Assessment of soil ecosystem services through an expert-based approach

Dr. Taru Sandén

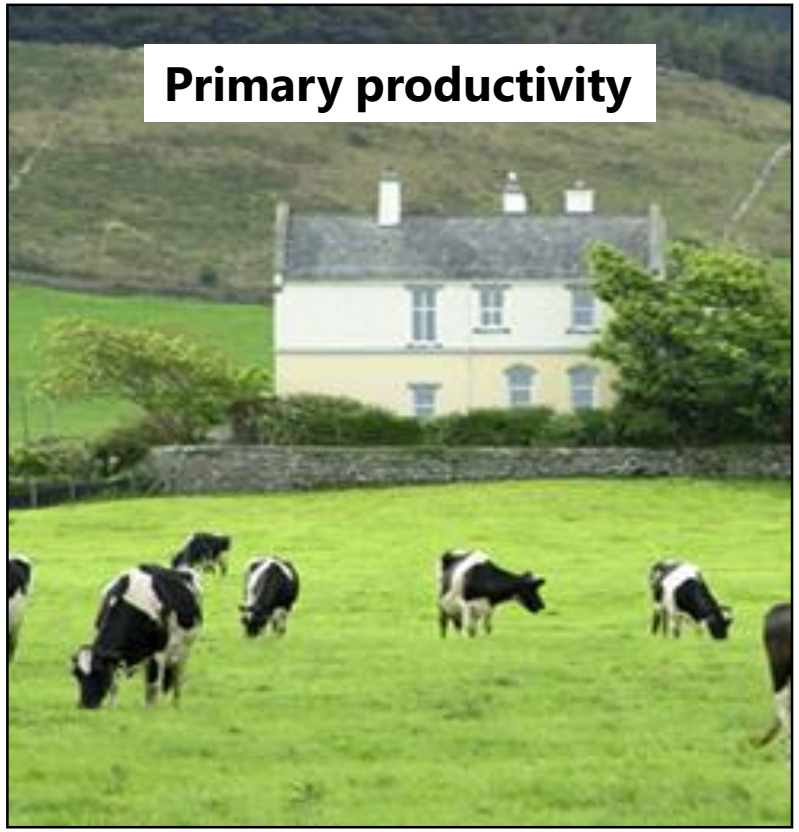
Department for Soil Health and Plant Nutrition

Water regulation and purification

Climate regulation

Biodiversity

Primary productivity



Nutrient cycling

Schulte et al., 2014 Environmental Science & Policy

DEMANDS ON OUR LAND

DEMANDS ON OUR LAND

We will provide clean drinking water

DEMANDS ON OUR LAND

DEMANDS ON OUR LAND

DEMANDS ON OUR LAND

WHAT CAN OUR LAND SUPPLY?

All soils / land perform all functions…

- Habit… …tional & i…
- Nutrie… …g

…but different parts of the land(scape) are better at delivering different functions

ENVIRONMENTAL SCIENCE & POLICY 38 (2014) 4…

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Functional land management: A framework for managing soil-based ecosystem services for the sustainable intensification of agriculture☆

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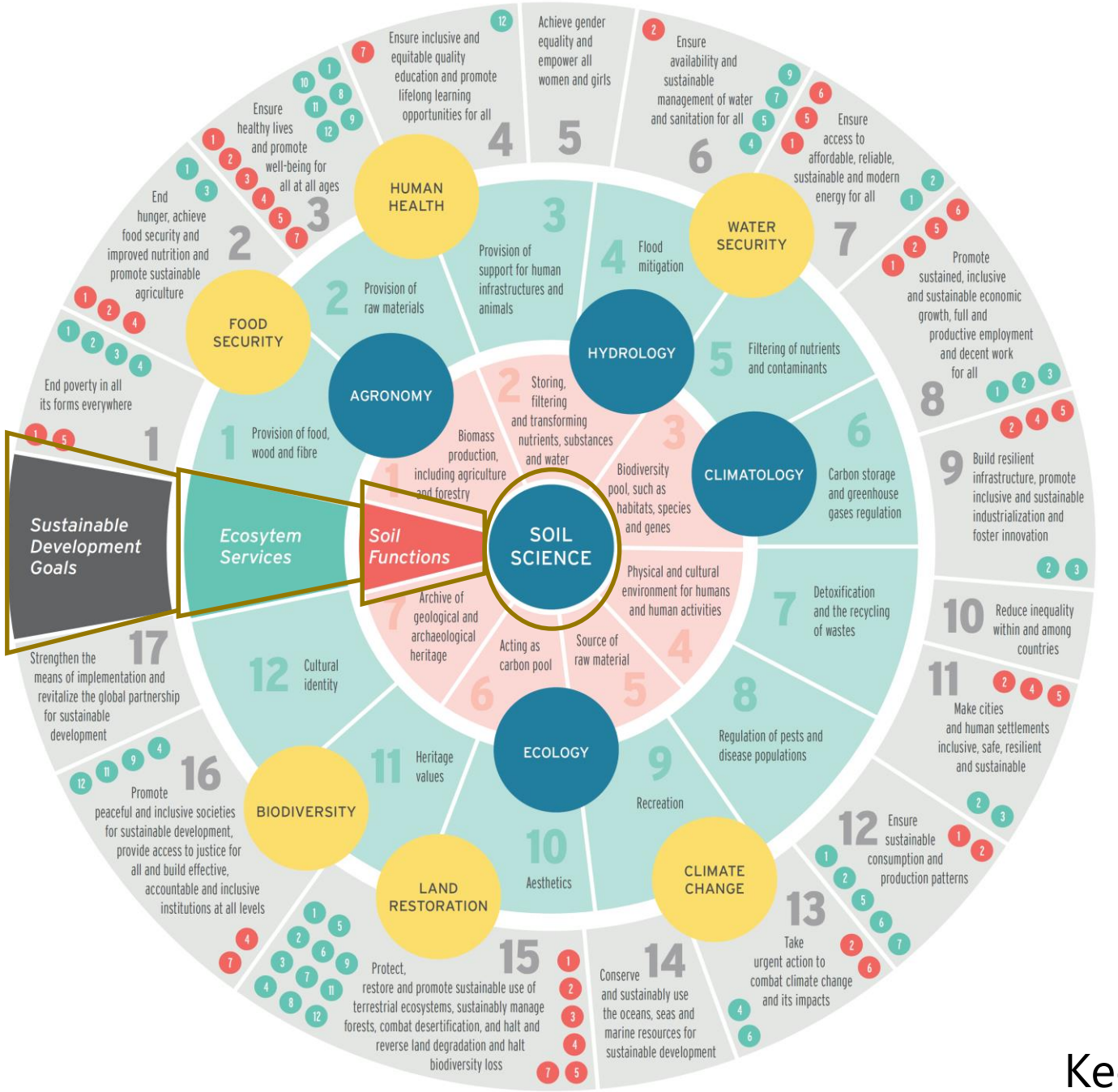
LANDMARK
LAND MANAGEMENT: ASSESSMENT, RESEARCH, KNOWLEDGE BASE

What can our land supply?



Keestra et al., 2016 *SOIL*

PRIMARY PRODUCTIVITY

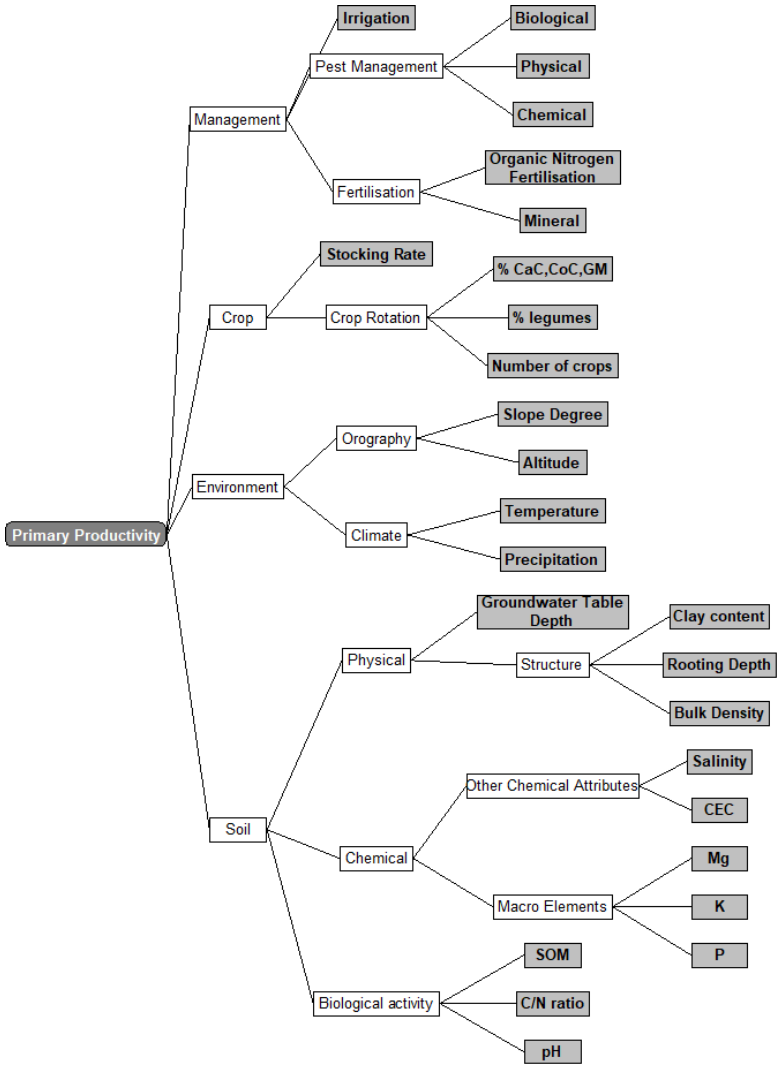
Definition

- The capacity of a soil to produce plant biomass for human use, providing food, feed, fiber and fuel within natural or managed ecosystem boundaries

Sandén et al., 2019 *Frontiers in Environmental Science*

PRIMARY PRODUCTIVITY

Decision modelling

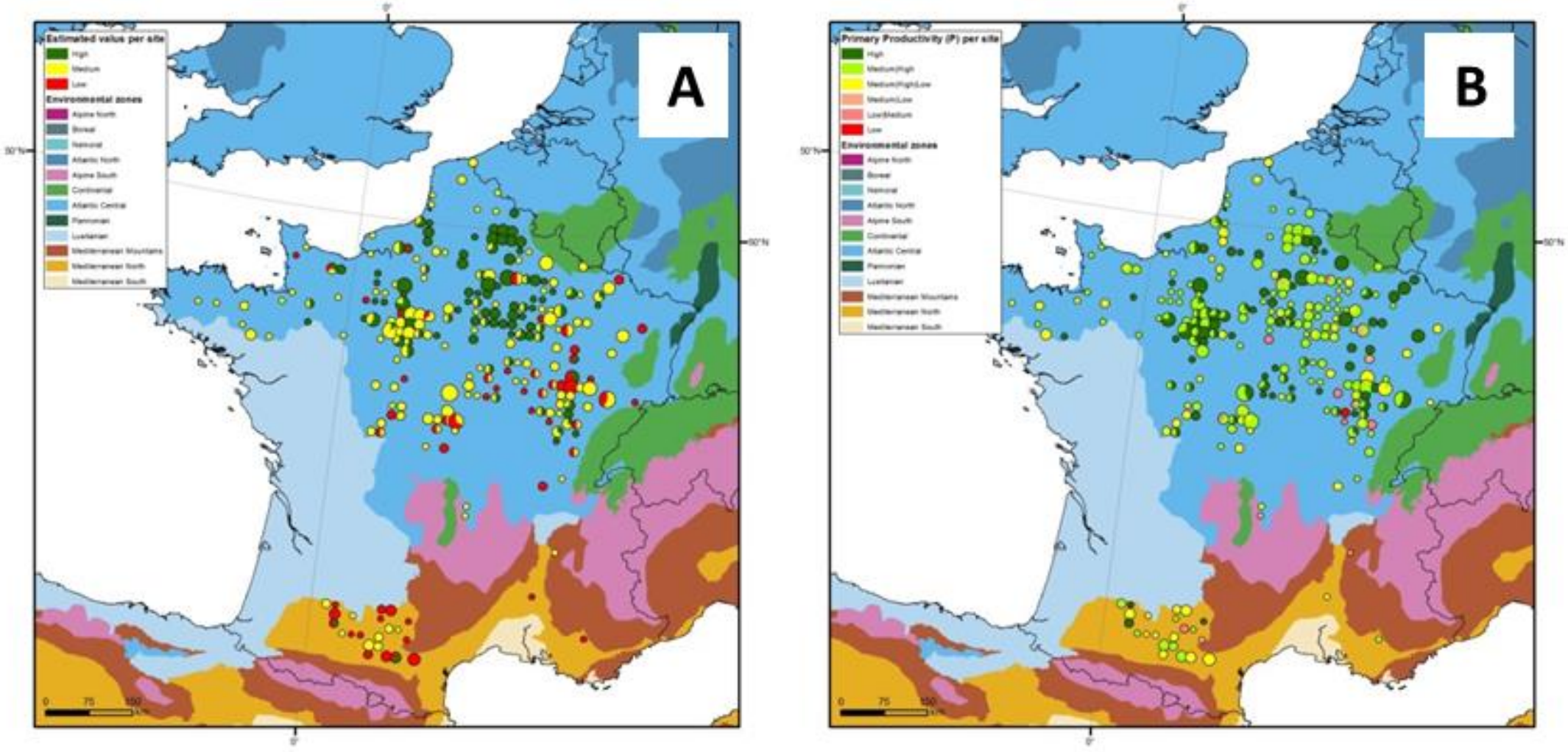


Attribute	Glob.norm.
Primary Productivity	
Soil	22
Biological activity	7
pH	3
C/N ratio	1
SOM	2
Chemical	7
Macro Elements	3
P	2
K	1
Mg	1
Other Chemical Attributes	4
CEC	1
Salinity	3
Physical	8
Structure	4
Bulk Density	2
Rooting Depth	1
Clay content	1
Groundwater Table Depth	4
Environment	30
Climate	15
Precipitation	10
Temperature	5
Orography	15
Altitude	6
Slope Degree	9
Crop	20
Crop Rotation	15
Number of crops	6
% legumes	5
% CaC,CoC,GM	4
Stocking Rate	5
Management	28
Fertilisation	12
Mineral	6
Organic Nitrogen Fertilisation	6
Pest Management	6
Chemical	2
Physical	2
Biological	2
Irrigation	10

Sandén et al., 2019
Frontiers in Environmental Science

COMPARING MODEL WITH EXPERT JUDGEMENT

A case study of nearly 400 sites in France



Sandén et al., 2019 *Frontiers in Environmental Science*

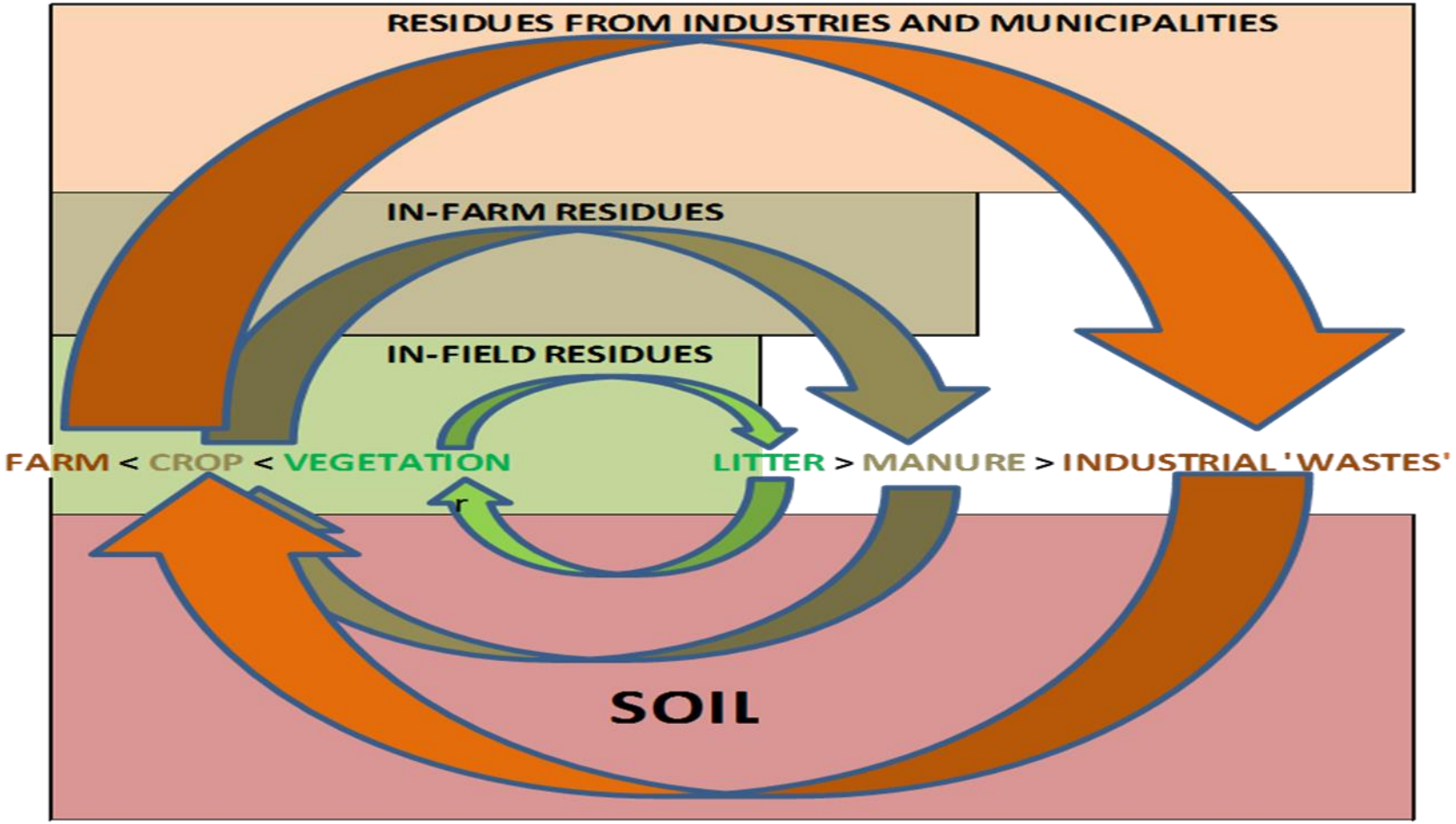
NUTRIENT CYCLING

Definition

The capacity of a soil to receive plant nutrients in the form of by-products, to provide nutrients from intrinsic resources or to support the acquisition of nutrients from air or water, and to effectively carry over these nutrients into harvested crops.

Schröder et al., 2016 *Soil Use and Management*

NUTRIENT CYCLING



© Jaap Schröder; Schröder et al., 2016 *Soil Use and Management*

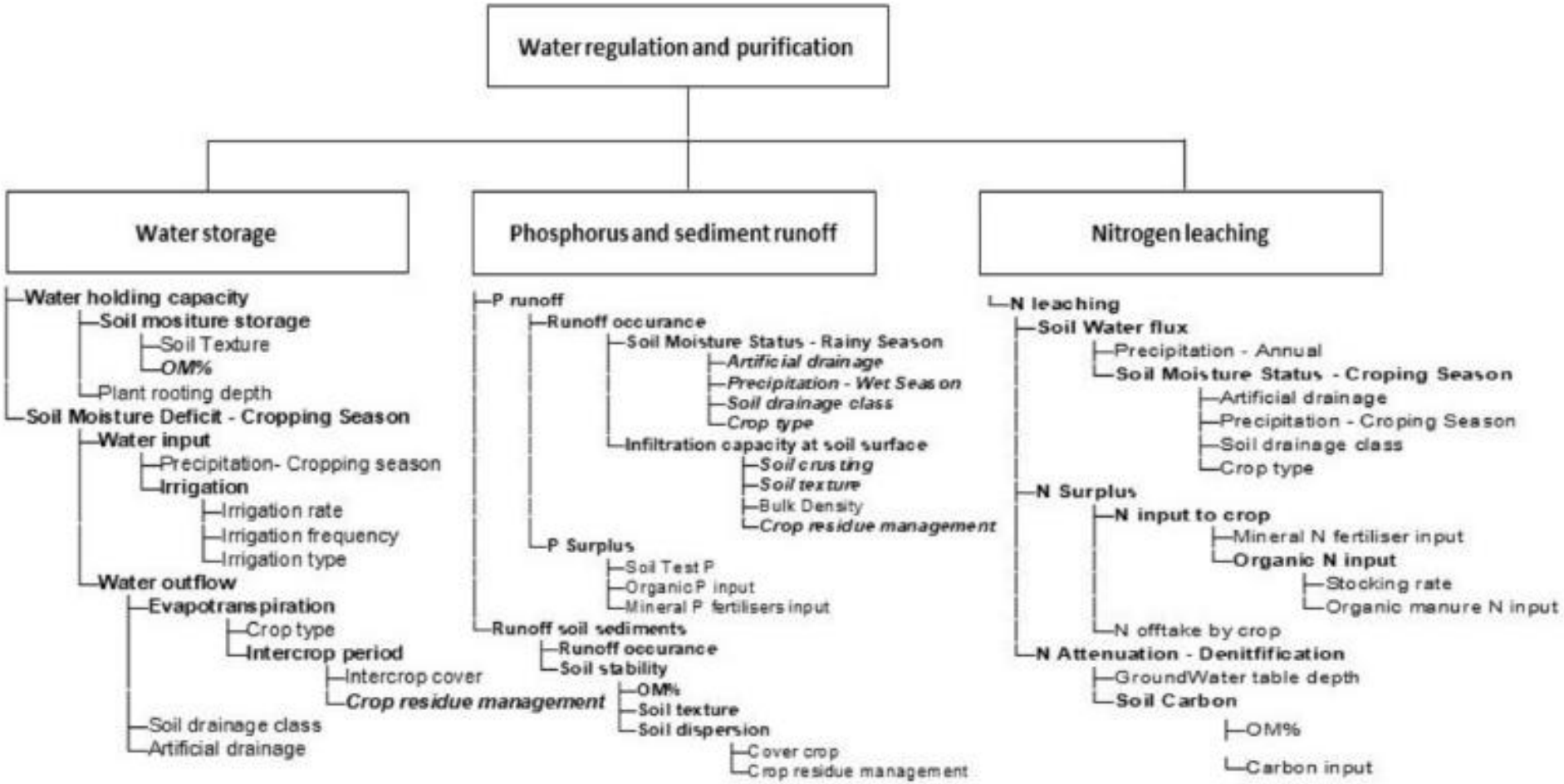
WATER REGULATION & PURIFICATION

Definition

The capacity of the soil to remove harmful compounds and the capacity of the soil to receive, store and conduct water for subsequent use and to prevent droughts, flooding and erosion.

Wall et al., 2020 *Frontiers in Sustainable Food Systems*

WATER REGULATION & PURIFICATION



Wall et al., 2020 *Frontiers in Sustainable Food Systems*

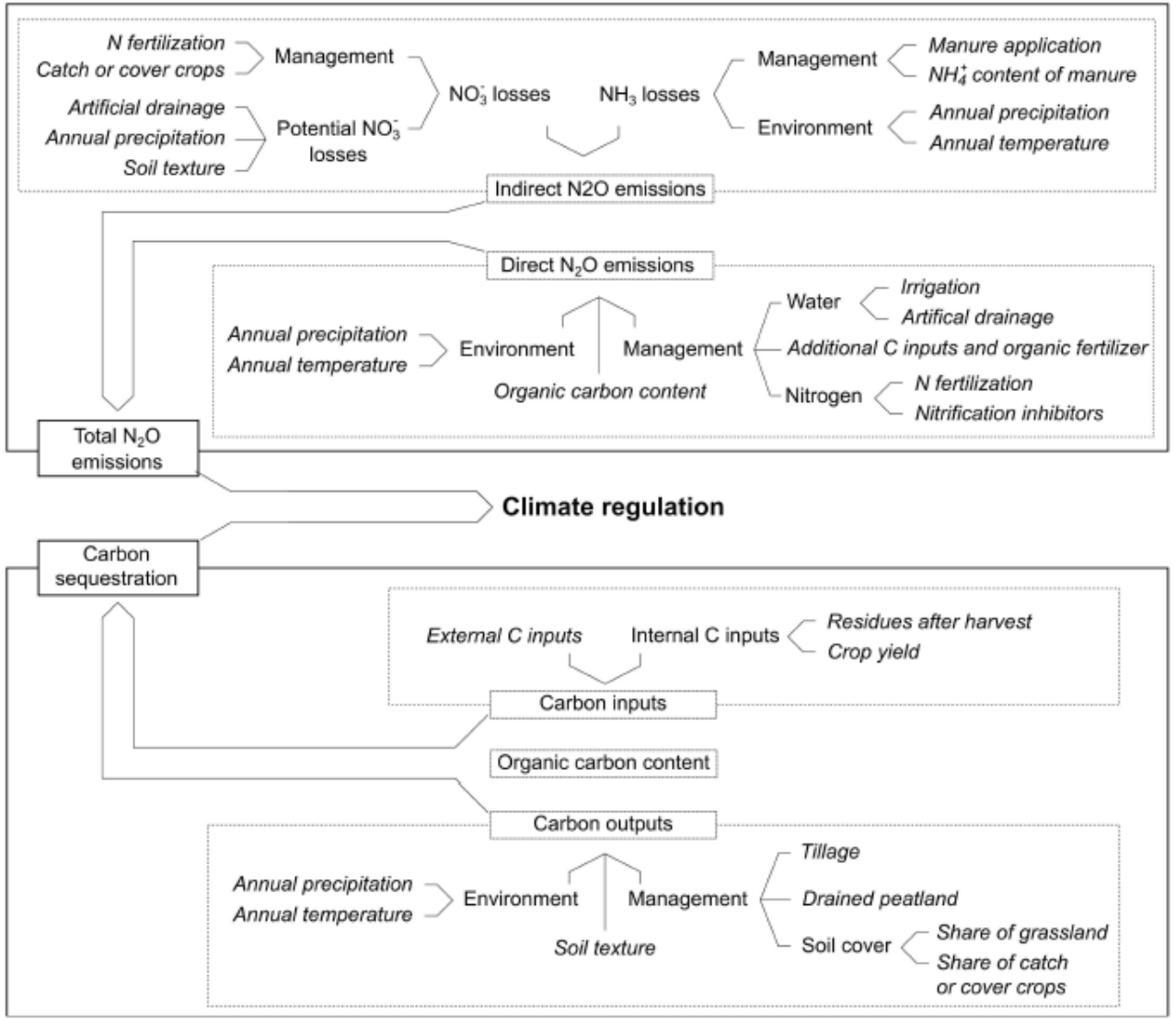
CLIMATE REGULATION

Definition

- The capacity of a soil to reduce the negative impact of increased greenhouse gas emissions on climate, among which its capacity to store carbon (C) and to minimize N_2O emissions.

Van de Broek et al., 2019 *Frontiers in Environmental Science*

CLIMATE REGULATION



Van de Broek et al., 2019 *Frontiers in Environmental Science*

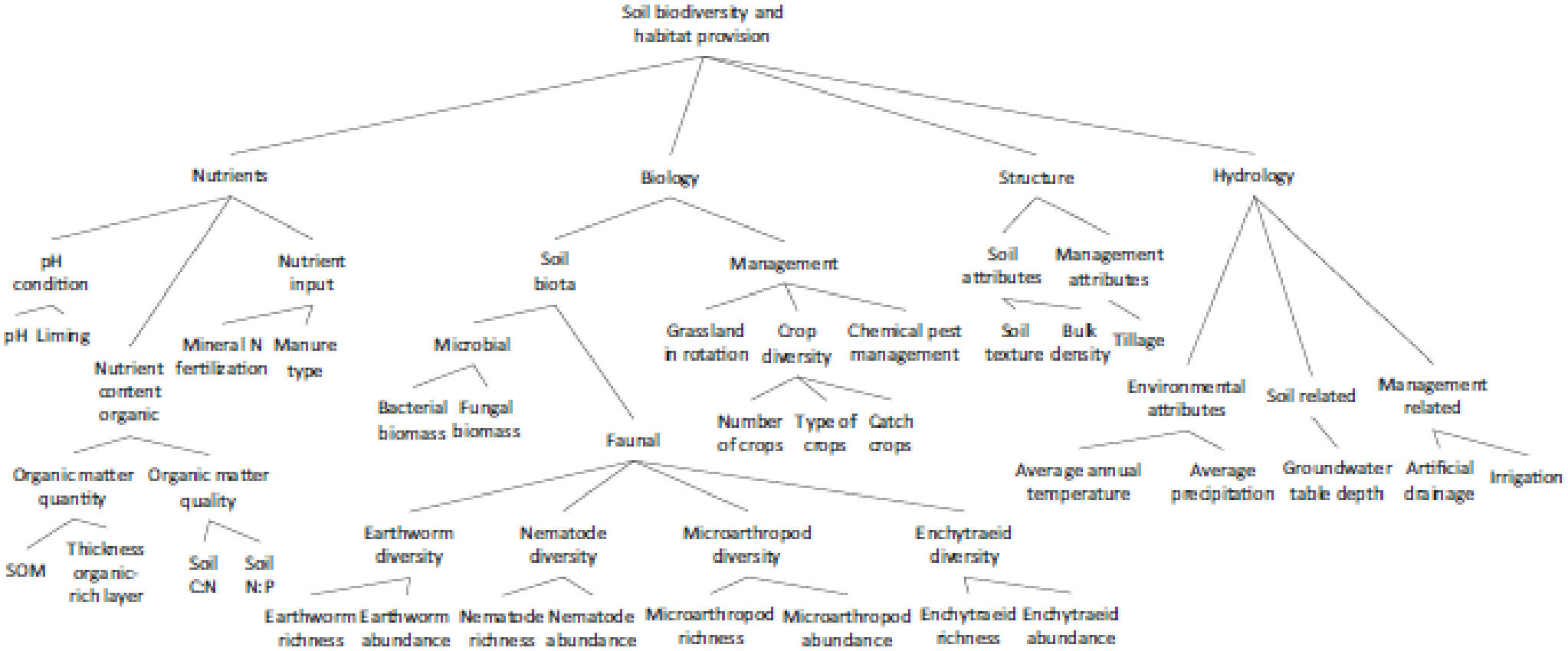
BIODIVERSITY & HABITAT PROVISIONING

Definition

- The multitude of soil organisms and processes, interacting in an ecosystem, providing society with a rich biodiversity source and contributing to a habitat for aboveground organisms.

Van Leeuwen et al., 2019 *Frontiers in Environmental Science*

BIODIVERSITY & HABITAT PROVISIONING



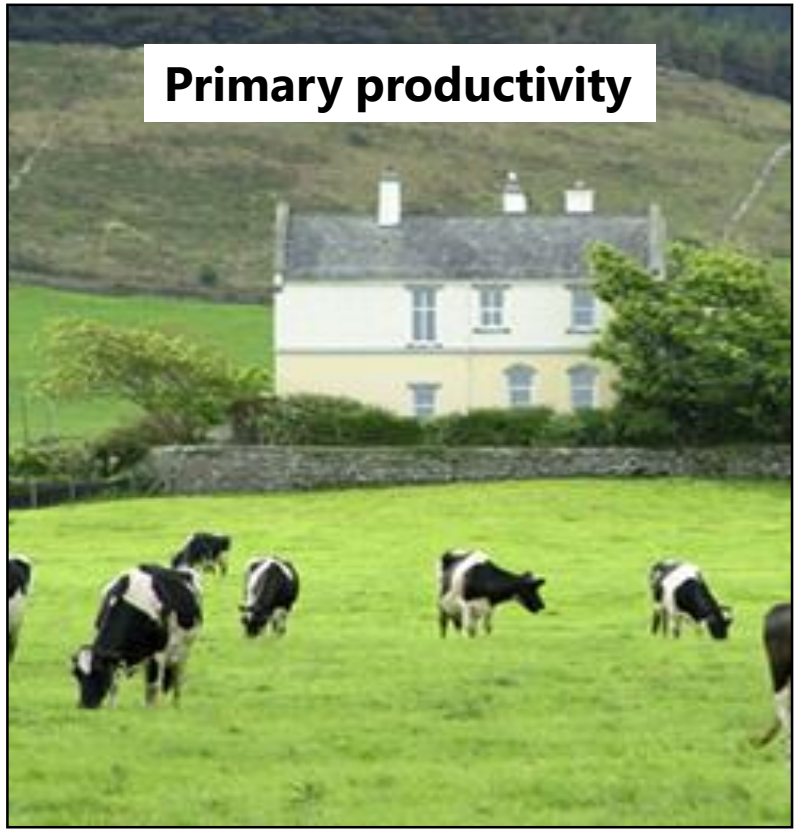
Van Leeuwen et al., 2019 *Frontiers in Environmental Science*

Water regulation and purification

Climate regulation

Biodiversity

Primary productivity



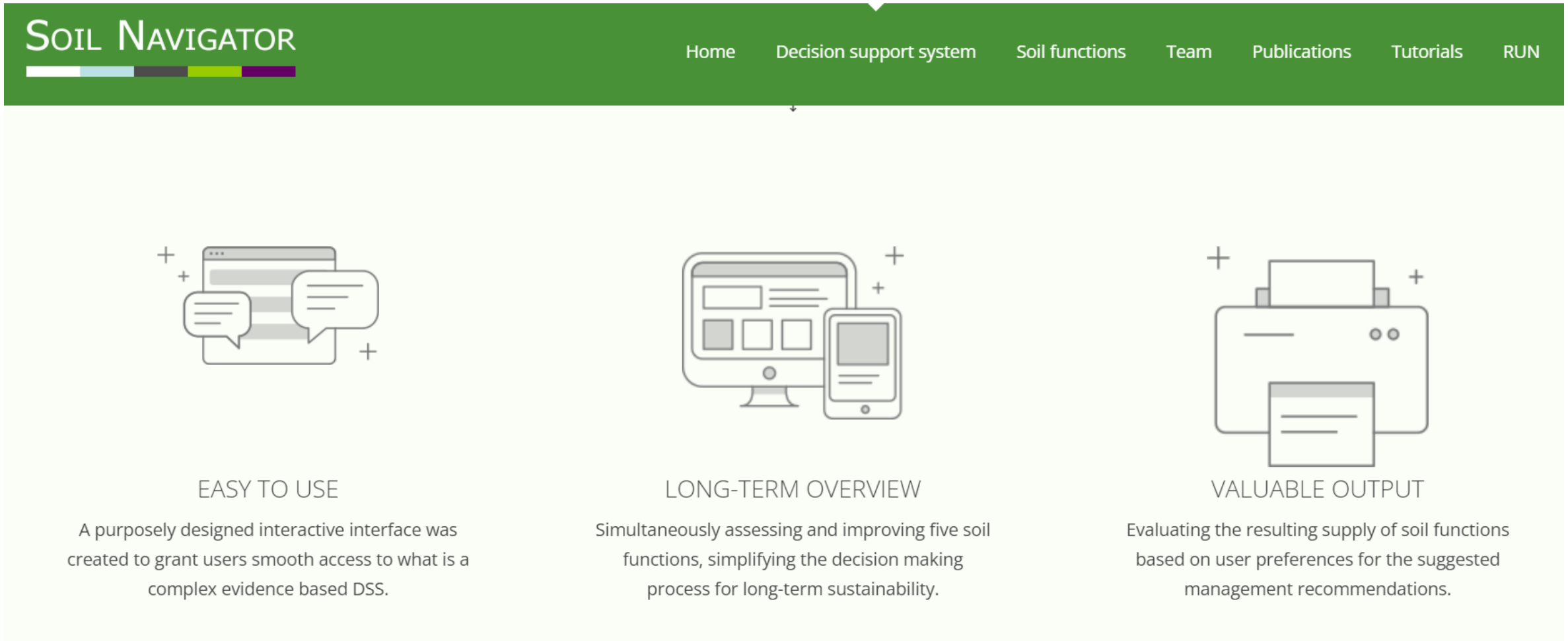
Nutrient cycling

LOW
MEDIUM
HIGH

Schulte et al., 2014 Environmental Science & Policy

SOIL NAVIGATOR

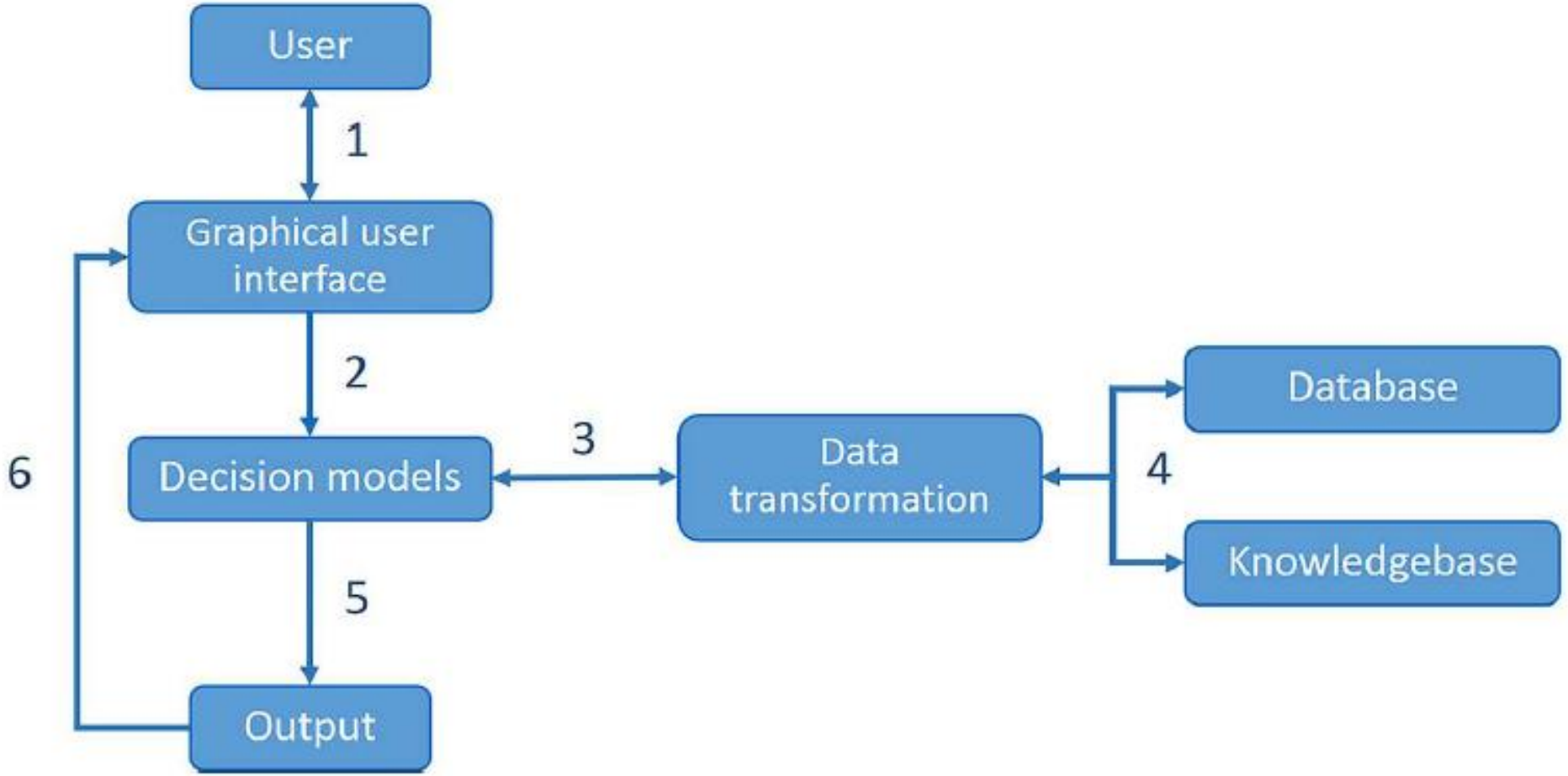
www.soilnavigator.eu



Debeljak et al., 2019 *Frontiers in Environmental Science*

SOIL NAVIGATOR

Performance of soil functions and how to manage them



Debeljak et al., 2019 *Frontiers in Environmental Science*

SOIL NAVIGATOR

Structural properties of the DEX models of the soil functions

What user needs to enter into the Soil Navigator

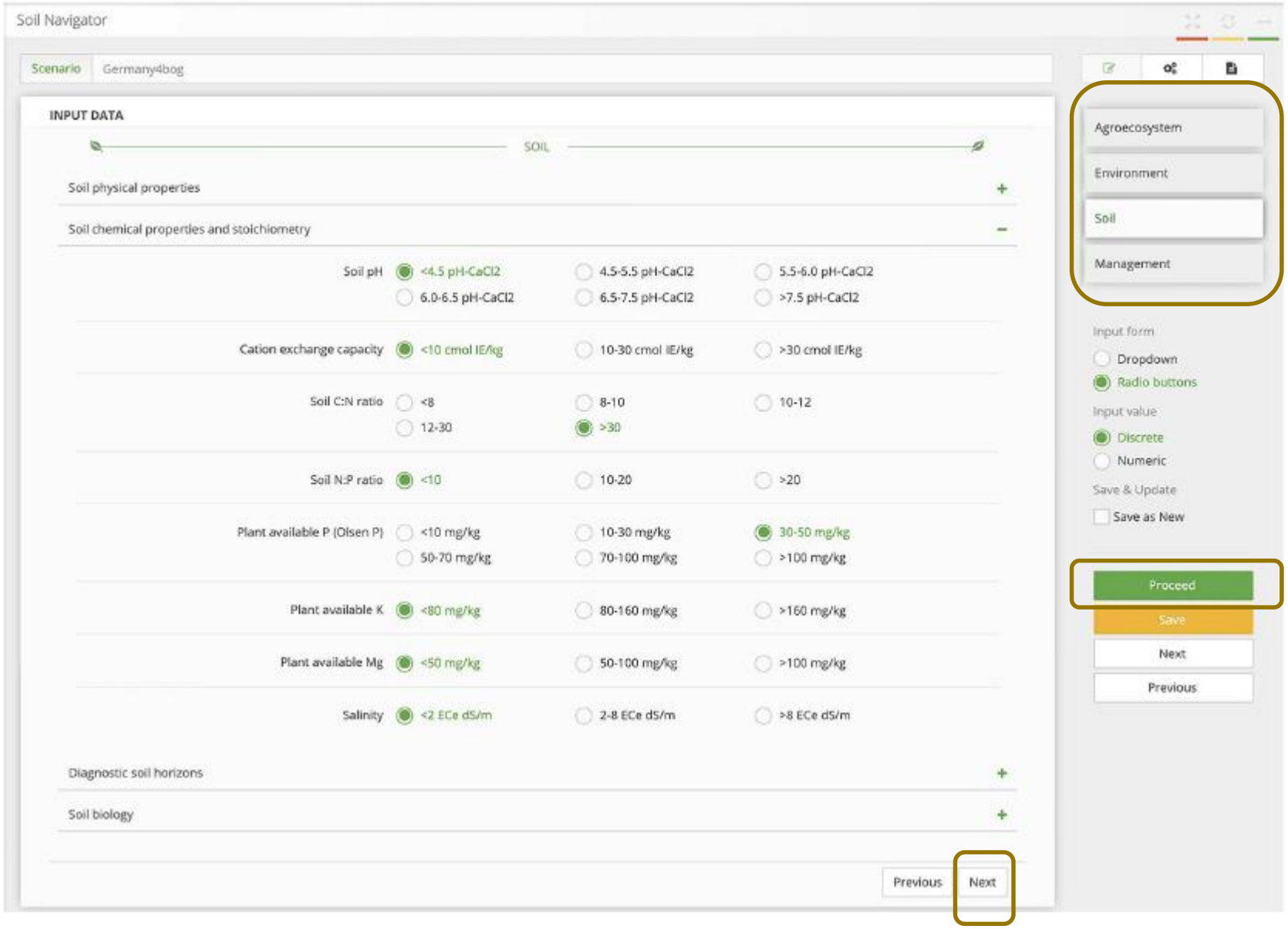
Soil function models	Total number of attributes	Number of aggregated attributes	Number of input attributes	Number of hierarchical levels	Number of integration rules
Primary productivity	42	16	25	4	294
Nutrient cycling	51	27	24	5	302
Climate regulation	540	21	19	5	301
Water regulation and purification	116	77	39	6	800
Biodiversity and habitat	55	24	31	5	612

Carbon sequestration	N_2O emissions	Climate regulation
Low	High	Low
Low	Medium	Low
Low	Low	Medium
Medium	High	Low
Medium	Medium	Medium
Medium	Low	High
High	High	Medium
High	Medium	High
High	Low	High

Debeljak et al., 2019 *Frontiers in Environmental Science*
Van de Broek et al., 2019 *Frontiers in Environmental Science*

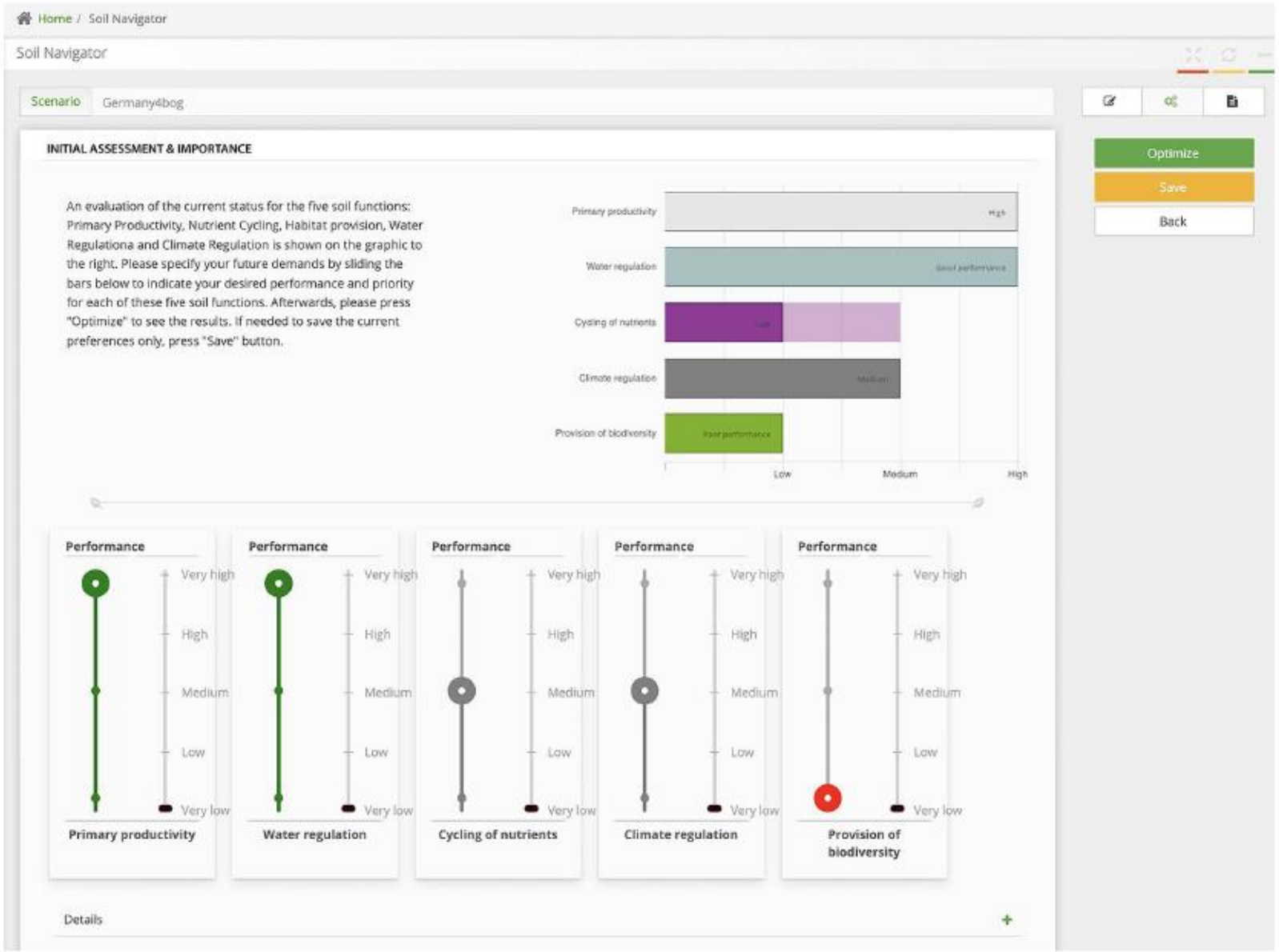
SOIL NAVIGATOR

Data entry



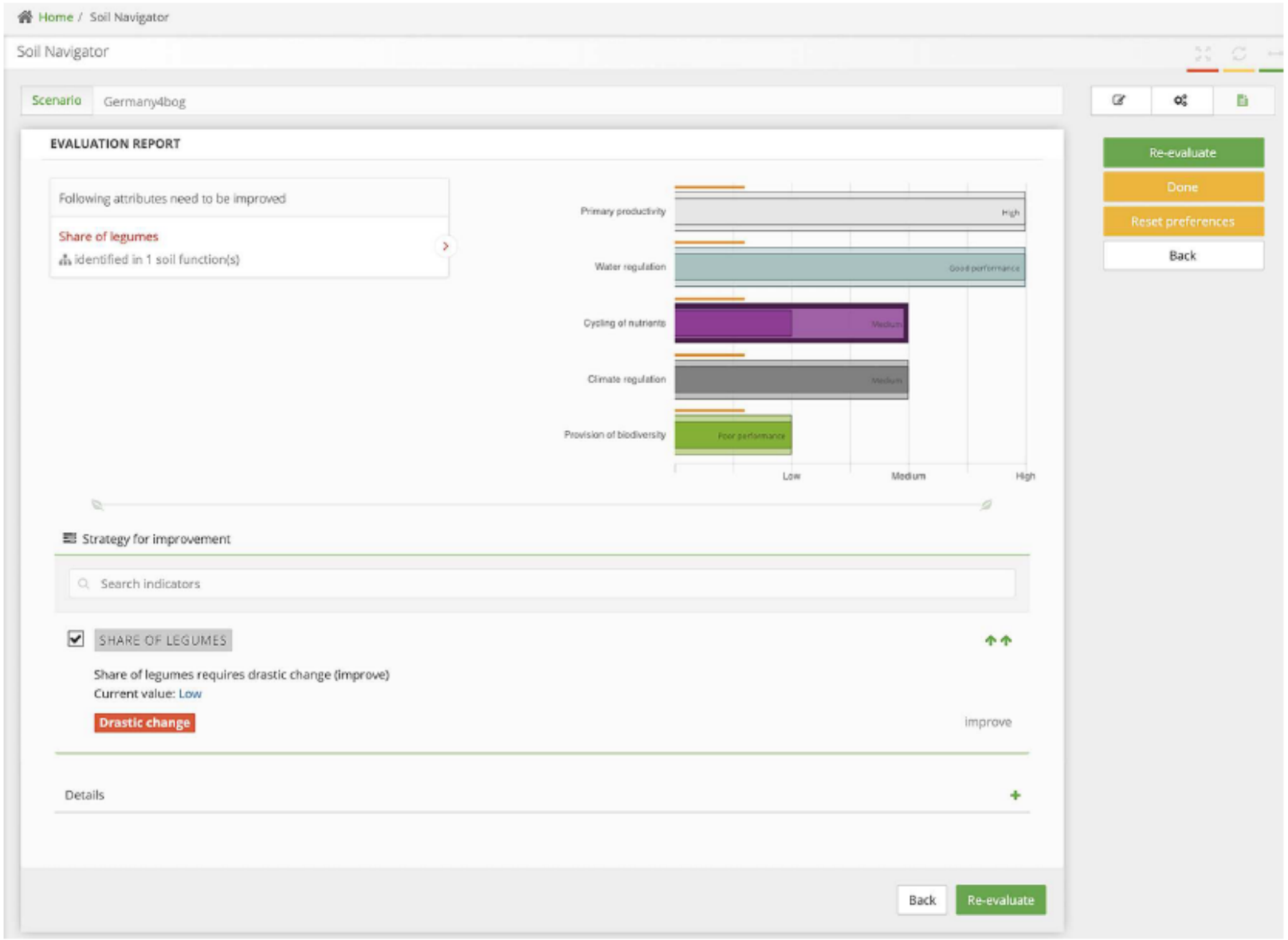
SOIL NAVIGATOR

Assessment



SOIL NAVIGATOR

Suggestions



YOUR TURN!

www.soilnavigator.eu – Archive – Taru_test_2023

- Lets divide into six groups
- Open the case, and save as new with a modified name

YOUR TURN!

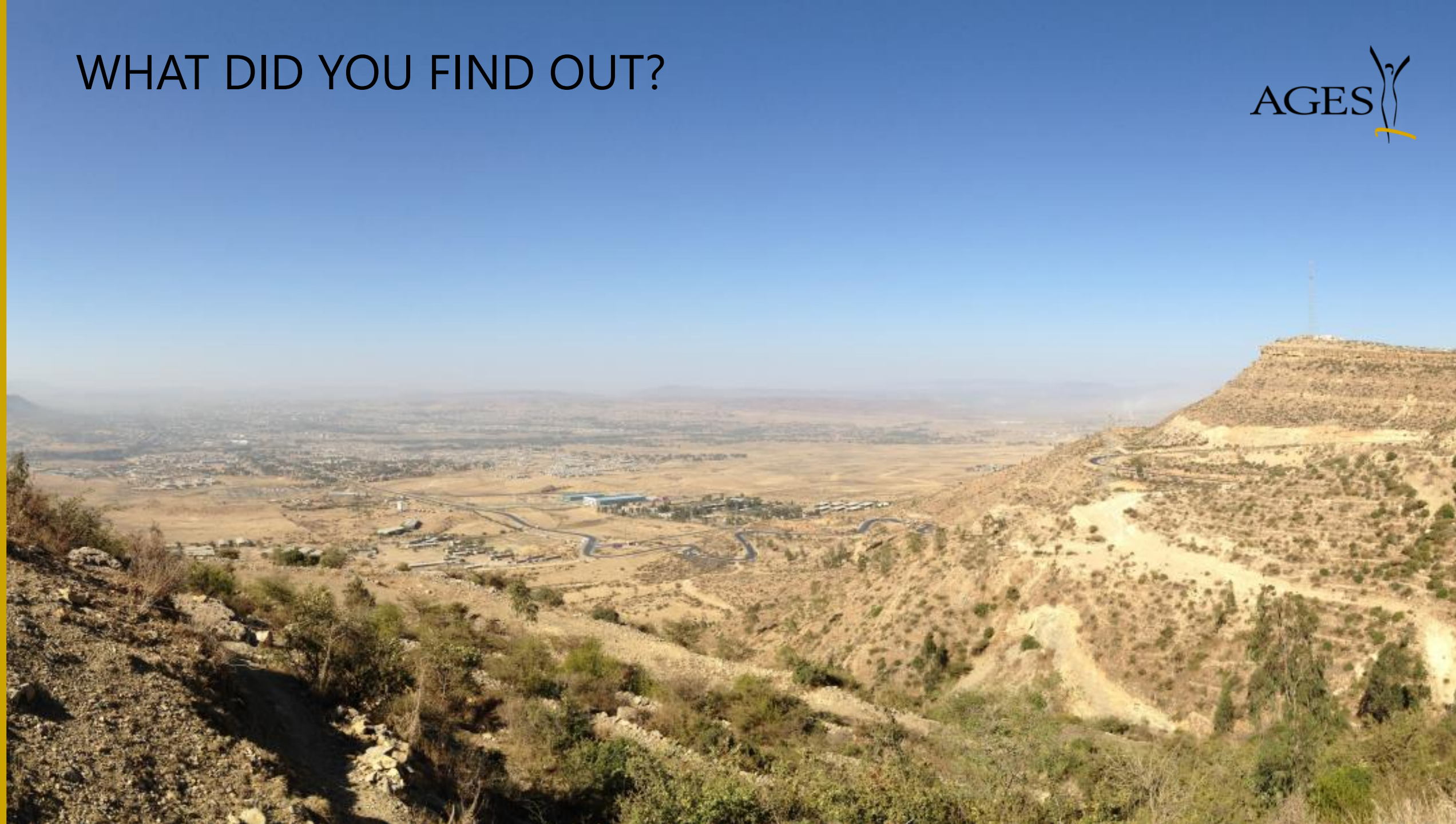
www.soilnavigator.eu – Archive – Taru_test_2023

1. You are in a Danish cropland, with a role of being:
   - Farmers (group 1)
   - Policy makers (group 2)
   - Researchers (group 3)
   - Urban planners (group 4)
   - Citizens (group 5)
   - Mayors of municipalities (group 6)
2. Get your first soil functions assessment
3. Try to get four soil functions to medium and PP to high
4. Try to get all soil functions to high
5. Try to get 3/5 soil functions to high
6. Summarise your findings and prepare a short presentation

GROUP PRESENTATIONS

- What kind of recommendations did you get?
- Was optimisation of all soil functions to high possible? If yes, why? If not, why?
- Which soil functions did you get to high (3/5)? Why these?
- What do the results mean in your role?
- How would you integrate soil functions assessments into your role?
- What would be required for you to include soil functions assessment into your daily work?
- What would you improve in the soil functions assessment?

WHAT DID YOU FIND OUT?



LANDMARK SOIL SAMPLING - 2018

94 sites, 13 countries, 2 land uses and 5 environmental zones

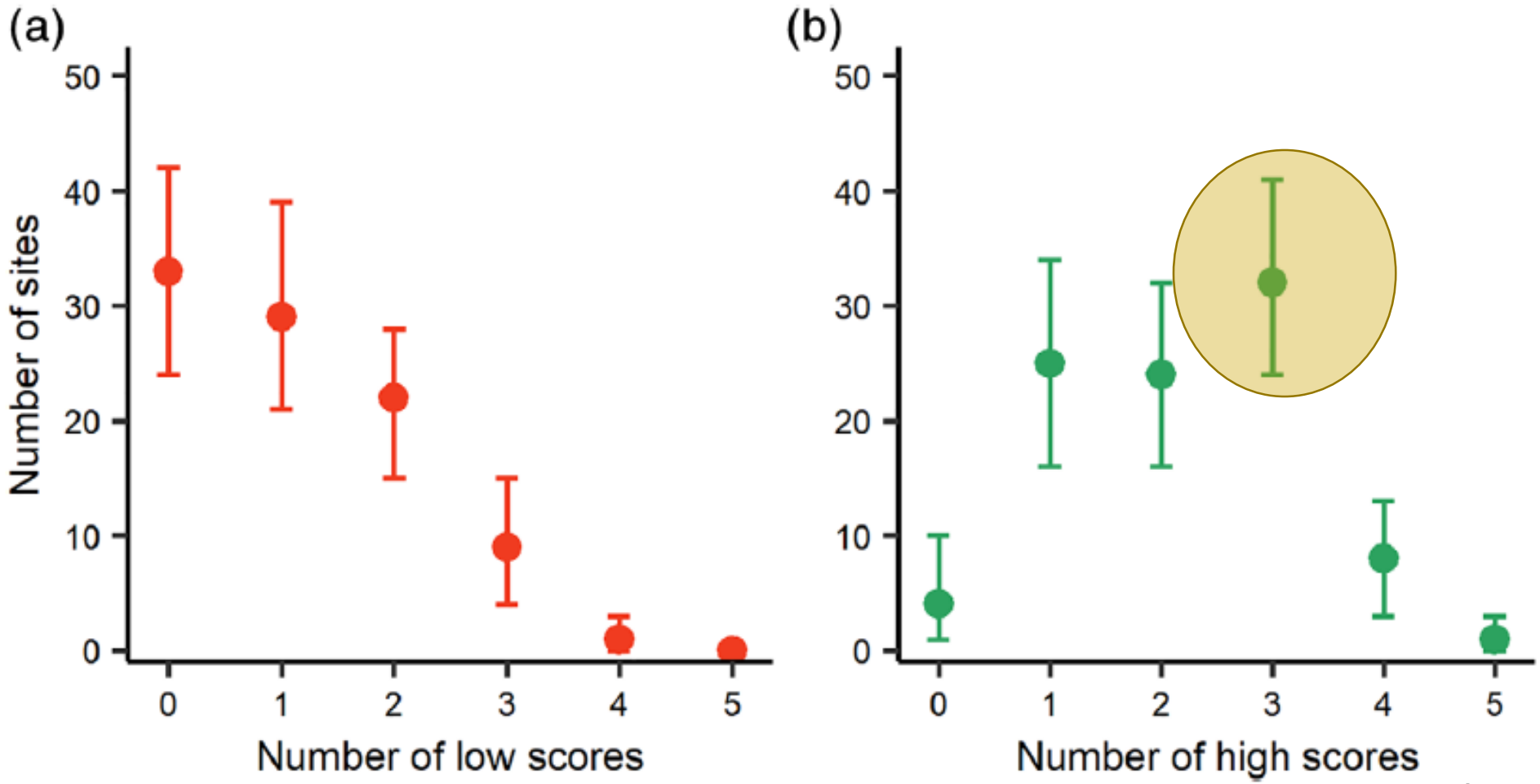
Climatic zone	Number of grassland sites	Number of arable sites	Number of sites with calcic diagnostic	Number of sites with argic diagnostic
Alpine south	7	6	7	6
Atlantic	10	10	10	10
Continental	9	11	10	10
Mediterranean north	8	11	6	12
Pannonian	12	10	12	10

Soil samples: 0-25cm and 25-50cm, for biological analyses 0-15cm
Soil analyses: soil texture, bulk density, soil moisture, pH, CEC, total and organic C&N, Mehlich-3 phosphorous, earthworm abundance, earthworm richness, nematode abundance, nematode richness, soil drainage class
Management practices: fertilisers, crops, livestock, irrigation, artificial drainage, liming, pest and disease control
Climate data: provided by Agri4Cast team of JRC, daily meteorological data interpolated on a 25 * 25 km grid

Zwetsloot et al., 2021 *EJSS*

3/5 SOIL FUNCTIONS HIGH IN 30% OF SITES

Results of 92 European croplands and grasslands



Zwetsloot et al., 2021 *EJSS*

RELATIONSHIPS BETWEEN SOIL FUNCTIONS

Local constraints and trade-offs

Land use	Climatic zone	Soil functions		r_s	*p*-value
Grassland	Mediterranean north	PP	WR	−0.77	**.02**
Grassland	Mediterranean north	WR	BD	−0.75	**.03**
Grassland	Pannonian	NC	CR	0.61	**.04**
Grassland	Pannonian	CR	BD	0.69	**.01**
Arable	Alpine south	NC	WR	1.00	**<.001**
Arable	Atlantic	CR	BD	−0.72	**.02**
Arable	Continental	PP	CR	−0.72	**.01**
Arable	Continental	WR	CR	0.81	**<.001**
Arable	Pannonian	CR	BD	0.69	**.03**

Zwetsloot et al., 2021 *EJSS*

TAKE HOME MESSAGES

- Evaluating and monitoring multifunctionality is important for identifying and avoiding potential trade-offs
  - Importance of quality criteria for assessments (ÖNORM, ISO, etc.)
- Transition towards stimulating the delivery of other soil functions than primary production may benefit society more than the farmers in the short term
  - Importance of considering trade-offs with primary productivity that is the economic foundation for farmers and associated sectors in rural areas
  - Importance of inclusion of farmers´ and stakeholders´ knowledge, needs and willingness in the transition
- Soil organic matter plays a crucial role for soil functions
  - E.g. soil biodiversity and climate regulation both benefit from it

THANK YOU FOR YOUR ATTENTION!

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