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The spatial variability of different levels of electrical conductivity (EC) in croplands remains poorly captured by various remote sensing-based indices

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Introduction

The current status of soil salinity in croplands and insightful assessments for the future are urgent necessities in Mediterranean biogeography. As a proxy of salinity, the electrical conductivity (EC) of a solution or a mixture of soil and water in EC1:5 or ECe, or conversions between them, can be used. The potential of remote sensing data for spatial estimation of soil EC is well understood, but there are some difficulties in croplands (Hopmans et al., 2021). Exploratory analyses of soil EC and remotely sensed indices of point observations in different soil EC levels are needed before spatial modelling process.

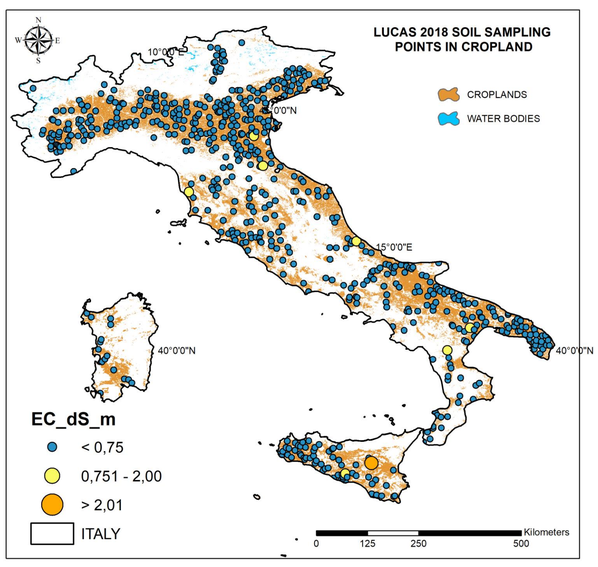

Figure 1: Study area and LUCAS 2018 sampling points on Croplands land use

Methodology

This study aims to assess the relationships, both quantitatively and qualitatively between different EC1:5 levels in Italian croplands using the LUCAS 2018 soil database (Fernandez-Ugalde et al., 2018) and some remote sensing-based indices commonly used as environmental variables for estimating soil EC in digital soil mapping. Salinity index (SI), normalized difference vegetation index (NDVI), and normalized difference soil index (NDSI) mean synthesis images were calculated from Sentinel 2 satellite images for April and September 2018 (with lower than 15% cloud cover) in the Google Earth engine environment at a resolution of 250 meters. The environmental variable values of 628 points in the croplands (Table 1) were extracted and their statistical relationships (Spearman correlation) with the soil EC values were analyzed. Qualitative assessments were carried out, focusing on spatial maps in an area representing the widest range of soil EC values.

Table 1: Dataset summary.

Site	EC level	Sampling amount
Italy	Low EC1:5 < 0.75 dS m^{-1}	620
	High EC1:5 > 0.75 dS m^{-1}	8
	Total	628

Results and Discussion

In Italy, out of 628 sampling points in croplands, 8 samples were found above 0.75 dS m^{-1} potentially indicating early sign of the salinization state threshold by FAO, with an average $EC_{1:5}$ of 1.22 dS m^{-1} for these 8 samples. The remaining 620 samples were found to be below 0.75 dS m^{-1} with an average $EC_{1:5}$ was 0.21 dS m^{-1} for these 620 samples (Table 1).

A statistically significant correlation between the Salinity Index-April and soil EC values above 0.75 dS m^{-1}, r: -0.69 ($p<0.05$) (Figure 2a), while no significant statistical relationship was found between NDVI and NDSI indices and soil EC values. There is no statistical relationship between the soil EC values below 0.75 dS m^{-1} and the considered indices, which could provide exploratory information (Figure 2b).

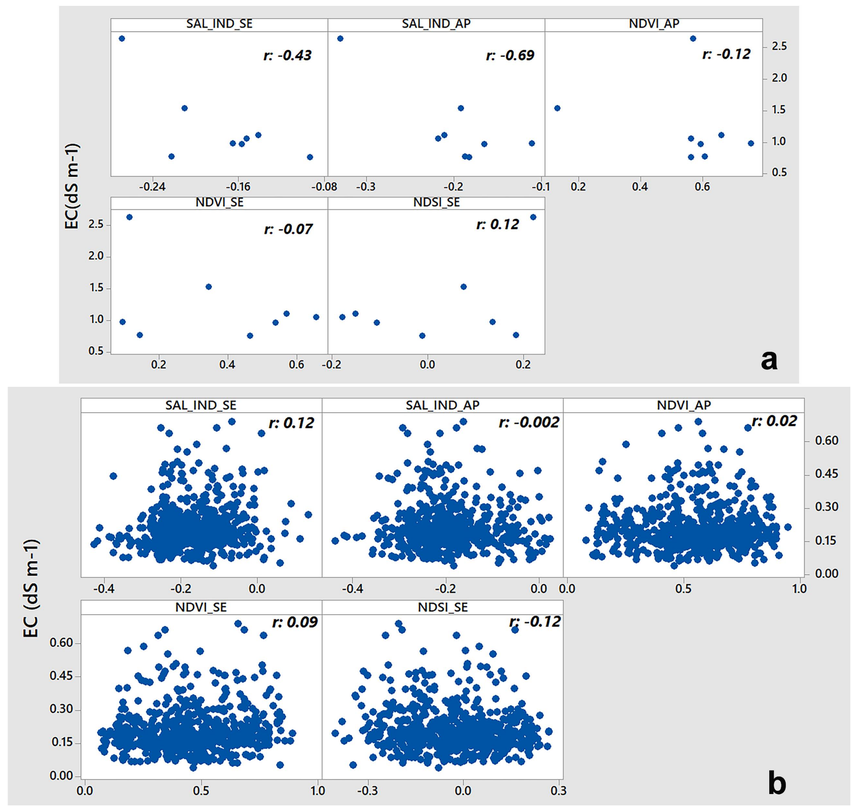

Figure 2: Correlations between Low and High EC values and environmental variables

In line with the qualitative assessments, it was observed that in areas where the variability of soil EC values was high, the variability of the considered indices was relatively low. This observation may have led to difficulties in capturing the variation of samples at different soil EC levels with the environmental variables we considered.

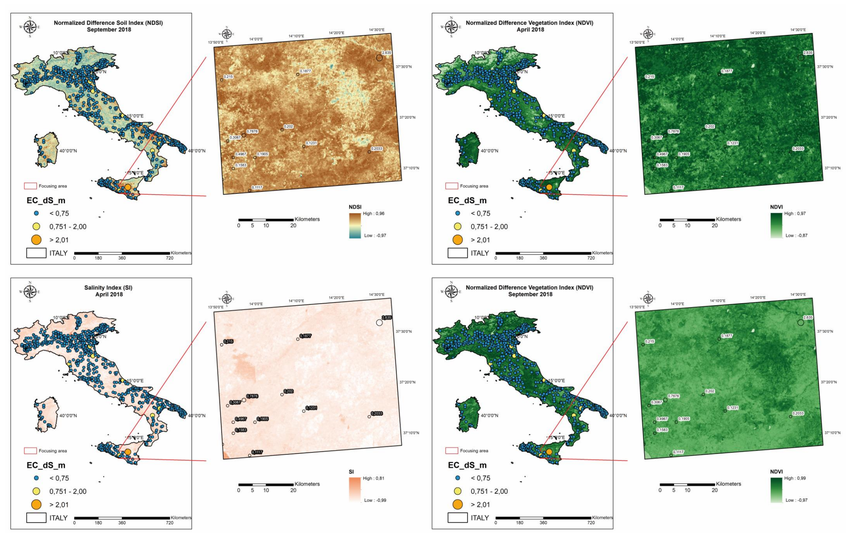

Figure 3: Overlaying of zoomed environmental variables from our study with EC values

To deepen the understanding of soil EC level mapping approaches and conduct exploratory analyses involving soil scientists to identify the environmental variables to be included in modeling, particularly in areas where croplands differ for mapping techniques that can provide early insights.

Conclusions

Particularly in the croplands, which are highly sensitive to the influence of the human environment, the focus should be on the development of new environmental variables that comprehensively characterize the information on the salinity relationships of sample points. Furthermore, the incorporation of foundational pedotransfer functions into soil EC assessment, considering soil texture's pivotal influence on soil water movement, is essential for comprehensive evaluation.

References

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