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

1. Assessing the **problem**
2. Collecting and verifying **information**
3. Identifying **alternatives**
4. **Making** the **choice**
5. Evaluating **decisions**

Making complex decisions

Complex task

Improvements of the **effectiveness** of decisions

Assistance of decision maker

Interactive computer tools

DECISION SUPPORT SYSTEMS

Prelude

Introduction

Outline

Modelling methodology

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

Implementation

- EVADIFF
- Soil Navigator
- Path Finder

Final remarks

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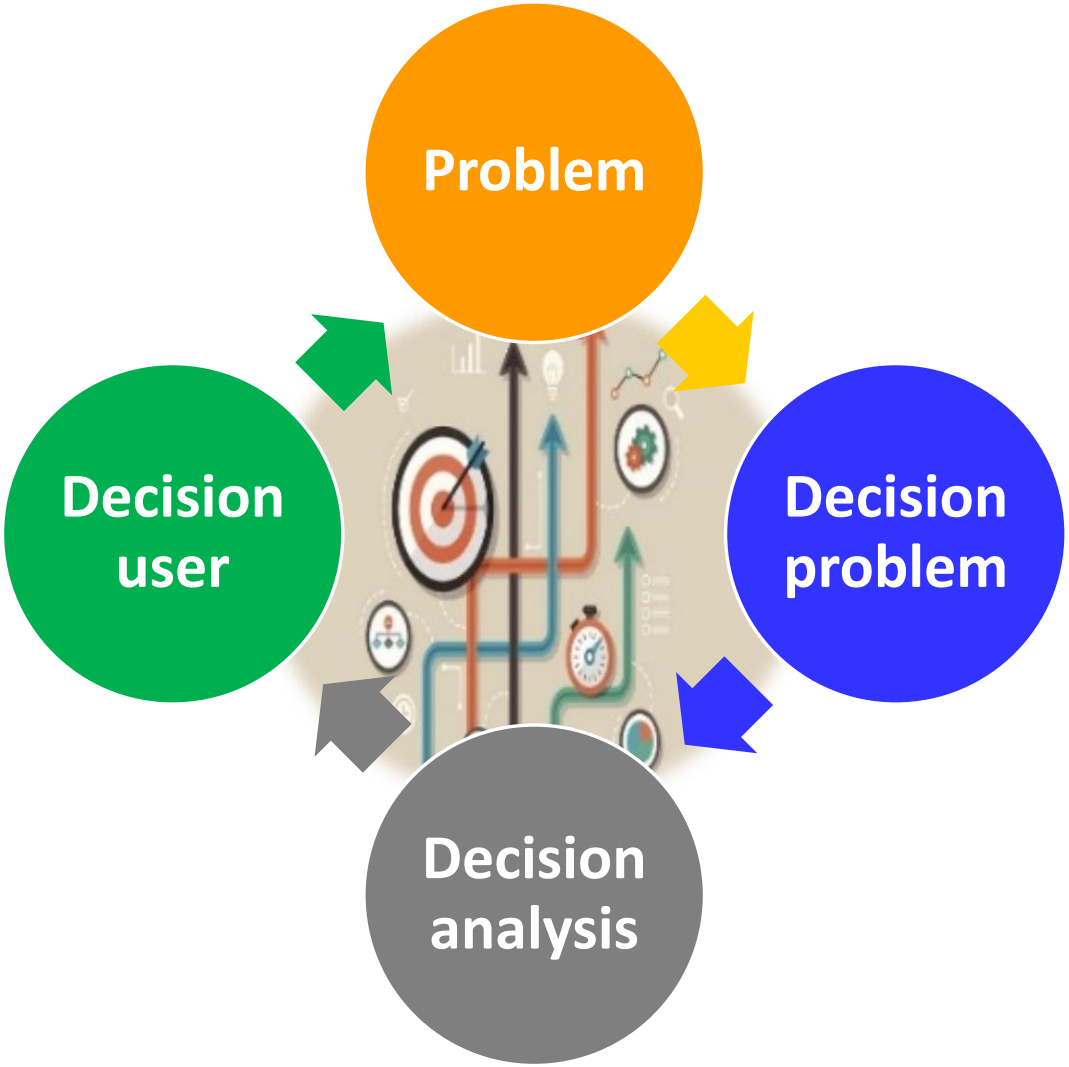
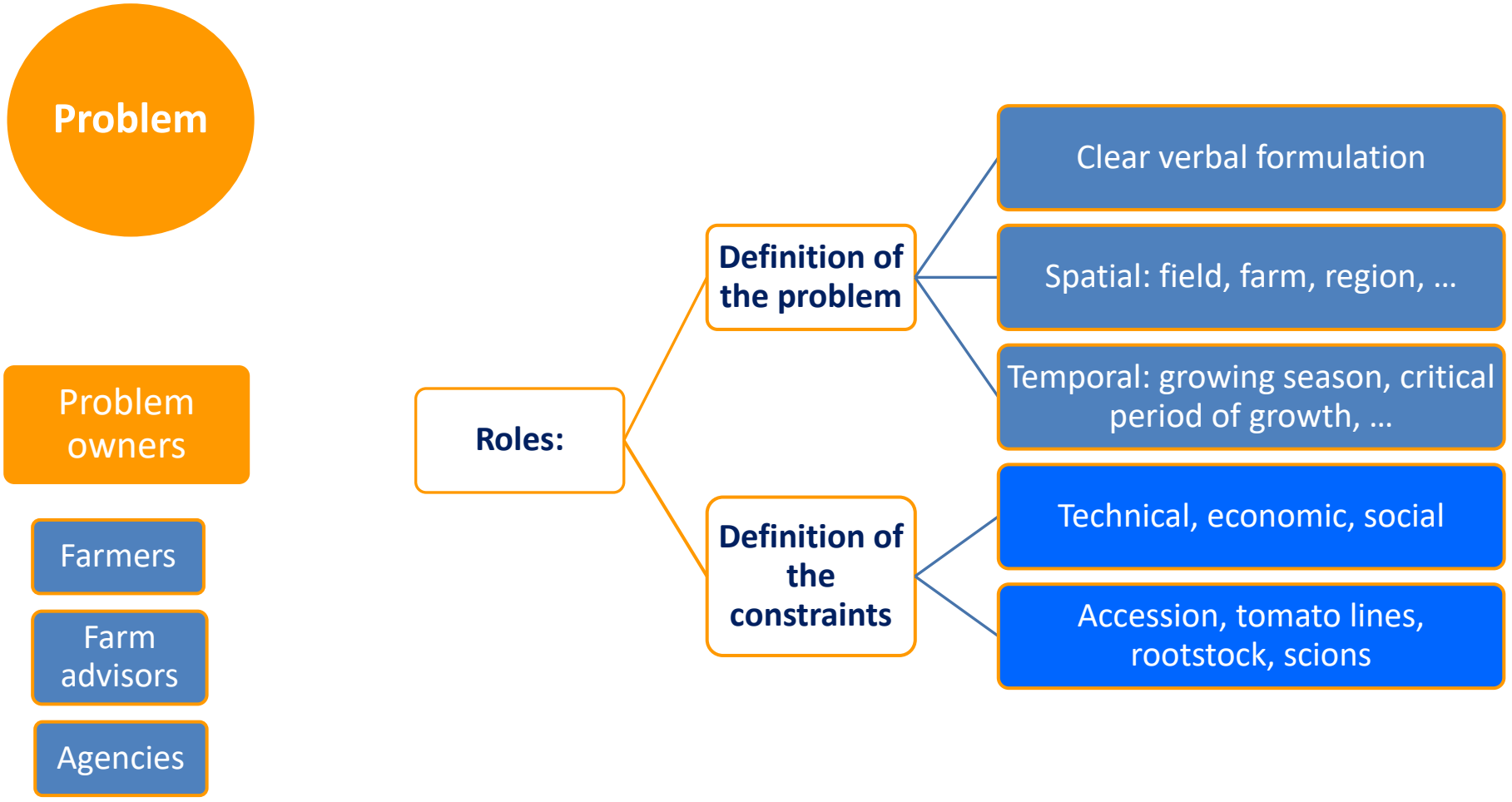
Conceptual framework

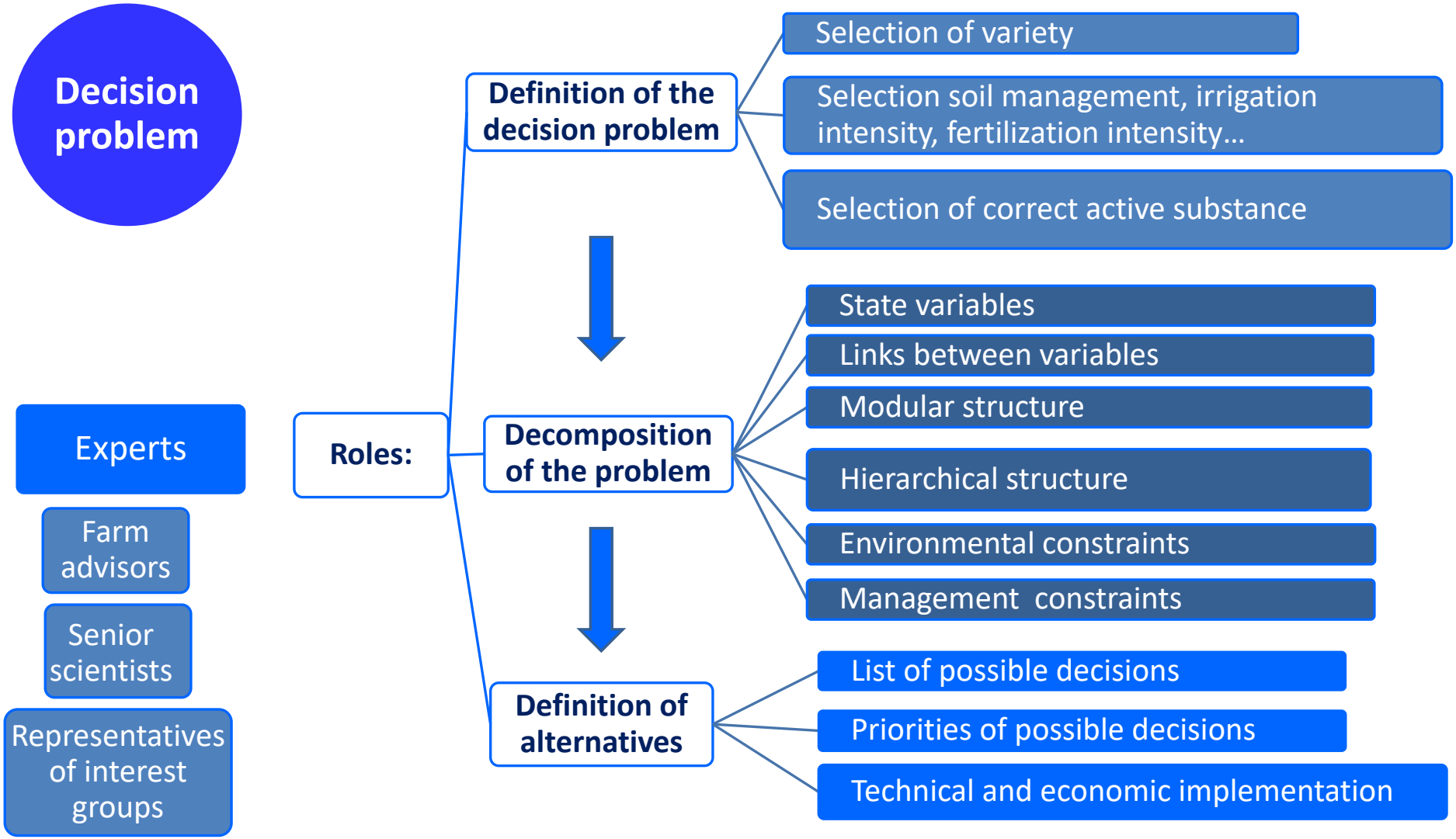


Conceptual framework



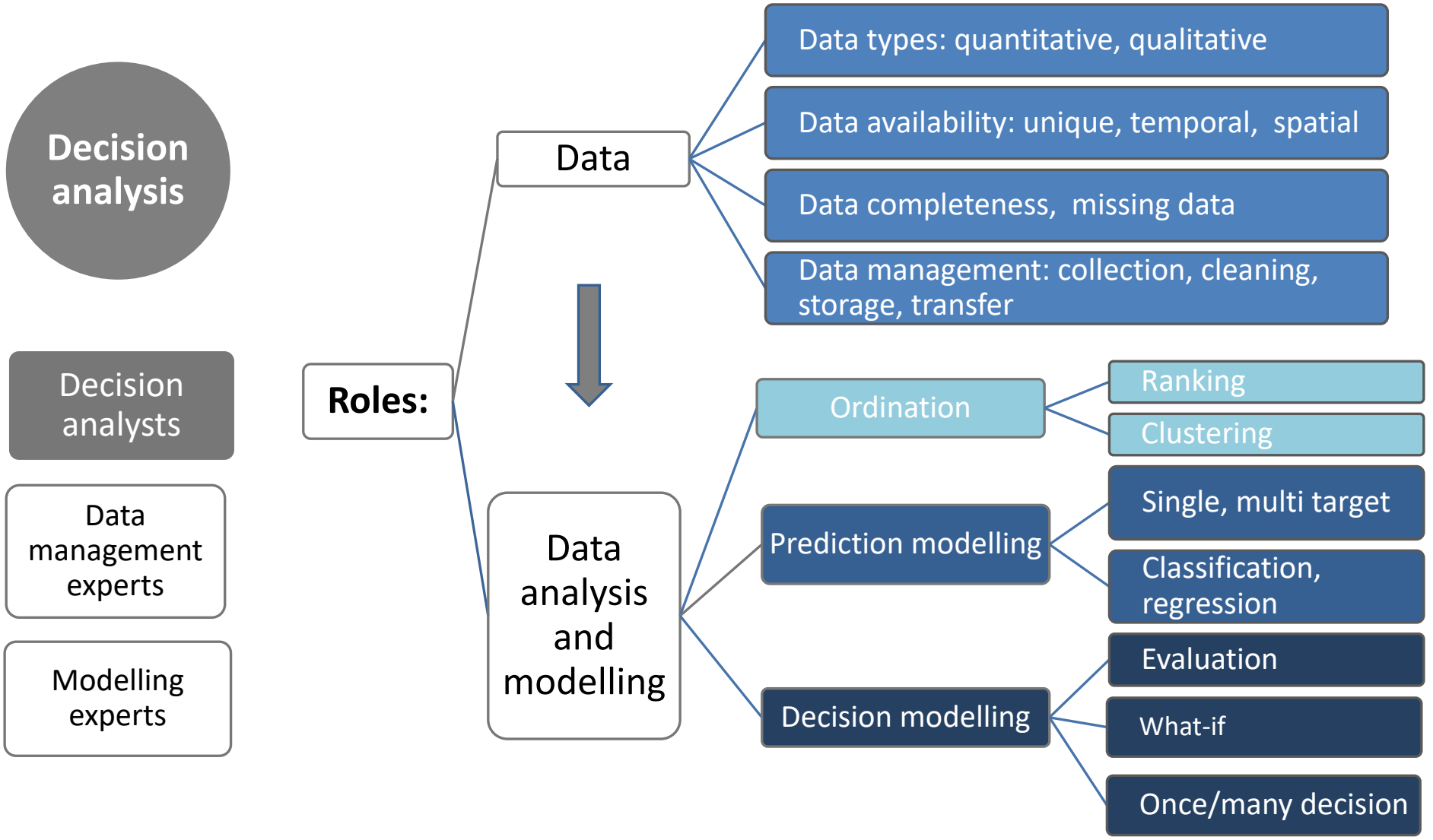
Example: Water pollution with pesticides.

Conceptual framework



Example: Active substance, concentration, time of application.

Conceptual framework



Example: Data mining and qualitative decision modeling

Conceptual framework

Decision user

Users

- Farmers
- Farm advisors
- Students

Roles:

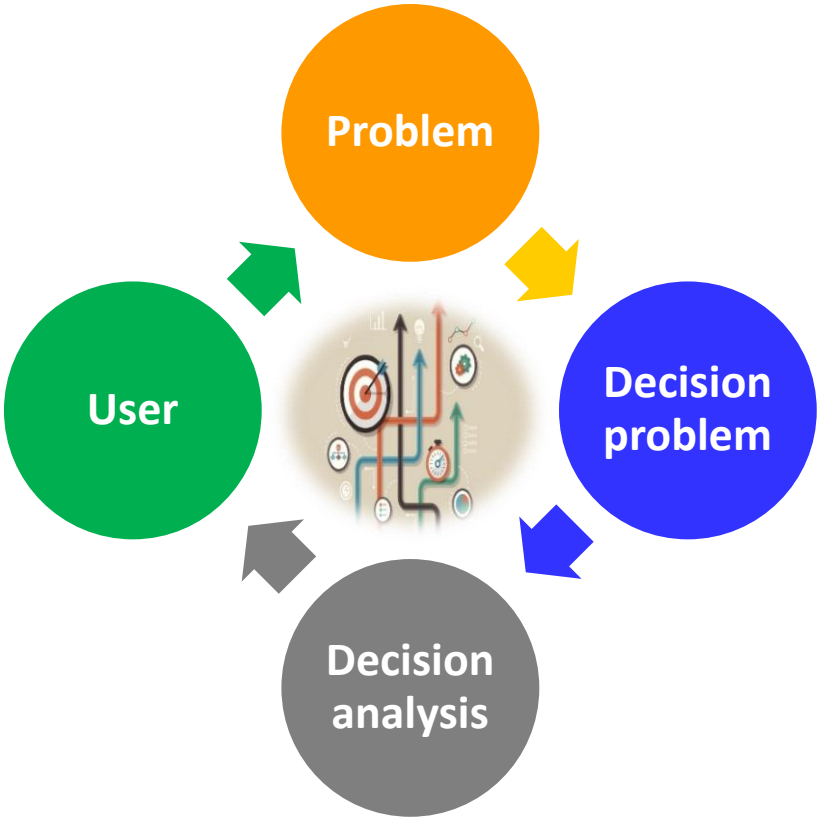
Type of implementation of proposed solutions

- User
  - Single
  - Many
- Usage
  - One-time use
  - Frequent use
- Tool
  - Paper decision map
  - Computer tool
- History
  - Storage
  - Sharing with other users

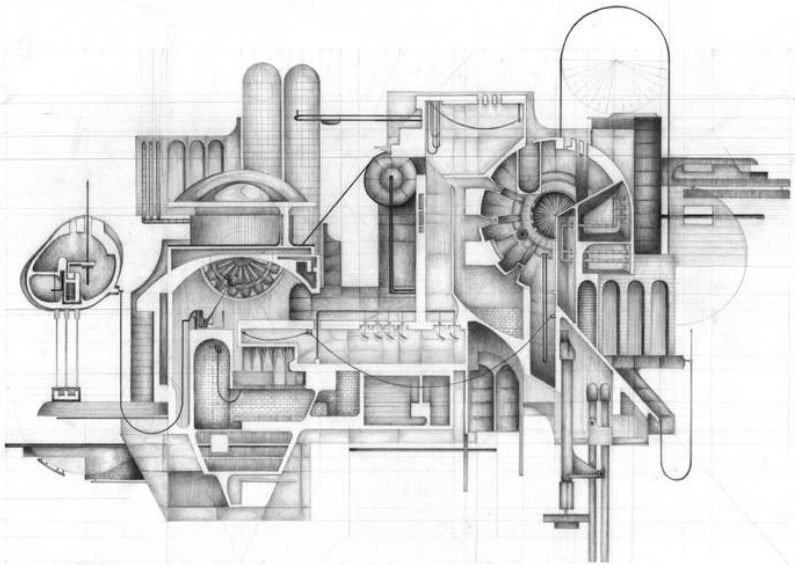
Example: Phone App, personalized support: Isoproturon before drainage period with 50% reduced concentration

Modeling methodology

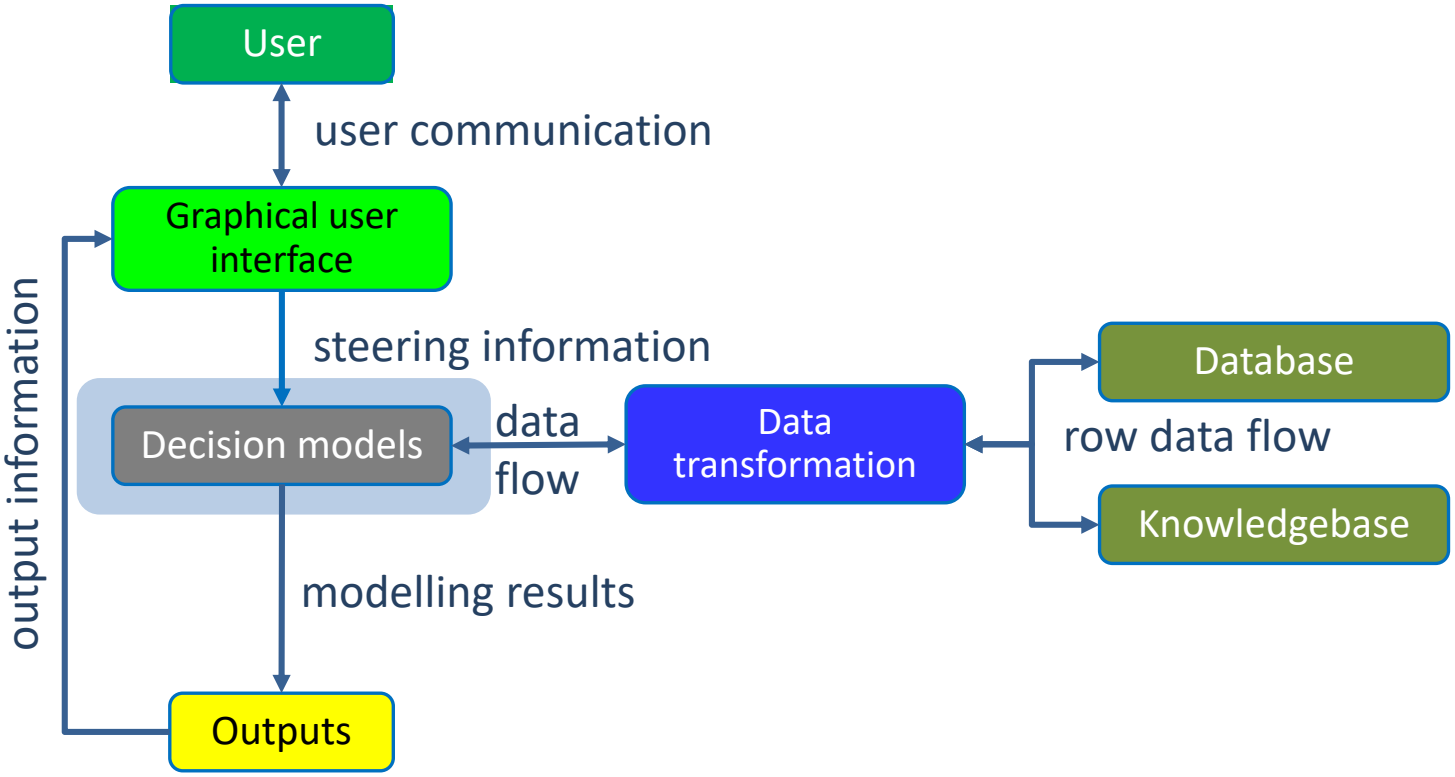
Conceptual framework of DSS



Architecture of DSS



Architecture of DSS



Modeling procedure

Decision models

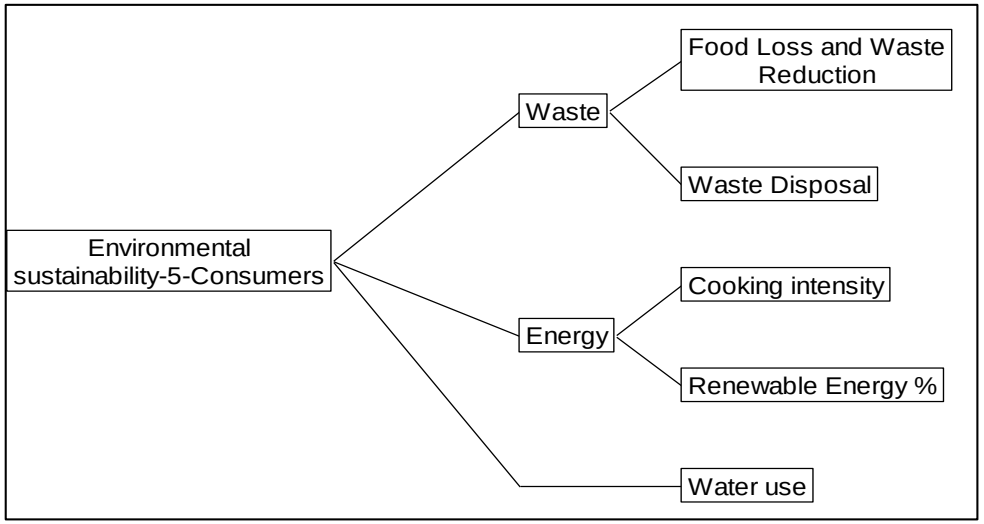
Multiobjective decision model:

- 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

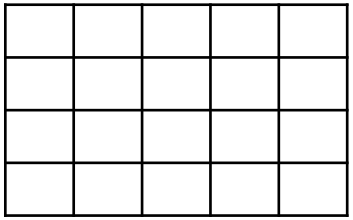


Golden roles of ecological modelling

Decision problem → Conceptual model → Decision model → Verification → Sensitivity analysis → Calibration → Validation → Final decision model

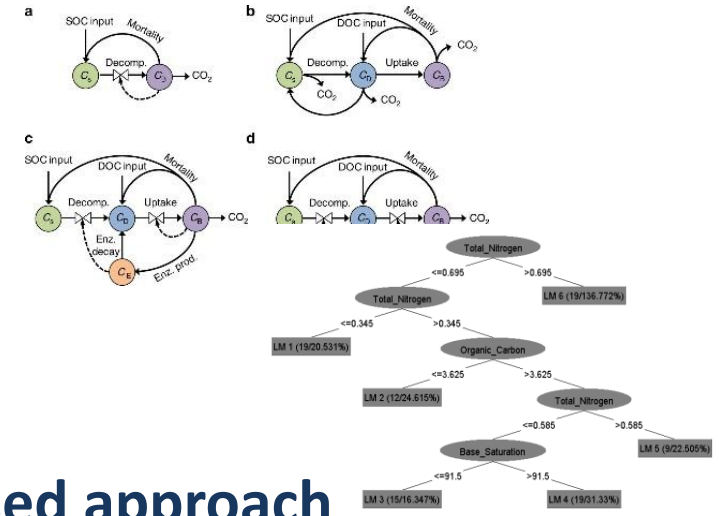
Modeling procedure

Decision problem → **Conceptual model**



Data

Mechanistic modelling
Data Mining



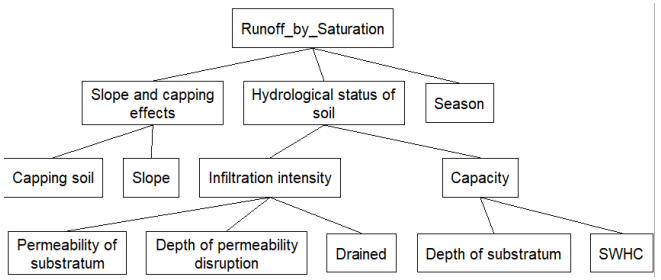
Knowledge discovery from data

Problem driven and knowledge based approach

Domain experts

Expert based Knowledge

Knowledge Modelling



Modeling procedure

Decision models

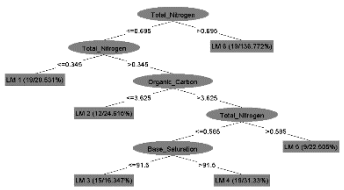
Decision model

Multi Criteria Decision Analysis (MCDA) → to generate → Multi-Attribute Decision Models (MADM) → using → DEX (Decision EXpert) integrative methodology

Experts

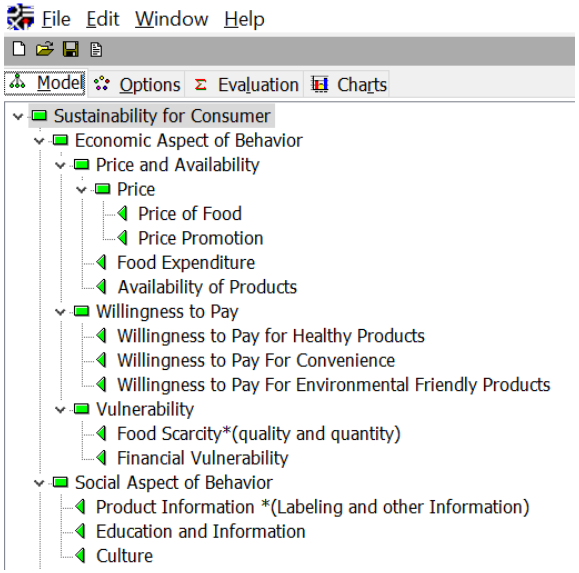
Expert based knowledge

Decision Modelling



Data mining

Data



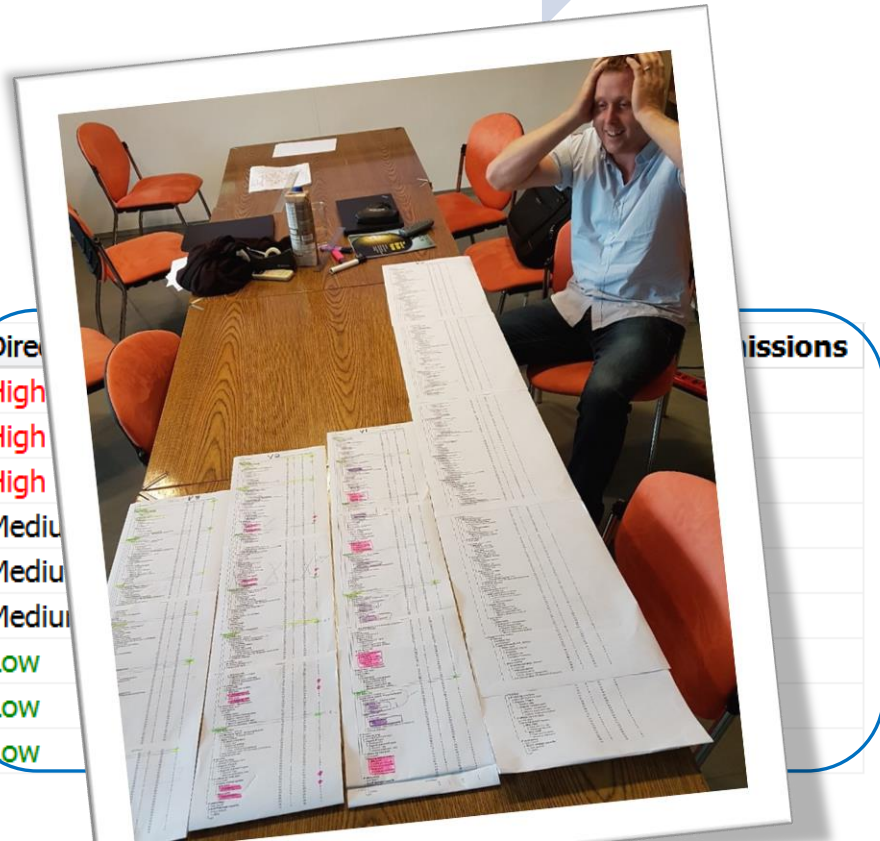
Modeling procedure

Decision model

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***



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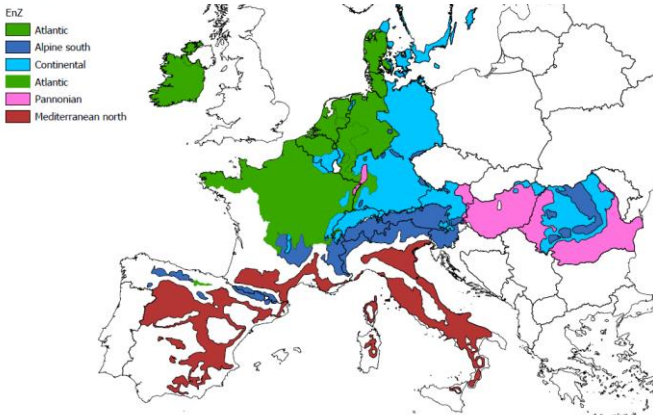
Modeling procedure

Decision models



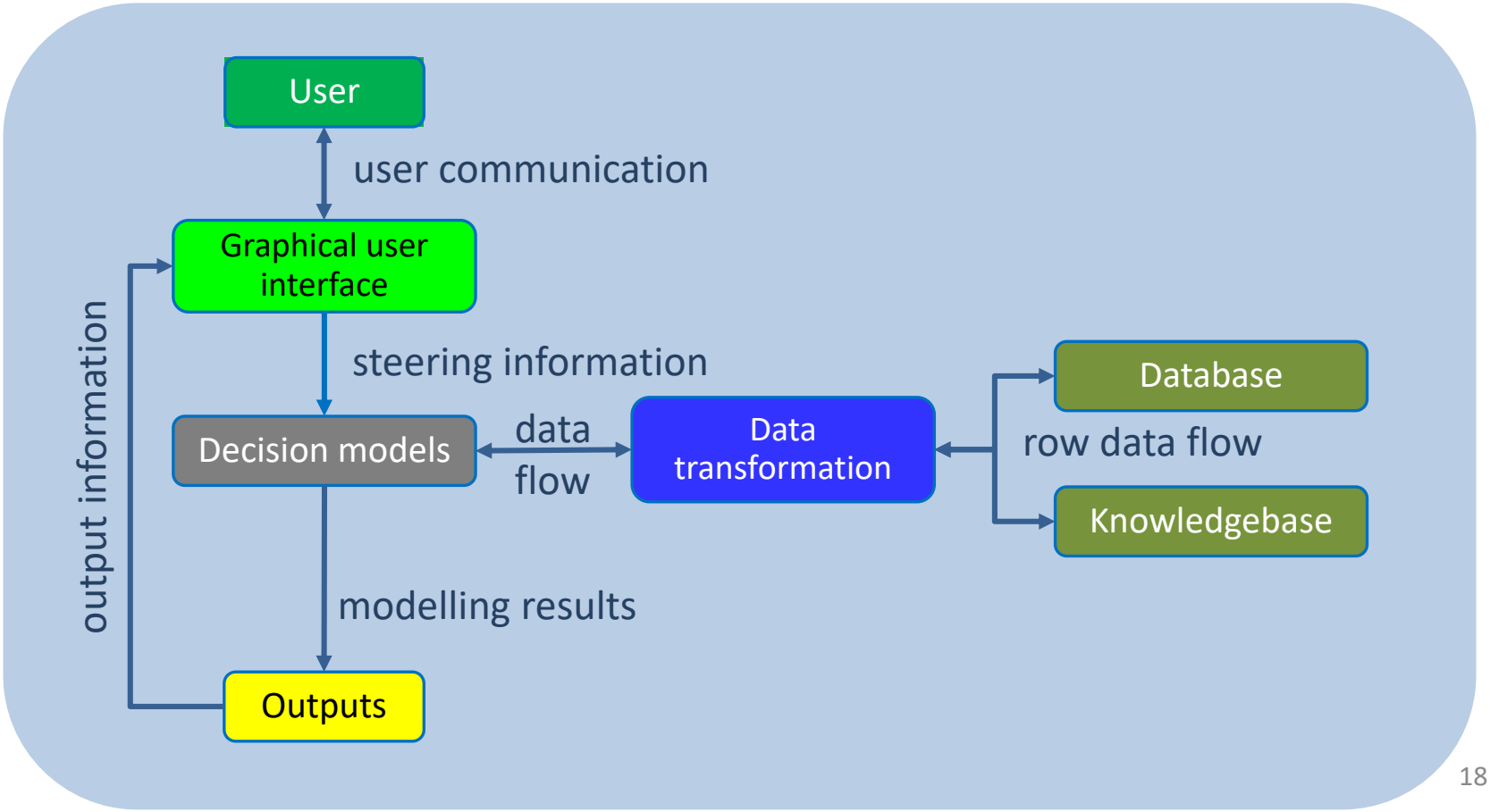
Verification → Sensitivity analysis → Calibration → Validation

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

Integration

Linking modules into operational DSS



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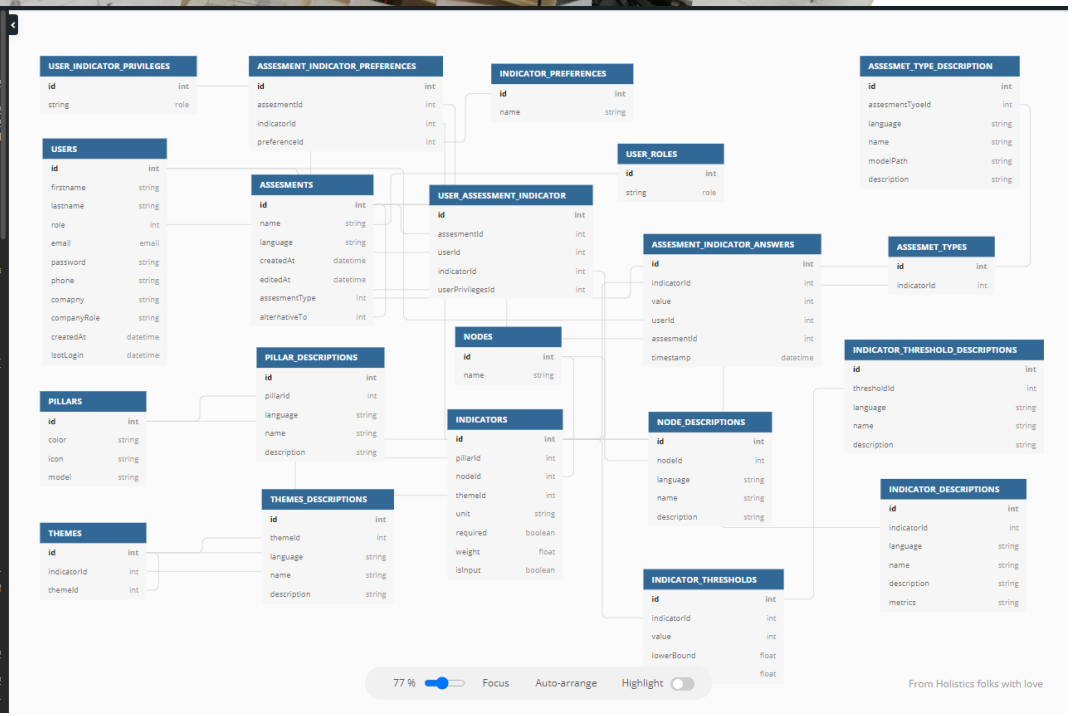
Integration

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

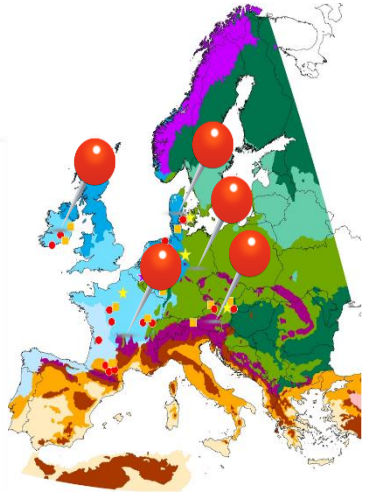
```
Table USER_INDICATOR_PRIVILEGES {
 id int [pk]
 string role [note: "edit, view"]
}

Table ASSESMENT_INDICATOR_PREFERENCES {
  id int [pk]
  assesmentId int [ref: > "ASSESMENTS
  indicatorId int [ref: > "INDICATORS
  preferenceId int [ref: > "INDICATOR
}

Table INDICATOR_PREFERENCES {
  id int [pk]
  name string
}

Table USER_ROLES {
 id int [pk]
 string role [note: "administrator, a
}

Table USERS {
  id int [pk]
  firstname string
  lastname string
  role int [ref: - "USER_ROLES"."id"
  email email
  password string
  phone string
  comapny string
  companyRole string
  createdAt datetime
  lsotLogin datetime
}

Table ASSESMENTS {
  id int [pk]
  name string
  language string
  createdAt datetime
  editedAt datetime
  assesmentType int [ref: - "ASSESME
  alternativeTo int [ref: - "ASSESMEI
}

Table USER_ASSESSMENT_INDICATOR {
  id int [pk]
  assesmentId int [ref: - "ASSESMENT
  userId int [ref: - "USERS"."id"]
  indicatorId int [ref: - "INDICATOR
  userPrivilegesId int [ref: - "USER_
}
```



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

Integration

9. Validation of DSS



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

Marko Debeljak
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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

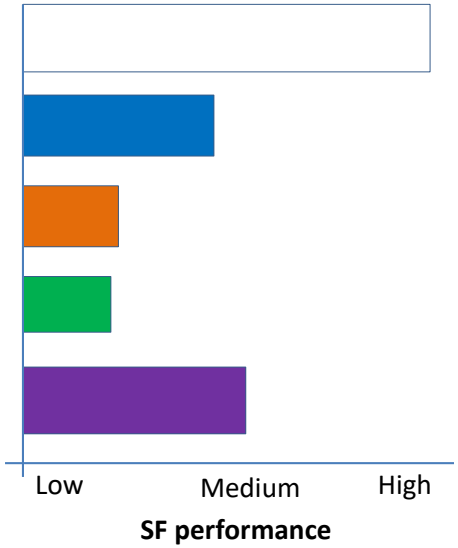
Nutrient cycling

Primary production

DECISION PROBLEM

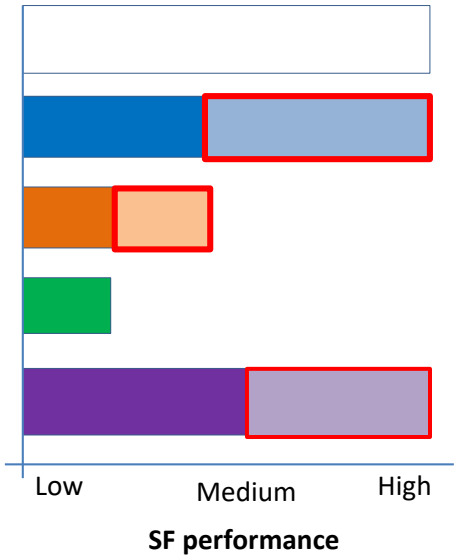
Assessing the performance of the **five soil functions**

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

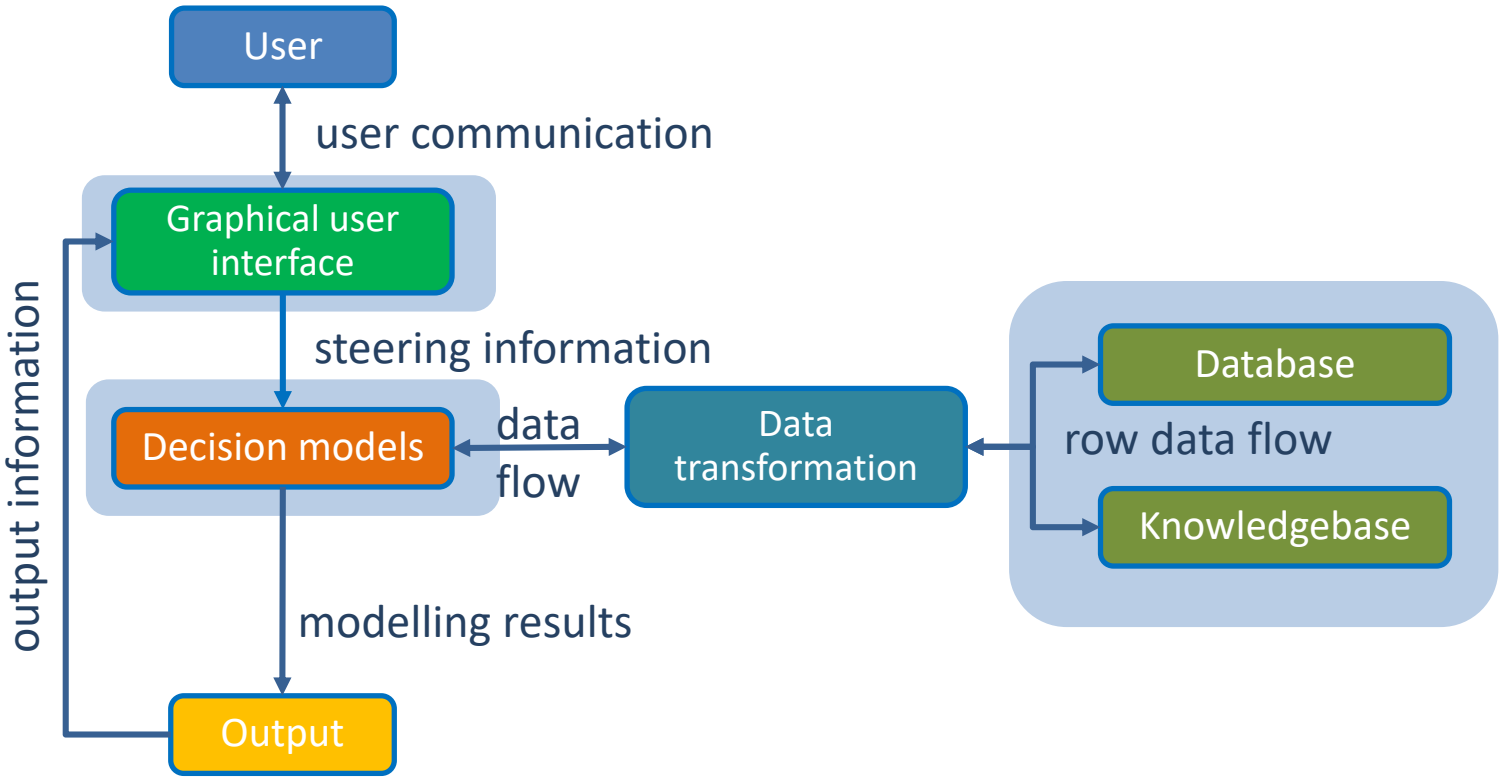


Choosing appropriate management practices that will **improve** the **performance** of the soil functions under:

- climatic conditions
- soil characteristics
- management options



Architecture of the Soil Navigator DSS

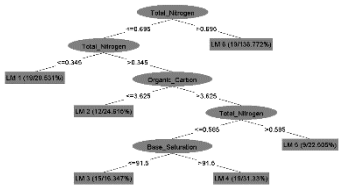


DECISION MODELS

Multi Criteria Decision Analysis (MCDA) → **to generate** → **Multi-Attribute Decision Models (MADM)** → **using** → **DEX (Decision EXpert) integrative methodology**

Experts

Data



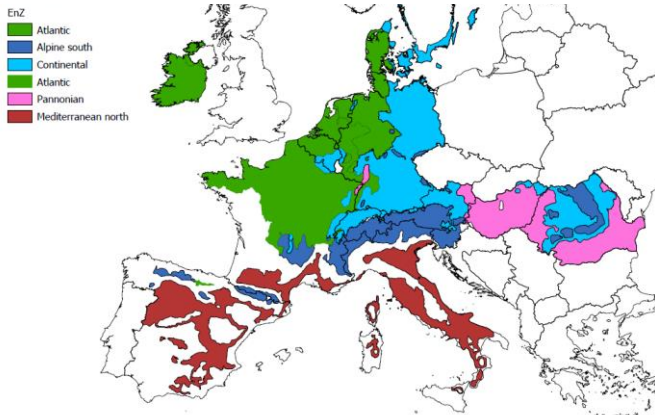
Expert based knowledge

Data mining

Decission Modelling

Attribute

Climate regulation
- **Carbon sequestration**
  - Carbon inputs
  - Potential carbon loss
  - Organic carbon content
- **N2O emissions**
  - Direct N2O emissions
  - Indirect N2O emissions
- **CH4 emissions**
  - Artificial drainage
  - Soil type



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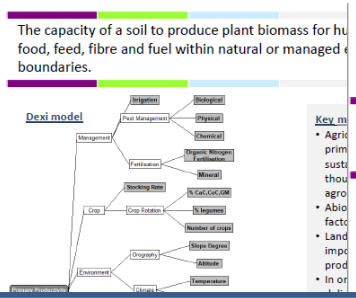
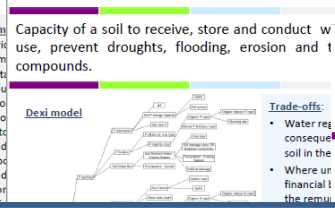
DECISION MODELS

PRIMARY PRODUCTIVITY



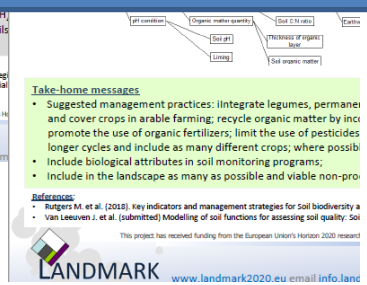
WATER REGULATION and PURIFICATION

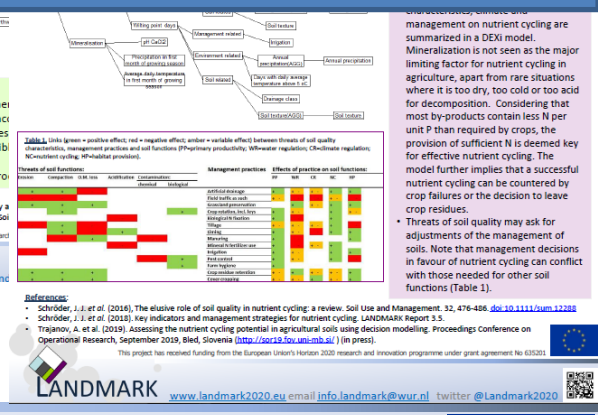


CLIMATE REGULATION and CARBON SEQUESTRATION

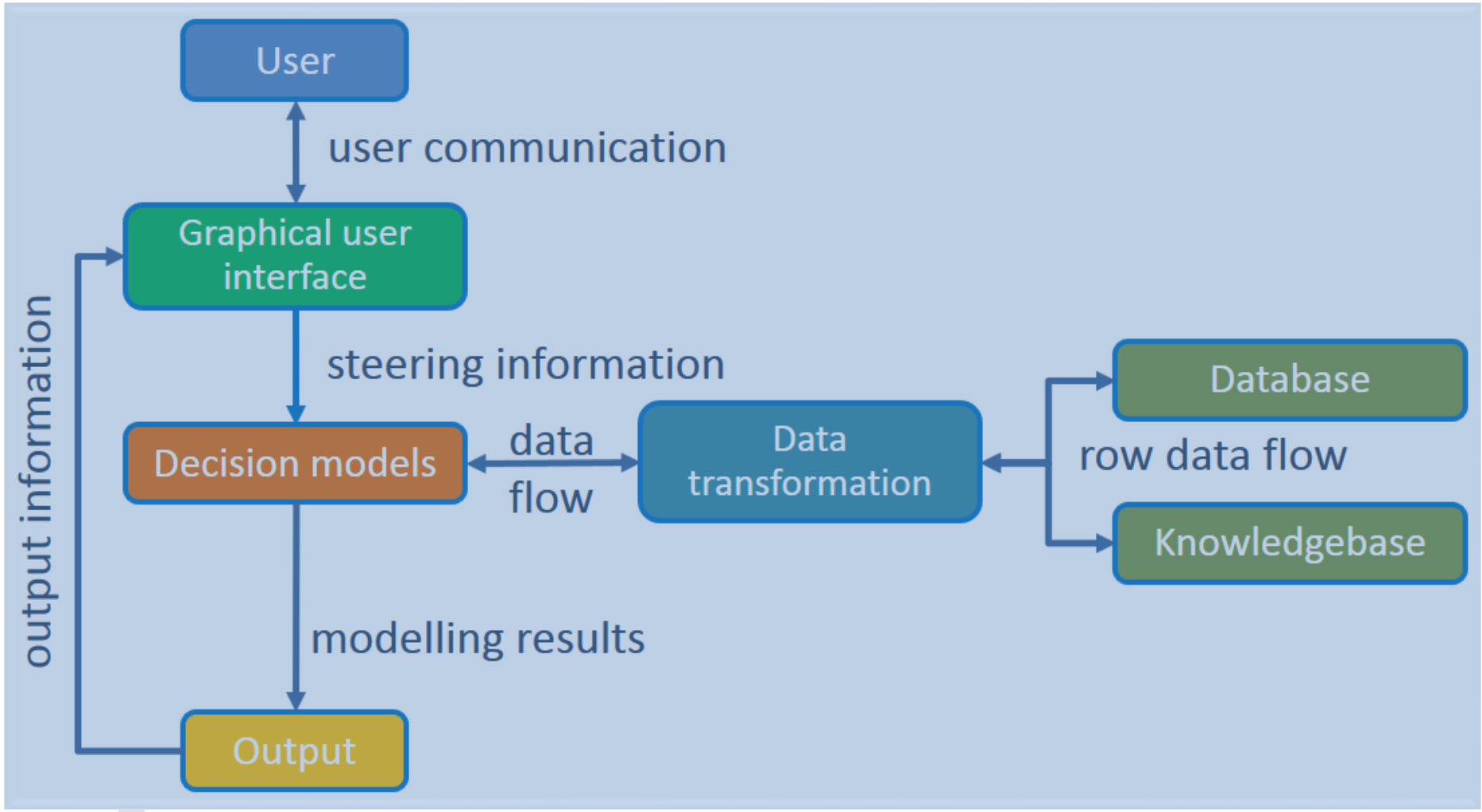
HABITAT FOR BIODIVERSITY

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





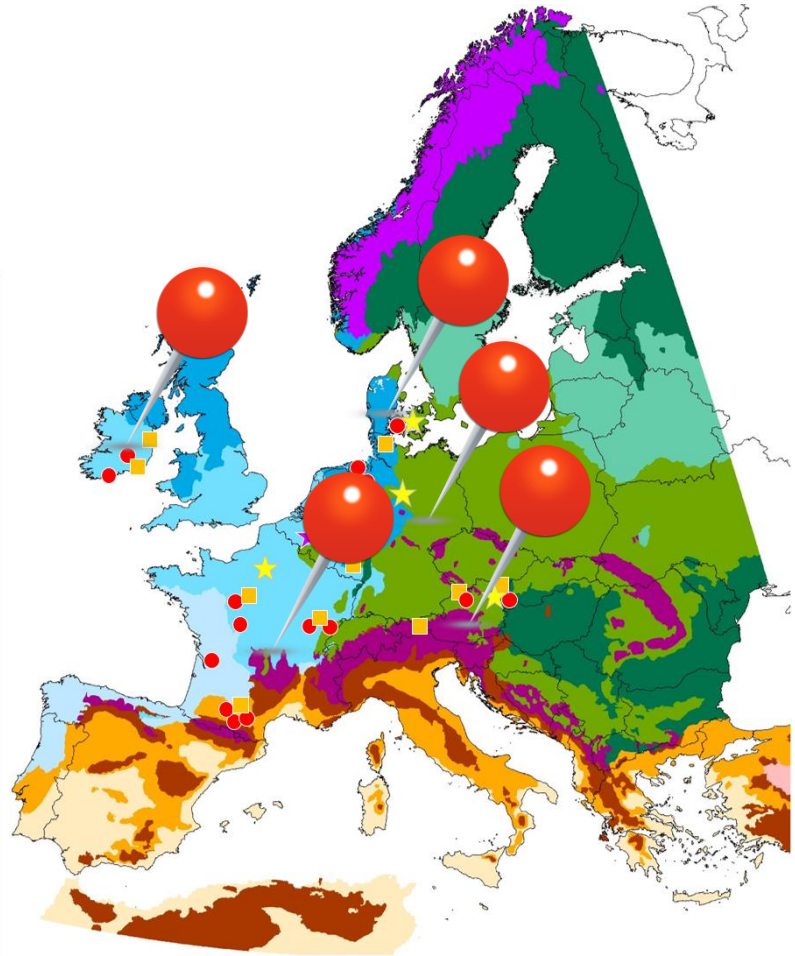
TRANSFER TO COMPUTER



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

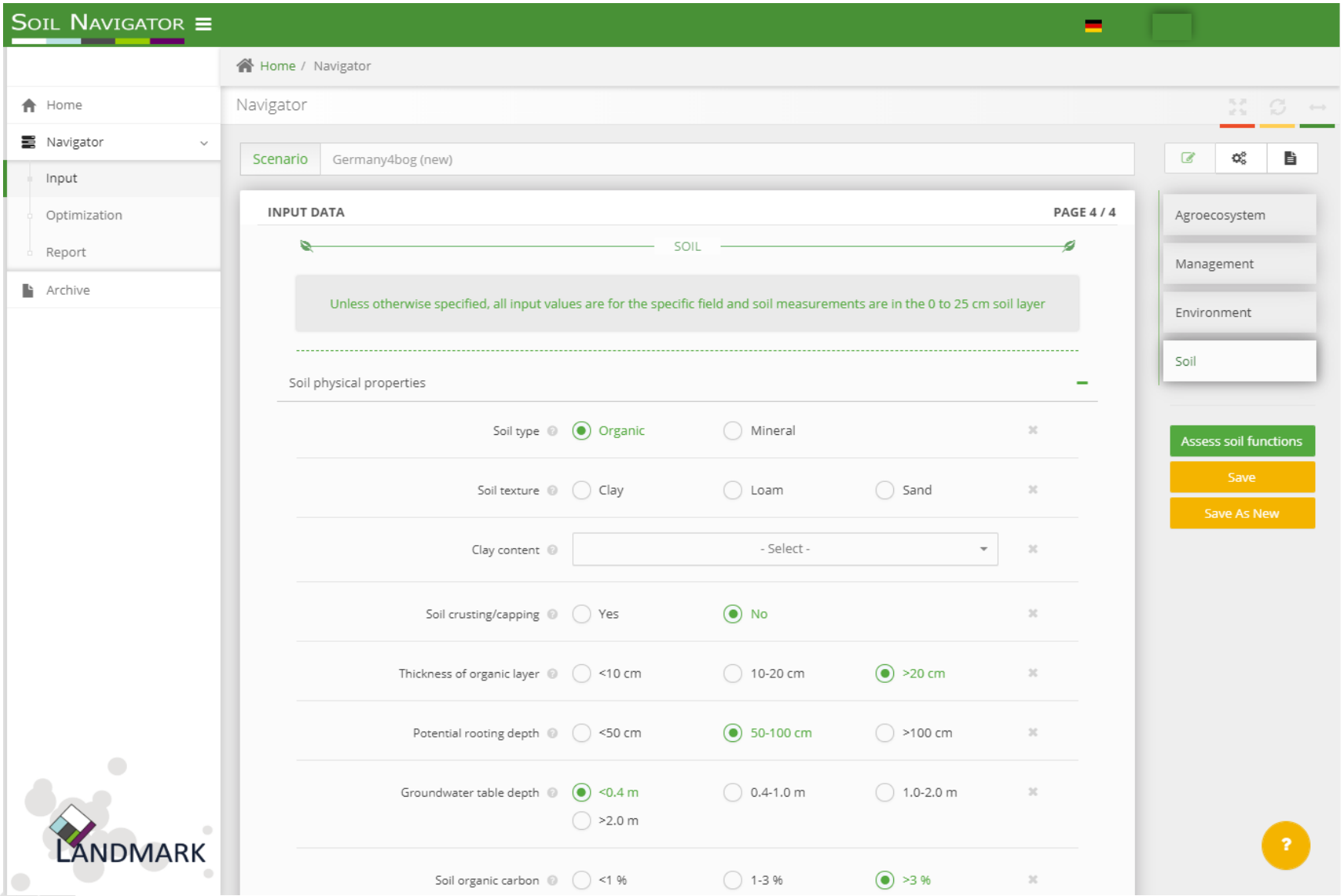
Home | Decision support system | Soil functions | Team | Publications | Tutorials | RUN

A Decision Support System for assessing and optimizing soil functions

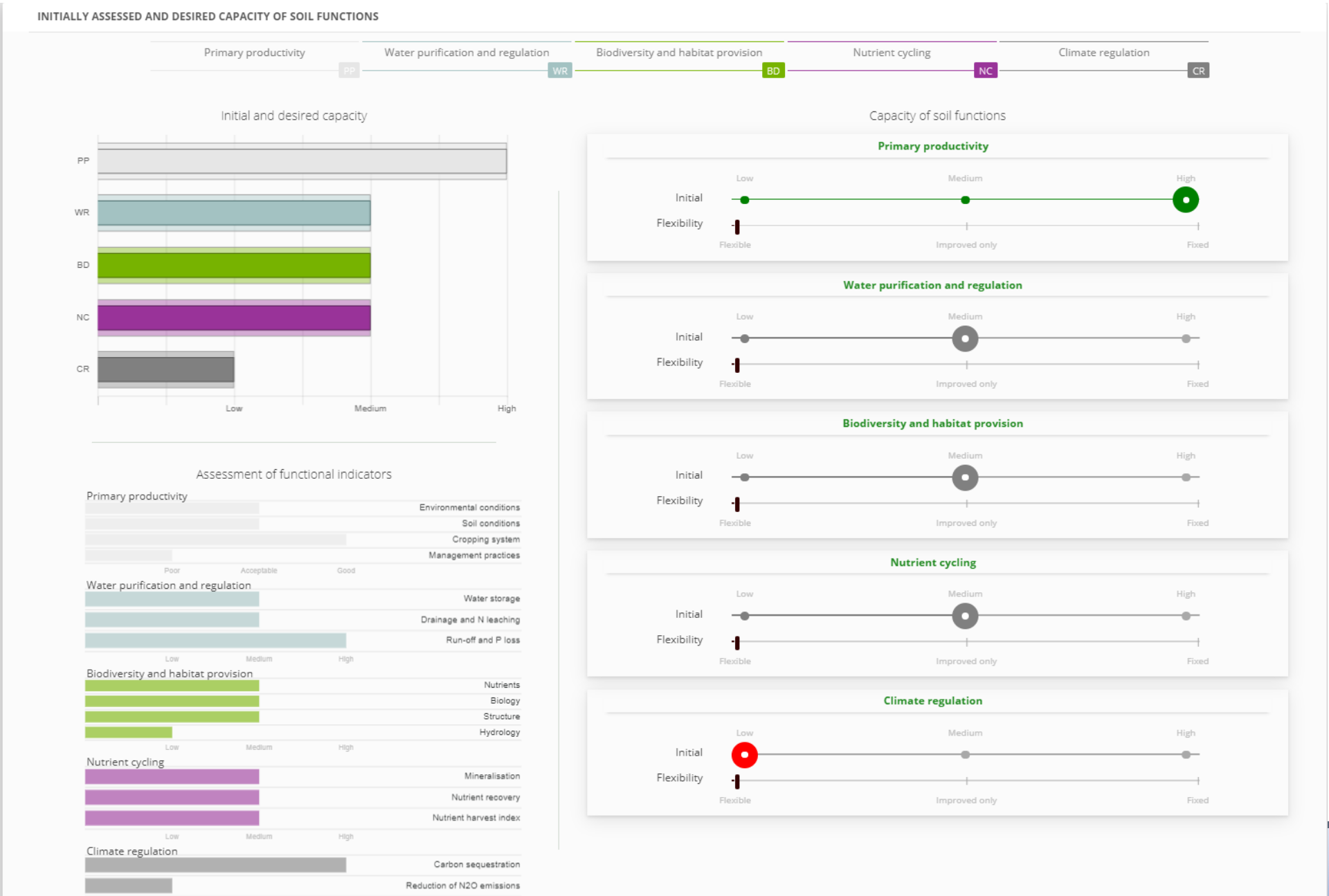
The Soil Navigator decision support system (DSS) was developed in the Horizon 2020 project **LANDMARK**. It assesses the initial capacities of five soil functions within a field including primary productivity, nutrient cycling, water purification and regulation, carbon sequestration and climate regulation, 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

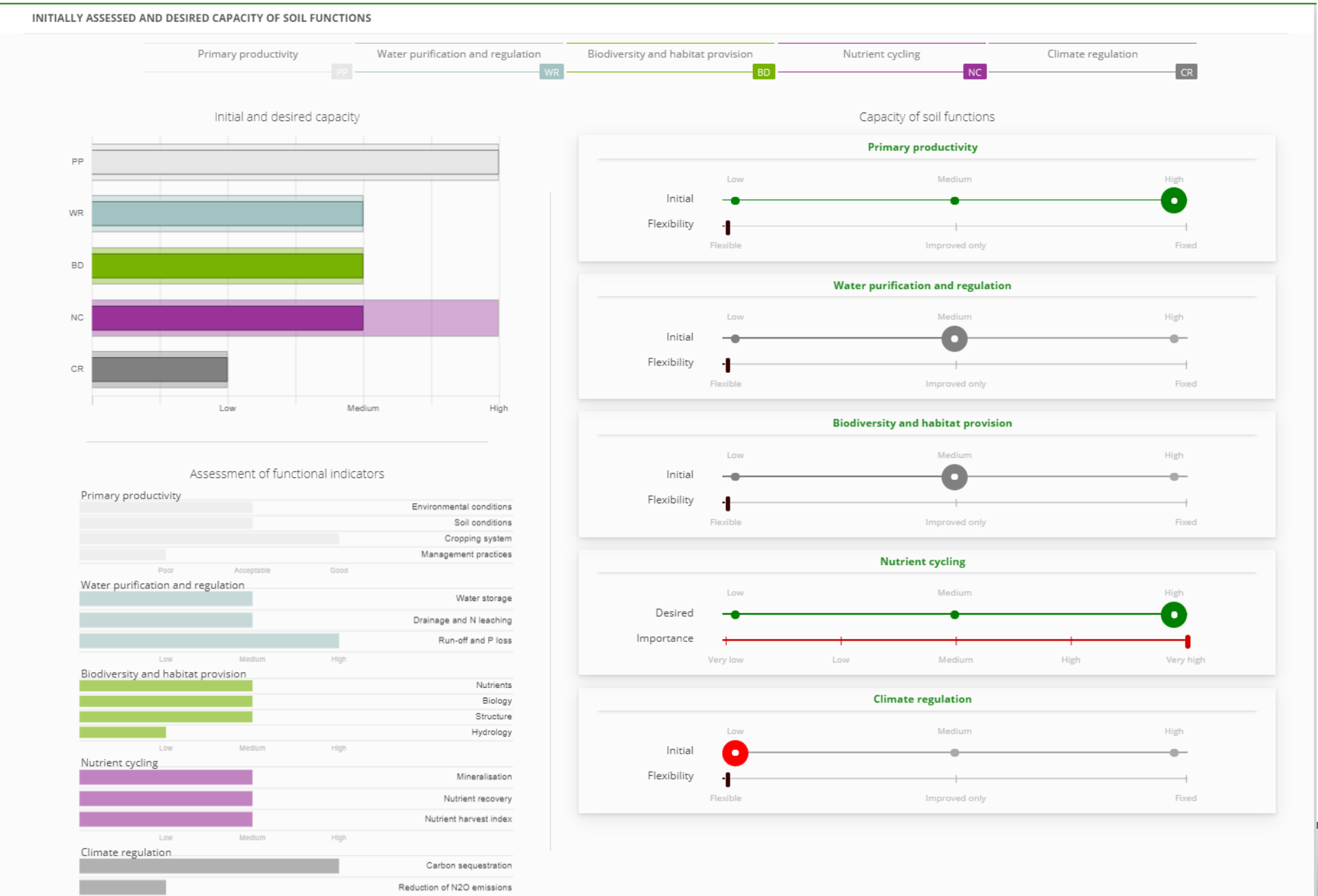
GRAPHICAL USER INTERFACE - DATA ENTRY



GUI– ASSESSMENT OF THE SOIL FUNCTIONS



GUI– ASSESSMENT OF THE SOIL FUNCTIONS

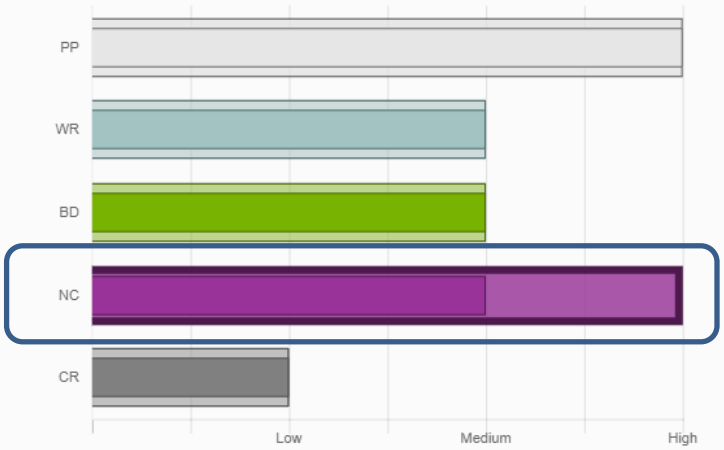


GUI– SUGGESTIONS FOR IMPROVEMENT OF SELECTED SF

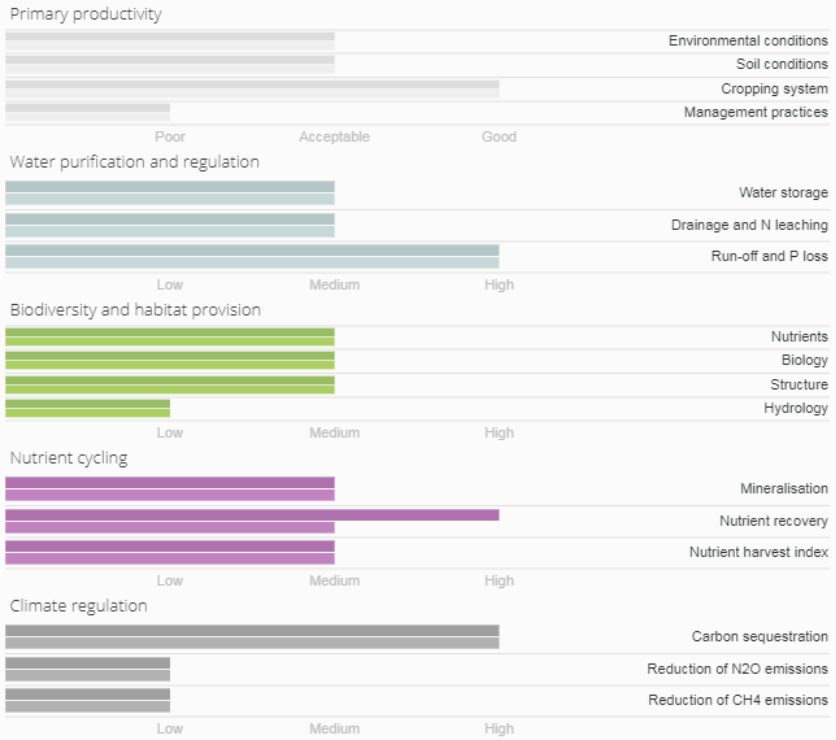
EVALUATION REPORT ON OPTIMIZED CAPACITIES OF SOIL FUNCTIONS

Primary productivity PP | Water purification and regulation WR | Biodiversity and habitat provision BD | Nutrient cycling NC | Climate regulation CR

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

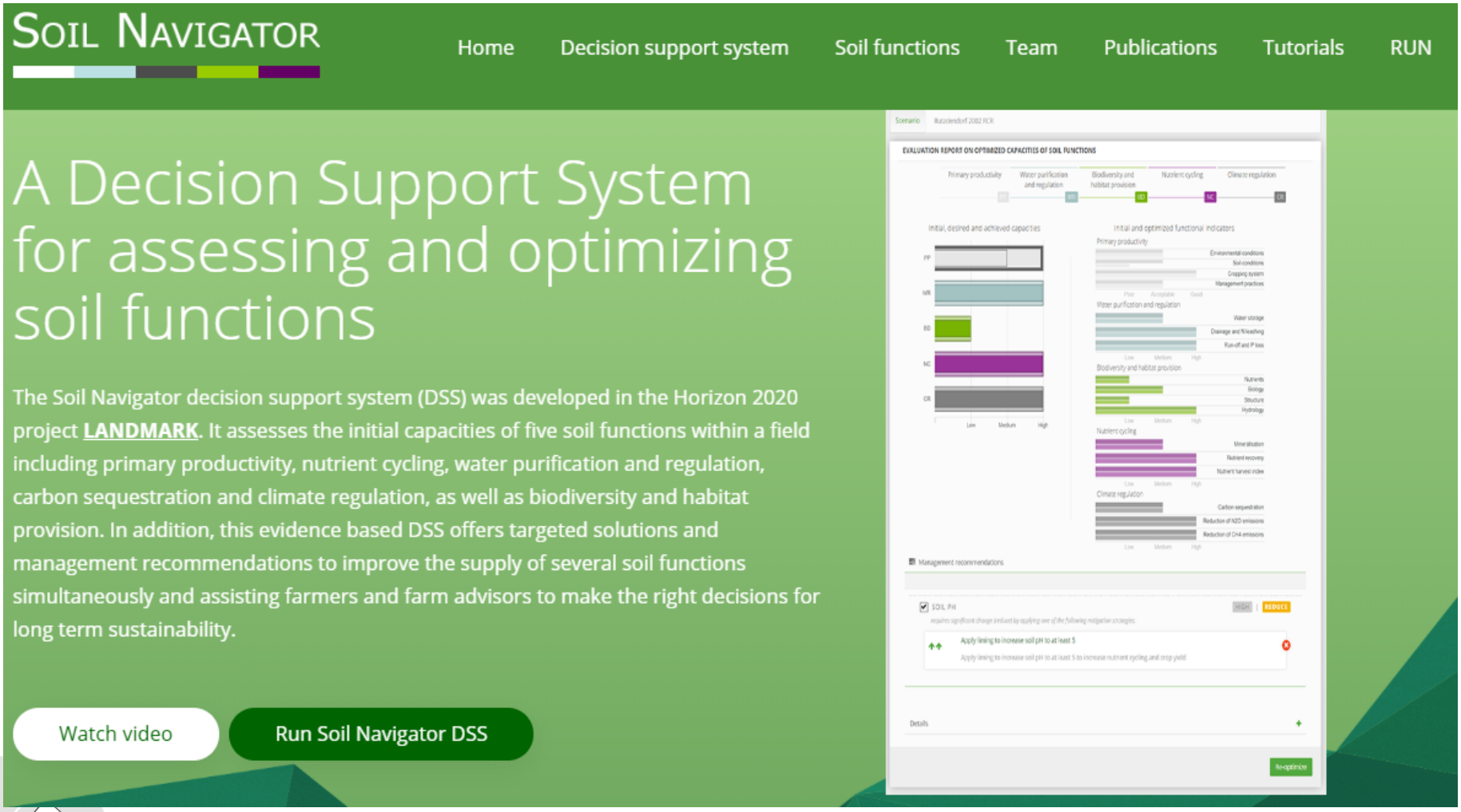
Increase/apply balanced mineral N fertilization in compliance with national fertilizer regulations to meet crop N demand, increase biomass production and sequester carbon in the soil

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

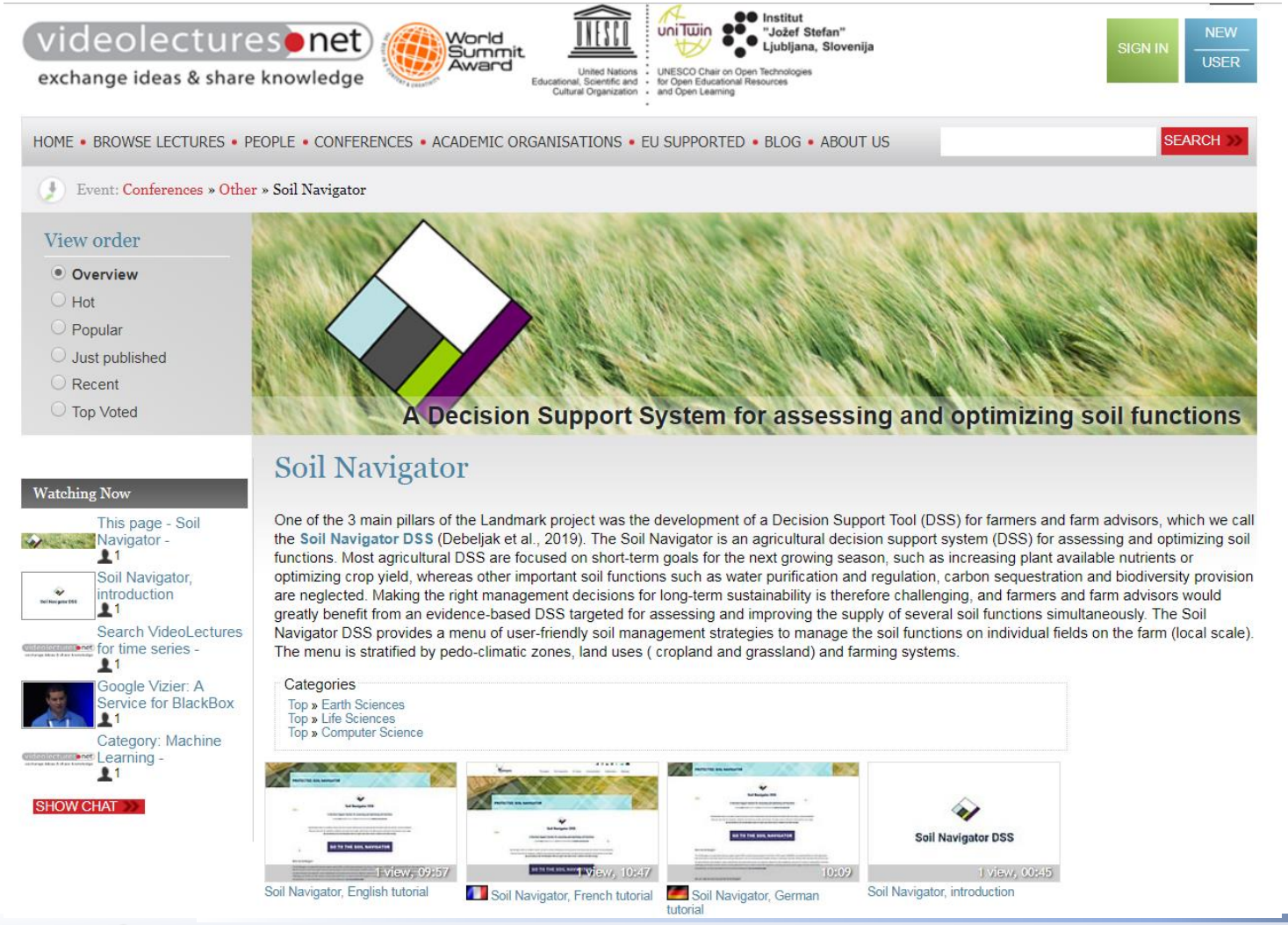
Open access: www.soilnavigator.eu



SUPPLEMENTING MATERIALS

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

http://videolectures.net/soil_english_tutorial/



SUPPLEMENTING MATERIALS

Methodological paper

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 Spiegel[1], Vladimir Kuzmanovski[2], Nicolas P. A. Saby[4], Calypso Picaud[5], Christian Bugge Henriksen[6] and Marko Debeljak[2,3]

ORIGINAL RESEARCH ARTICLE

Front. Environ. Sci., 22 August 2019 | https://doi.org/10.3389/fenvs.2019.00113

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

Jeroen P. van Leeuwen[1], Rachel E. Creamer[2], Daniel Cluzeau[3], Marko Debeljak[4], Fabio Gatti[5], Christian B. Henriksen[6], Vladimir Kuzmanovski[4], Cristina Menta[5], Guénola Pérès[7], Calypso Picaud[8], Nicolas P. A. Saby[9], Aneta Trajanov[4], Isabelle Trinsoutrot-Gattin[10], Giovanna Visioli[5] and Michiel Rutgers[11*]

Soil Use and Management — British Society of Soil Science

SPECIAL ISSUE PAPER | Open Access

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

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

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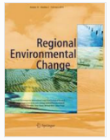

Regional Environmental Change

February 2019, Volume 19, Issue 2, pp 325–337 | Cite as

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

Authors | Authors and affiliations

Aneta Trajanov, Heide Spiegel, Marko Debeljak, Taru Sandén

Soil Use and Management — British Society of Soil Science

Review Article | Open Access

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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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, Lilian M O'Sullivan, Marko Debeljak, Rachel Creamer and Christain Bugge Henriksen

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

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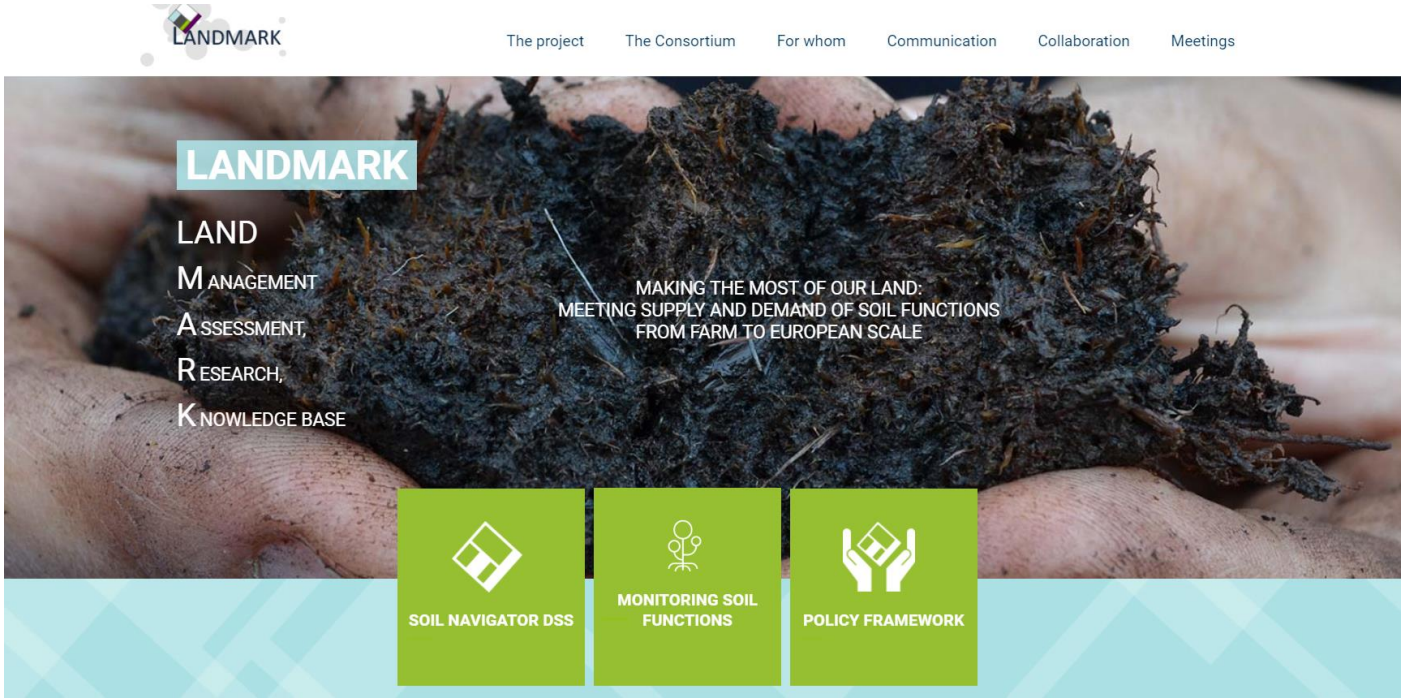

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Final remarks

- 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!