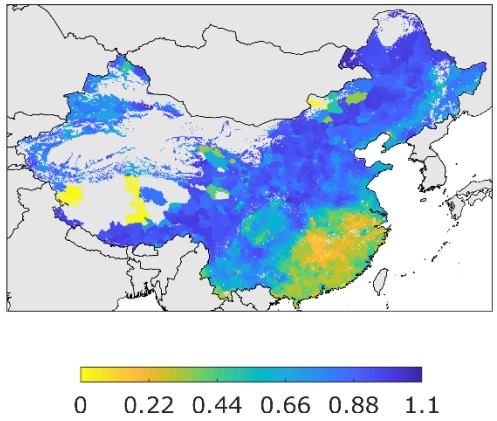
Projected effect of uniform 10% increase in implementation of **organic farming** on mean increase in **crop yield** across all **farming systems**

Global model results

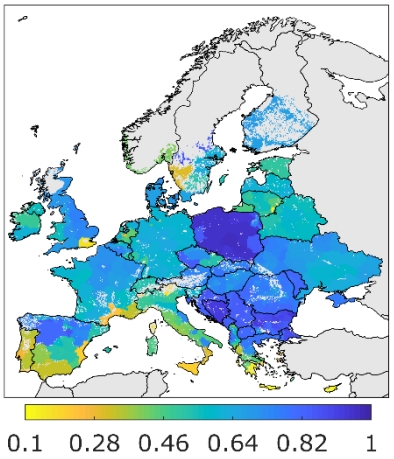
The model produces the effect of the implementation of an agricultural management practice on the three soil quality indicators

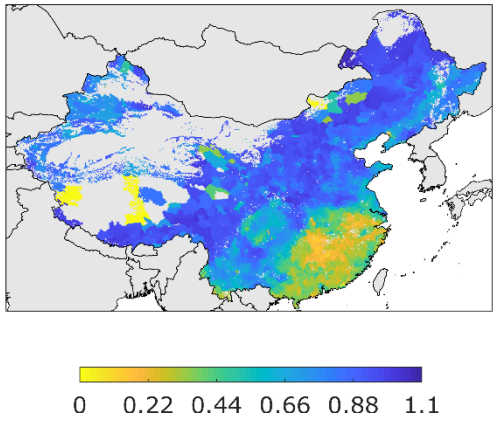
Δ Yield



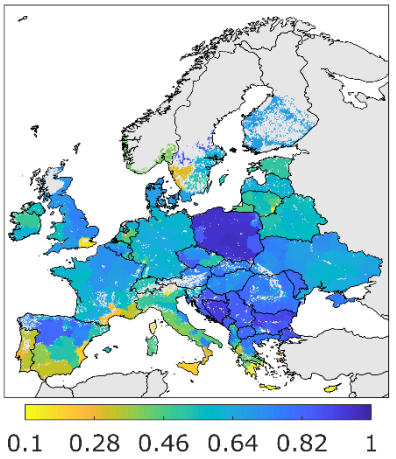


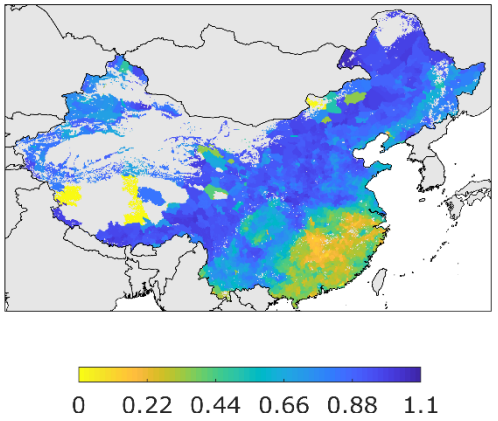
Δ Soil Organic Carbon





Δ Biodiversity





Projected effect of uniform 10% increase in implementation of **crop rotation** on mean increase in **soil quality indicators** across all **farming systems**

Model application

- The model can be applied to obtain expected changes of soil ecosystem services under different policy scenarios

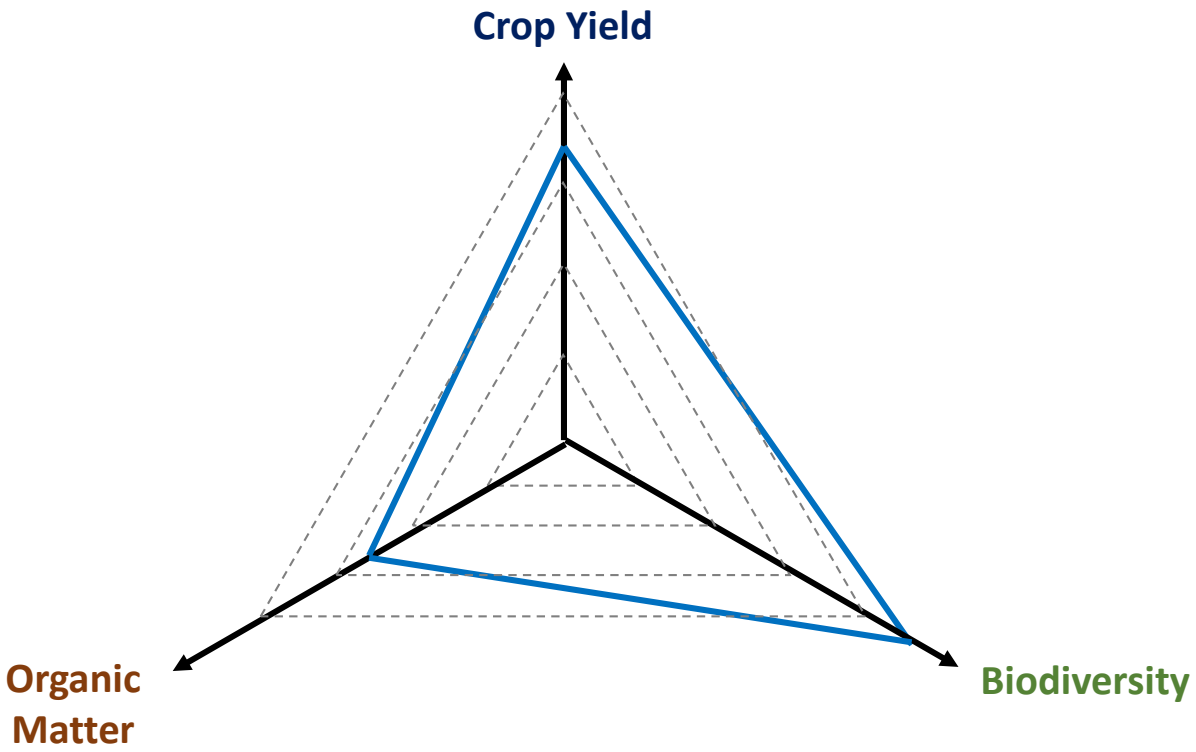
- Definition of policy and management scenarios
  - Defined by % increment of implementation of AMPs
  - The degree of implementation may vary locally
  - The results may be upscaled to the entire region

- Three scenarios
  - SC1: **Expected**: similar intensity as before
  - SC2: **Regional Targets**: same as SC1, but acting where it is needed most
  - SC3: **Towards 2050**: duplicate intensity of SC1

The policy scenarios (presented in SSS9.4) provide an global picture of the expected rate of implementation of different agricultural management practices

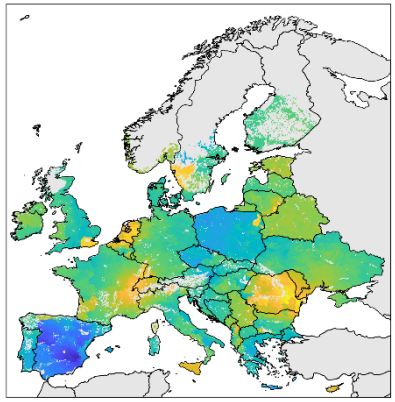
Analysis of soil ecosystem services

- Soil ecosystem services are considered to be proportional to the area of the triangle formed by the three soil quality indicators

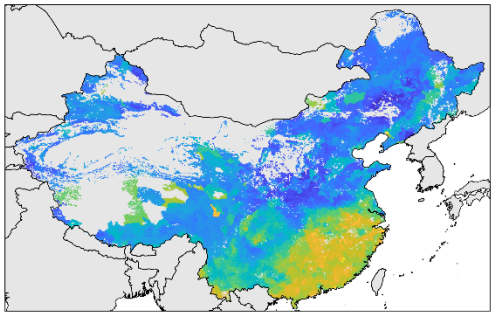


Improvement of soil ecosystem services

Expected

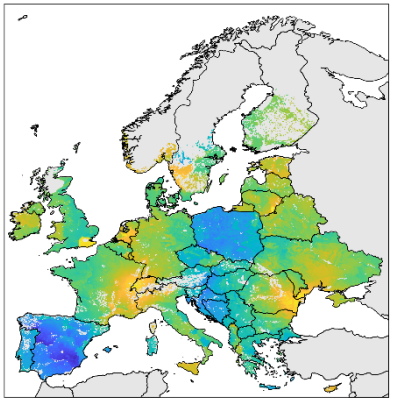


0.45 0.78 1.11 1.44 1.77 2.1

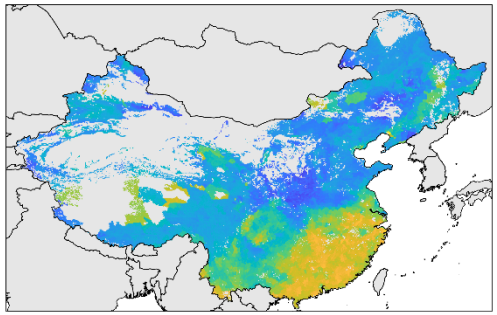


0.25 0.49 0.73 0.97 1.21 1.45

Regional Targets

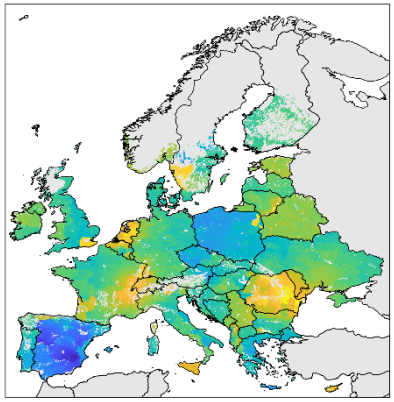


0.7 1.05 1.4 1.75 2.1 2.45

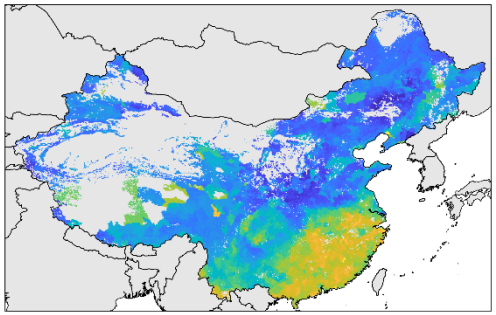


0.3 0.63 0.96 1.29 1.62 1.95

Towards 2050



1.65 2.69 3.73 4.77 5.81 6.85



1 1.82 2.64 3.46 4.28 5.1

Projected increase of **soil ecosystem services** under different **policy scenarios**

Conclusions

- **Regional Targets** improves Soil Ecosystem Services over **Expected** baseline with no additional effort, but
- **Towards 2050** really makes a change

Expected increase of Soil Ecosystem Services

	Europe	China
Expected	1.13	0.96
Regional Targets	1.41	1.19
Towards 2050	3.85	3.47