



Development of DSS for application in agriculture



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Decision making – Decision support system

DECISION

The **choice** of one among a number alternatives

A **process** of making the choices

DECISION MAKING

DECISION MAKING is a PROCESS

Assessing the **problem**

Collecting and verifying **information**

Identifying **alternatives**

Making the **choice**

Evaluating **decisions**

Making complex decisions



Complex task

Improvements of the effectiveness of decisions

Assistance of decision maker

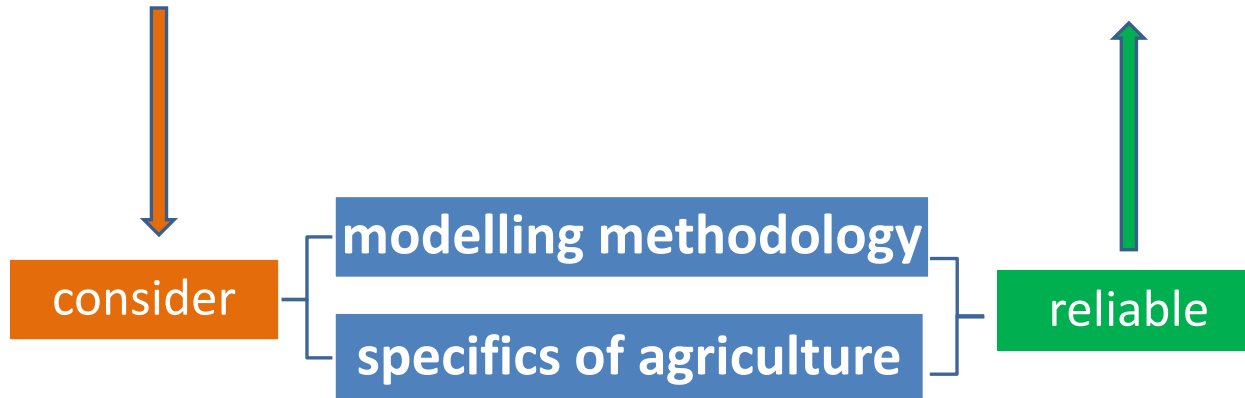
Interactive computer tools

DECISION SUPPORT SYSTEMS

Prelude



Development of **DSS** for application in agriculture



Modelling methodology

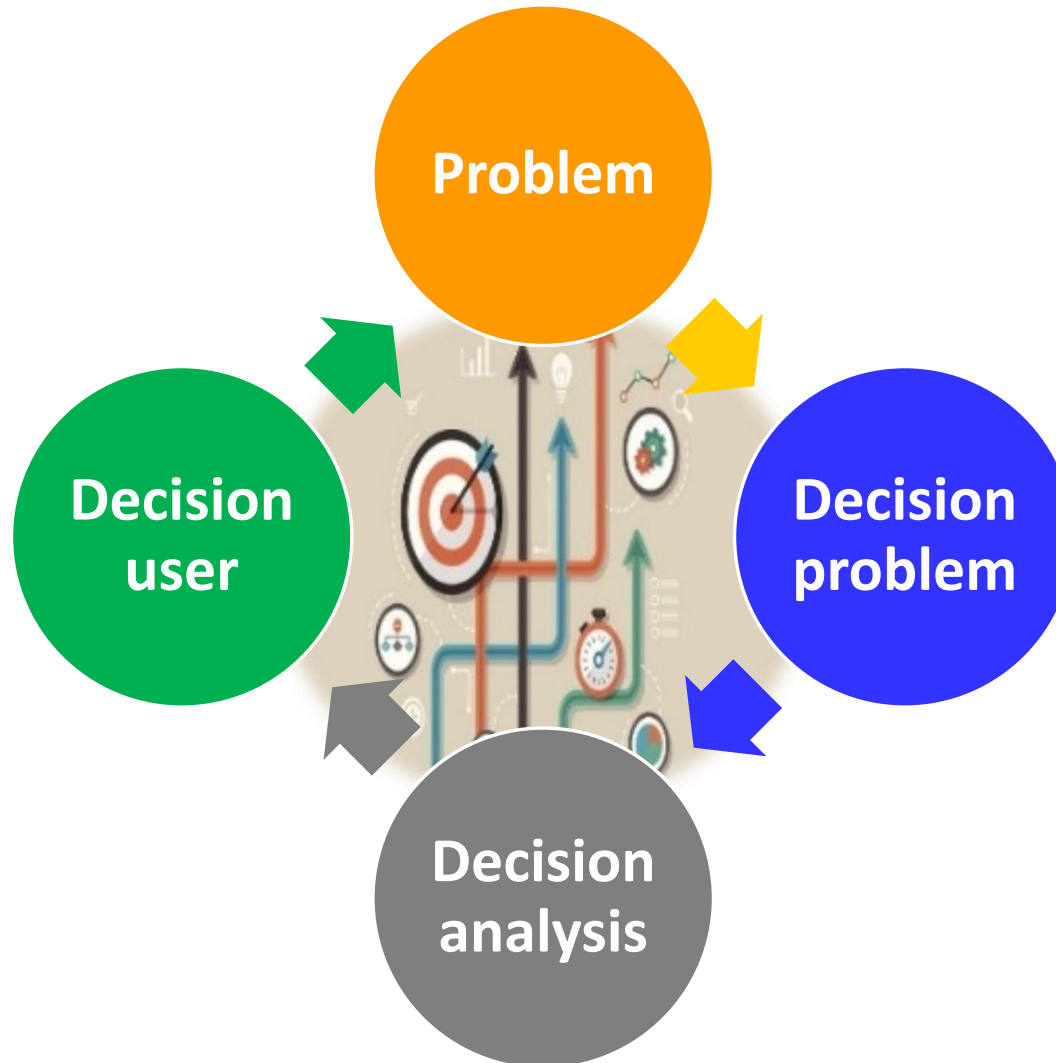
- Conceptual framework
- Architecture of DSS
- Modeling procedure
- Integration

Implementation

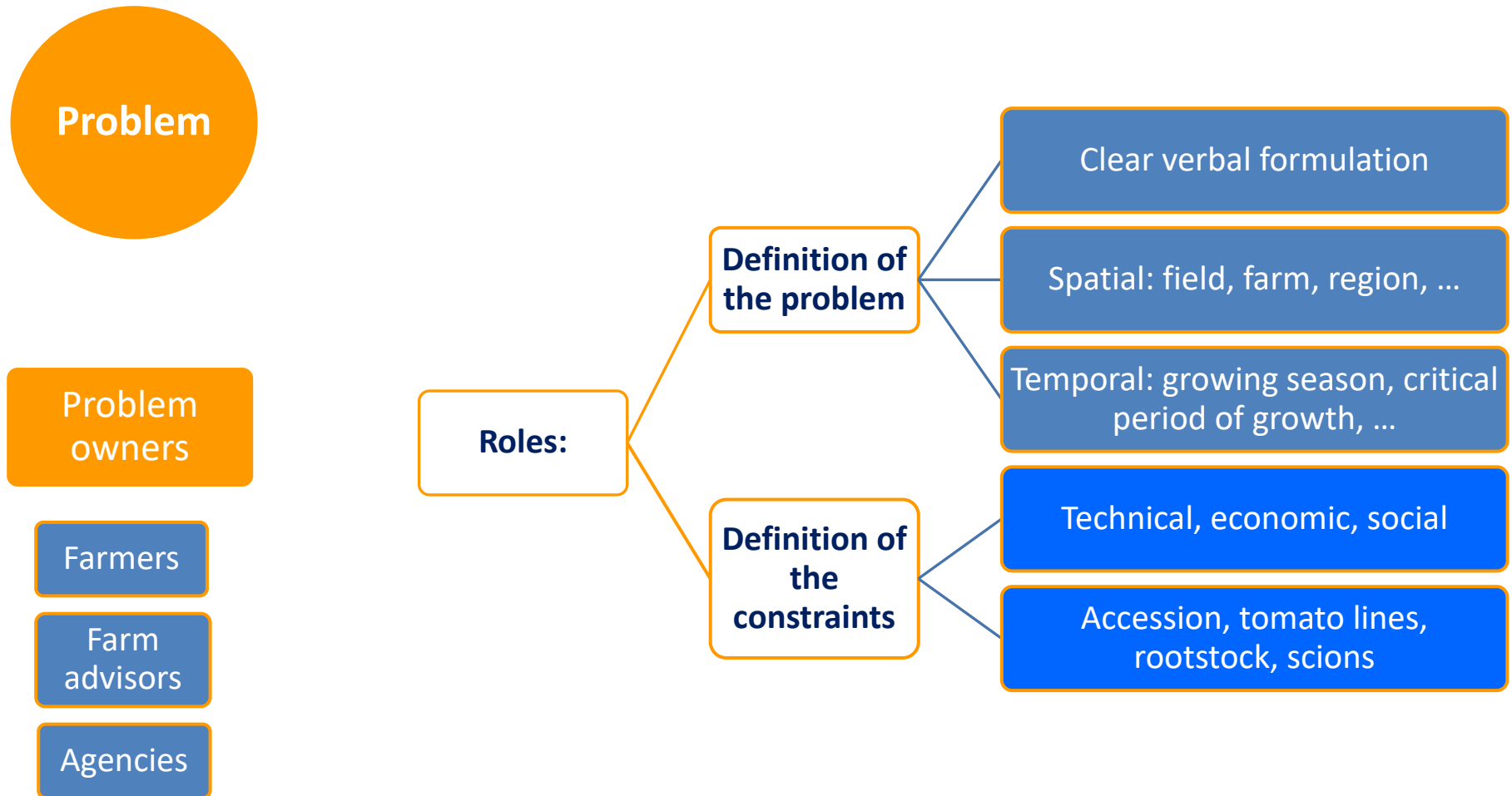
- EVADIFF
- Soil Navigator
- Path Finder

Final remarks

Conceptual framework



Conceptual framework



Example: Water pollution with pesticides.

Conceptual framework

Decision problem

Experts

Farm advisors

Senior scientists

Representatives of interest groups

Roles:

Definition of the decision problem

Selection of variety

Selection soil management, irrigation intensity, fertilization intensity...

Selection of correct active substance

Decomposition of the problem

State variables

Links between variables

Modular structure

Hierarchical structure

Environmental constraints

Management constraints

Definition of alternatives

List of possible decisions

Priorities of possible decisions

Technical and economic implementation

Example: Active substance, concentration, time of application.

Conceptual framework

Decision
analysis

Decision
analysts

Data
management
experts

Modelling
experts

Roles:

Data

Data types: quantitative, qualitative

Data availability: unique, temporal, spatial

Data completeness, missing data

Data management: collection, cleaning,
storage, transfer

Data
analysis
and
modelling

Ordination

Ranking

Clustering

Prediction modelling

Single, multi target

Classification,
regression

Decision modelling

Evaluation

What-if

Once/many decision

Example: Data mining and qualitative decision modeling

Conceptual framework

Decision
user

Users

Farmers

Farm
advisors

Students

Roles:

Type of
implementation
of proposed
solutions

User

Single

Many

Usage

One-time use

Frequent use

Tool

Paper decision map

Computer tool

History

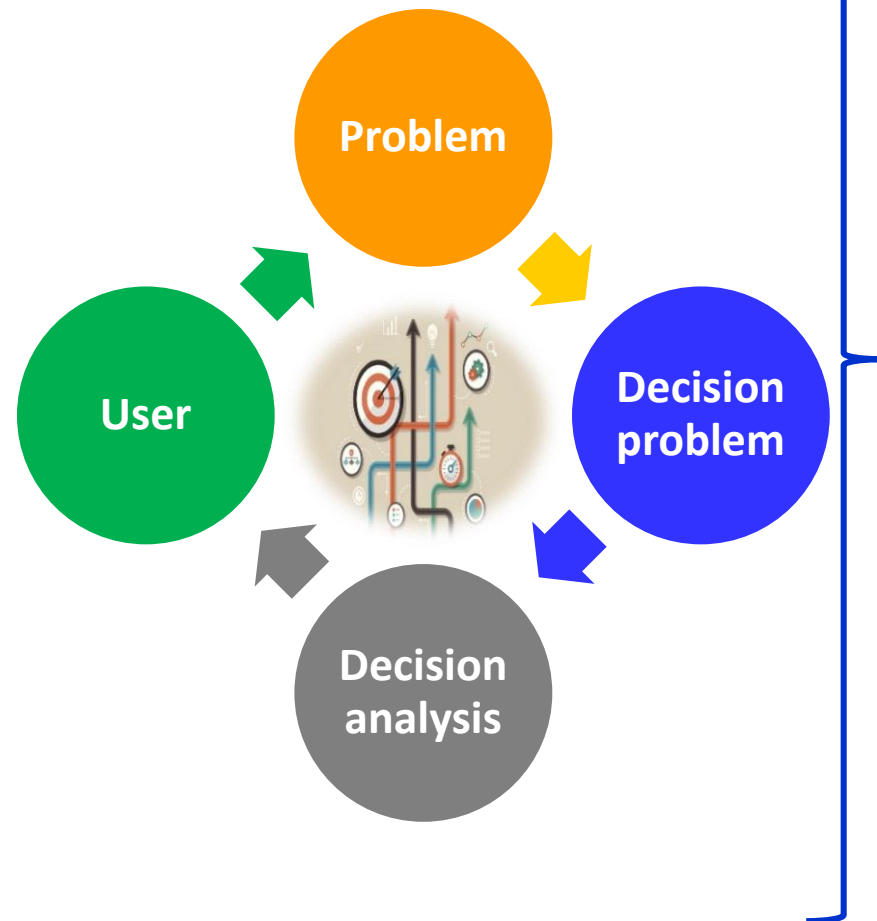
Storage

Sharing with other users

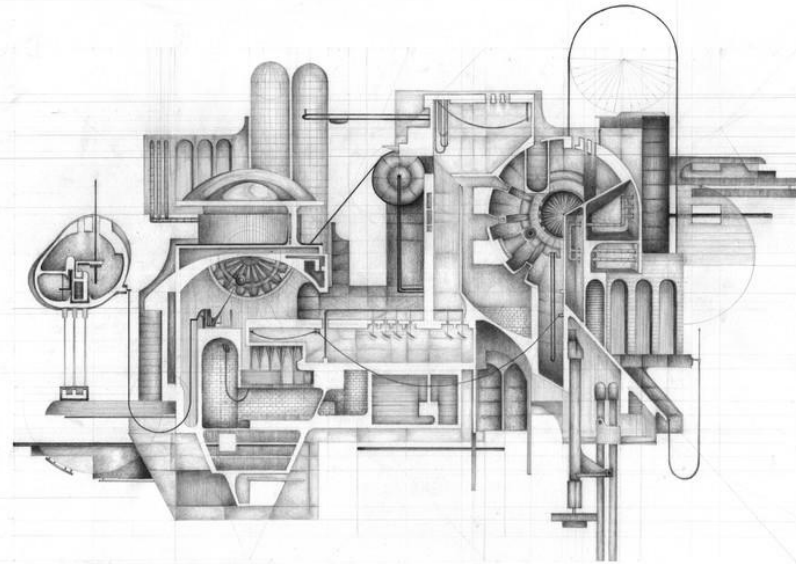
Example: Phone App, personalized support: Isoproturon before drainage period with 50% reduced concentration

Modeling methodology

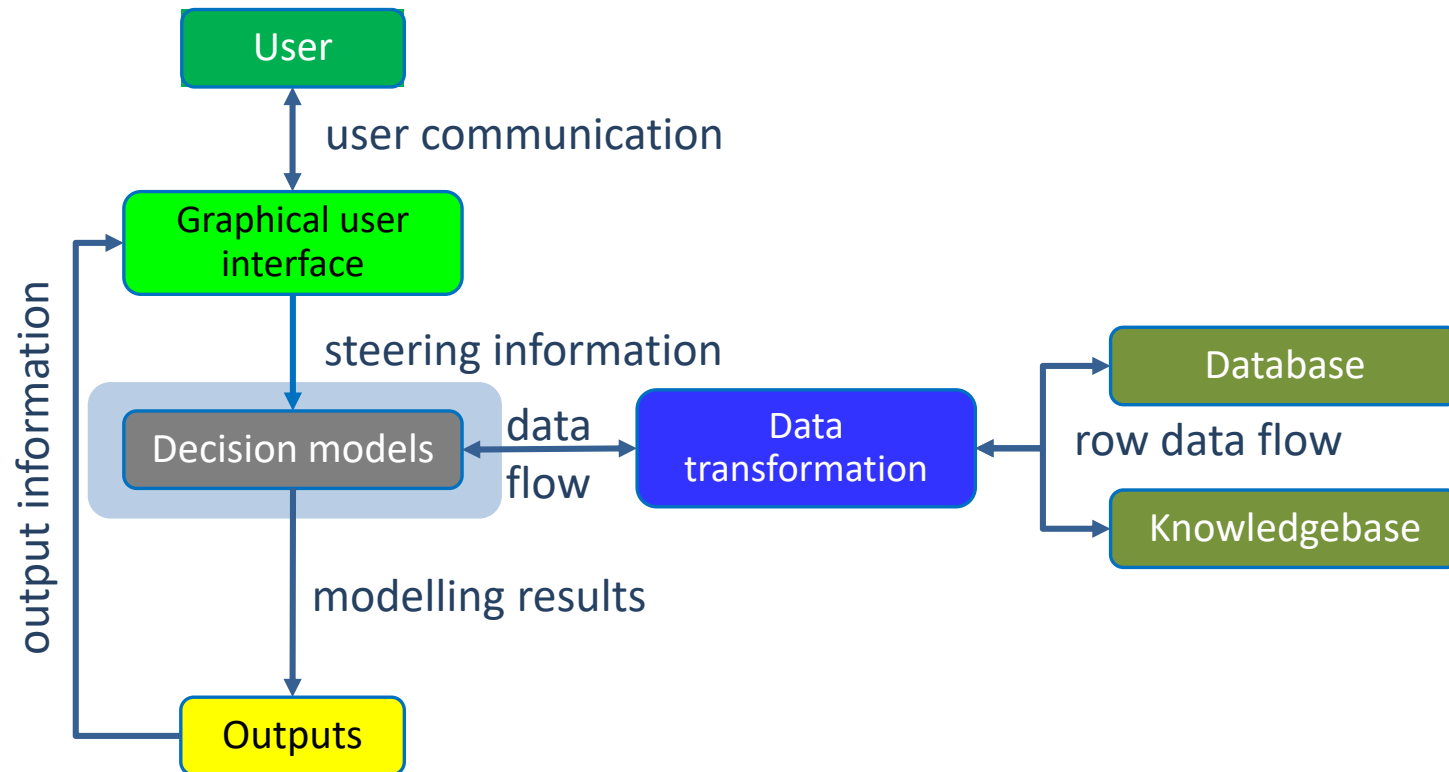
Conceptual framework of DSS



Architecture of DSS



Architecture of DSS



Modeling procedure

Decision models

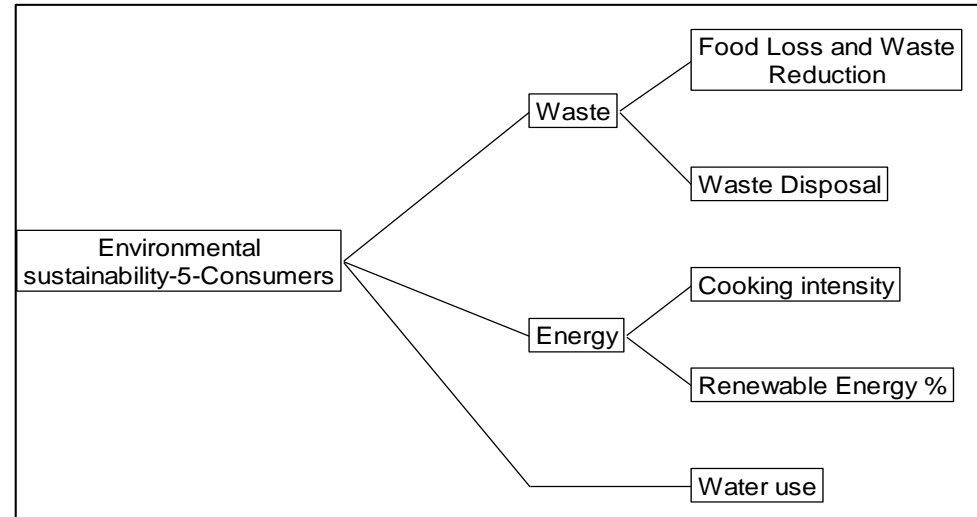
Multiobjective decision model:

- Soil properties,
- Soil management,
- Cropping system,
- Climate, ...

Systematic structural approach is needed:

- **Structuring and braking** complex decision problems into **less** complex parts that are manageable
- **Understanding** of the **problem**
- **Communication** between experts
- **Obtaining required knowledge**

Multi-attribute utility models



Golden roles of ecological modelling



Modeling procedure

Decision
problem



Conceptual
model

Data

Mechanistic modelling
Data Mining

Knowledge discovery from data

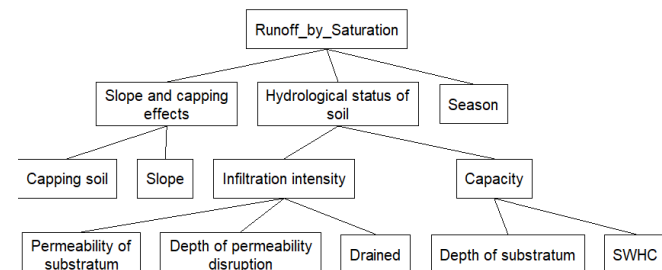
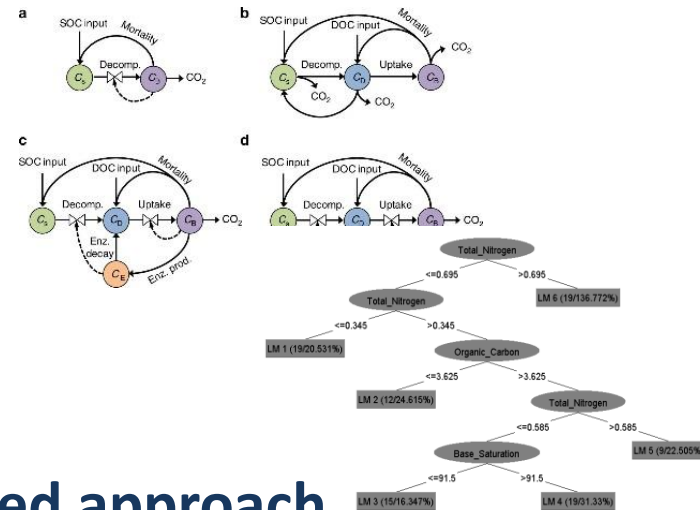
Problem driven and knowledge based approach



Domain experts

Expert based Knowledge

Knowledge Modelling



Modeling procedure

Decision models



Multi Criteria
Decision Analysis
(MCDA)

to generate

Multi-Attribute
Decision Models
(MADM)

using

DEX (Decision
EXpert) integrative
methodology

Experts

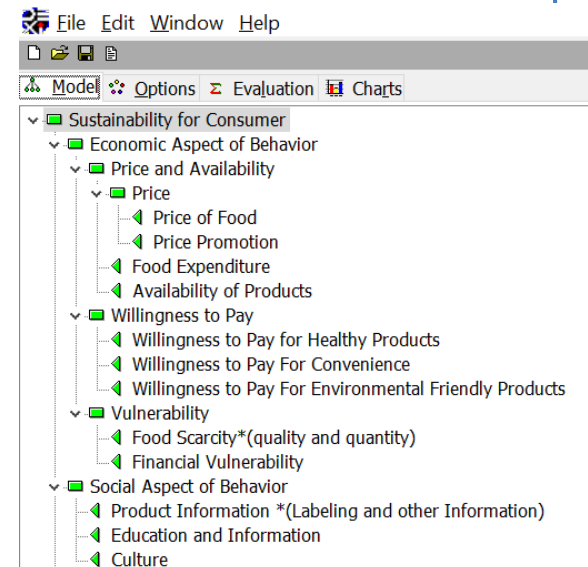
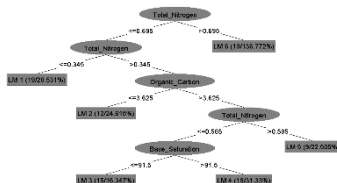


Expert based knowledge

Decision Modelling

Data mining

Data

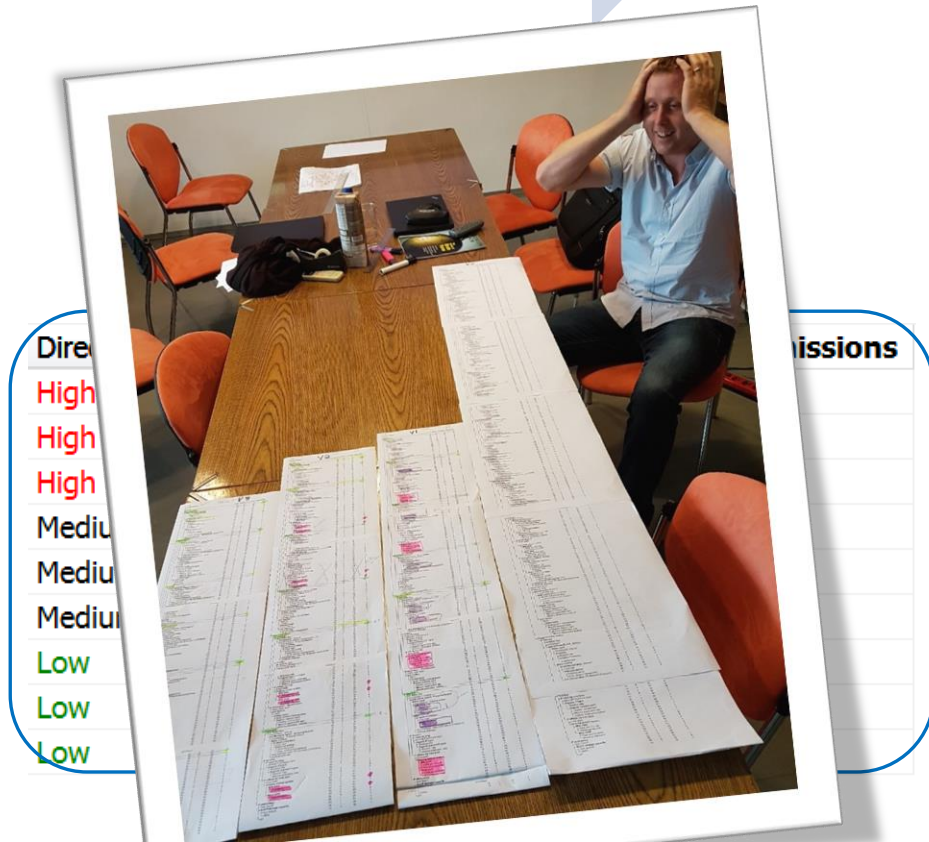




hierarchical decomposition of decision problem

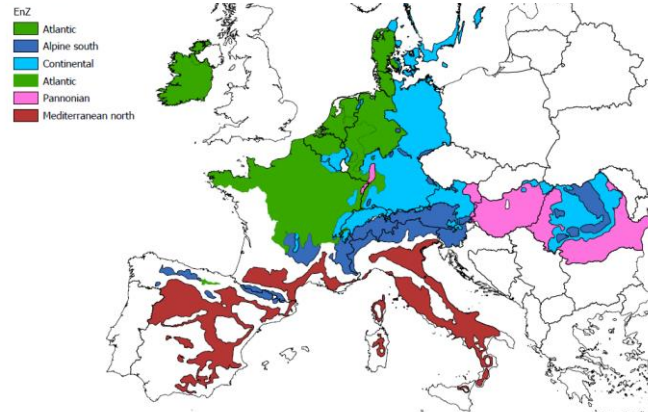
definitions of integration rules

Attribute	Scale
Climate regulation	Low ; Medium; High
Carbon sequestration	Low ; Medium; High
Carbon inputs	Low ; Medium; High
Potential carbon loss	High ; Medium; Low
Organic carbon content	Low ; Medium; High
N2O emissions	High ; Medium; Low
Direct N2O emissions	High ; Medium; Low
Indirect N2O emissions	High ; Medium; Low
CH4 emissions	High ; Medium; Low
Artificial drainage	No ; Yes
Soil type	Organic ; Mineral



Modeling procedure

Decision models



Verification



Sensitivity
analysis



Calibration



Validation

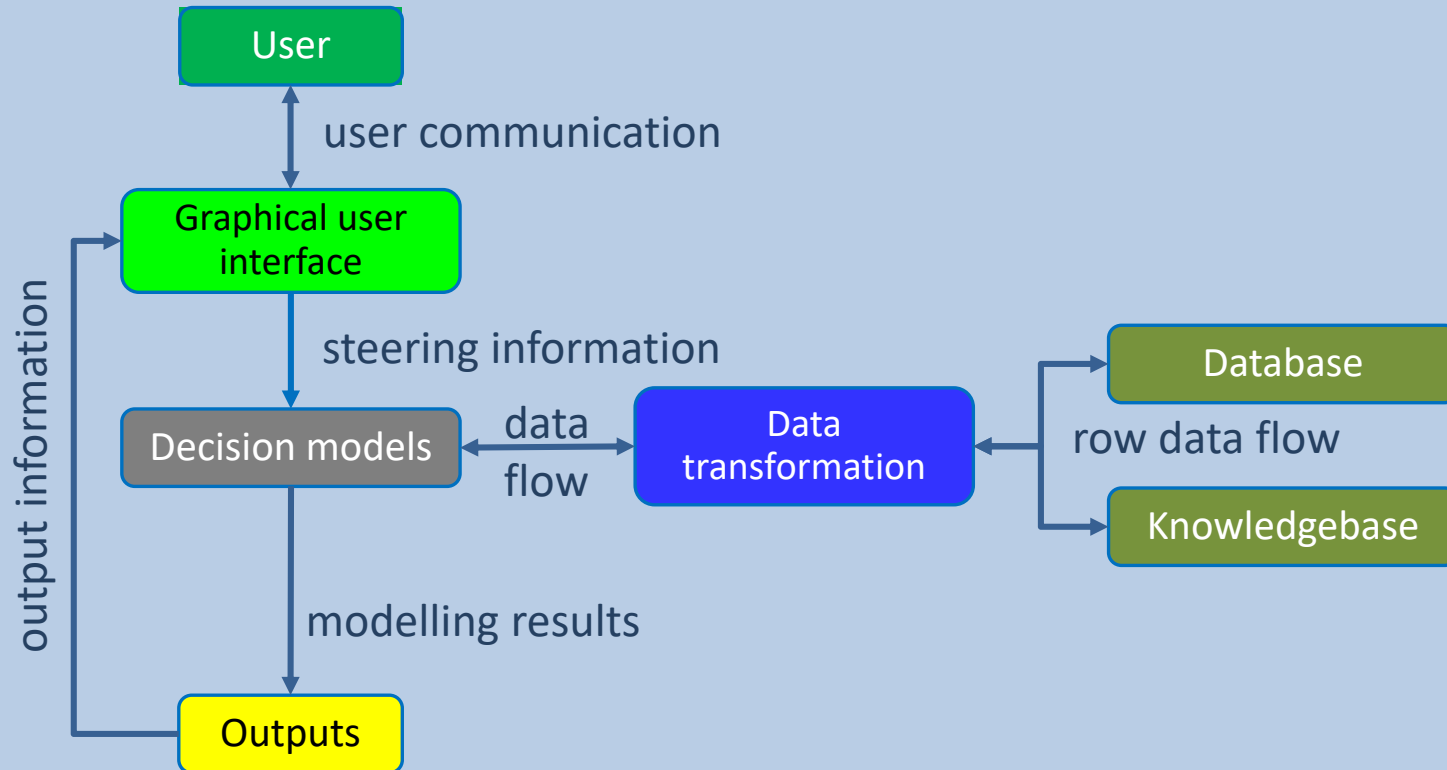


Average weights

Attribute	Local	Global	Loc.norm.	Glob.norm.
Primary Productivity				
Soil	19	19	22	22
Biological activity	26	5	31	7
pH	50	2	50	3
C/N ratio	20	1	20	1
SOM	30	1	30	2
Chemical	26	5	31	7
Macro Elements	33	2	43	3
P	57	1	57	2
K	26	0	26	1
Mg	17	0	17	1
Other Chemical Attributes	67	3	57	4
CEC	25	1	25	1
Salinity	75	2	75	3
Physical	47	9	37	8
Structure	50	4	50	4
Bulk Density	41	2	41	2
Rooting Depth	27	1	27	1
Clay content	32	1	32	1
Groundwater Table Depth	50	4	50	4



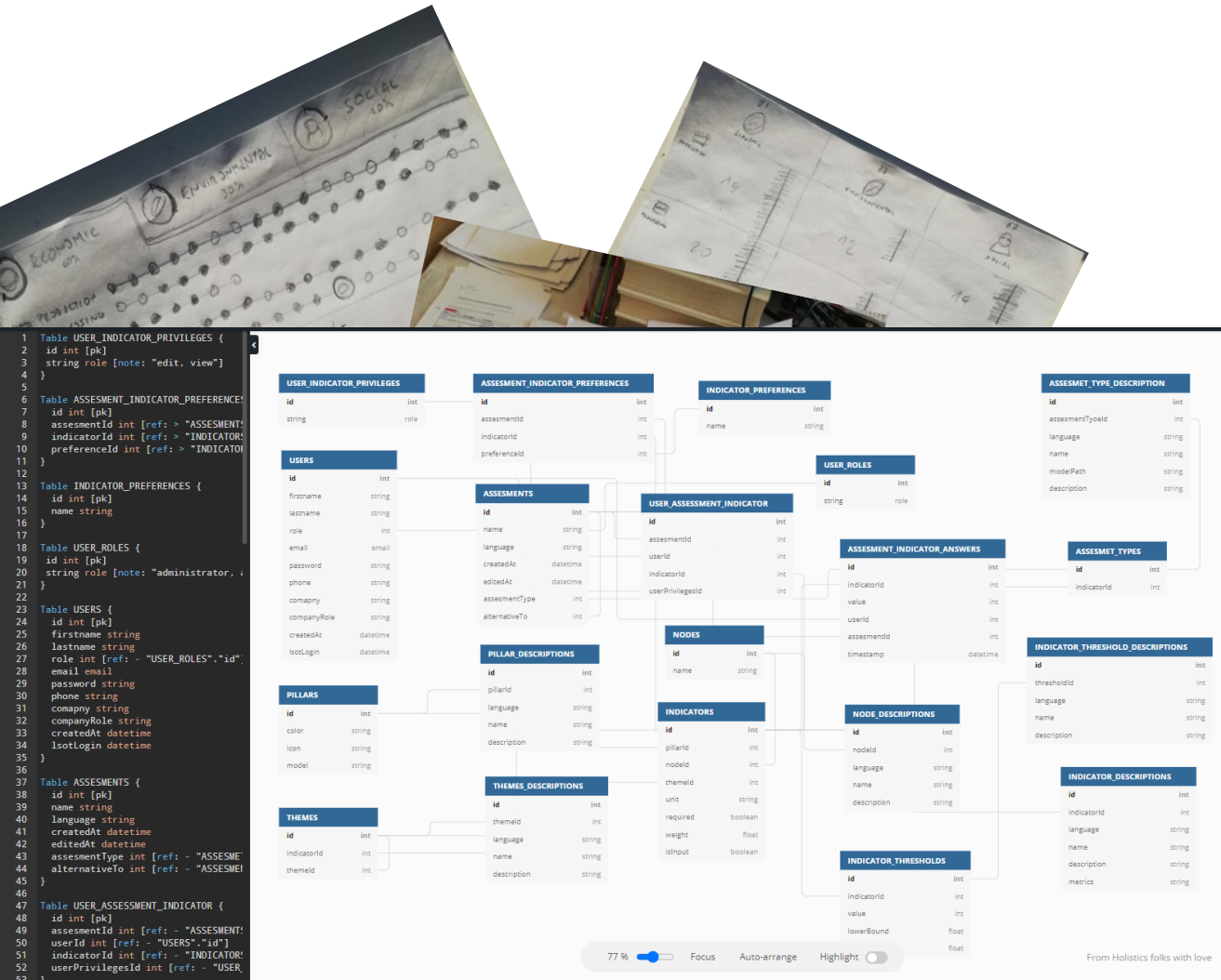
Linking modules into operational DSS



Linking modules into operational DSS

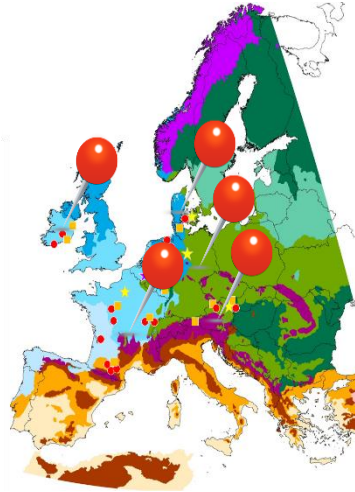
1. Contextual interviews
2. Analysis of available materials (factsheets)
3. Inventory of input parameters
4. Initial design of data input flow
5. Refinement
6. Initial design of output parameters and analysis tools
7. Refinement
8. Wrap-up in interactive mock-up
- 9. Validation of DSS**

Integration



- NodeJS server
- Express web framework
- PostgreSQL database
- Sequelize ORM
- Frontend: Angular

9. Validation of DSS



THE SOIL NAVIGATOR: A DECISION SUPPORT SYSTEM FOR THE ASSESSMENT AND MANAGEMENT OF SOIL FUNCTIONS

Marko Debeljak
Jožef Stefan Institute

Aneta Trajanov, Vladimir Kuzmanovski, Jaap Schröder, Taru Sandén,
Heide Spiegel, David P. Wall, Marijn Van de Broek, Michiel Rutgers,
Francesca Bampa, Rachel E. Creamer, Christian Bugge Henriksen

THE SOIL NAVIGATOR

Specific objective of the H2020 **LANDMARK** project

Decision support system that operates at the **field level**

Provides **advices** on the management of soils that optimise **5 soil functions**

Water
regulation &
purification

Carbon
sequestration

Biodiversity

Nutrient
cycling



Primary
production



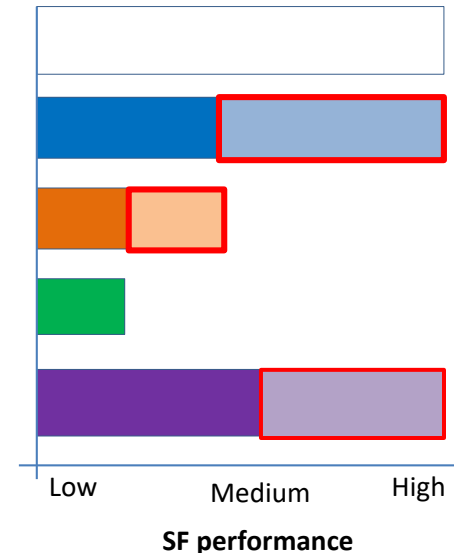
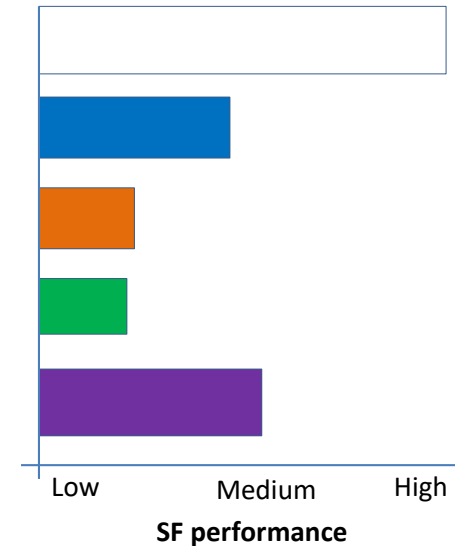
DECISION PROBLEM

Assessing the performance of the five soil functions

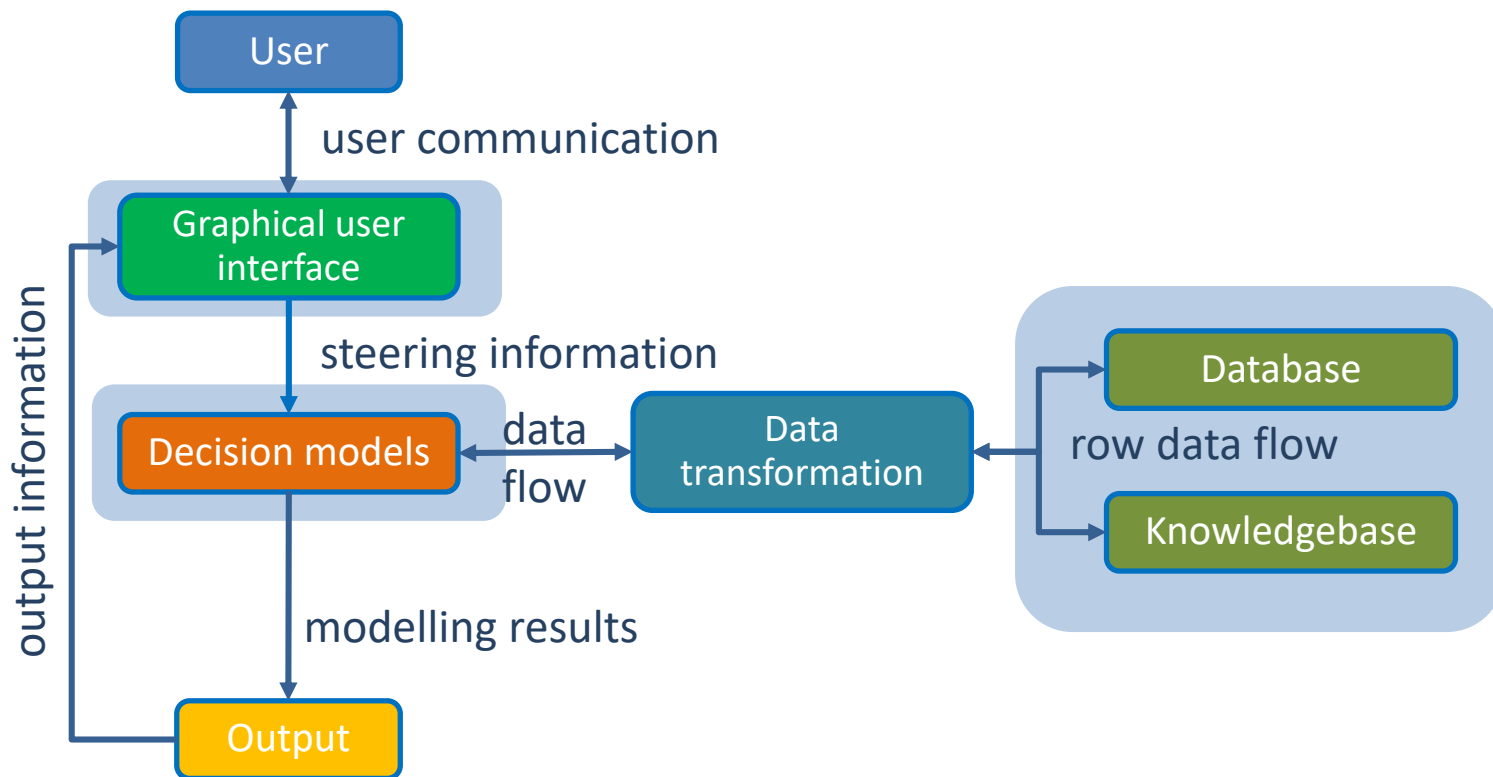
- specific management practices,
- environmental/climatic conditions
- soil characteristics

Choosing appropriate management practices that will improve the performance of the soil functions under:

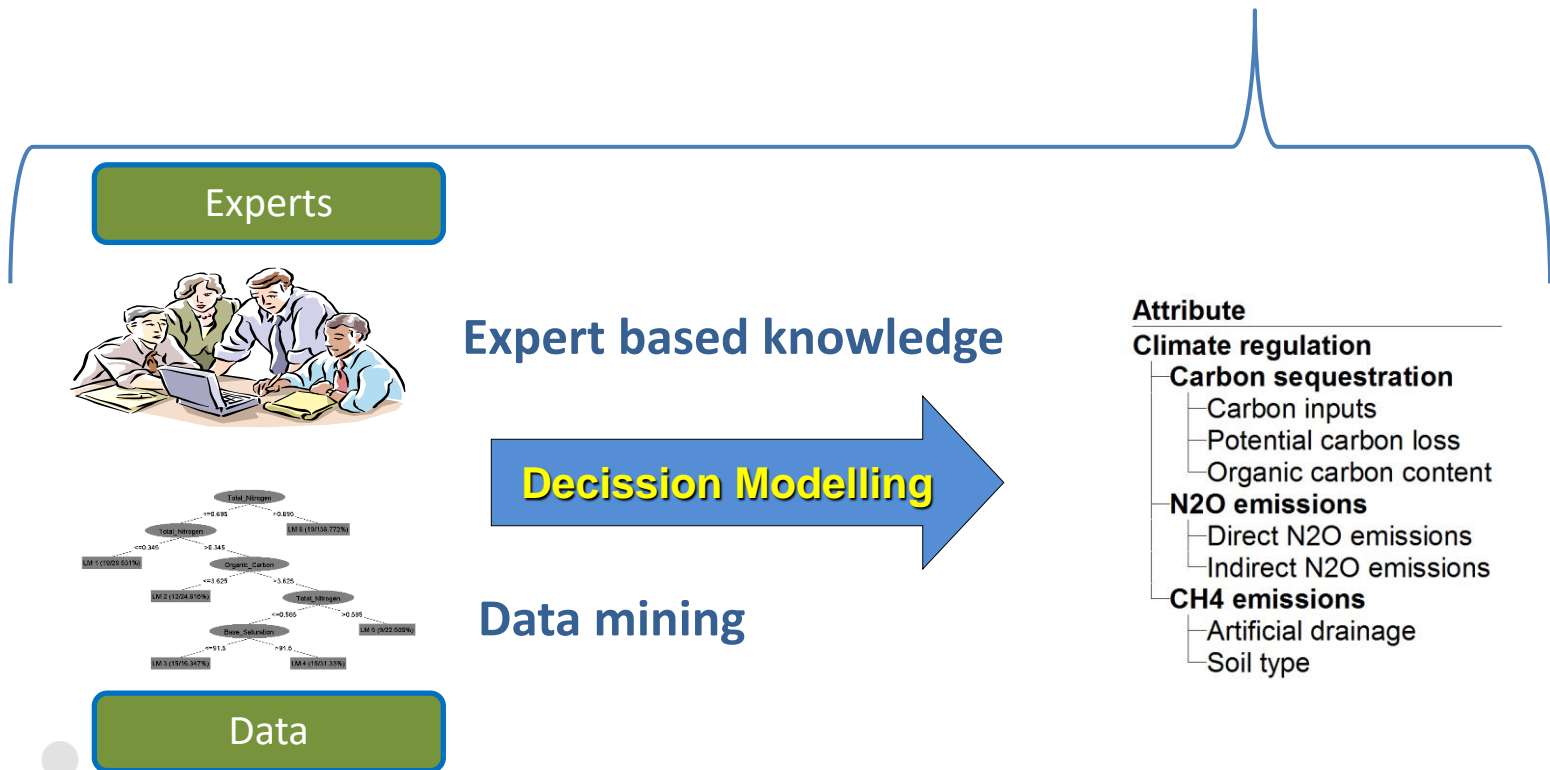
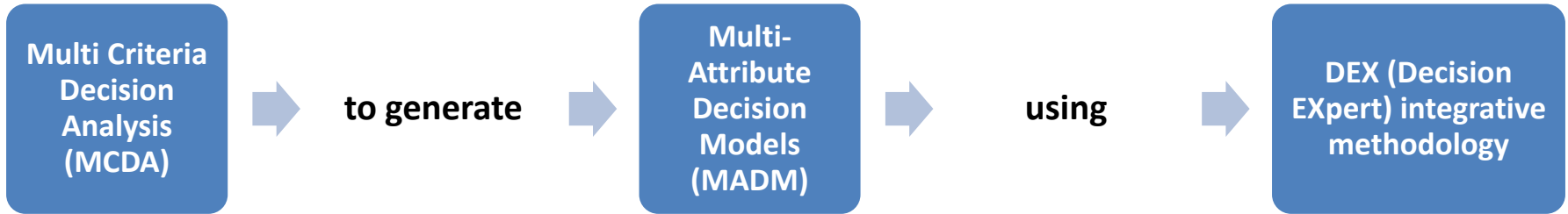
- climatic conditions
- soil characteristics
- management options

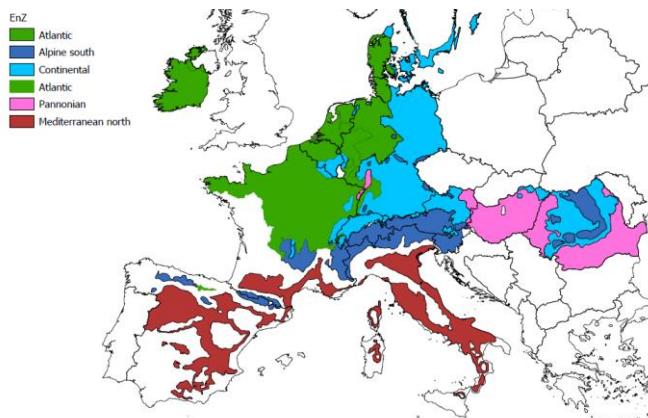


ARCHITECTURE OF THE SOIL NAVIGATOR DSS



DECISION MODELS





Average weights

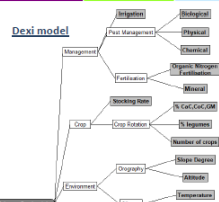
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DECISION MODELS

PRIMARY PRODUCTIVITY

The capacity of a soil to produce plant biomass for food, feed, fibre and fuel within natural or managed boundaries.



Key m

- Agric prim sust
- Abio
- Land imp
- prod
- In or

WATER REGULATION and PURIFICATION

Capacity of a soil to receive, store and conduct water, prevent droughts, flooding, erosion and toxic compounds.

DEXI model



Trade-offs:

- Water req conse
- Where ur
- the remu

CLIMATE REGULATION and CARBON SEQUESTRATION

Carbon sequestration is the capacity of a soil to store carbon in a stable form. Climate Regulation is the capacity of a soil to reduce the amount of GHG emissions from the soil.

HABITAT FOR BIODIVERSITY

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

LANDMARK www.landmark2020.eu email info.landmark@wur.nl

sequestration, and include trade-offs with N₂O and CH₄ which often dominate GHG emissions from arable soils enhancing climate change.

- Buggs Henriksen, C. et al. (2016). Key Indicators and Management Strategies for Assessing the Climate Regulation Potential of Agricultural Soils: A Review.
- Van de Broek et al. (submitted). Assessing the climate regulation potential of agricultural soils: A review.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101019719.

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Take-home messages

- Suggested management practices: Integrate legumes, permanent cover crops in arable farming; recycle organic matter by incorporating crop residues; limit the use of pesticides; longer cycles and include as many different crops; where possible, include biological attributes in soil monitoring programs; include in the landscape as many as possible and viable non-productive areas.

- Rutgers M. et al. (2018). Key Indicators and Management Strategies for Soil Biodiversity: A Review.
- Van Leeuwen J. et al. (submitted). Modelling of soil functions for assessing soil quality: Soil Biodiversity.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101019719.

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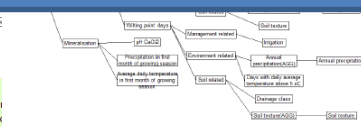


Table 1. Links (green = positive effect; red = negative effect; under = variable effect) between threats of soil quality (characteristics, management practices and soil functions) (P=primary productivity, W=water regulation, C=climate regulation, N=nutrient cycling, H=habitat provision).

Threats of soil functions	Management practices	Effects of practice on soil functions
Primary productivity	Plant management	PP
Water regulation	Soil structure	W
Climate regulation	Soil chemistry	C
Nutrient cycling	Soil biology	N
Habitat provision	Soil water	H

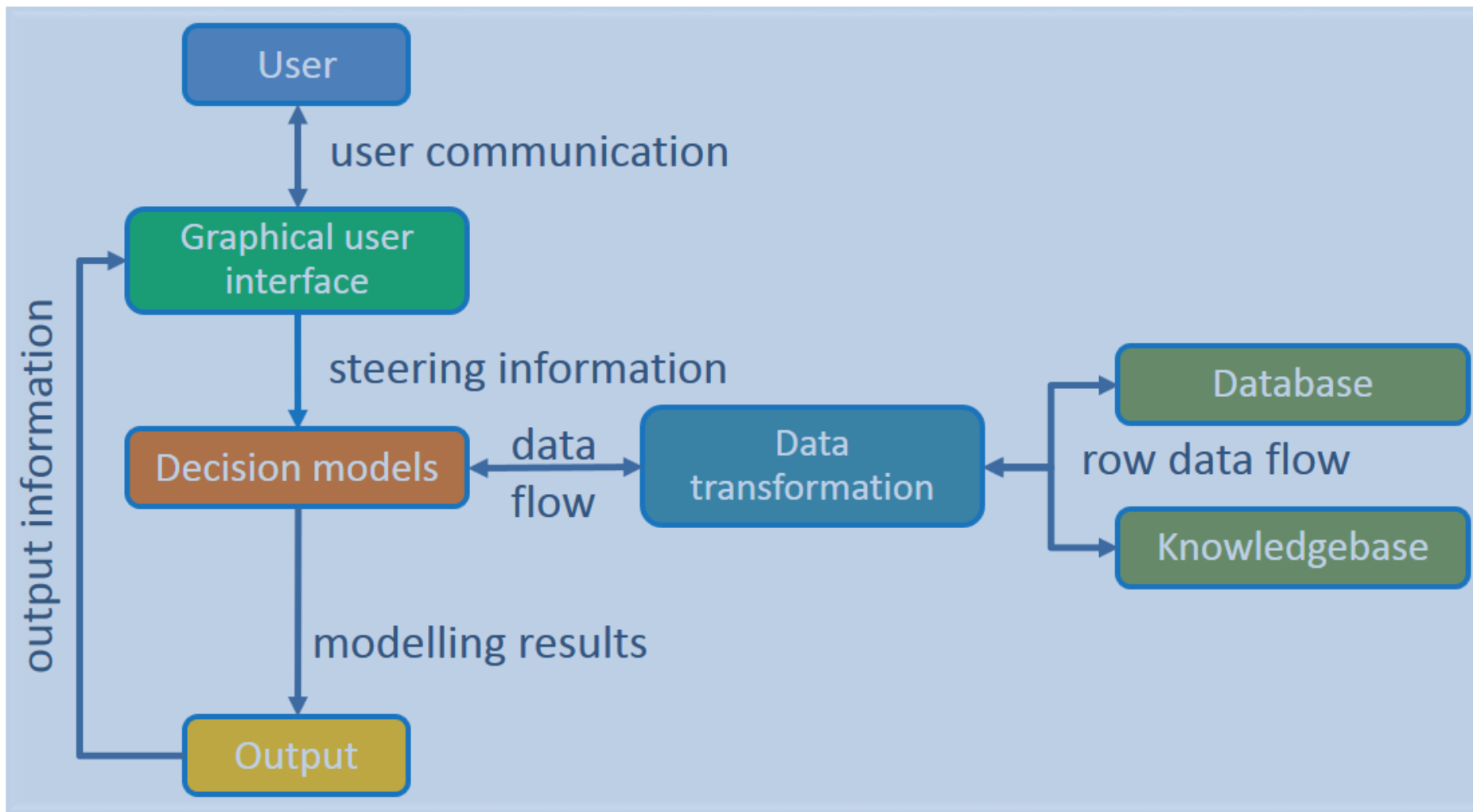
References:

- Schröder, J. J. et al. (2016). The elusive role of soil quality in nutrient cycling: a review. *Soil Use and Management* 32, 476-486. doi:10.1111/sum.12288
- Schröder, J. J. et al. (2018). Key indicators and management strategies for nutrient cycling. *LANDMARK Report 3.5*.
- Trajanov, A. et al. (2019). Assessing the nutrient cycling potential in agricultural soils using decision modelling. *Proceedings Conference on Operational Research*, September 2019, Bled, Slovenia (<http://sor19.fon.uni-mb.si/>) (in press).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101019719.

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TRANSFER TO COMPUTER



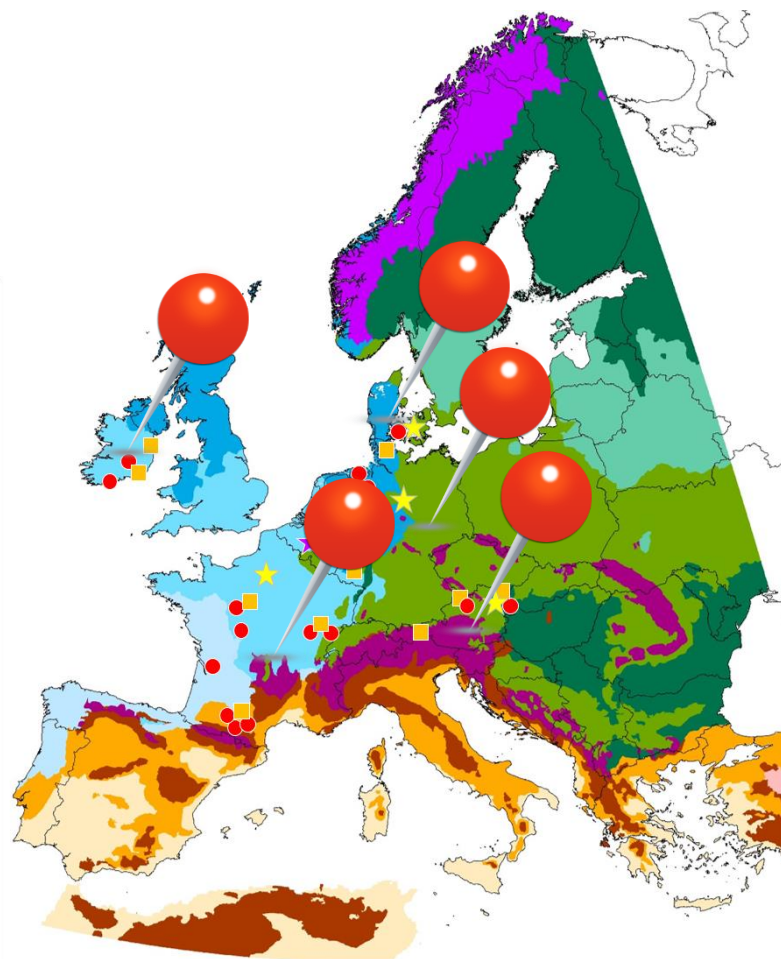
SOIL NAVIGATOR - VALIDATION

Farmers

Farm advisors

5 countries (A, D, DK, UK, IE, F)

> 90 sites across Europe



SOIL NAVIGATOR - GRAPHICAL USER INTERFACE

SOIL NAVIGATOR

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A Decision Support System for assessing and optimizing soil functions

The Soil Navigator decision support system (DSS) was developed in the Horizon 2020 project **LANDMARK**. It assesses the initial capacities of five soil functions within a field including primary productivity, nutrient cycling, water purification and regulation, carbon sequestration and climate regulation, as well as biodiversity and habitat provision. In addition, this evidence based DSS offers targeted solutions and management recommendations to improve the supply of several soil functions simultaneously and assisting farmers and farm advisors to make the right decisions for long term sustainability.

Watch video

Run Soil Navigator DSS



GRAPHICAL USER INTERFACE - DATA ENTRY

SOIL NAVIGATOR

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Navigator

Input

Optimization

Report

Archive

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Navigator

ScenarioGermany4bog (new)

INPUT DATA

PAGE 4 / 4

Unless otherwise specified, all input values are for the specific field and soil measurements are in the 0 to 25 cm soil layer

Soil physical properties

Soil type

☒ Organic☐ Mineral

Soil texture

☐ Clay☐ Loam☐ Sand

Clay content

- Select -

Soil crusting/capping

☐ Yes☒ No

Thickness of organic layer

☐ <10 cm☐ 10-20 cm☒ >20 cm

Potential rooting depth

☐ <50 cm☒ 50-100 cm☐ >100 cm

Groundwater table depth

☒ <0.4 m☐ 0.4-1.0 m☐ 1.0-2.0 m☐ >2.0 m

Soil organic carbon

☐ <1 %☐ 1-3 %☒ >3 %

Agroecosystem

Management

Environment

Soil

Assess soil functions

Save

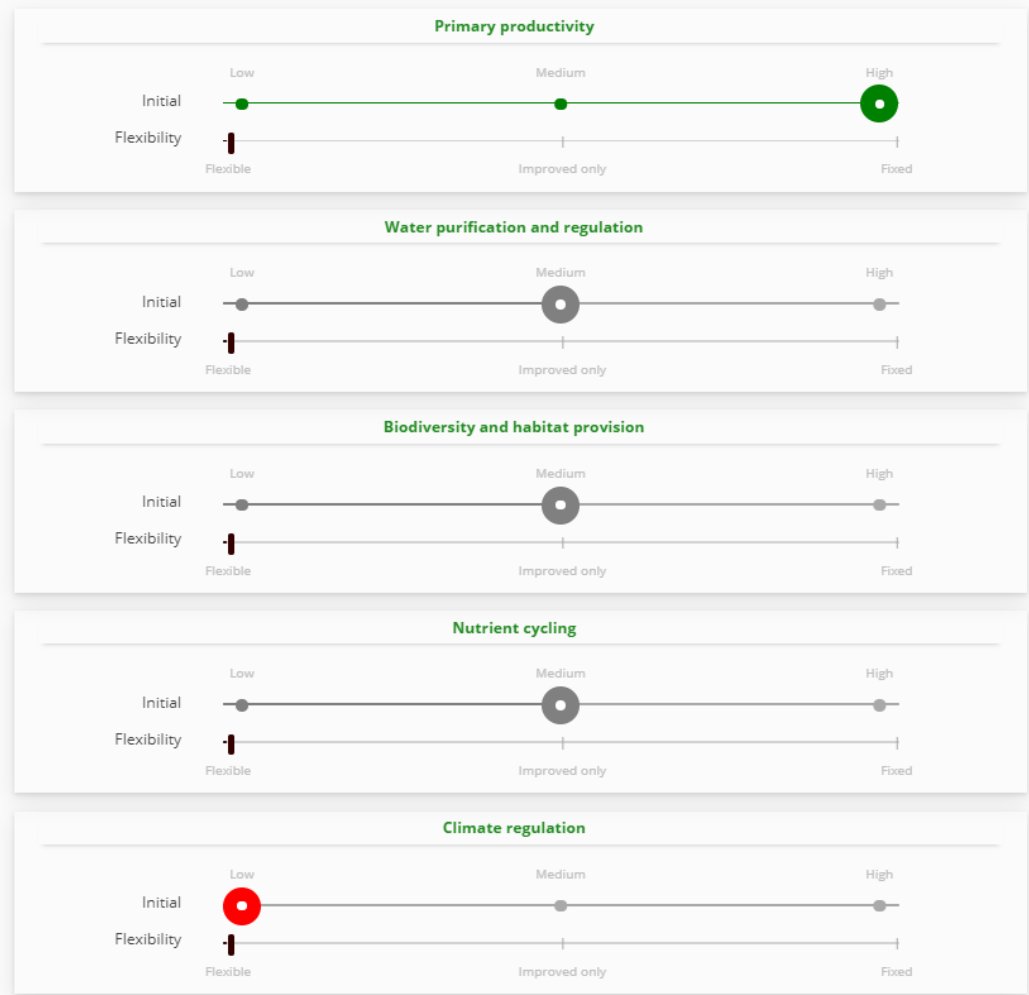
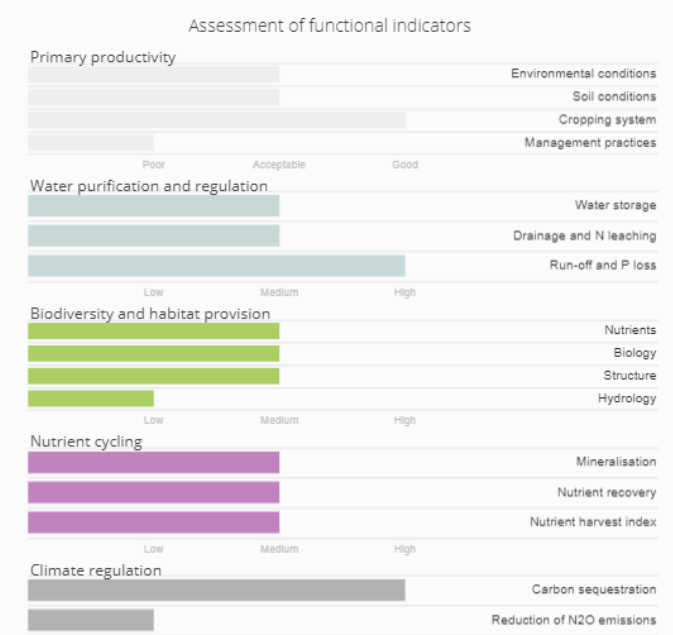
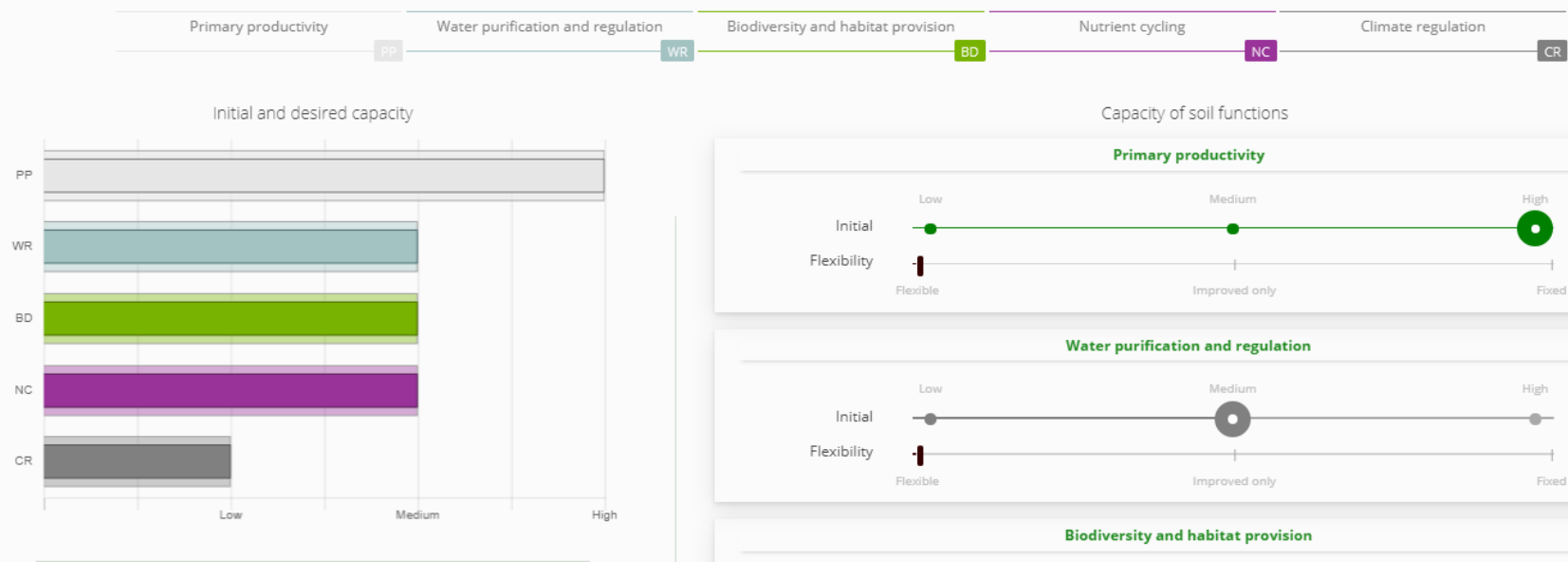
Save As New

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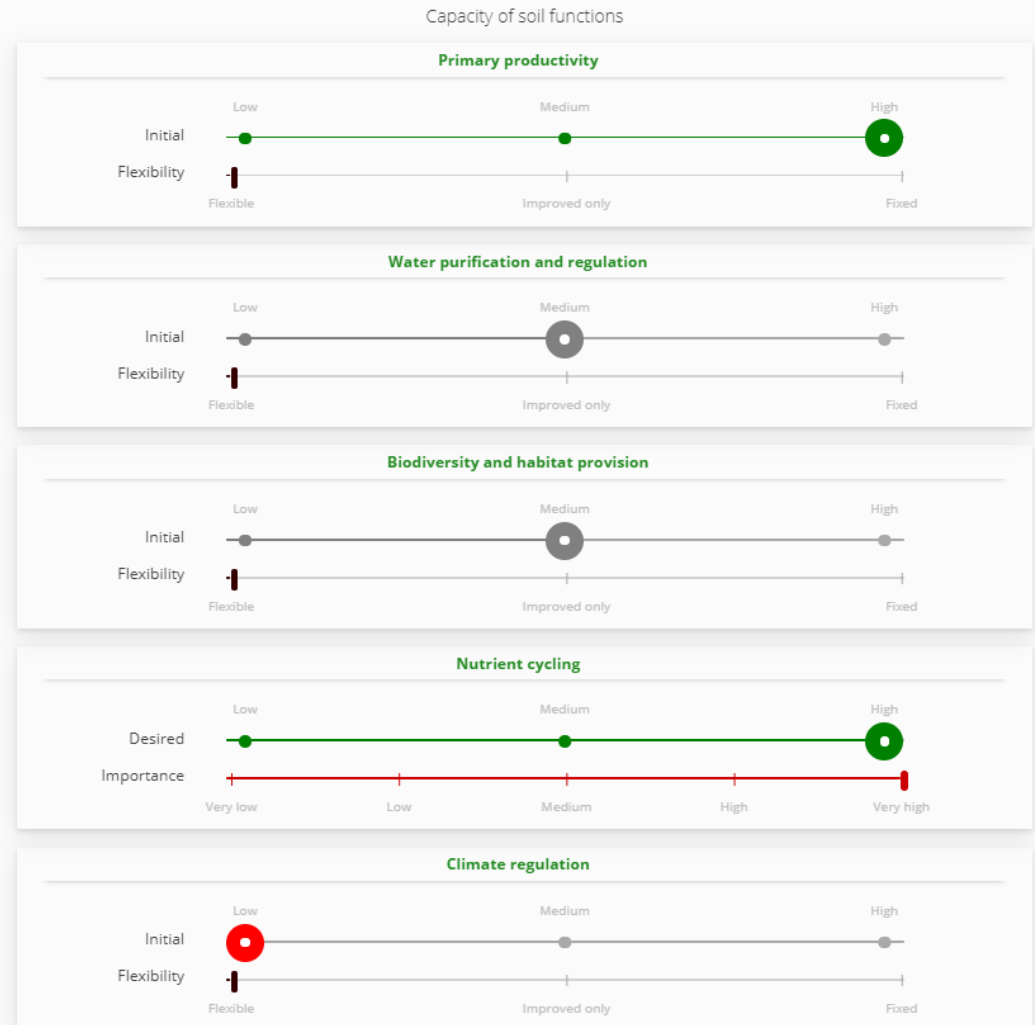
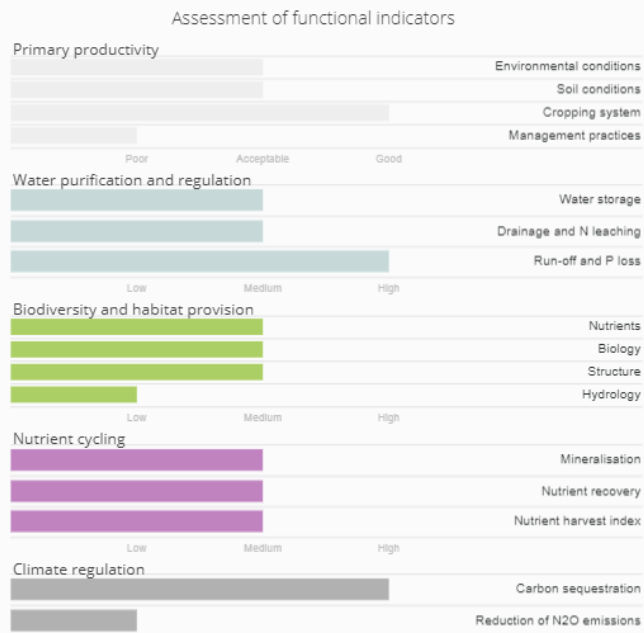
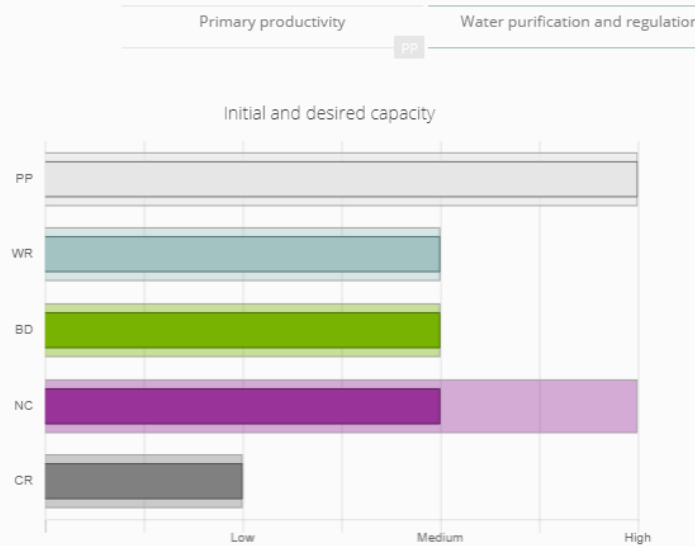
GUI- ASSESSMENT OF THE SOIL FUNCTIONS

INITIALLY ASSESSED AND DESIRED CAPACITY OF SOIL FUNCTIONS



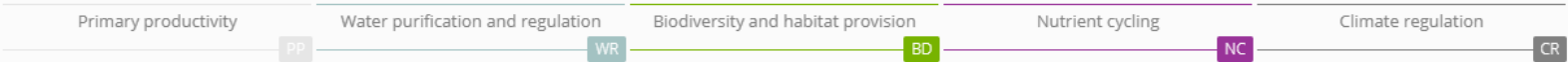
GUI- ASSESSMENT OF THE SOIL FUNCTIONS

INITIALLY ASSESSED AND DESIRED CAPACITY OF SOIL FUNCTIONS



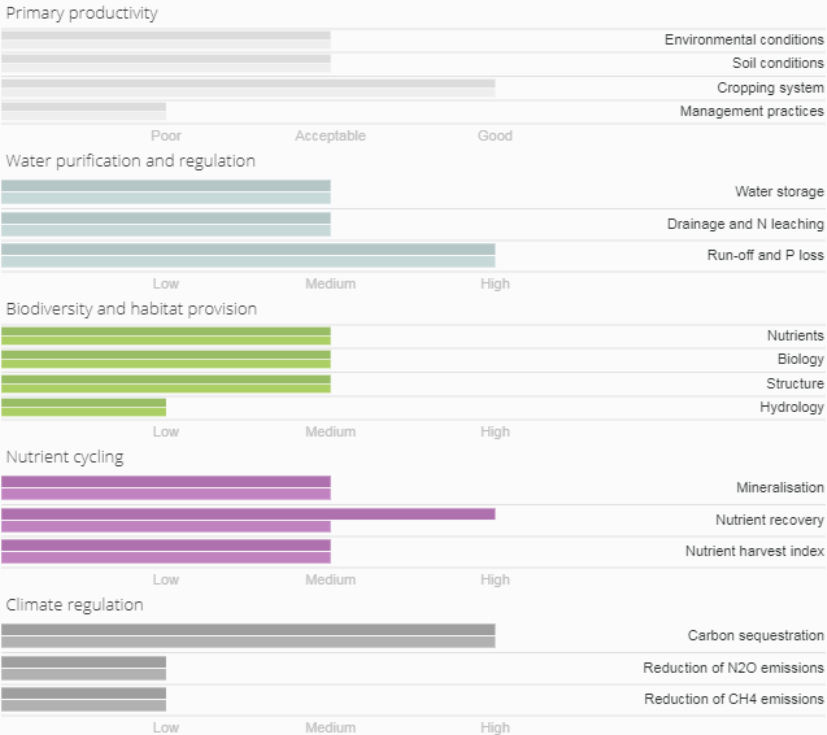
GUI- SUGGESTIONS FOR IMPROVEMENT OF SELECTED SF

EVALUATION REPORT ON OPTIMIZED CAPACITIES OF SOIL FUNCTIONS



Initial, desired and achieved capacities

Initial and optimized functional indicators



Management recommendations

☒ NITROGEN FERTILIZATION (MINERAL)

LOW | INCREASE

requires significant change (increase) by applying one of the following mitigation strategies:



Increase mineral N fertilization in compliance with national fertilizer regulations

Increase/apply balanced mineral N fertilization in compliance with national fertilizer regulations to meet crop N demand, increase biomass production and sequester carbon in the soil

Requirements for compliance with national law and cross-compliance with GAEC and SMR

Please note that in order to comply with German law and obtain the GAEC and SMR cross-compliance required for obtaining payments via the Single Payment Scheme the application of fertilizer must follow the national guidelines for fertilizer application ([this link](#)) and the national cross-compliance guidelines ([this link](#)) / Lower Saxony: [this link](#) -> GAEC 6

SOIL NAVIGATOR

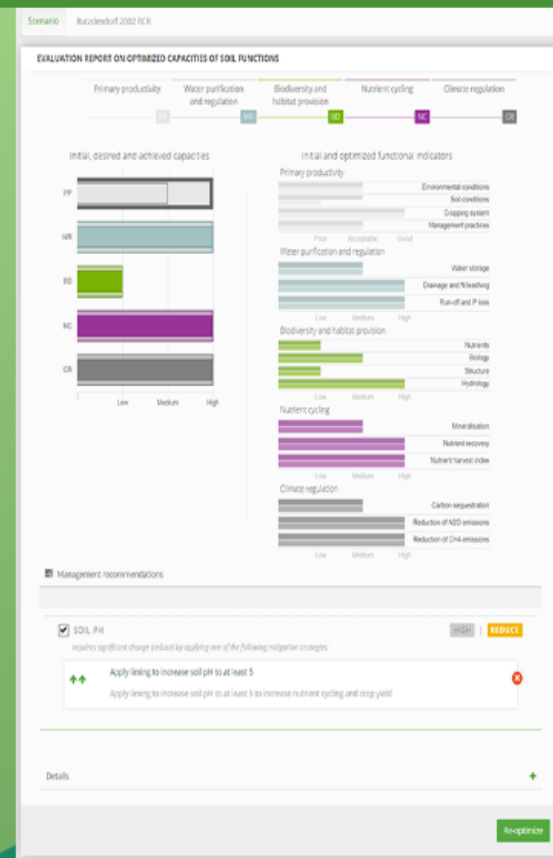
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SOIL NAVIGATOR

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A Decision Support System for assessing and optimizing soil functions

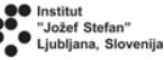




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[Watch video](#)[Run Soil Navigator DSS](#)

SUPPLEMENTING MATERIALS

Video tutorials (English, French, German, Danish):

http://videlectures.net/soil_english_tutorial/



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A Decision Support System for assessing and optimizing soil functions

Soil Navigator

One of the 3 main pillars of the Landmark project was the development of a Decision Support Tool (DSS) for farmers and farm advisors, which we call the **Soil Navigator DSS** (Debeljak et al., 2019). The Soil Navigator is an agricultural decision support system (DSS) for assessing and optimizing soil functions. Most agricultural DSS are focused on short-term goals for the next growing season, such as increasing plant available nutrients or optimizing crop yield, whereas other important soil functions such as water purification and regulation, carbon sequestration and biodiversity provision are neglected. Making the right management decisions for long-term sustainability is therefore challenging, and farmers and farm advisors would greatly benefit from an evidence-based DSS targeted for assessing and improving the supply of several soil functions simultaneously. The Soil Navigator DSS provides a menu of user-friendly soil management strategies to manage the soil functions on individual fields on the farm (local scale). The menu is stratified by pedo-climatic zones, land uses (cropland and grassland) and farming systems.


Categories


Top » Earth Sciences


Top » Life Sciences


Top » Computer Science


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 This page - Soil Navigator - 1


 Soil Navigator, introduction 1

 Search VideoLectures for time series - 1

 Google Vizio: A Service for BlackBox 1


 Category: Machine Learning - 1

SHOW CHAT




1 view, 09:57

Soil Navigator, English tutorial




1 view, 10:47

Soil Navigator, French tutorial



10:09

Soil Navigator, German tutorial



1 view, 00:45

Soil Navigator, introduction

SUPPLEMENTING MATERIALS

Methodological paper



in Environmental Science

Soil Processes

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Assessment and Modeling of Soil Functions or Soil-Based Ecosystem Services
Problems [View all 8 Articles >](#)

ORIGINAL RESEARCH ARTICLE

Front. Environ. Sci., 05 August 2019 | <https://doi.org/10.3389/fenvs.2019.00115>



A Field-Scale Decision Support System for Assessment and Management of Soil Functions

Marko Debeljak^{1*}, Aneta Trajanov¹, Vladimir Kuzmanovski¹, Jaap Schröder², Taru Sandén³, Heide Spiegel³,
 David P. Wall⁴, Marijn Van de Broek⁵, Michiel Rutgers⁶, Francesca Bampa⁷, Rachel E. Creamer⁷ and Christian B. Henriksen⁸



SUPPLEMENTING MATERIALS

Soil functions research papers

ORIGINAL RESEARCH ARTICLE

Front. Environ. Sci., 17 May 2019 | <https://doi.org/10.3389/fenvs.2019.00058>



Development of an Agricultural Primary Productivity Decision Support Model: A Case Study in France

Taru Sandén^{1*}, Aneta Trajanov^{2,3}, Heide Spiegel¹, Vladimir Kuzmanovski², Nicolas P. A. Saby⁴, Calypso Picaud⁵, Christian Bugge Henriksen⁶ and Marko Debeljak^{2,3}



SPECIAL ISSUE PAPER | Open Access |

Harvesting European knowledge on soil functions and land management using multi-criteria decision analysis

Francesca Bampa , Lillian O'Sullivan, Kirsten Madena, Taru Sandén, Heide Spiegel, Christian Bugge Henriksen, Bhim Bahadur Ghaley, Arwyn Jones, Jan Staes, Sylvain Sturel ... [See all authors](#)

First published: 25 February 2019 | <https://doi.org/10.1111/sum.12506> | Cited by: 4



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The elusive role of soil quality in nutrient cycling: a review

J. J. Schröder , R. P. O. Schulte, R. E. Creamer, A. Delgado, J. van Leeuwen, T. Lehtinen, M. Rutgers, H. Spiegel, J. Staes, G. Tóth, D. P. Wall

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Modeling of Soil Functions for Assessing Soil Quality: Soil Biodiversity and Habitat Provisioning

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Using data mining techniques to model primary productivity from international long-term ecological research (ILTER) agricultural experiments in Austria

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Assessing the climate regulation potential of agricultural soils using a decision support tool adapted to stakeholders' needs and possibilities

Marijn Van De Broek^{*}, Christian Bugge Henriksen, Ghaley Bahadur Bhim, Emanuele Lugato, Vladimir Kuzmanovski, Aneta Trajanov, Marko Debeljak, Taru Sandén, Adelheid Spiegel, Charlotte Lore Marie Decock, Rachel Creamer and Johan Six

Original Research, Front. Environ. Sci. - Soil Processes

Submitted on: 01 Feb 2019, Edited by: Hans-Joerg Vogel

Farming systems targeted to water regulation and purification in agricultural soils

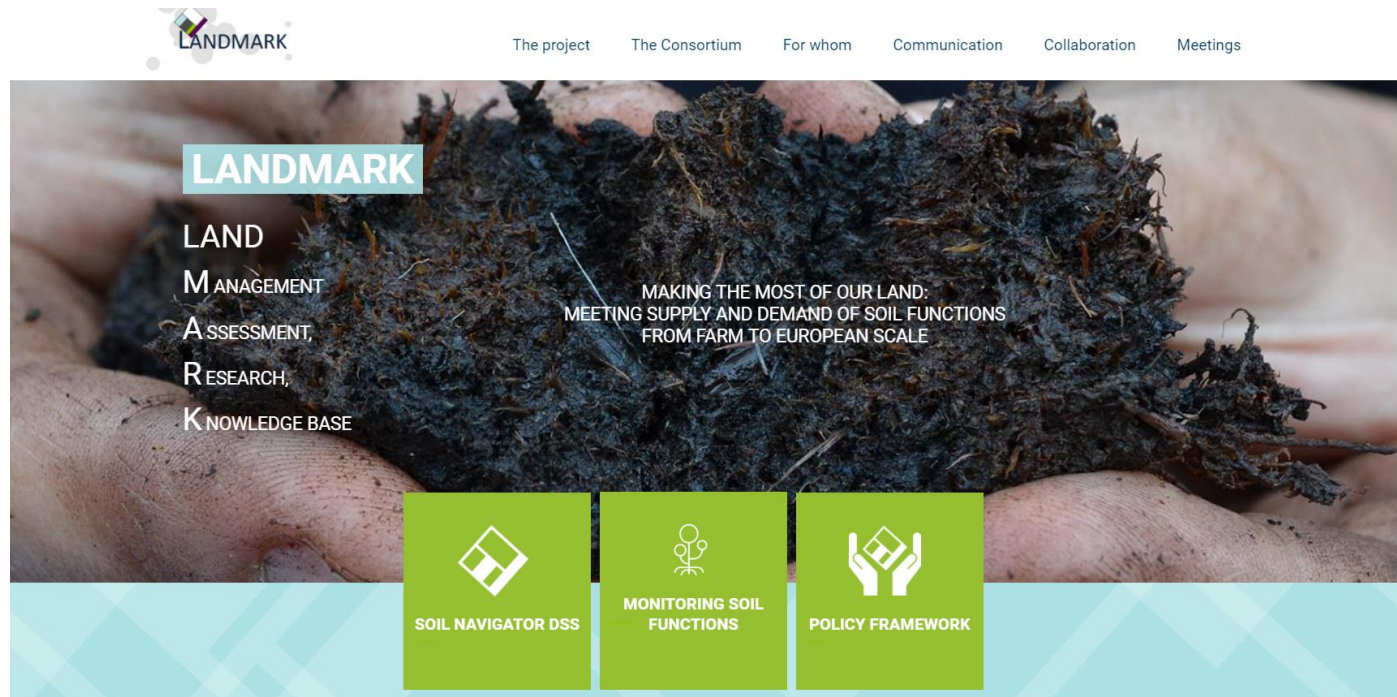
David P. Wall^{*}, Antonio Delgado, Lillian M. O'Sullivan, Marko Debeljak, Rachel Creamer and Christain Bugge Henriksen

Review, Front. Sustain. Food Syst. - Agroecology and Ecosystem Services

Submitted on: 01 Mar 2019, Edited by: Philippe C. Baveye



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Final remarks

- Methodology for development DSS in agriculture is confirmed.
- Following modelling procedure is required.
- Large synergistic effects between data driven and knowledge driven modelling.
- Advanced information technology is needed for integration of modules into DSS.
- Knowledge of UI-UX design of interface is crucial.
- Digitalization and application of artificial intelligence stimulate fast development of DSS in agronomy.
- Development of DSS in agronomy is transdisciplinary task.

Thank you!