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Geographic Object-Based Image Analysis to delineate mapping units for land suitability assessment

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INTRODUCTION

- **Land suitability assessment (LSA)** provides geospatial information about growing crops where they are best suited.

- it can play a crucial role in addressing contemporary challenges such as a sustainable production (e.g., reduce soil erosion, pollution, nutrient depletion).

- Digital LSA is most often conducted using **conventional soil map units** → manually delineated on the map.

INTRODUCTION

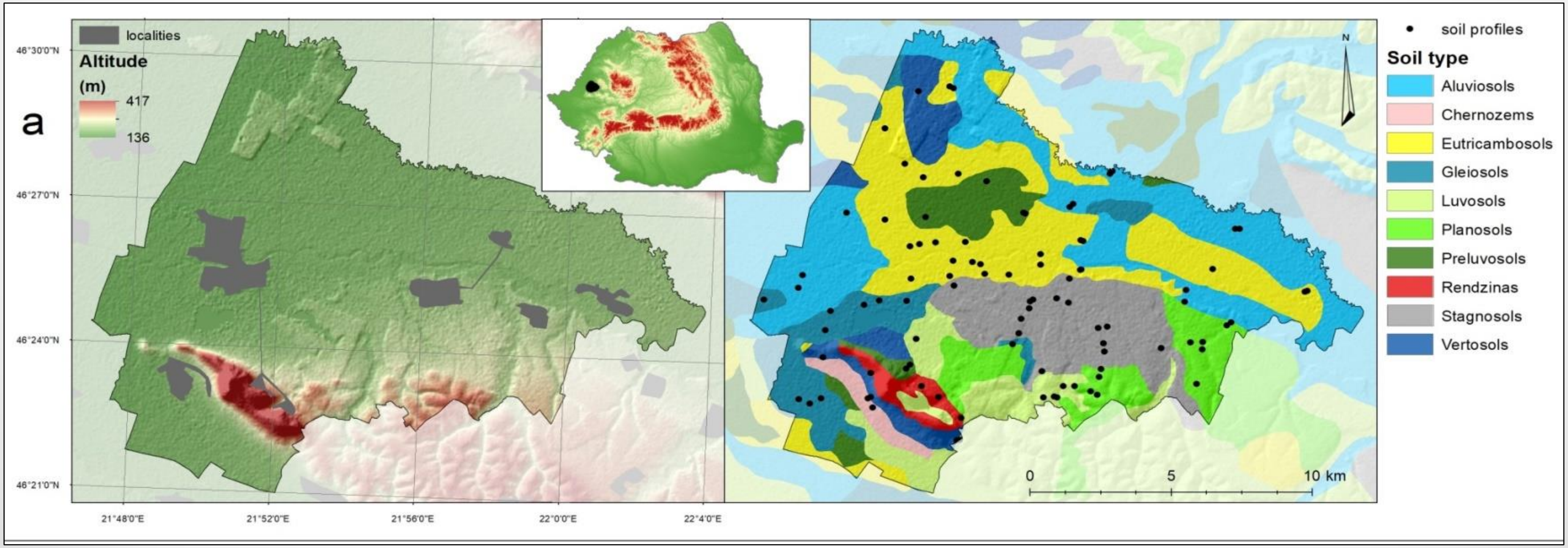
- the subjectivity of the manual delineation disregard the fact that **other methods** have been proven useful for helping soil experts in the process of objectively delineating mapping units → Geographic Object-Based Image Analysis (GEOBIA).

- GEOBIA was recently successfully tested for digital soil mapping → improved accuracy.

- This work presents preliminary results of LSA conducted using **two mapping units**: 1) conventional soil map units; 2) polygons delineated in a semi-automatic and objective manner using GEOBIA.

MATERIAL AND METHODS

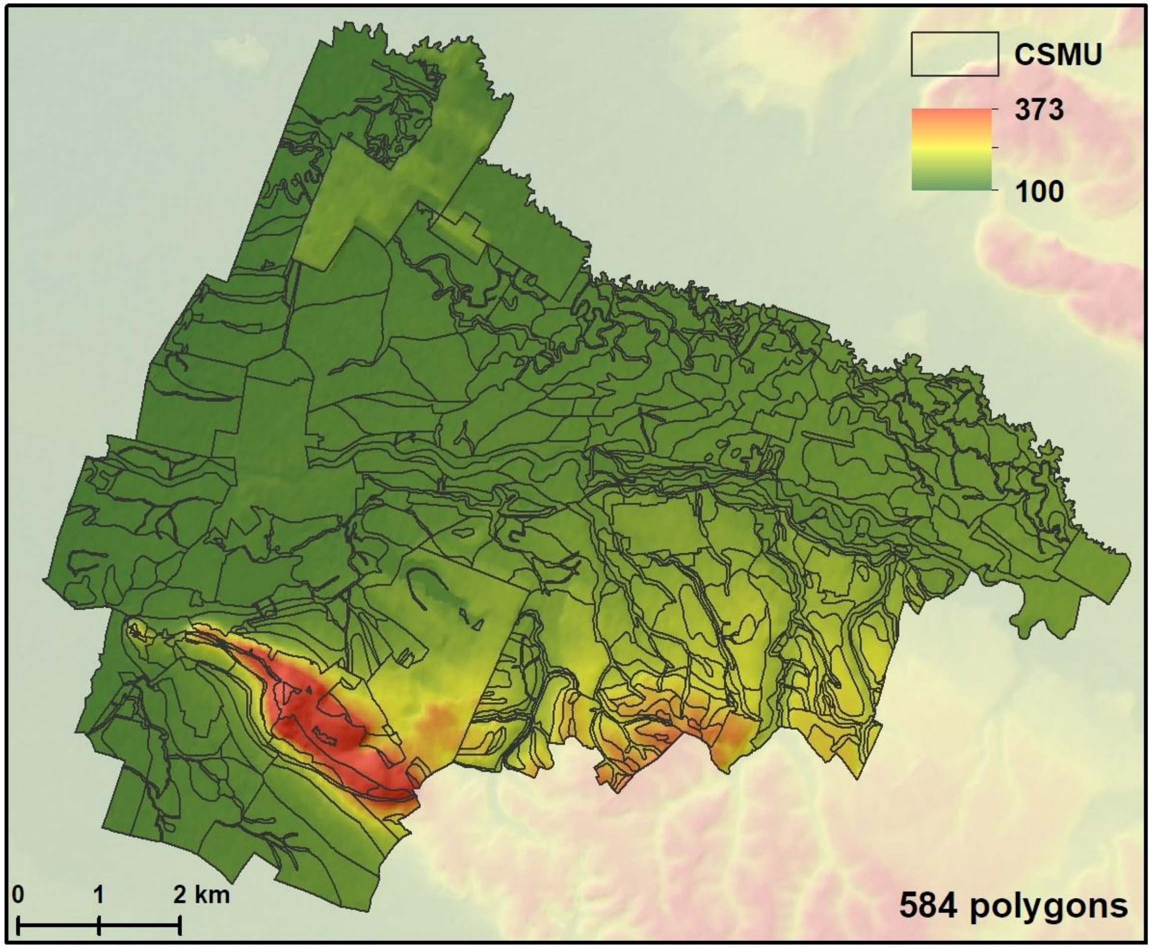
The study area is located in western Romania, with a digital soil database consisting of 92 georeferenced soil profiles.



MATERIAL AND METHODS

1) conventional soil map units

- non-overlapping polygons manually delineated on the map by soil scientists, characterized by soils with similar characteristics.

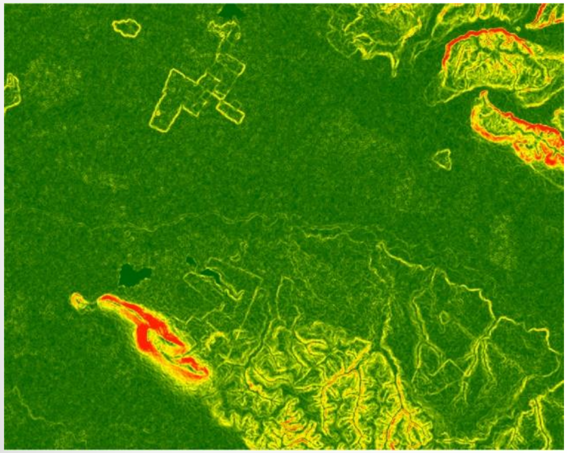


MATERIAL AND METHODS

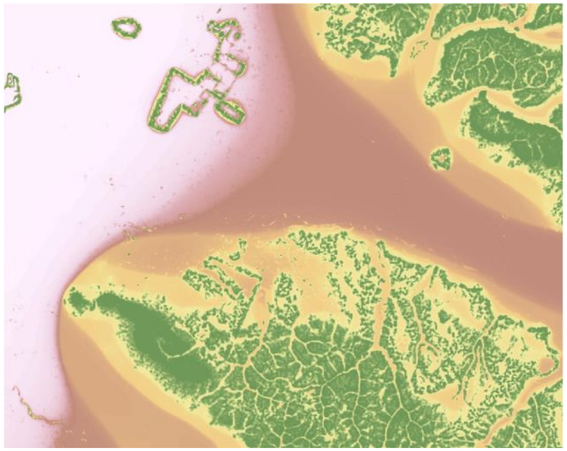
2) polygons delineated in a semi-automatic and objective manner using GEOBIA

- 3 digital terrain models (DTMs) used for segmentation into polygons → multi-resolution segmentation (MRS) algorithm

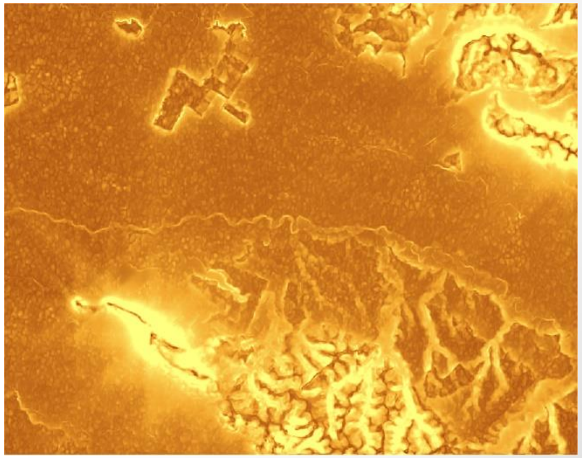
slope



multi-resolution index of valley bottom flatness (MrVBF)



positive topographic openness



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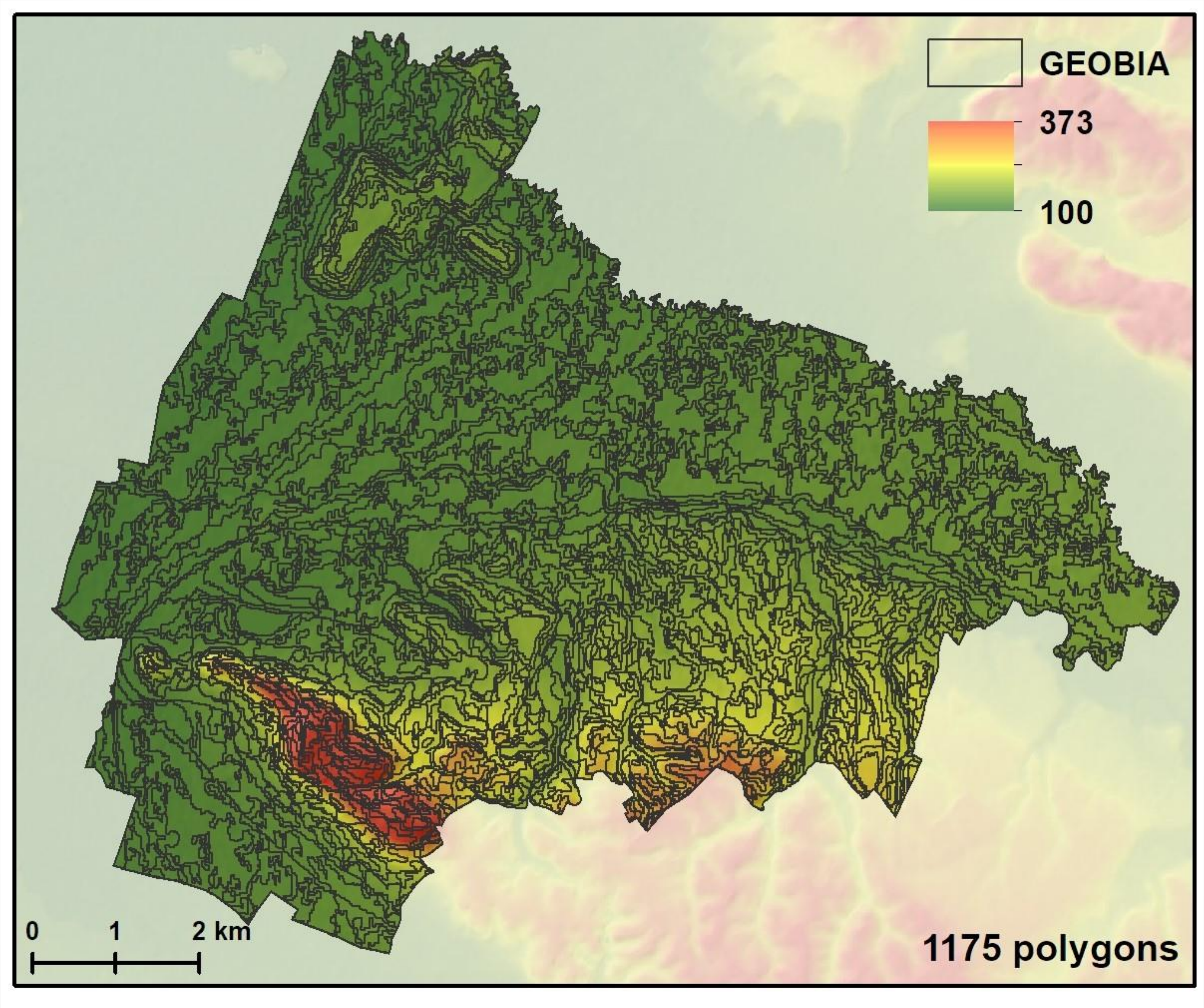
MATERIAL AND METHODS



MATERIAL AND METHODS

- **existing Romanian LS methodology** - developed based on a huge amount of data, as well as statistical analyses to calculate the suitability rating (Florea et al., 1987)
  - conditions for plant growth
  - environmental and land conditions
  - agricultural yield
- multiplicative parametric technique, designed as a relational database
- developed based on the FAO guideline for land evaluation.

MATERIAL AND METHODS

- We use georeferenced soil profiles with field-measured soil properties and DTMs to **digitally map 18 eco-pedological indicators**

No.	Indicator	Data/method
1	mean annual temperature	https://www.worldclim.org/
2	total annual precipitation	https://www.worldclim.org/
3	groundwater table depth	https://aquaknow.jrc.ec.europa.eu/en/content/global-patterns-groundwater-table-depth-wtd (Fan et al., 2017)
4	flooding risk	https://data.jrc.ec.europa.eu/dataset/jrc-floods-floodmapgl_rp10y-tif (Dottori et al., 2016)
5	salinization/ alkalinization	https://data.mendeley.com/datasets/v9mgbmtnf2/1 (Hassani et al., 2020)
6	soil pollution	https://esdac.jrc.ec.europa.eu/content/maps-heavy-metals-soils-eu-based-lucas-2009-hm-data-0 (Tóth et al., 2016)
7	slope	Derived from 25 m EU-DEM v1.1 using RSAGA
8	texture class in 0-20 cm	RF prediction based on PP, SL, TP, TRI, VD
9	total porosity of restrictive horizon	RF prediction based on SL, GENC, SAGAWI, MrVBF, PP
10	soil pH in 0-20 cm	RF prediction based on SL, PLC, PRC, GENC, SAGAWI, MrVBF, VD, TP, PP
11	humus content in 0-50 cm	RF prediction based on GENC, SAGAWI, MrVBF, PP
12	carbonate content in 0-50 cm	RF prediction based on EL, MrVBF, PP, SAGAWI, SL
13	edaphic volume	RF prediction based on SL, TRI, VD, TP, PP
14	gleization	RF prediction based on MrVBF, SL, GWT
15	stagnogleyzation	RF prediction based on EL, DTB, TRI
16	landslides	RF prediction based on SL
17	moisture excess at the surface	Derived using the look-up table from RMLSA, based on: topography (depression vs non-depression areas), SL, PP, potential evapotranspiration (developed by Trabucco and Zomer (2019) - CGIAR-CSI), and soil permeability (estimated from soil textural classes)

MATERIAL AND METHODS

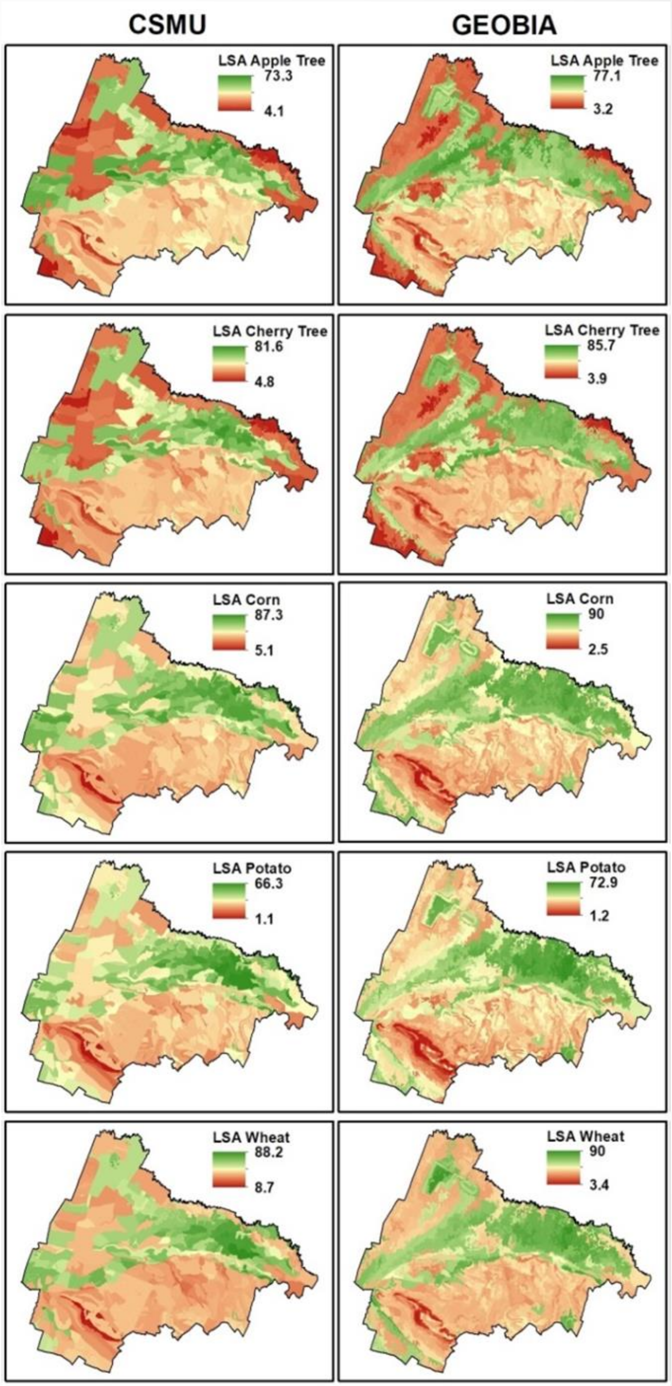
- lookup tables – **the maps are transformed into suitability ratings** for 14 crops, 7 fruit trees, and 2 land-use types, ranging from 0 (not suitable) to 100 (maximum suitability).

Ind. 3C cod	PS	FN	MR	PR	PN	CV	CS	PC	VV	VM	GR	OR	PB	FS	CT	SF	SO	MF	IU	IF	CN	LU	TR	LG
-03,0	0,3	0,2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0
-01,0	0,5	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0	0	0	0	0	0	0	0,1	0
01,0	0,6	0,4	0	0	0	0	0	0	0	0	0,1	0	0	0	0,1	0	0	0	0	0,1	0	0	0,2	0
03,0	0,8	0,6	0,2	0	0	0	0	0	0	0	0,2	0,1	0,1	0	0,2	0,1	0	0	0	0,3	0	0	0,3	0,3
04,5	0,9	0,8	0,3	0,1	0,1	0,1	0	0	0	0	0,5	0,5	0,1	0,1	0,6	0,4	0,1	0,1	0	0,5	0,1	0,1	0,5	0,5
05,5	0,9	0,9	0,5	0,3	0,3	0,3	0	0,1	0	0	0,7	0,7	0,3	0,2	0,7	0,6	0,2	0,4	0,1	0,7	0,2	0,2	0,7	0,8
06,5	1	1	O,6	0,5	0,5	0,5	0,1	0,2	0,1	0,1	0,8	0,8	0,5	0,3	0,9	0,8	0,4	0,6	0,3	0,9	0,5	0,4	0,9	0,9
07,5	1	1	0,9	0,8	0,8	0,8	0,4	0,4	0,2	0,1	0,9	0,9	0,8	0,5	1	0,9	0,6	0,8	0,5	1	0,7	0,6	1	1
08,5	1	1	0,9	0,9	0,9	1	0,7	0,6	0,8	0,3	1	1	0,9	0,9	1	1	0,9	0,9	0,9	1	1	0,9	1	1
09,5	1	1	1	1	1	1	1	0,9	1	0,8	1	1	0,9	0,9	0,9	1	1	1	1	1	1	1	0,9	1
10,5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,9	1	1	1	1	0,9	1	1	0,8	1
11,5	1	1	0,9	0,8	0,8	0,9	1	1	1	1	1	1	1	1	0,8	0,9	0,9	1	1	0,7	0,9	1	0,7	1
12,5	0,9	0,9	0,8	0,7	0,7	0,8	1	1	0,9	1	0,9	1	1	1	0,7	0,8	0,8	0,9	0,9	0,6	0,8	0,9	0,6	0,9

Accuracy assessment

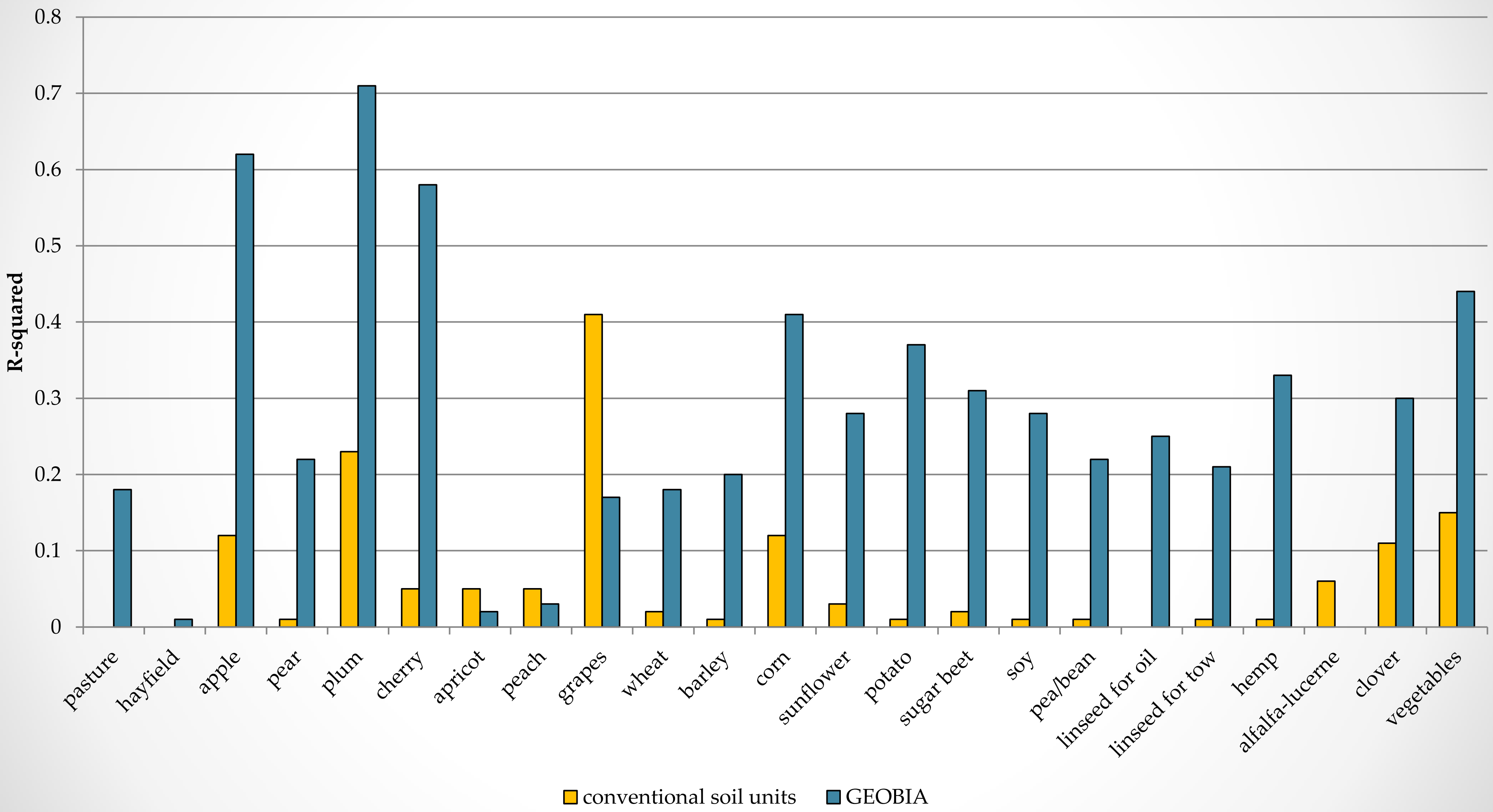
- root mean square error (RMSE)
- R-squared

RESULTS

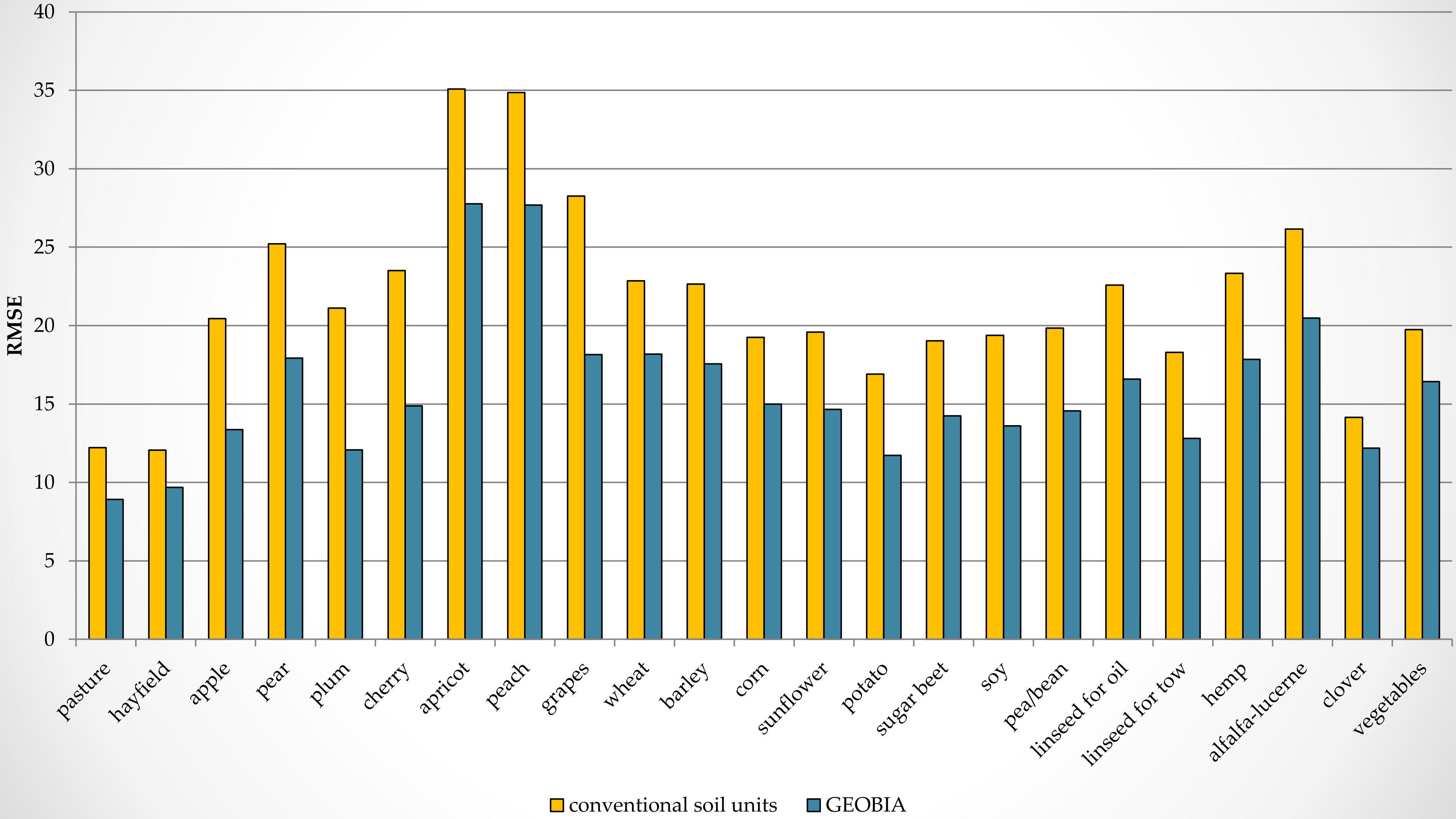


CSMU
GEOBIA
LSA Apple Tree
73.3
4.1
LSA Apple Tree
77.1
3.2
LSA Cherry Tree
81.6
4.8
LSA Cherry Tree
85.7
3.9
LSA Corn
87.3
5.1
LSA Corn
90
2.5
LSA Potato
66.3
1.1
LSA Potato
72.9
1.2
LSA Wheat
88.2
8.7
LSA Wheat
90
3.4

RESULTS


0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
R-squared
pasture
hayfield
apple
pear
plum
cherry
apricot
peach
grapes
wheat
barley
corn
sunflower
potato
sugar beet
soy
pea/bean
linseed for oil
linseed for tow
hemp
alfalfa-lucerne
clover
vegetables
conventional soil units
GEOBIA

RESULTS


RMSE
40
35
30
25
20
15
10
5
0
pasture
hayfield
apple
pear
plum
cherry
apricot
peach
grapes
wheat
barley
corn
sunflower
potato
sugar beet
soy
pea/bean
linseed for oil
linseed for tow
hemp
alfalfa-lucerne
clover
vegetables
conventional soil units
GEOBIA

DISCUSSION

- GEOBIA-based LSA maps should be used by farmers or land managers, who need delineated units as semi-permanent and stable regions to manage them as stable spatial entities.
- GEOBIA could improve the existing methodologies and procedures for LSA to crops, twofold:
  - higher accuracy
  - objective delineation of soil units treated as soil management units (homogenous agricultural uses)
- improving the accuracy of spatial prediction of the 10 eco-pedological indicators (e.g., by collecting more georeferenced soil profiles, or finding more suitable predictors) must be the cornerstone for the future analysis if such maps would be used for operational purposes.

CONCLUSIONS

- Our work showed that **LSA based on GEOBIA units is more accurate than the conventional soil map units**

- on average among all crops/land-uses, **a 5.8 lower RMSE**, with individual values as lower as 9.03 for plum trees and 10.1 for grapes.

- The **R-squared metric** shows the same tendency, with GEOBIA units resulting in **a 0.19 higher accuracy** LSA, on average.

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Thank you!