AI applications in agriculture

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Agriculture

Benefits of agriculture

- **Food** being produced in **appreciable abundance**
- Farming creates **opportunities to lift people out of poverty** in developing nations
- Over 60 percent of the world's working poor works in agriculture
- **Farming creates more jobs:**
  - farmers, farm equipment makers, food processing plants, transportation, infrastructure and manufacturing
- Agriculture – a **scientific area**
- Farmers more **educated**
- Agriculture - **modernized**

Threats

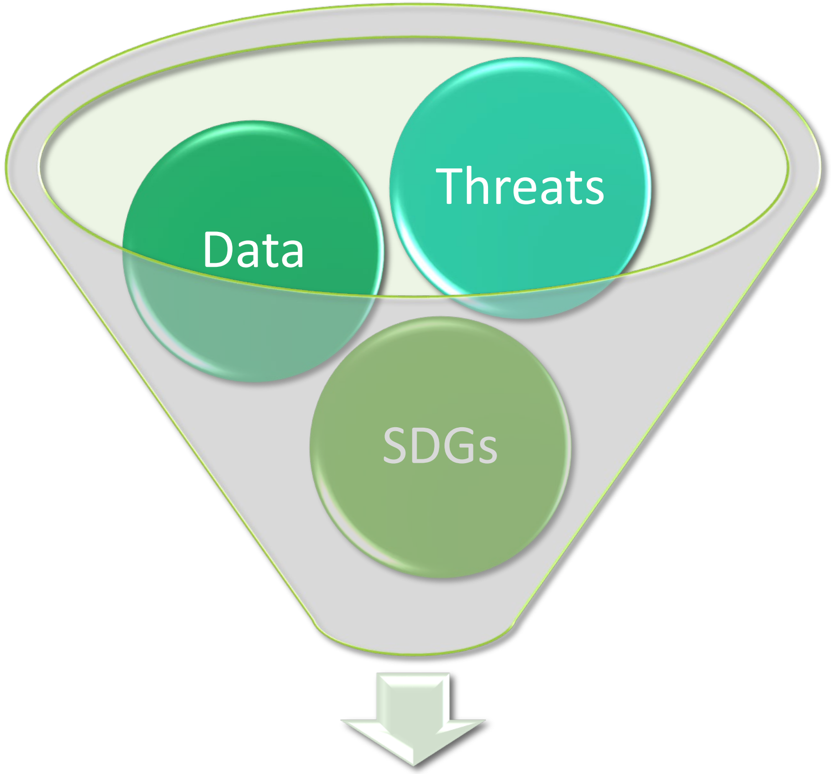
- Human population approaches 10 billion people by 2050
- Modern agriculture's huge reliance upon a few crops
- Climate change
- Huge environmental and health pressure (biodiversity loss, water pollution, pesticides, …)

Modernization of agriculture

- Transforming agriculture from **traditional labour-based** to **technology-based agriculture**
- New technologies (precision farming, drones, robots) for
  - combatting disease and pests
  - monitoring nutrient levels
  - monitor soil and growing conditions
  - …

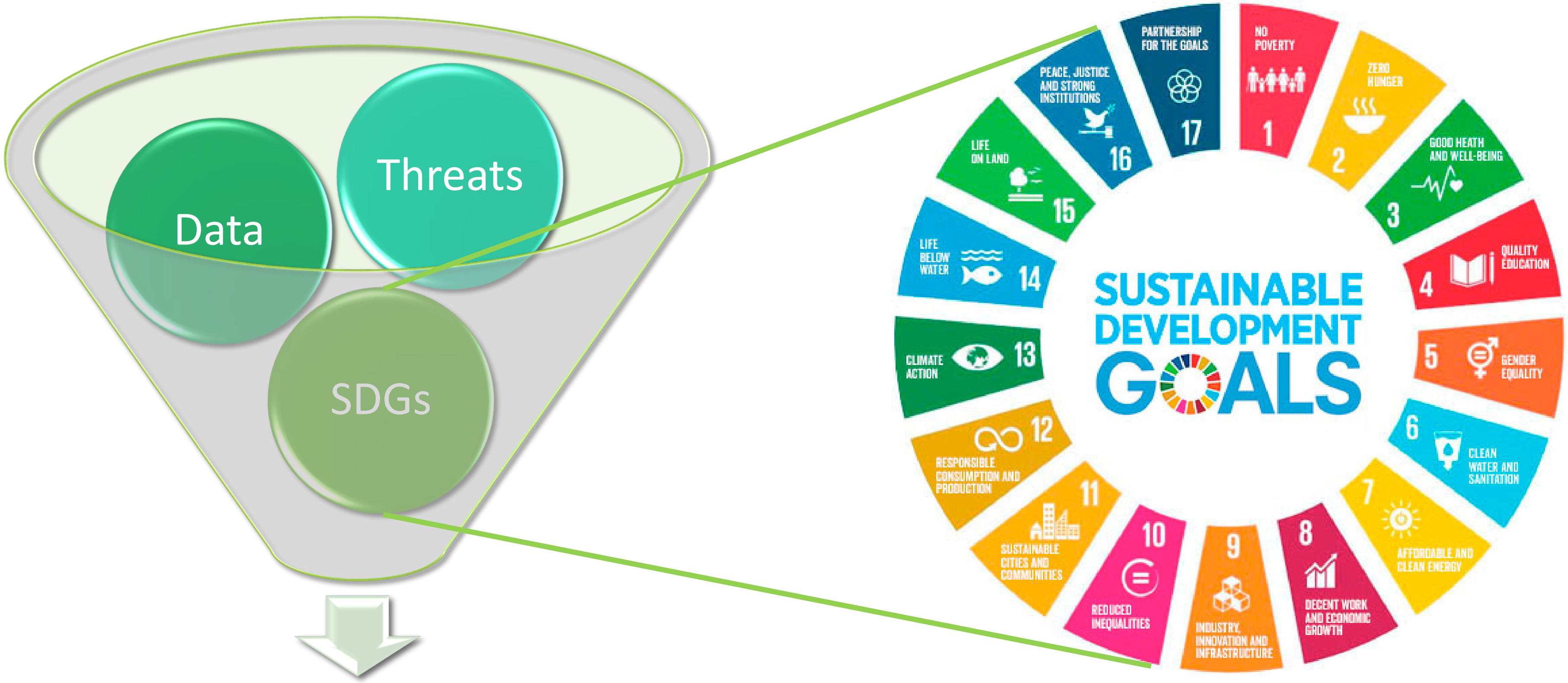
- **Huge amounts of structured or unstructured data produced daily!**

Challenges



AI in agriculture

Challenges



AI in agriculture

AI in agriculture

- Most popular applications of AI in agriculture fall into three major categories:
  - **Agricultural robots** – autonomous robots to handle essential agricultural tasks at a higher volume and faster pace than human laborers
  - **Crop and soil monitoring** – computer vision and deep learning algorithms to process data captured from drones and/or software-based technology to monitor crop and soil health
  - **Predictive analytics** – machine learning models developed to track and predict various variables/aspects in agriculture

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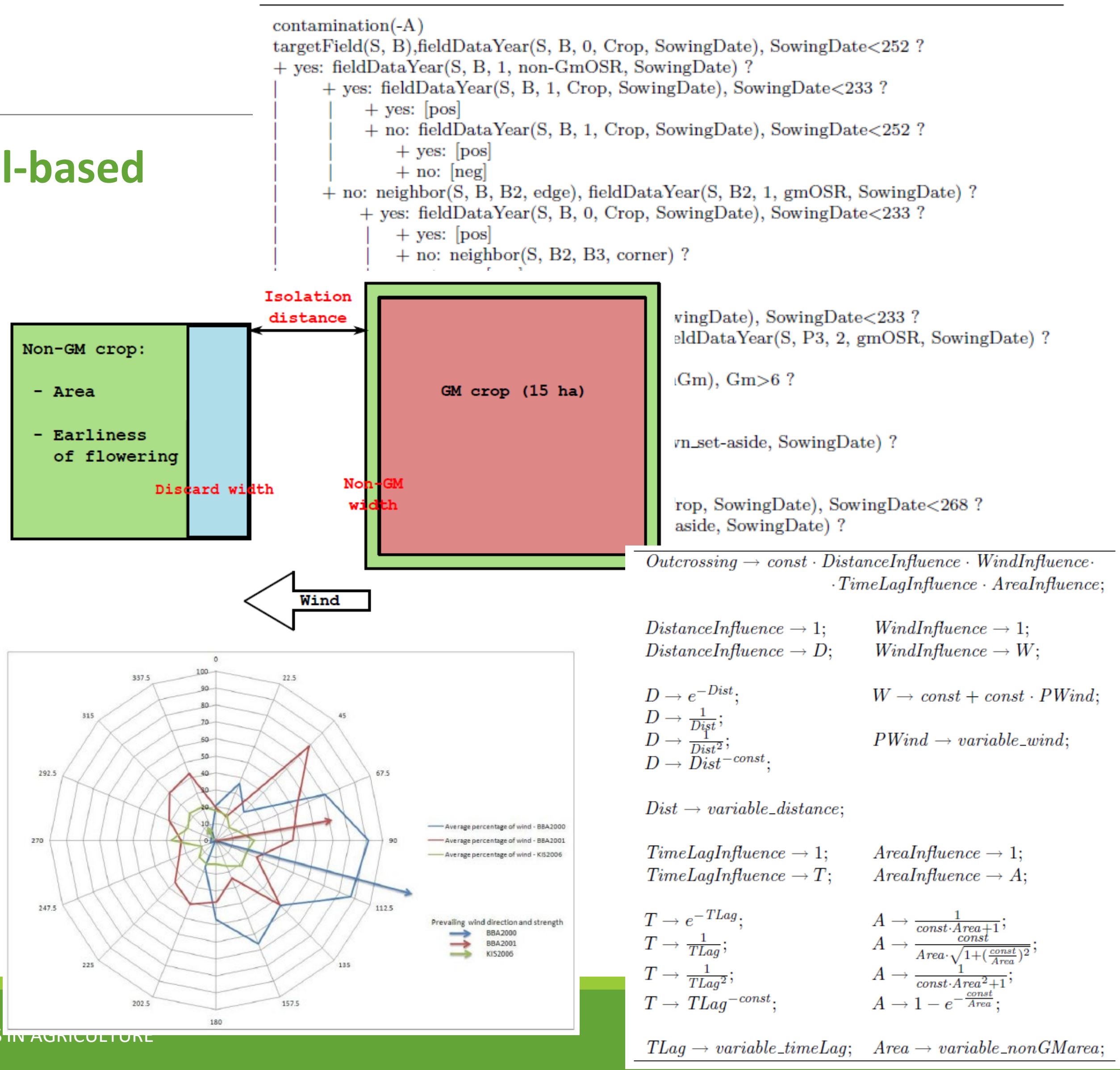
AI applications in agriculture at JSI

- More than 15 years of work in this area
- Different areas of agriculture:
  - **Co-existence of GM and conventional crops**
  - **Water pollution** with plant protection products
  - **Biological pest control**
  - Soil preservation and **assessment of soil functions**
  - **Tomato resilience** and resource use efficiency
  - **Sustainability** of legume agri-food chains
  - **Integrated pest management**

Co-existence of GM and conventional crops

- Analysis of results of **large-scale** and **individual-based simulation models**
  - Crops: **oilseed rape** and **maize**
  - Simulation models: GENESYS, MAPOD, IBM-OSR
- Problem:
  - **Co-existence** issue
  - Influence on **natural habitats**
  - Consequences on **human health**
  - **0.9% of GM material** in conventional harvest
- **Machine learning analysis:**
  - Relational decision trees
  - Equation discovery
  - Process-based modelling



Water pollution with plant-protection products

Crop production without environment pollution

Water pollution with plant-protection products

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Crop production without environment pollution

PESTICIDES APPLICATION

Water pollution with plant-protection products

Crop production without environment pollution

Directives

- European water framework directive
- Directive on the sustainable use of plant protection products

Application instructions of pesticide producers

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Crop production without environment pollution

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Monitoring of water quality
INDICATES WATER POLLUTION

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Check the level of pollution risk for a certain crop management plan

Water pollution with plant-protection products

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No risk

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Water pollution with plant-protection products

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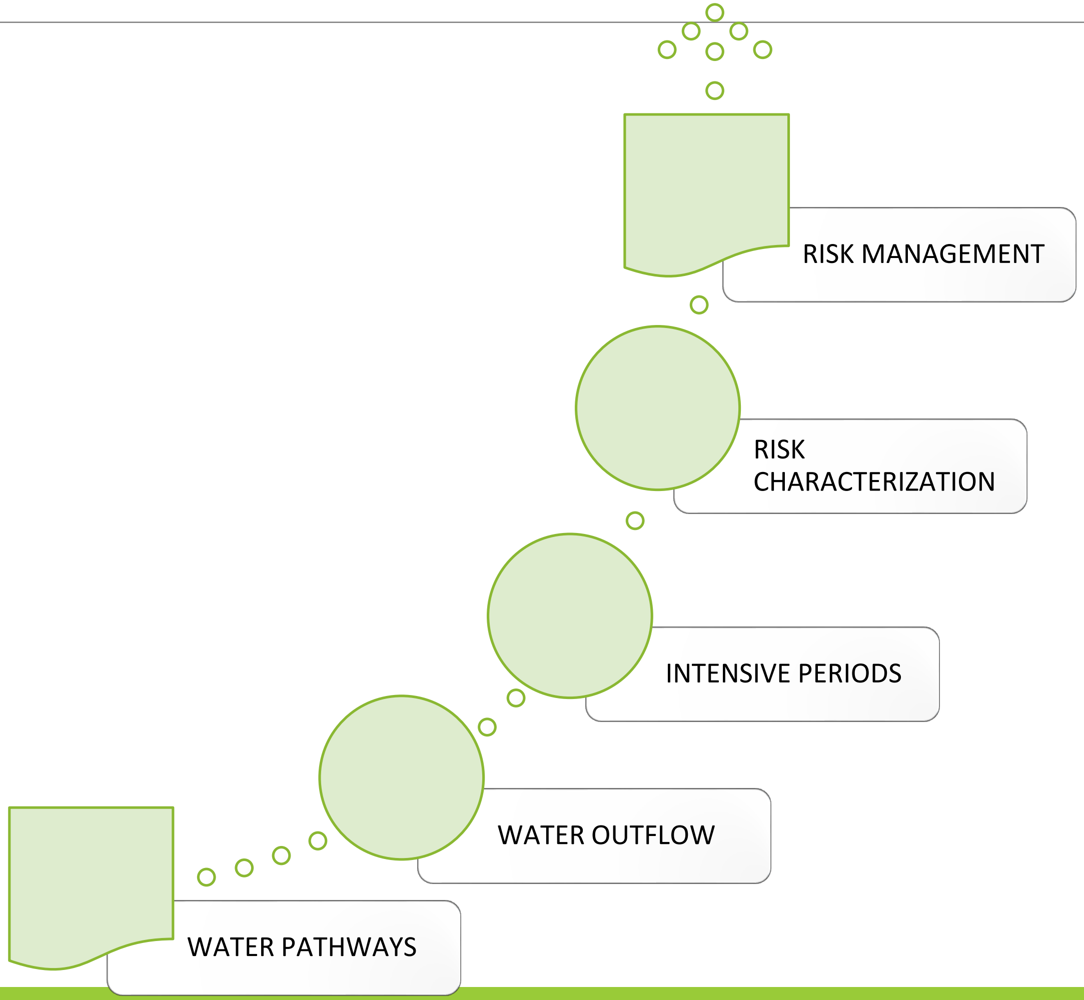
PESTICIDES APPLICATION

Check the level of pollution risk for a certain crop management plan

No risk → **Apply crop management plan**

Risk → **Change crop management plan**

Water pollution with plant-protection products



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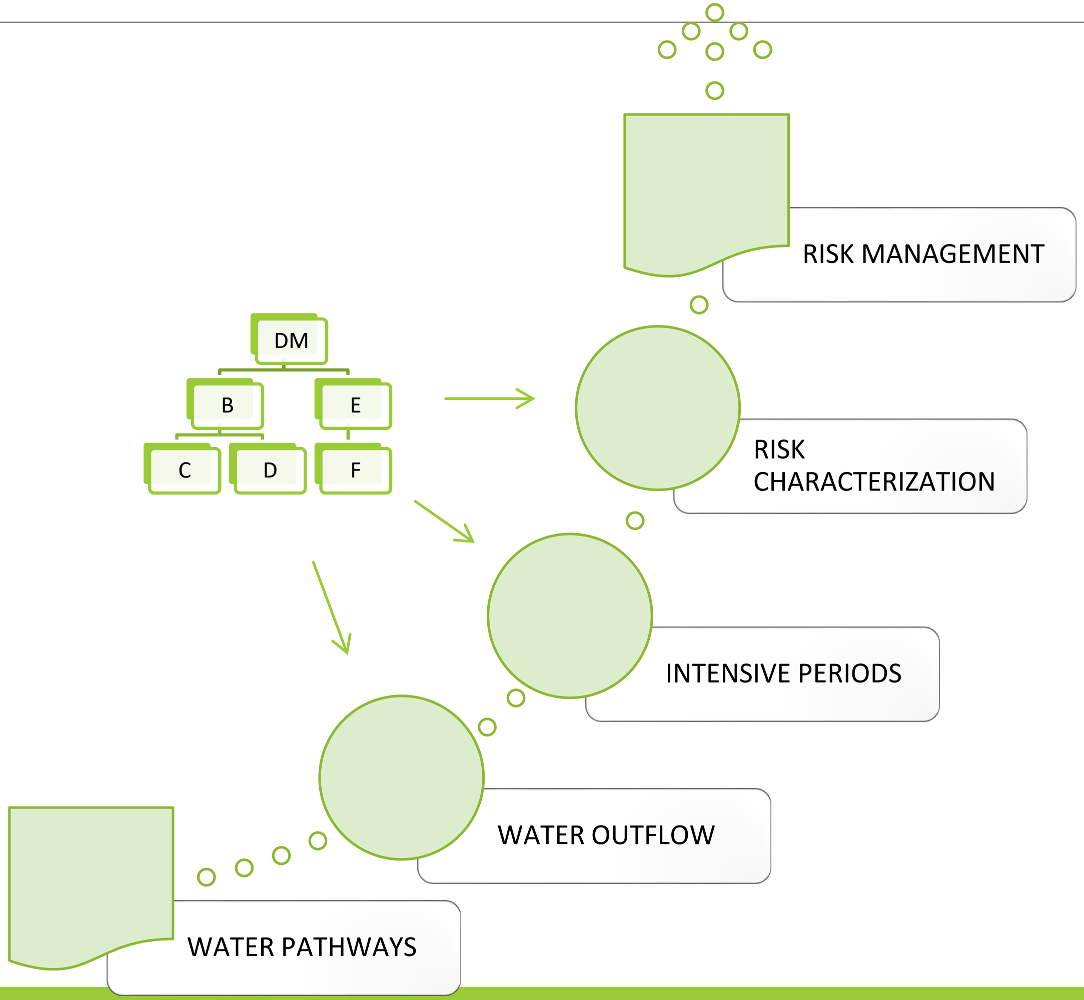

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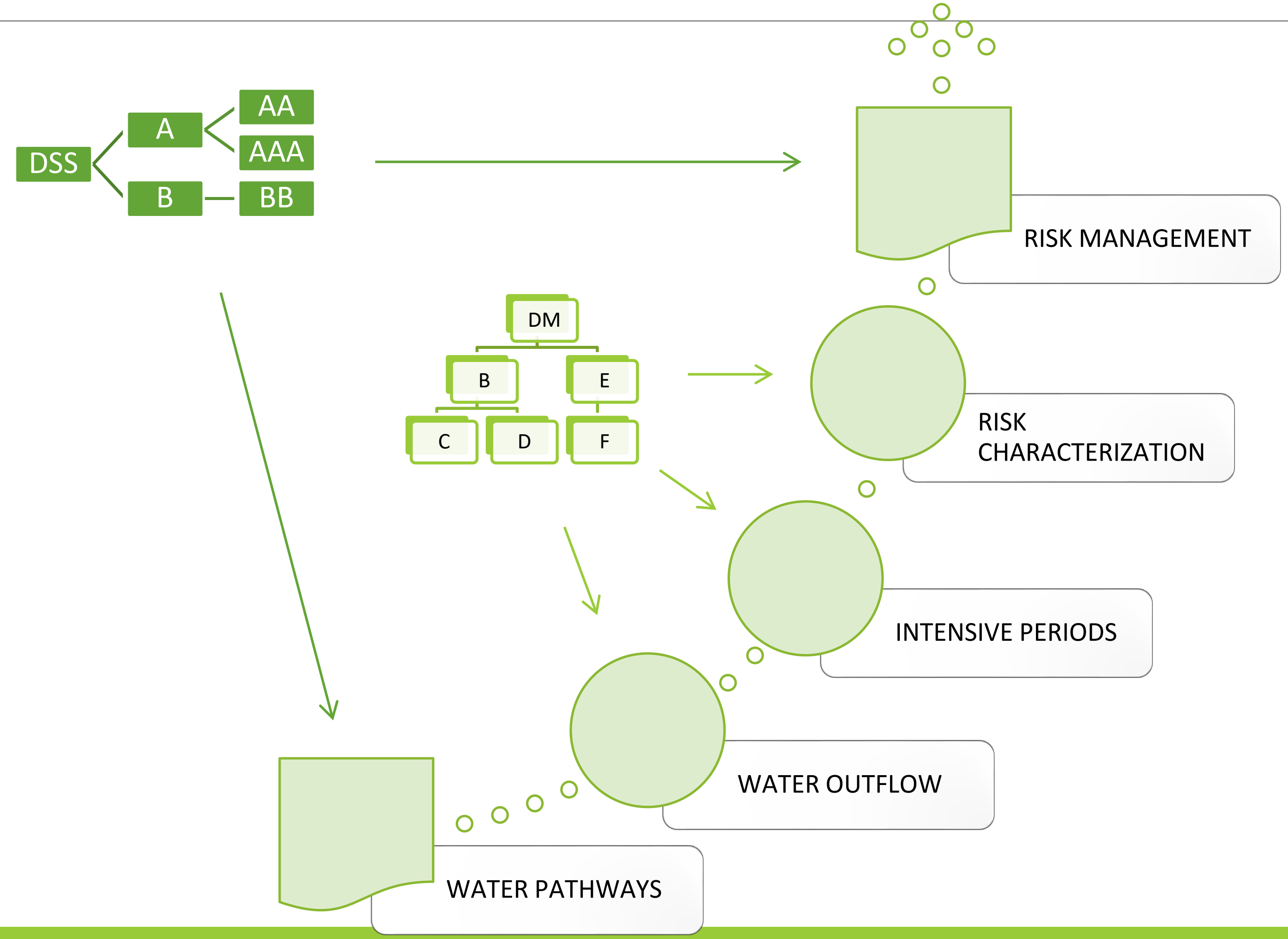

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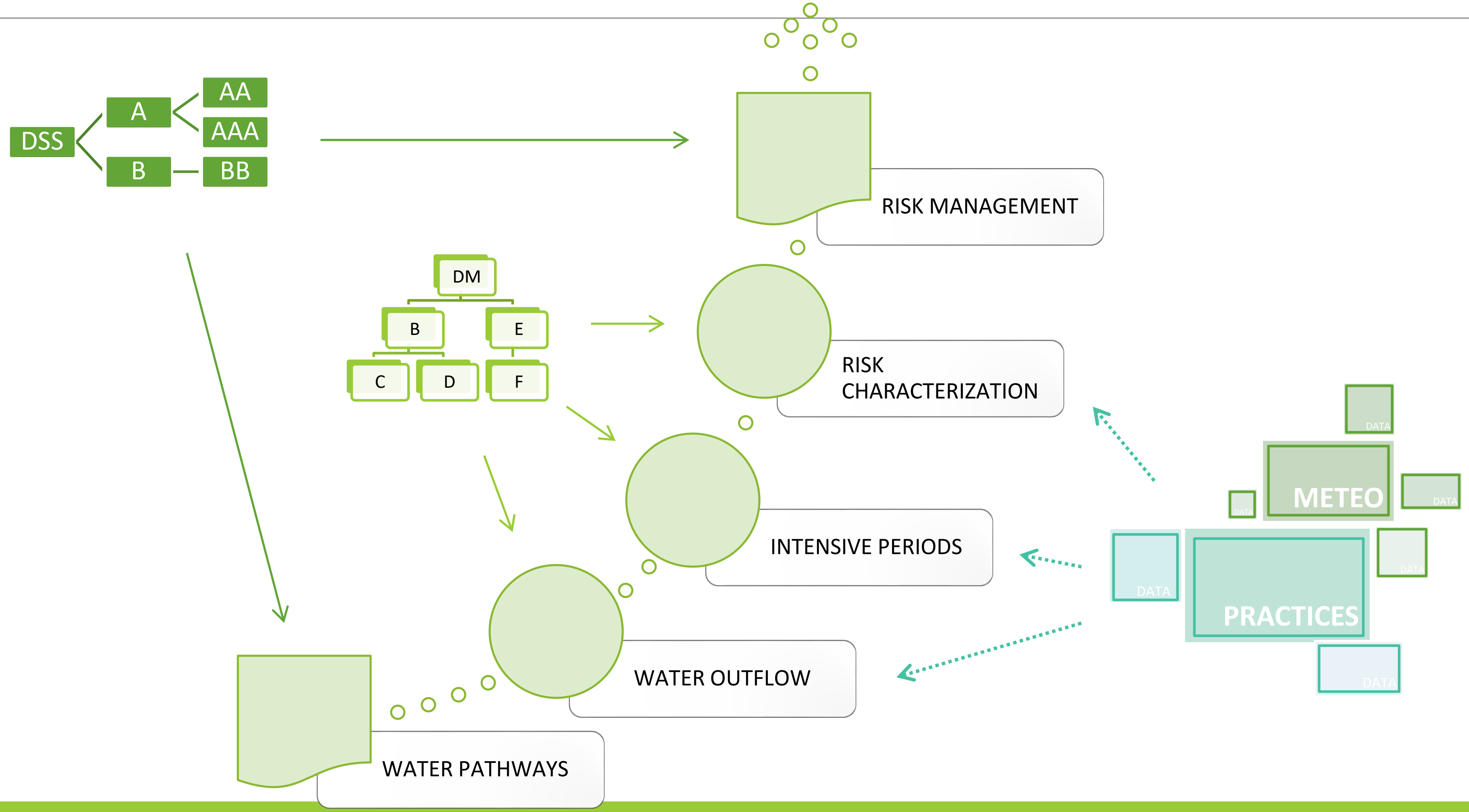

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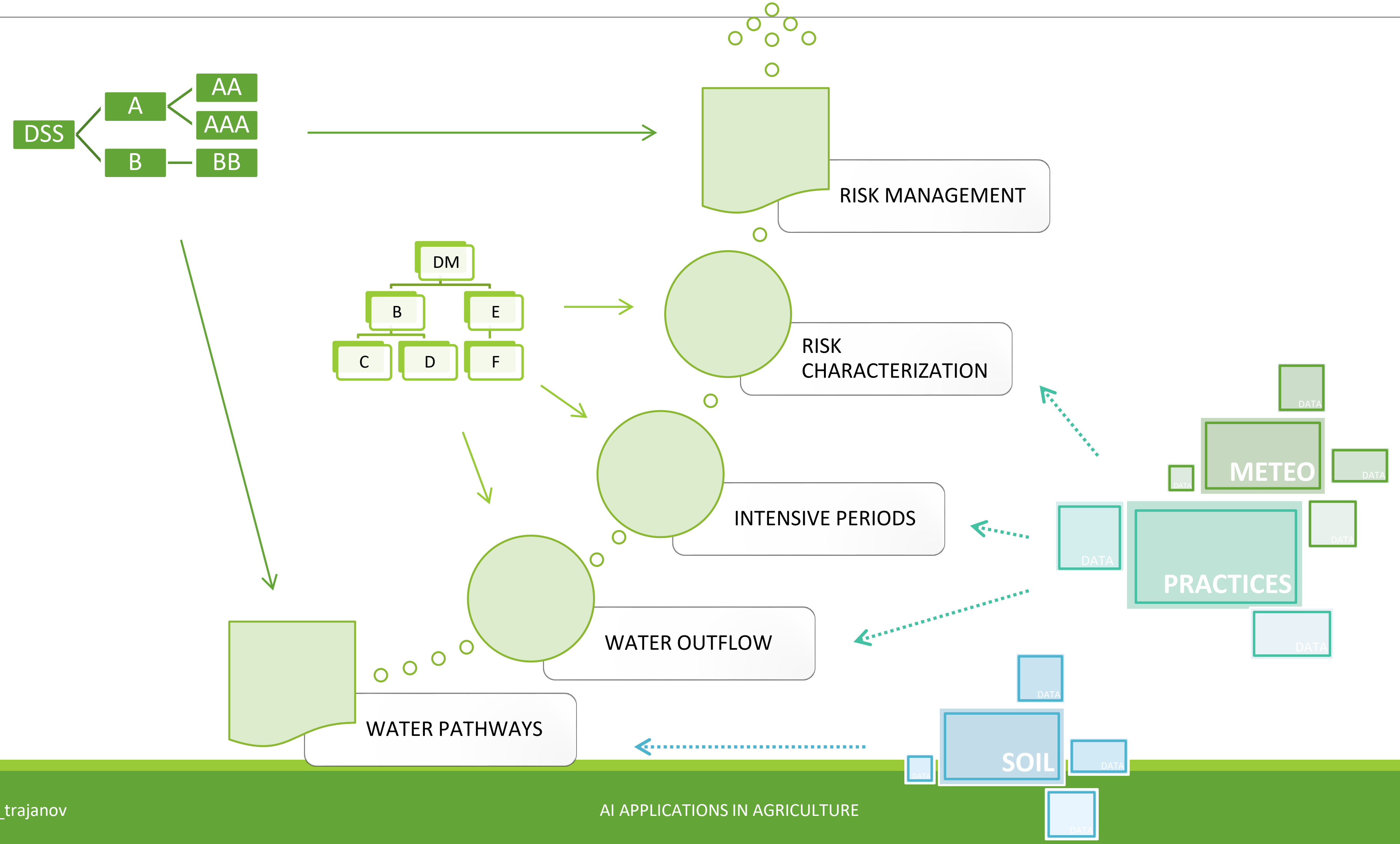

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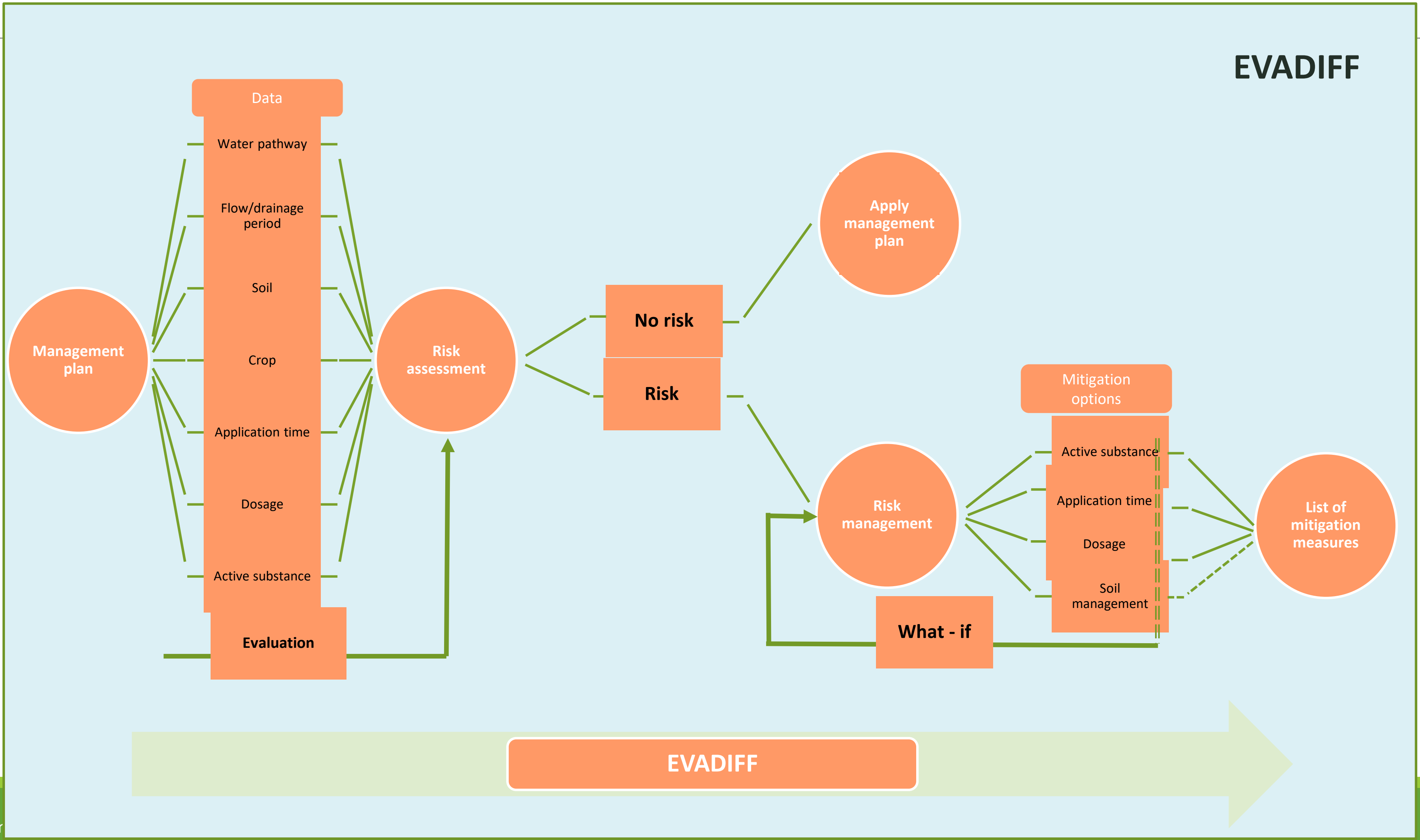

Biological pest control

- **Understanding and management of biodiversity** of agricultural ecosystems (natural enemies of pests)
- **Reduce pressure of agriculture** on the environment
  - Smaller amounts of plant protection products used
  - Enhanced biological pest control
- Research goals:
  - **Effects of** agricultural management, cropping systems, landscape and climate on **natural enemies populations (abundance and diversity)**
  - **Effect** of natural enemies **on pests** (aphids, slugs) populations
  - Case study: Boigneville, Erceville, Maisse, Picardie (France)
  - Natural enemies: **syrphids, carabids**

Biological pest control

The potential of Syrphids and Carabids for biological pest control

Syrphidae (**hoverflies**) and **Carabidae**

taxonomic diversity

functional diversity

Modelling the size and structure of populations of syrphid and carabid species

Biological pest control

- Huge amount of **preprocessing** to harmonize datasets → very **complex dataset**
  - **Taxonomic, meteorological** and **landscape** data
  - **Diversity indexes** calculated
  - **Functional categories** defined

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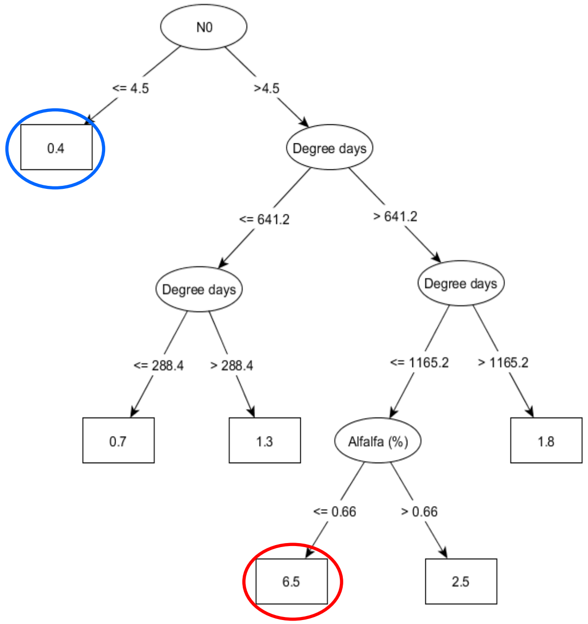

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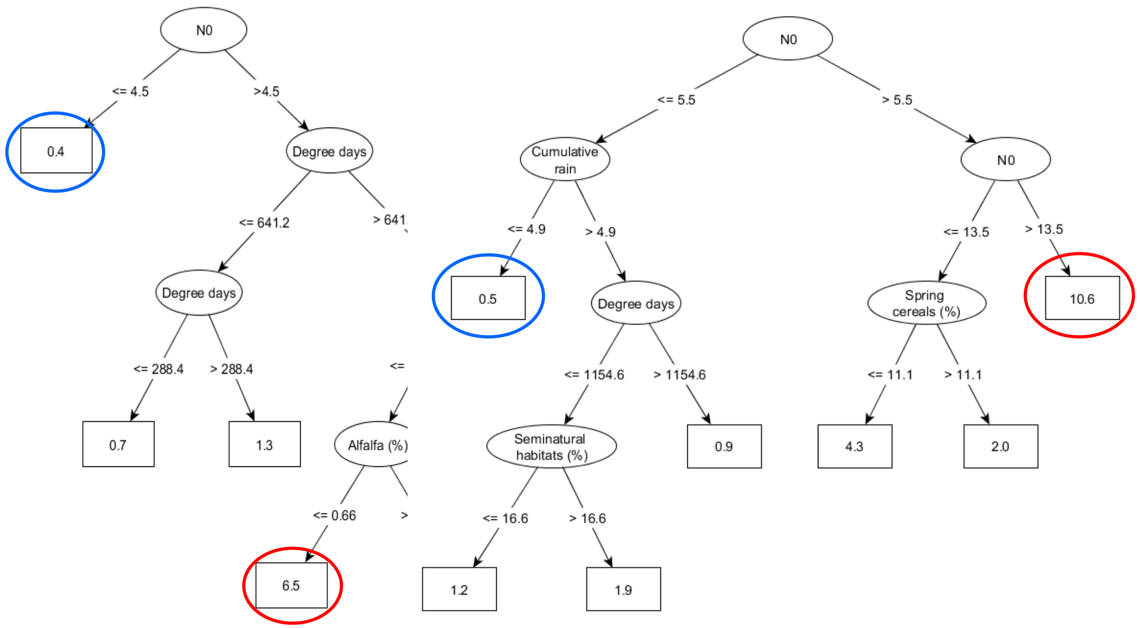

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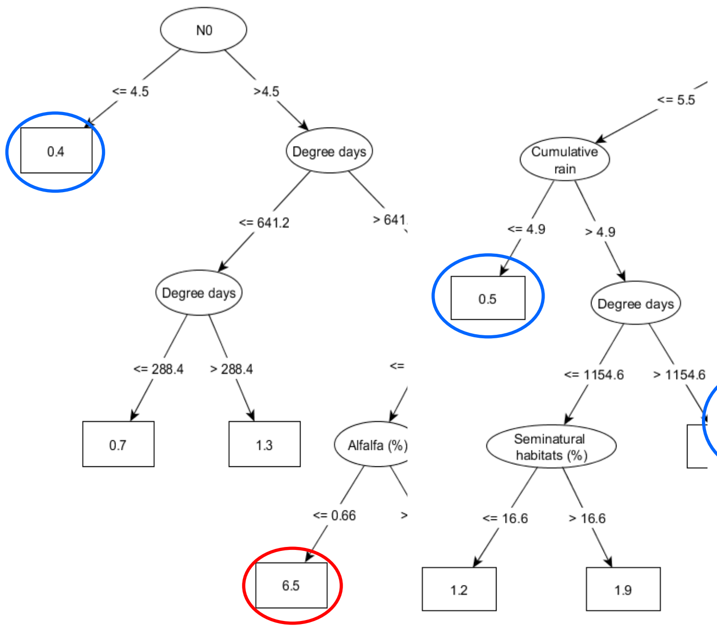

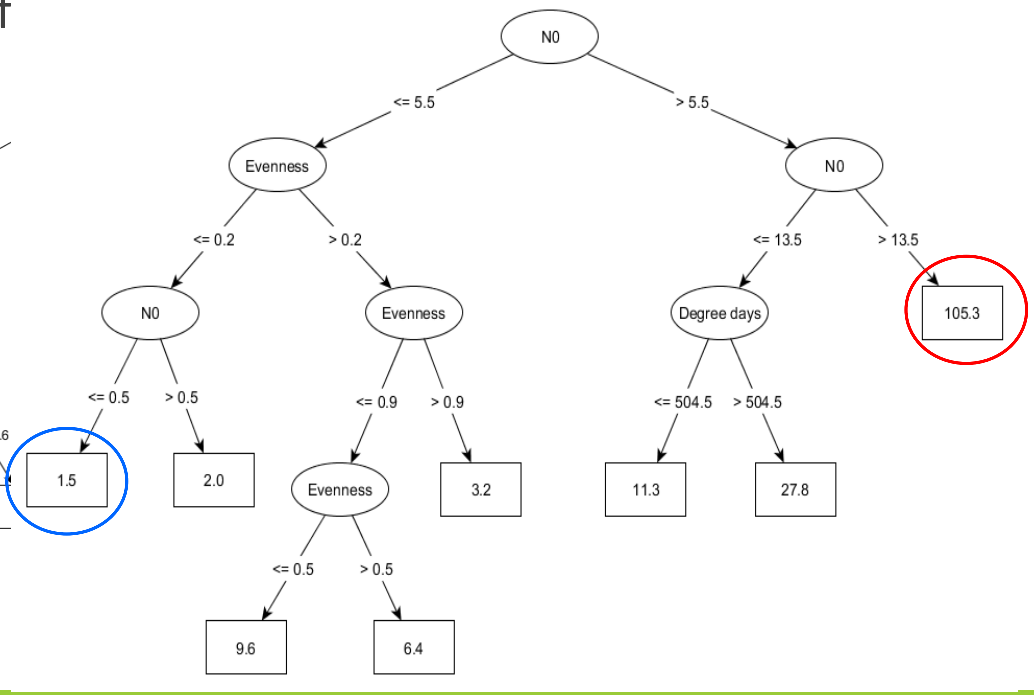

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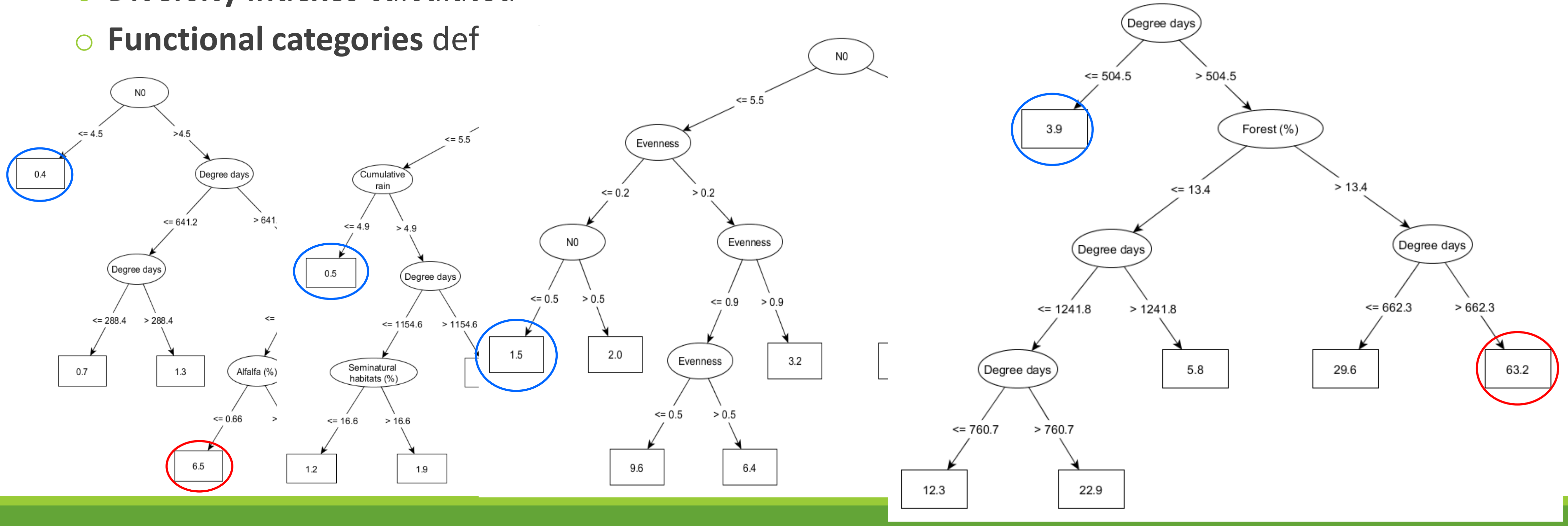

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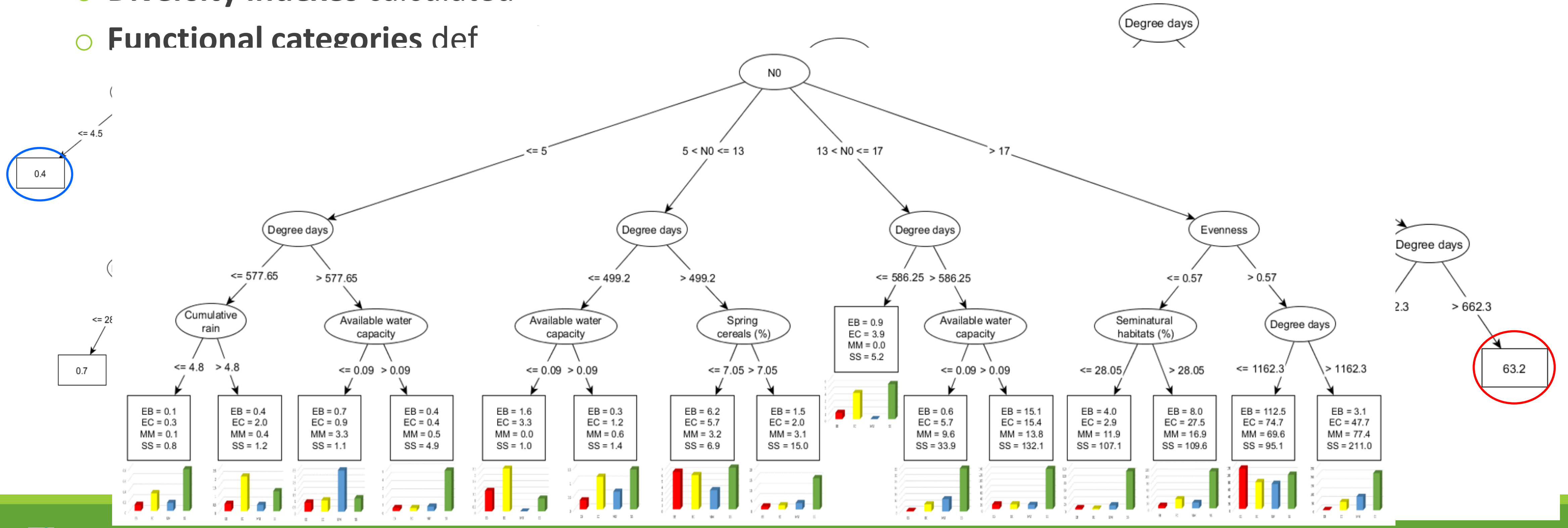


Assessment of soil functions

- **5 soil functions**
- **Goal:** development of the **Soil Navigator DSS** that operates on field level
- Provides **advices** on the management of soils that **optimizes** the 5 soil functions

Water regulation & purification

Carbon sequestration

Biodiversity

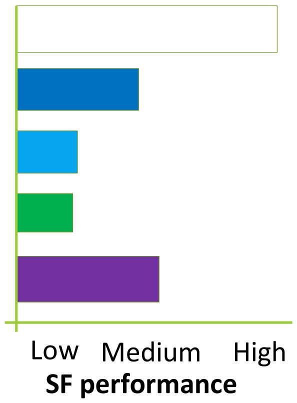
Nutrient cycling

Primary production

Assessment of soil functions

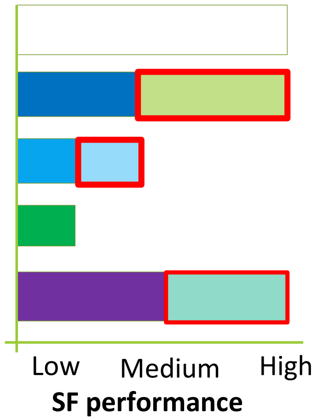
Assessing the performance of the **five soil functions**

- 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



Assessment of soil functions

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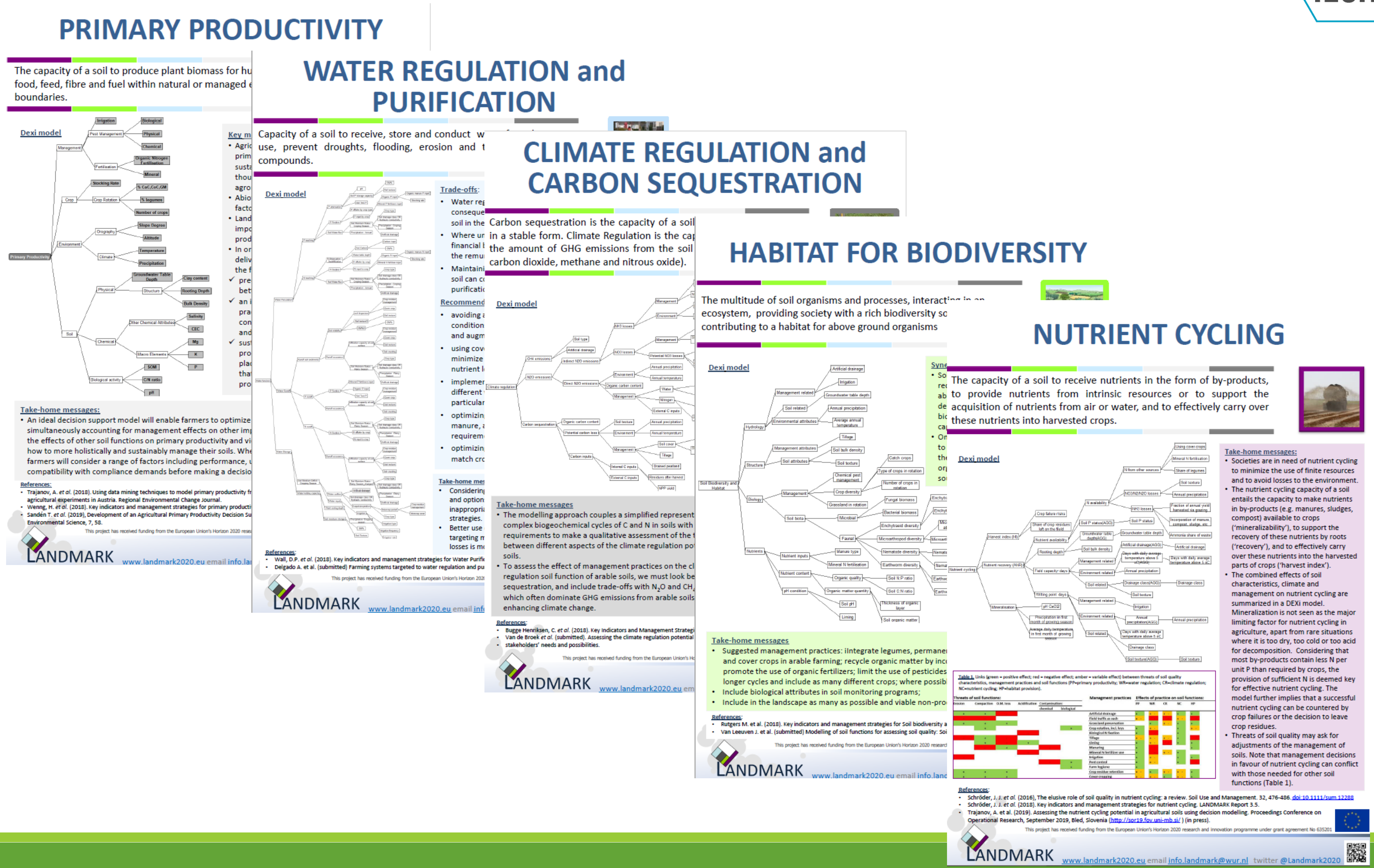

Assessment of soil functions

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PRIMARY PRODUCTIVITY

WATER REGULATION and PURIFICATION

CLIMATE REGULATION and CARBON SEQUESTRATION

HABITAT FOR BIODIVERSITY

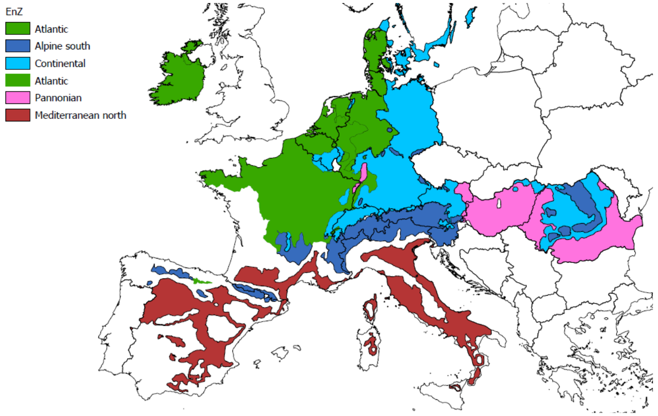
Soil function models	Total number of attributes	Number of aggregated attributes	Number of input attributes	Number of hierarchical levels	Number of integration rules
Primary productivity	42	16	25	4	294
Nutrient cycling	51	27	24	5	302
Climate regulation	540	21	19	5	301
Water regulation and purification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

Verification

Verification → Sensitivity analysis

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



Verification → Sensitivity analysis → Calibration

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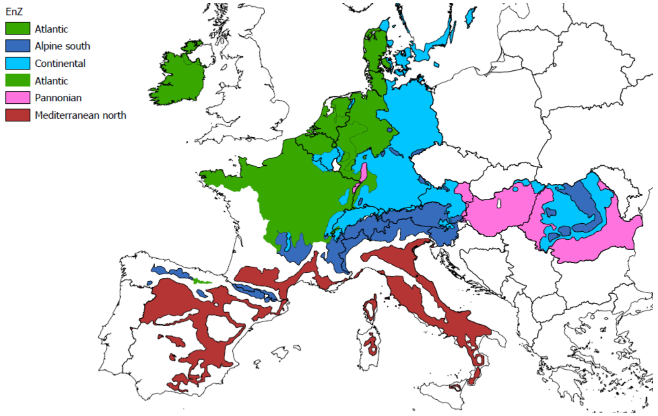

Verification → Sensitivity analysis → Calibration → Validation

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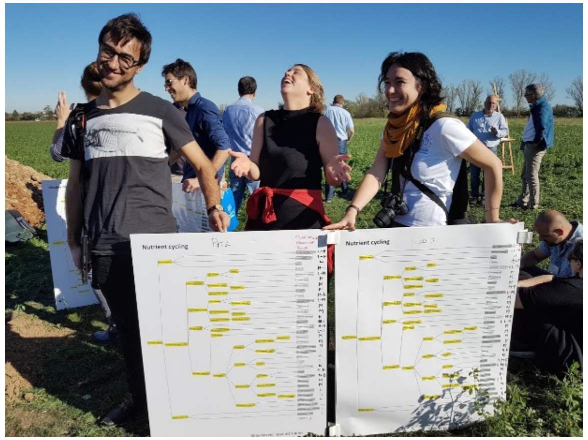
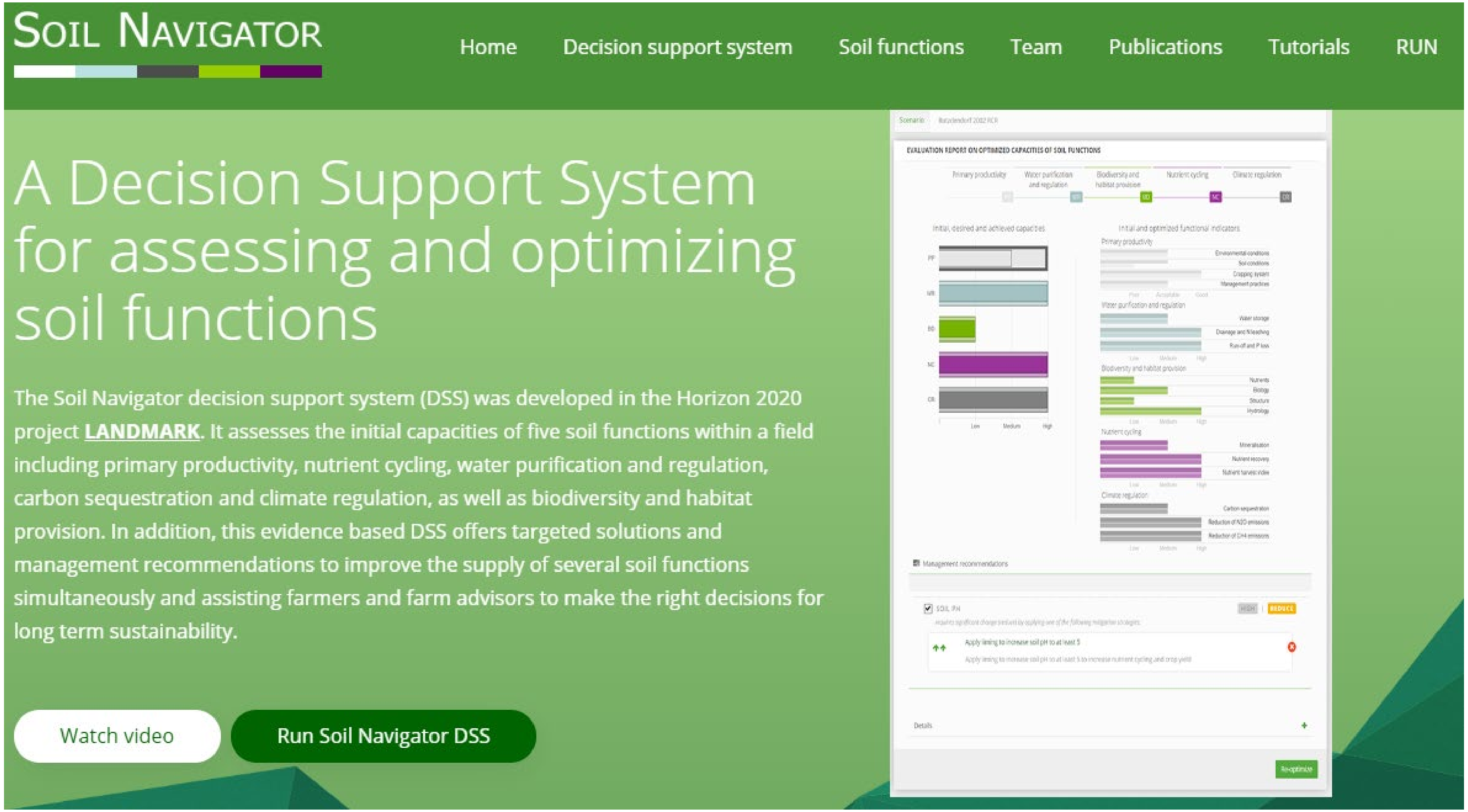


Soil Navigator

Open access: www.soilnavigator.eu



Graphical user Interface - Data Entry

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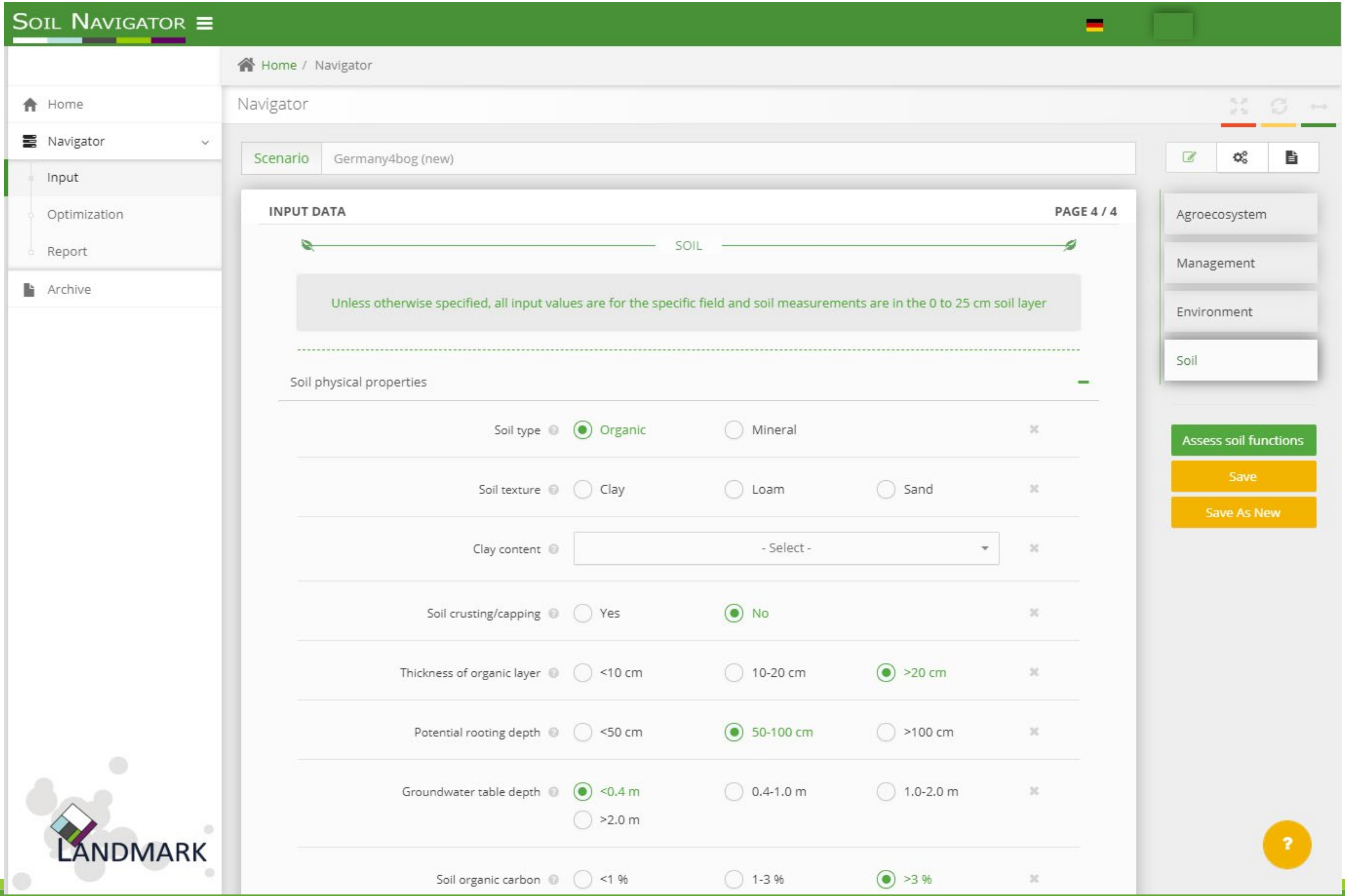
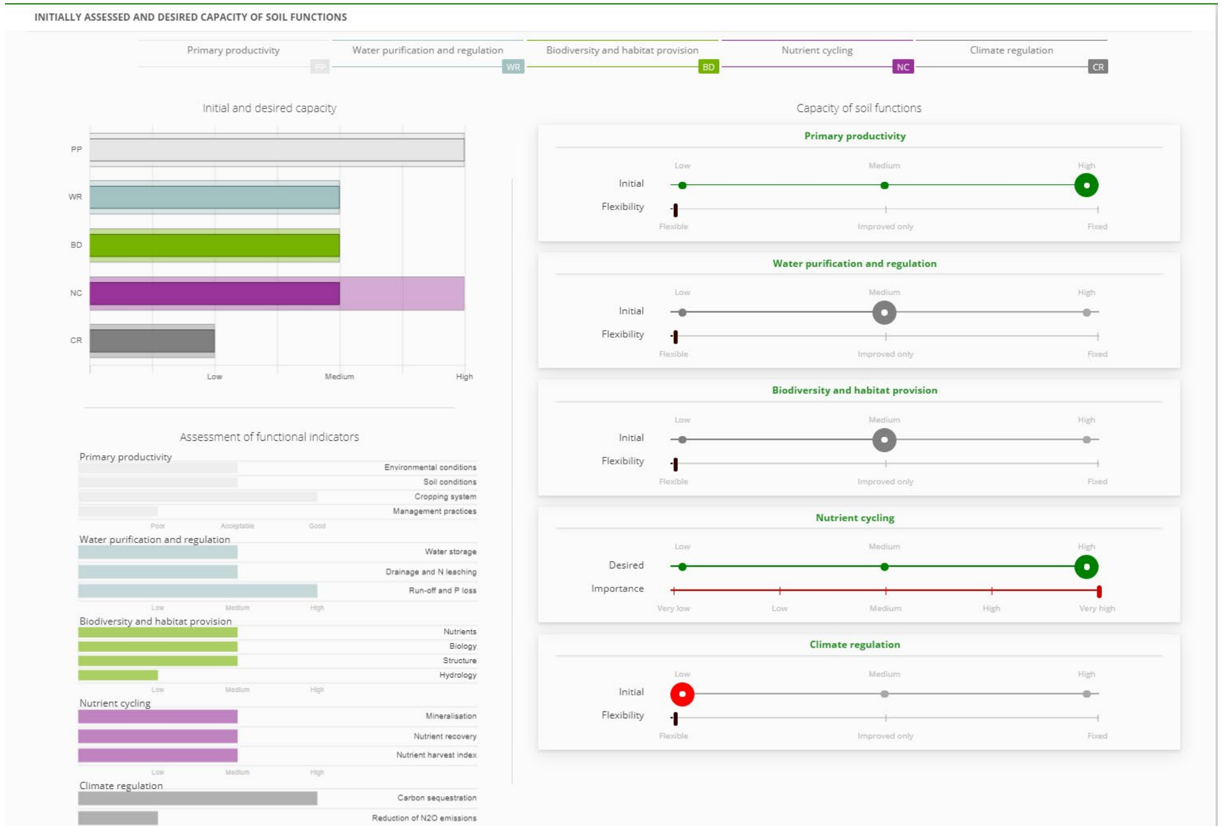
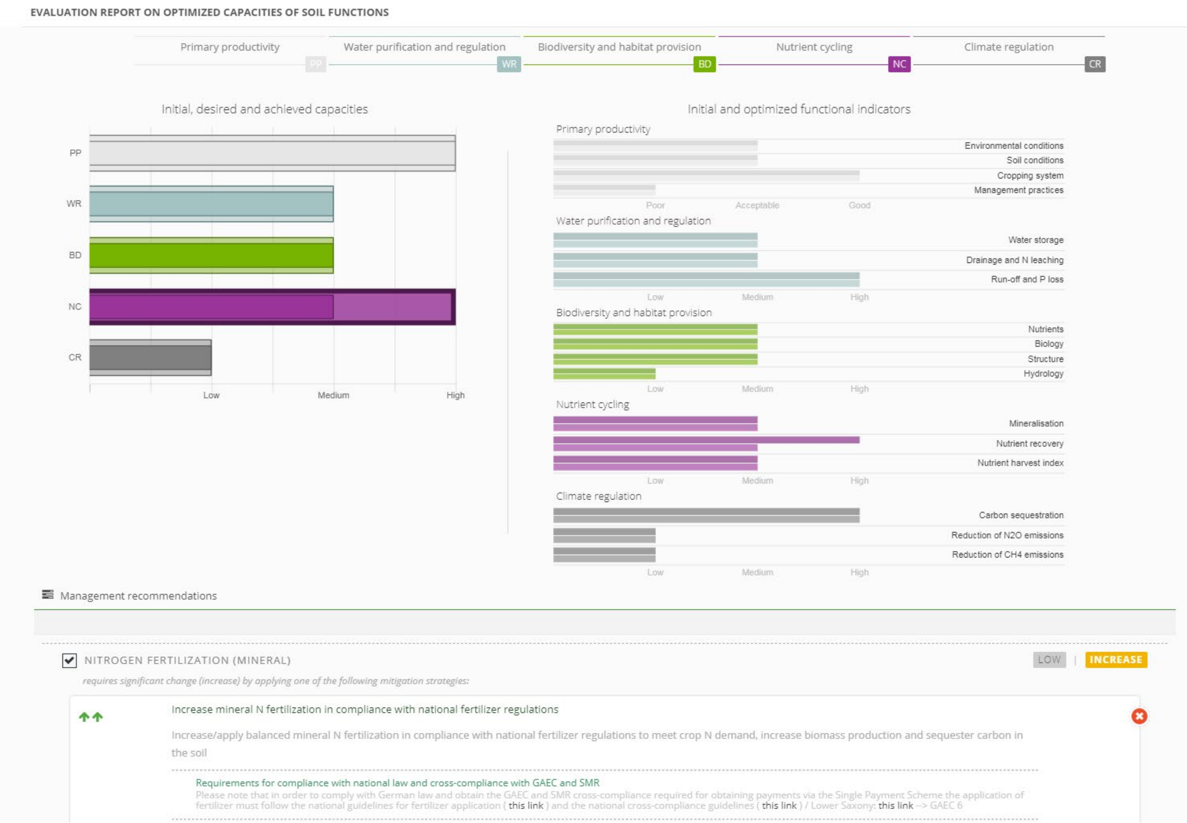


ASSESSMENT AND SUGGESTIONS FOR IMPROVEMENT OF THE SOIL FUNCTIONS



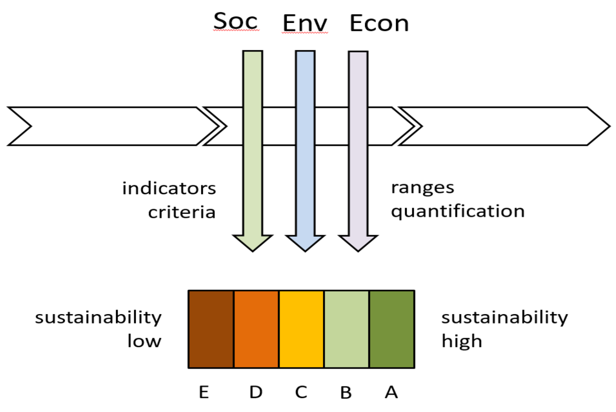


Sustainability of legume agri-food chains

- Identify **"transition paths"** to increase **sustainable legume cultivation and consumption** across Europe
- Include the **entire value chain** of legume feed and food
- Develop a **decision support tool** for primary producers, agronomists, processors, associated businesses and decision makers
  - Help determine a **range of options for successful transitions**
  - Take into account the **three different aspects of sustainability** and their intersections

Sustainability of legume agri-food chains

Sustainability of legume agri-food chains



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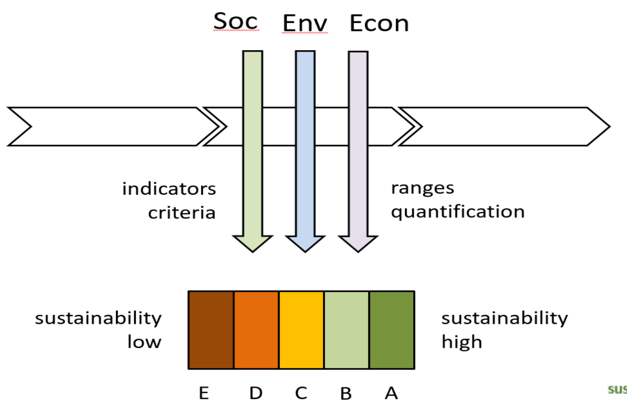

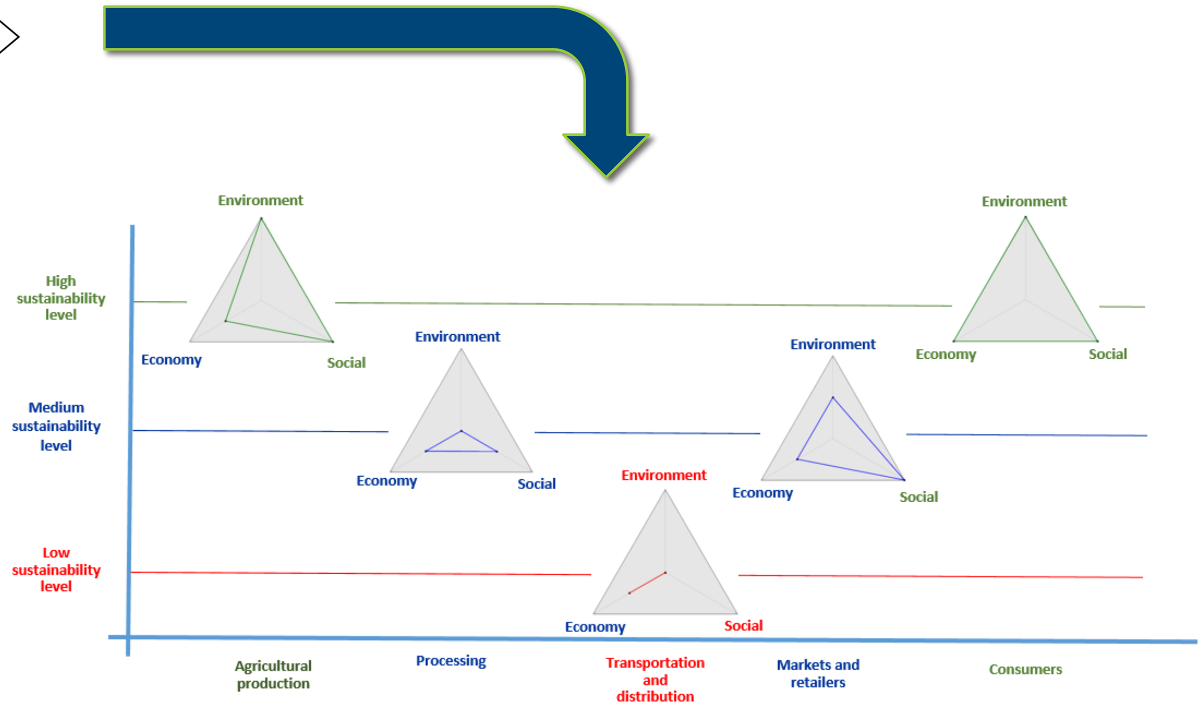

Sustainability of legume agri-food chains

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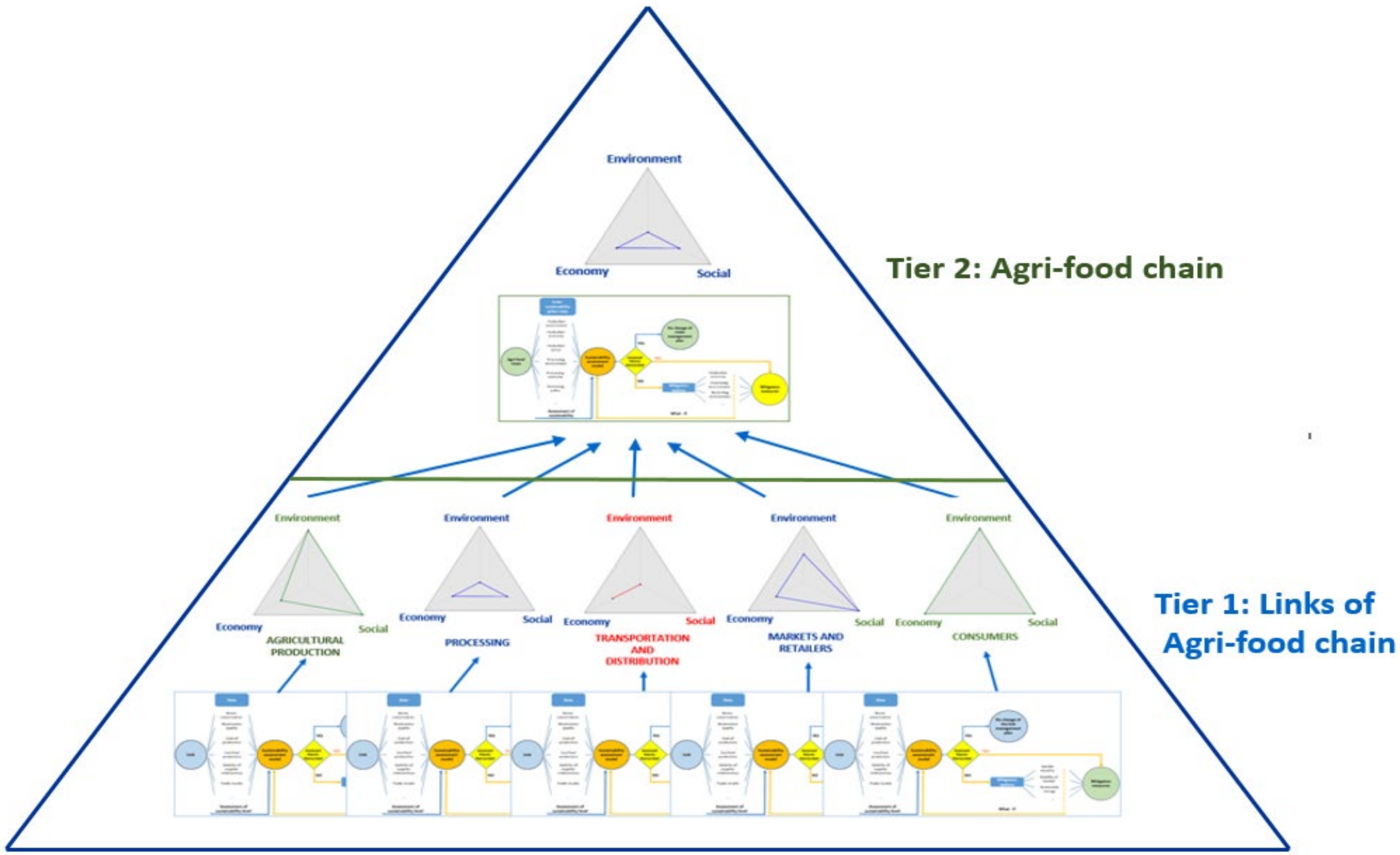

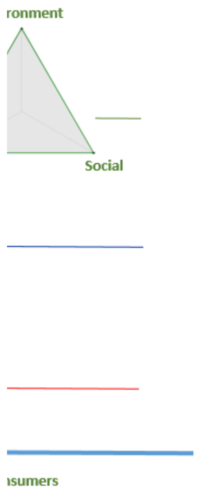

Sustainability of legume agri-food chains

An integrated decision support system for assessment of the sustainability of legume systems

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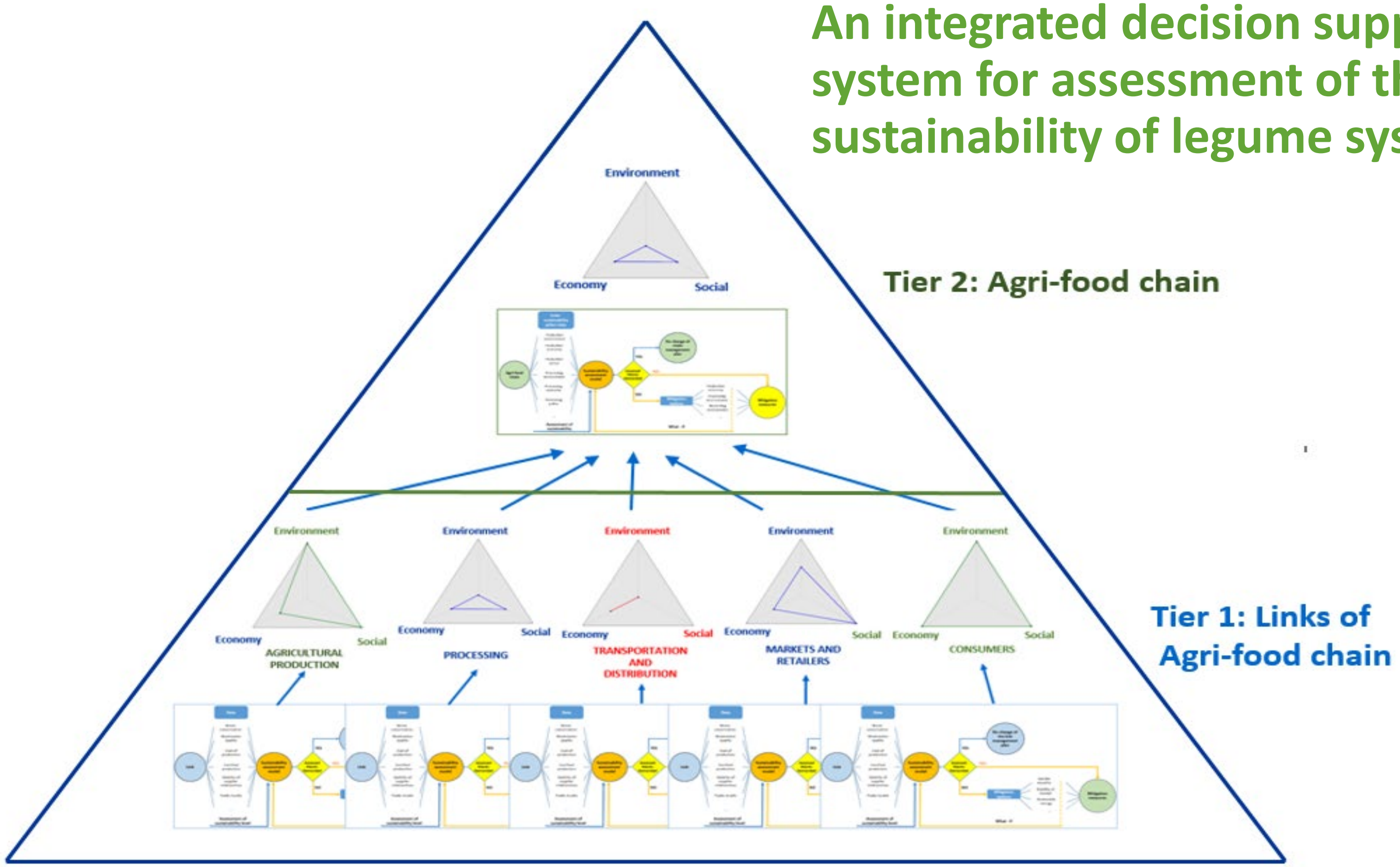
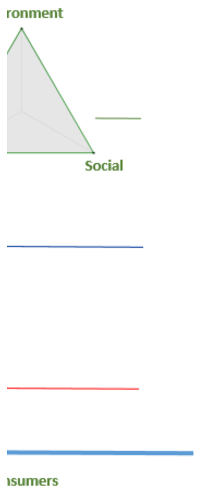
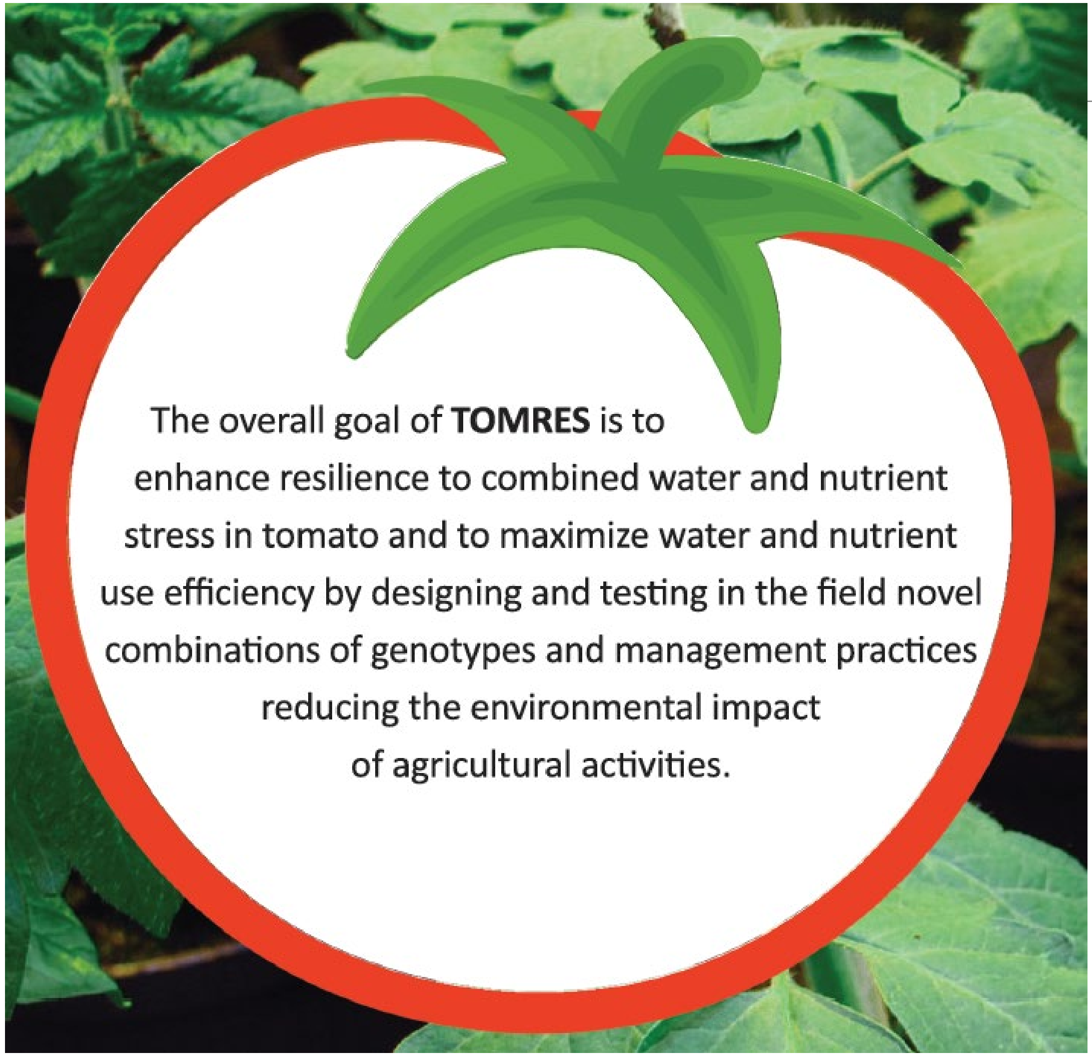




Tomato resilience and resource use efficiency



- Goals:
  - To **investigate the factors** that **influence the water, nitrogen** and **phosphorus use efficiency under experimental conditions** using **machine learning**
  - To **assess open-field** and **glasshouse tomato production** from **socio-economic, environmental** and **RUE perspective** using **qualitative decision modelling**

Conclusions

- Agriculture is becoming **digital**
- **AI in agriculture** is already a **reality**
- More efficient and **sustainable agriculture**
  - Environmental benefits
- Some **disadvantages**:
  - Modernization/digitalization of agriculture is **expensive**
  - **Decrease in employment** and workforce in the agricultural sector