Interreg
EUROPEAN UNION
North-West Europe
NWE-REGENERATIS
European Regional Development Fund


# SMARTIX development

2nd Advisory Board Meeting 4th October 2022

# Tasks for the SMARTIX development

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## Activity I

Acquisition of the SMARTIX Input data related to Mineral processing techniques applied in laboratories on samples from the 3 demonstration sites, to prepare mined waste and raw materials for reuse (led by CTP).

2

## Activity II

Acquisition of the SMARTIX Input data related to Metallurgy techniques applied in laboratories on samples from the 3 demonstration sites, for metals recovery (led by MPI)

3

## Activity III

Acquisition of the SMARTIX Input data related to Post extractive remediation innovative technics applied in laboratory on samples from the 3 demonstration sites (and other additional sites), for eco-catalyst production (led by IX )

4

## Activity IV

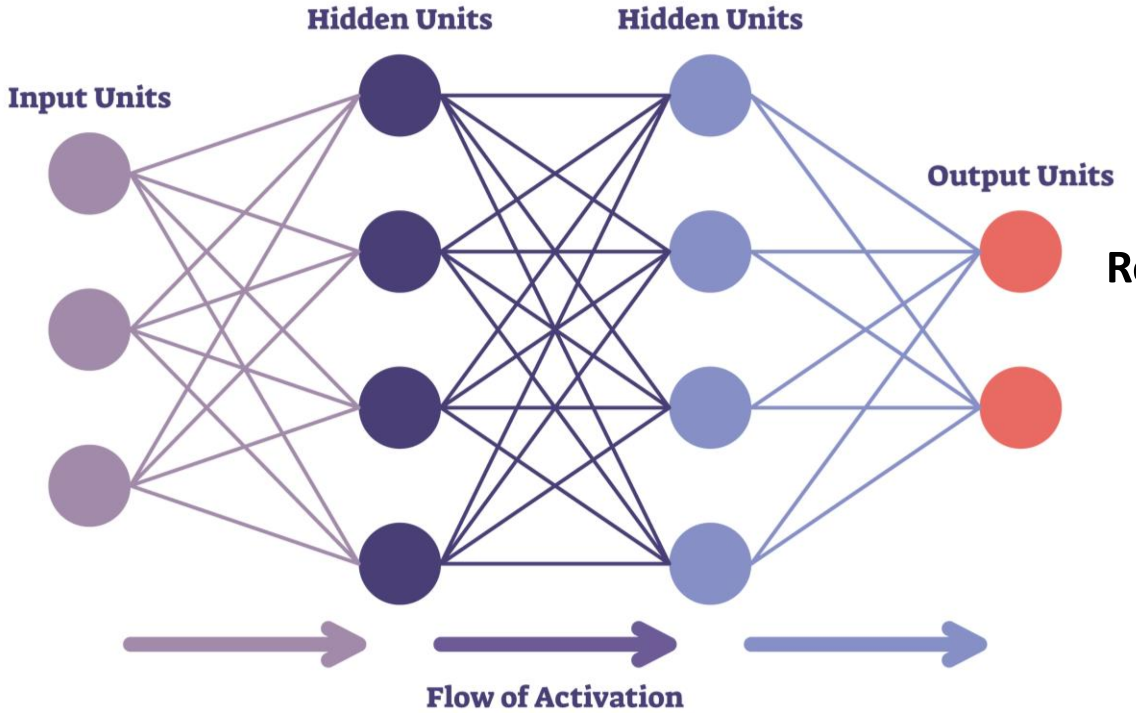
Design of the SMARTIX, the Decision Support Tool (DST) to evaluate the options for the regeneration of Past Metalurgical Sites and Deposits (PMSD) through the valuation of raw materials (led by IX with support from THK)

## Overall goal of the SMARTIX system

- Use available site information to predict which methods for site investigation, excavation, mineral and metallurgical processing as well as eco-catalyst production are best suited.

**Input Data**

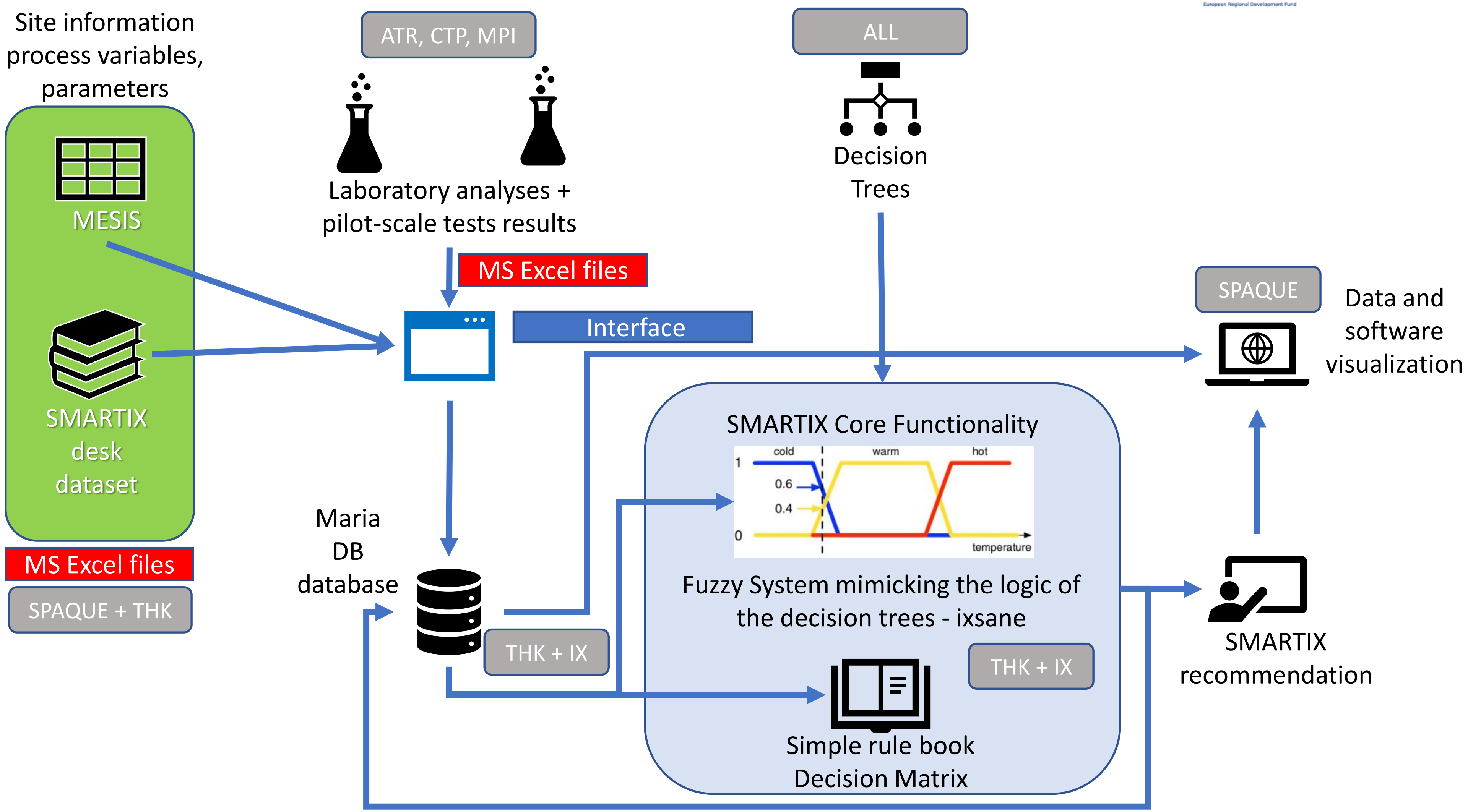
**MESIS**
and
**SMARTIX desk dataset**




**Recommendation for best suited method**

- There are separate models created and trained for each category for the first three sites and tested on the additional sites.

# Setup of data sources, data flow and longtime data storage



# SMARTIX Decision Trees

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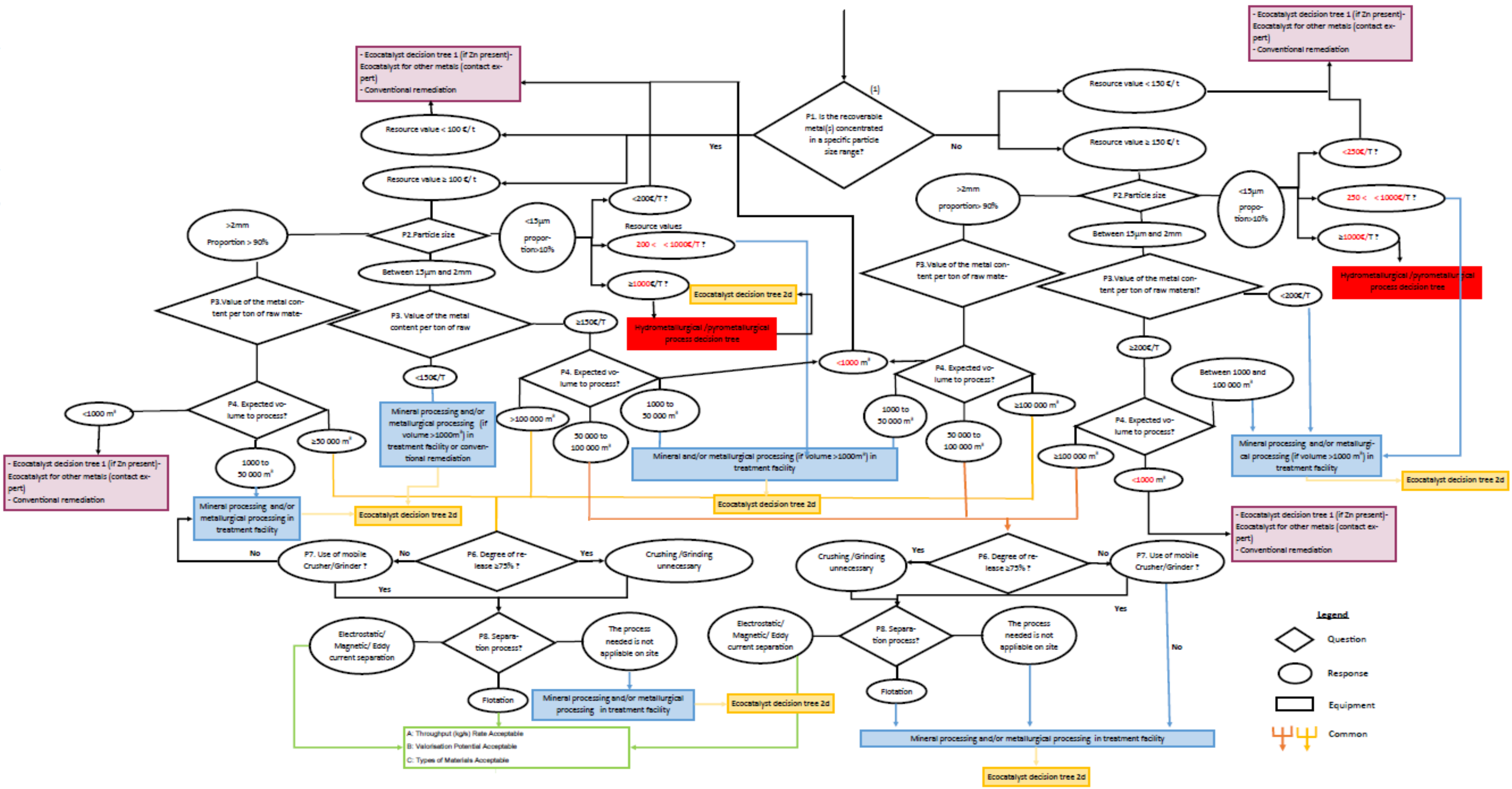
- The decision trees show the range of input values and how the processes depend on them.



# SMARTIX desk dataset

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- Tables for the relevant site data have been developed by IXANE and CTP and filled out for all sites plus additional fictive but realistic data that will be used for training.

| Metal case study N° | | Unit | Site 1 | Site 2 |
|---|---|---|---|---|
| | Comments/Desription | | | |
| Sample Description | | | | |
| Accessibility | Presence of access road wide enough for the transit of vehicles (excavators, etc.) | | | |
| Approx tonnage | Minimum Economic Quantity | (kt) | | |
| Hazardness | Heavy metals, PAHs, BTEX, hydrocarbons | | | |
| Presence of metal scrap | Gross percentage in waste | | | |
| Fe/Steel scrap | | (%) | | |
| Al scrap | | (%) | | |
| Zn scrap | | (%) | | |
| Pb scrap | | (%) | | |
| Particle size | Particle size of waste In-situ | | | |
| > 100 mm | | (%) | | |
| < 100 µm | | (%) | | |
| Chemical composition | | | | |
| Fe grade | | (%) | | |
| Fe° (metal) grade | Native Fe in waste (BF slag for ex) | (%) | | |
| Zn grade | | (%) | | |
| C grade | | (%) | | |
| S grade | May require a pre-processing stage for high S | (%) | | |
| Cu grade | | (%) | | |
| Al2O3 | cement (pozzolanic material) | (%) | | |
| CaO grade | cement, C sequestration | (%) | | |
| Quicklime grade | cement, C sequestration | (%) | | |
| SiO2+Al2O3+Fe2O3 grade | | (%) | | |
| MgO grade | Swelling properties | (%) | | |
| Cr2O3 grade | Pollution Cr(VI) | (%) | | |
| ZrO grade | | (%) | | |
| Pre-treatment | In situ or outside | | | |
| Crushing | To reduce size or liberate components | | | |
| Screening | To remove fine particle and/or reduce PSD range | | | |
| Magnetic separation | To recover ferrous (Fe) particles | | | |
| Gravimetric separation | | | | |
| Eddy current separation | To recover non-ferrous (Al/Cu) particles | | | |
| Electrostatic separation | | | | |
| Pelletizing of fines | | | | |
| Technology or Use | Availability must be considered in the decision | | | |
| Sintering and blast furnace | | | | |
| Waelz kiln or Rotary hearth | | | | |
| Electric arc furnace | | | x | |
| Hydrometallurgy | To extract metal or remove pollutant | | | |
| CO2 capture | | | | |
| Sustainable cement production | By-product | | | |

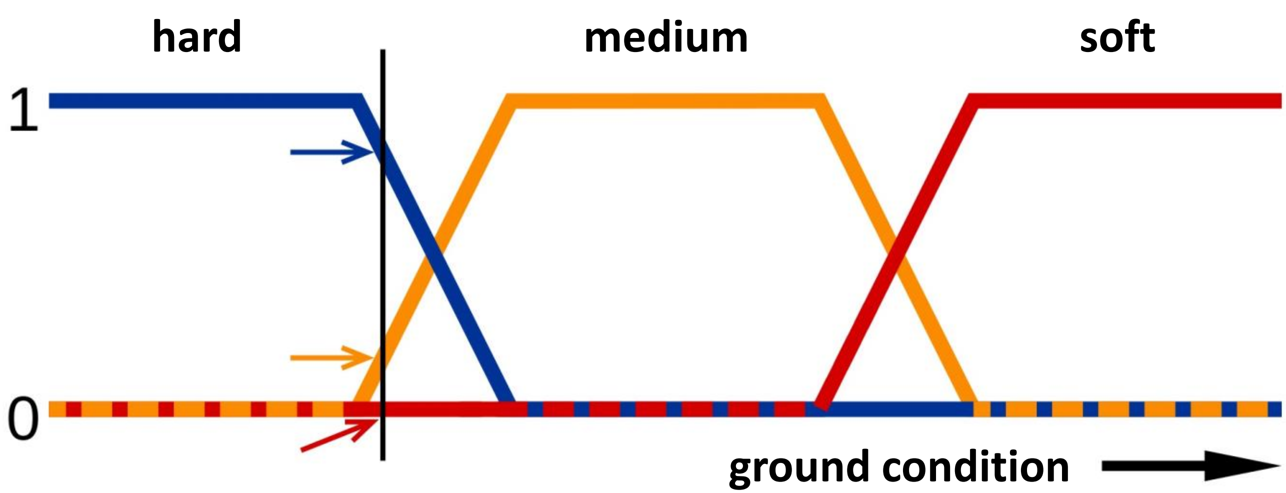
| Mineral case study N° | | Unit | 1 | 2 |
|---|---|---|---|---|
| | Comments/Desription | | | |
| Sample Description | | | Refractories | Cast sand |
| Accessibility | Presence of access road wide enough for the transit of vehicles (excavators, etc.) | | Good | Good |
| Approx tonnage | Minimum Economic Quantity | (kt) | > 100 | > 100 |
| Hazardness | Heavy metals, PAHs, BTEX, hydrocarbons | | Yes | Yes |
| Presence of metal scrap | Gross percentage in waste | | | |
| Fe/Steel scrap | | (%) | < 1 | < 1 |
| Al scrap | | (%) | < 1 | < 1 |
| Zn scrap | | (%) | < 1 | < 1 |
| Pb scrap | | (%) | < 1 | < 1 |
| Particle size | Particle size of waste In-situ | | | |
| > 100 mm | | (%) | > 50 | < 1 |
| < 100 µm | | (%) | | |
| Chemical composition | | | | |
| Fe grade | | (%) | | |
| Fe° (metal) grade | Native Fe in waste (BF slag for ex) | (%) | | |
| Zn grade | | (%) | | |
| C grade | | (%) | | |
| S grade | May require a pre-processing stage for high S | (%) | | |
| Cu grade | | (%) | | |
| Al2O3 | cement (pozzolanic material) | (%) | > 25 | |
| CaO grade | cement, C sequestration | (%) | | |
| Quicklime grade | cement, C sequestration | (%) | | |
| SiO2+Al2O3+Fe2O3 grade | | (%) | | |
| MgO grade | Swelling | (%) | | |
| Cr2O3 grade | Pollution Cr(VI) | (%) | > 25 | |
| ZrO grade | | (%) | > 2 | |
| | | | | |
| Pre-treatment | In situ or outside | | | |
| Crushing | To reduce size or liberate components | | x | |
| Screening | To remove fine particle and/or reduce PSD range | | x | x |
| Gravimetric separation | | | x | |
| Electrostatic separation | | | | |
| Pelletizing of fines | | | | |
| | | | | |
| Technology or Use | Availability must be considered in the decision | | | |
| Washing | To remove pollutant | | x | x |
| Thermal plasma | Stabilization/immobilisation of pollutants | | | |
| Sustainable cement production | By-product | | | x |
| Recovery in road sub-base | By-product | | | x |
| Recycling / material recovery | | | x | x |
| Soil improvement | | | | x |

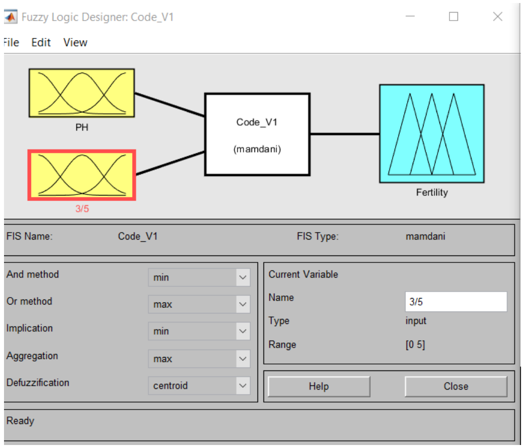
# The SMARTIX Fuzzy System

- Instead of using exact input values, Fuzzy Logic can work with ranges of values that are itself overlapping.
  - Is excavation difficult? (Yes or No) – Binary decision
  - Is excavation difficult? (Very, Medium, A little, Not) – Fuzzy decision

- How to combine several input values in order to get a result? – A set of rules.

- If the ground is hard and the terrain is steep and the metals are deep in the ground, the excavation is difficult.



# The SMARTIX Fuzzy System – Example ECO-Catalyst

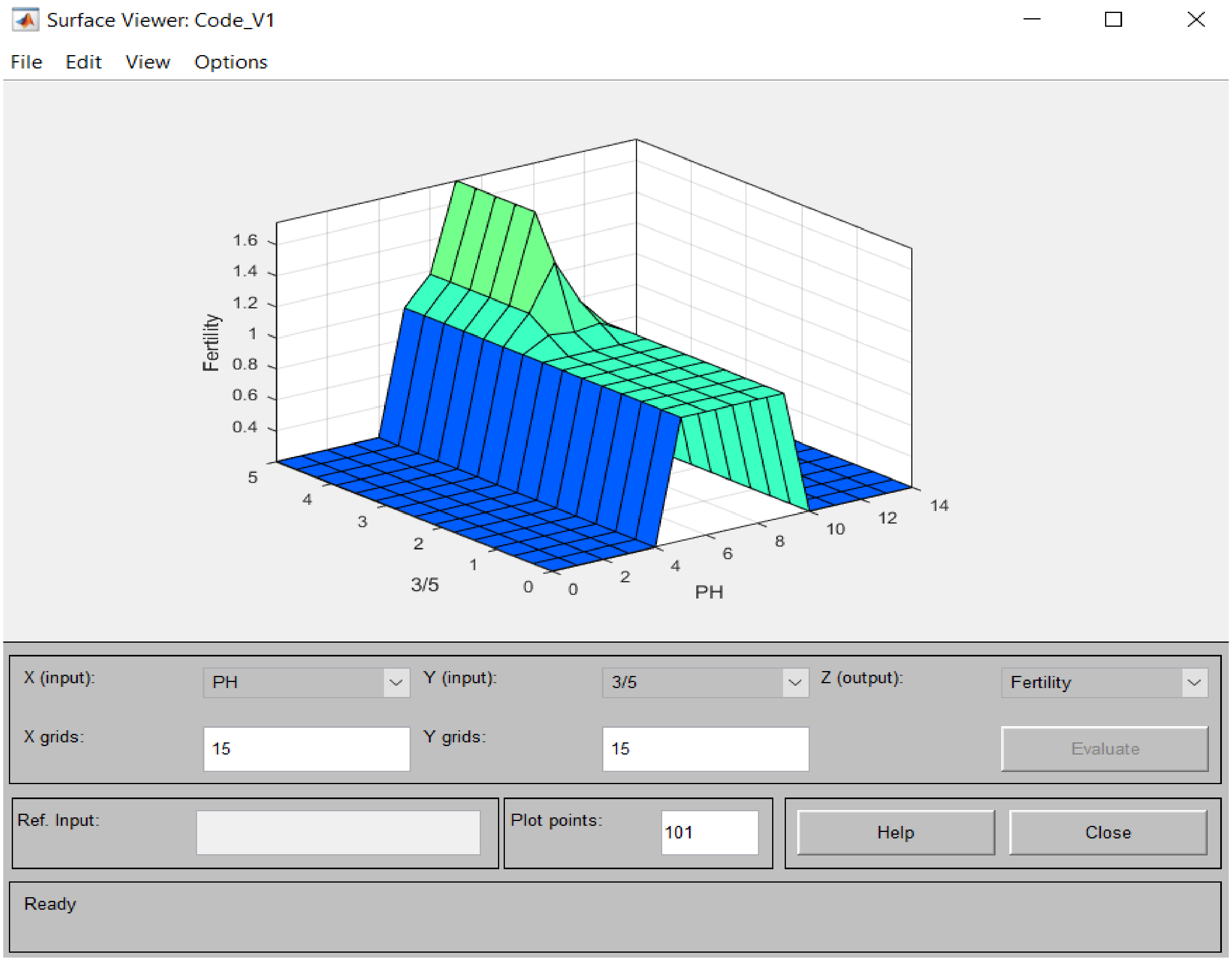
- For each of the inputs the three input ranges need to be defined.

| Inputs module 1 | Range | | 0 | 1 | 2 |
|---|---|---|---|---|---|
| Surface | <1ha // >1ha | | <0,5ha | 0,5ha<..<1ha | >1ha |
| Fertility | [0 2] | | 0 | 1 | 2 |
| Zn in soil | >1g/kg // <0,5g/kg | | <0,5g/kg | 0,5<..< 1g/kg | >1g/kg |
| **Interest** | **[0 2]** | | **Low** | **Medium** | **High** |

- For every possible combination of the input values, the site interest is defined in rules.

| Soil | F | 0 | | | 1 | | | 2 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Zn | S | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 2 |
| 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 2 |
| 2 | | 0 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 |

# The SMARTIX Fuzzy System – Example ECO-Catalyst



# The SMARTIX AI – Data Preprocessing

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**STEP I**

Identification of measurement errors and data gaps

Data cleaning

**STEP II**

Data smoothing and filtering

If necessary interpolation

**STEP III**

Unifying sample interval

Graphical representation of dataset

**STEP IV**

Data normalization

0 to 1;

0 mean, std 1

etc.

**STEP V**

Application of data analysis methods

# The SMARTIX AI – Example ECO-Catalyst

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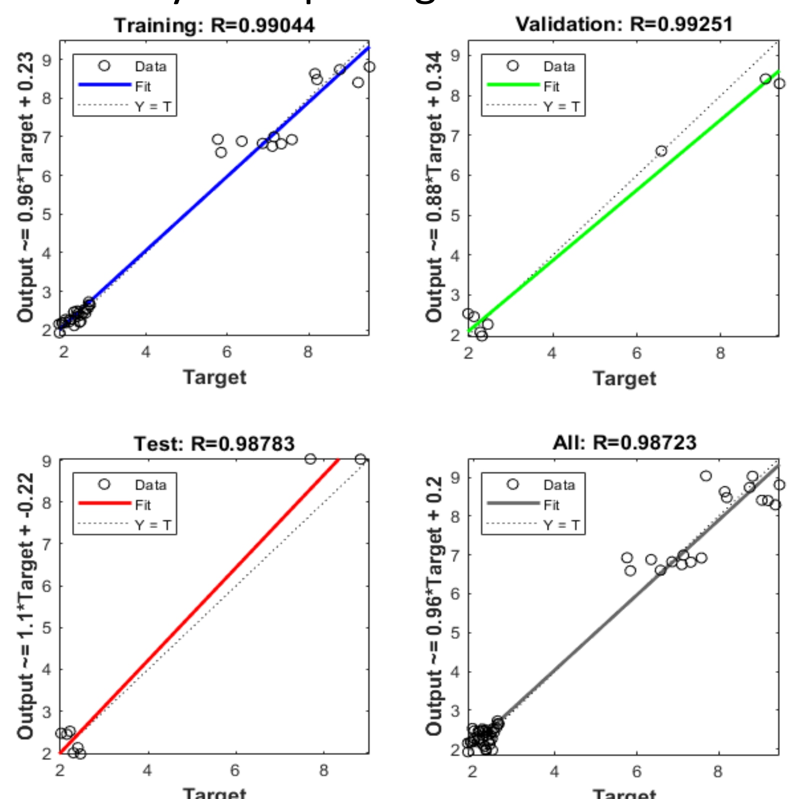
- For each input variable it is investigated how it influences the output in a so called sensitivity analysis.
- Results are the discussed and validated by the experts in the project.
- The result is a correlation matrix that indicates dependencies.
- The results show that in the case of fertility a simple regression is sufficient for modeling.

# The SMARTIX – Next steps

- Finish the SMARTIX desk dataset.
- Define Fuzzy sets and rules.
- Develop and train the AI-models.
- Run tests on mineral, metallurgical and geophysics data sets.
- Finish the SMARTIX database.

# Thank you.