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Surface Electrical Resistivity Tomography: a non-invasive tool to assess compaction in paddy soils

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Objective and Study area

The physical properties of sandy loam paddy soils – specifically soil compaction – were investigated through ERT and the analysis of soil profiles with traditional methods, to **evaluate the effectiveness of ERT in assessing soil compaction**

Detection of depth, thickness and lateral continuity of compacted soil layers in paddy fields is of crucial importance for the assessment of the efficiency of the flooding irrigation

Lomellina, the most important Italian rice area

Lombardy, in the northern Italy

an area of 35 hectares, where winter flooding is practiced for a few years and since 2004 in some fileds

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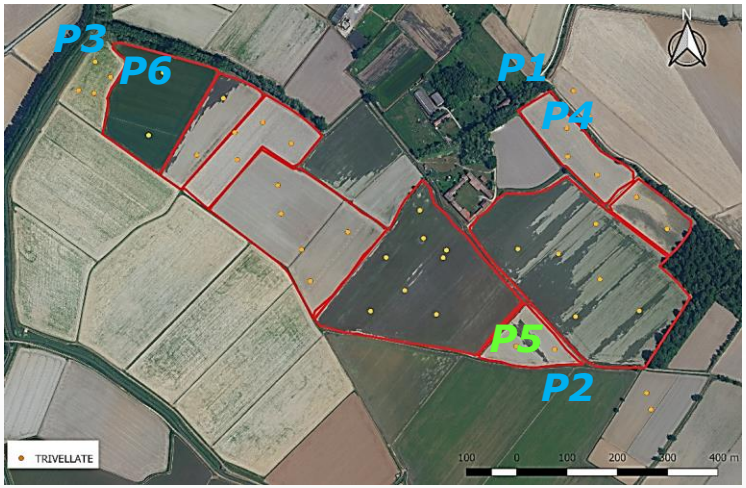
Soil survey



The effect of flooding (and winter flooding) on soil compaction was studied by comparing the soil survey results in locations with similar soils, within paddy fields (P4, P5, P6) and outside them (P1, P2, P3)

accurate description of soil horizons, including the compacted layer, were considered as reference data to evaluate the reliability of ERT results

Soil profile

After the winter flooding period, from the beginning of October until the end of January, soil surveys through **surface ERT and analysis of soil profiles with traditional methods** were carried out in **March 2018** in all the locations, and in **February 2019** only **in location P5**, to collect soil samples for texture, bulk density and porosity measurements.

Surface ERT

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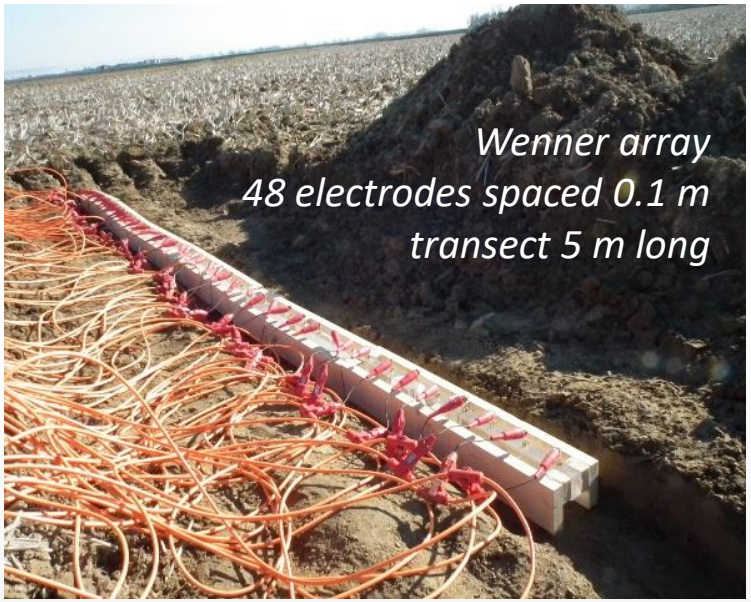
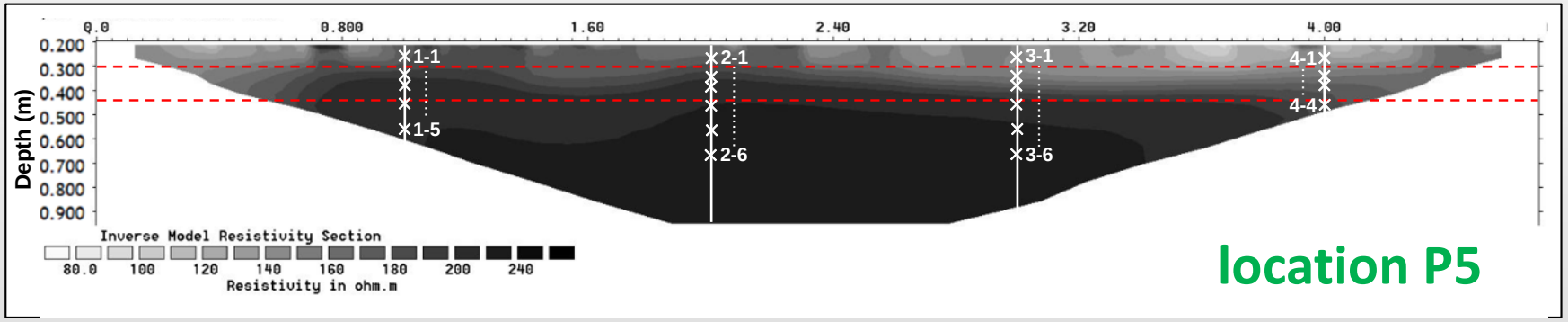
Experimental design

Surface ERT: short and thin electrodes spaced a few cm, to investigate with high vertical resolution the soil profile up to about 1 m depth.



Soil samples were collected along four profiles, at different depths and distances along the ERT transect, to measure **texture**, **bulk density** and **porosity**.

Volumetric soil water content was measured at different depths along the profiles with ML2 ThetaProbe (Delta-T Devices)



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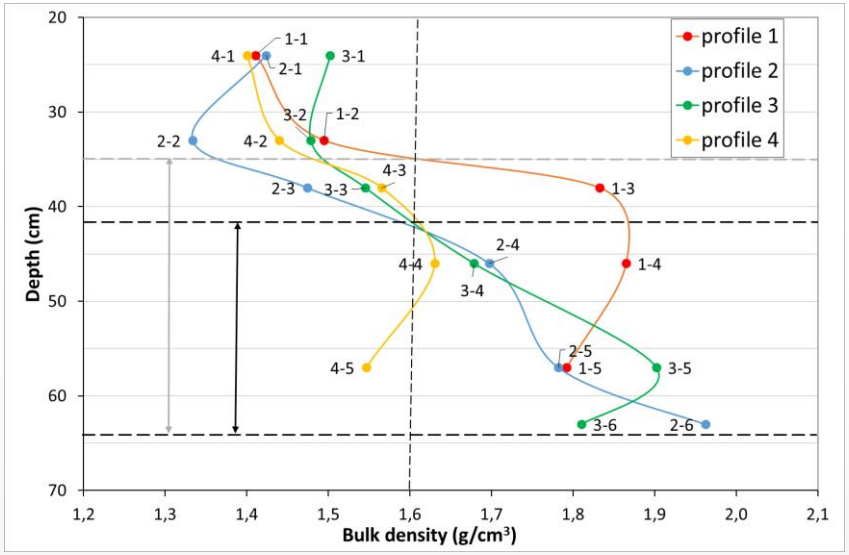
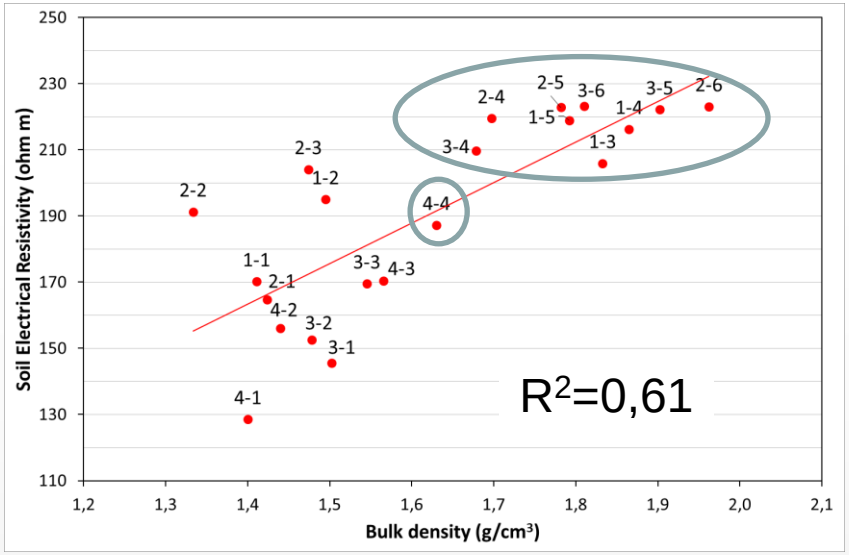
Results: bulk density and ER



Bulk density profile



Correlation bulk density - ER

Soil compaction for bulk density greater than 1.6 g/cm^3

Compacted layer:
from 35 cm to 65 cm depths along profile 1;
from 45 cm to 65 cm depths along profiles 2 and 3;
from 40 cm to 50 cm depths along profile 4

Compacted soils correspond to the cluster of points with the highest ER values (except for point 4-4), due to the soil water content

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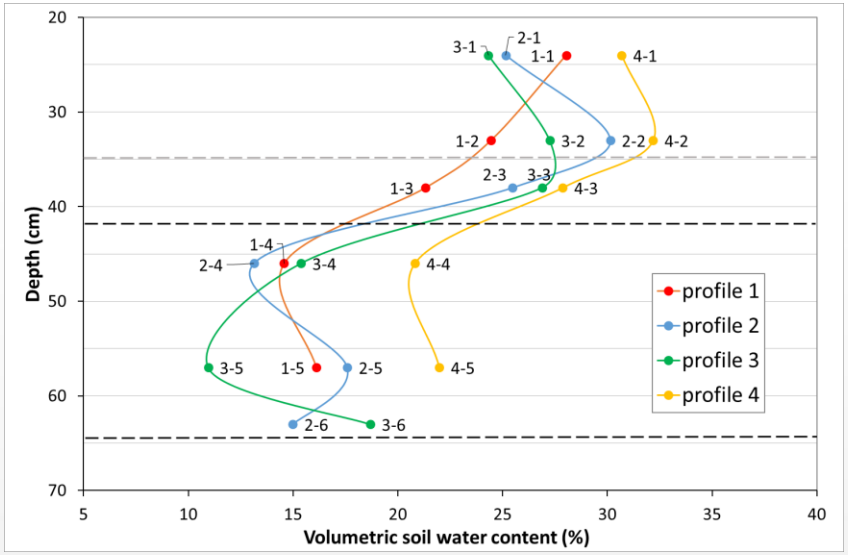
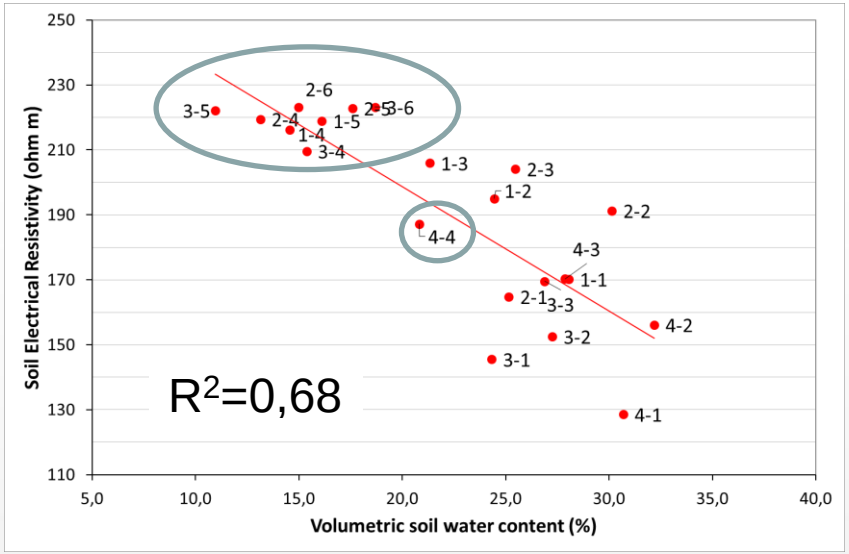
Results: soil water content and ER

SWC measured with ML2 ThetaProbe were corrected to consider the dependence from bulk density, by applying the calibration relation suggested in *Huang et al.* (2004)



SWC profile



Correlation SWC- ER

SWC along the profiles are greater for the soils above the compacted layer (where the reduction in SWC is significant, generally greater than 30%).

The survey was carried out after a long period of winter flooding (from the beginning of October 2018 until the end of January 2019), when the SWC were relatively high due to the long period with saturation

Compacted soils correspond to the cluster of points with the highest ER values and the lowest SWC (except for point 4-4), due to the soil water status following a long period with saturation

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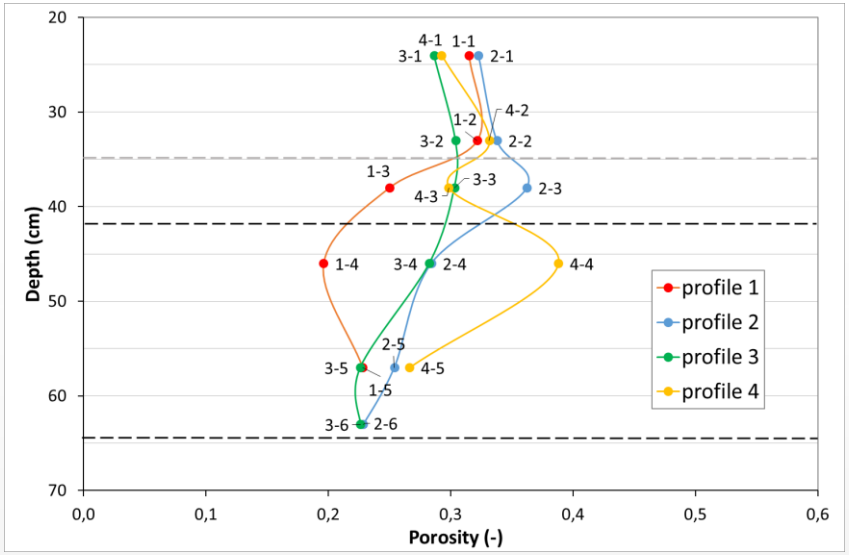
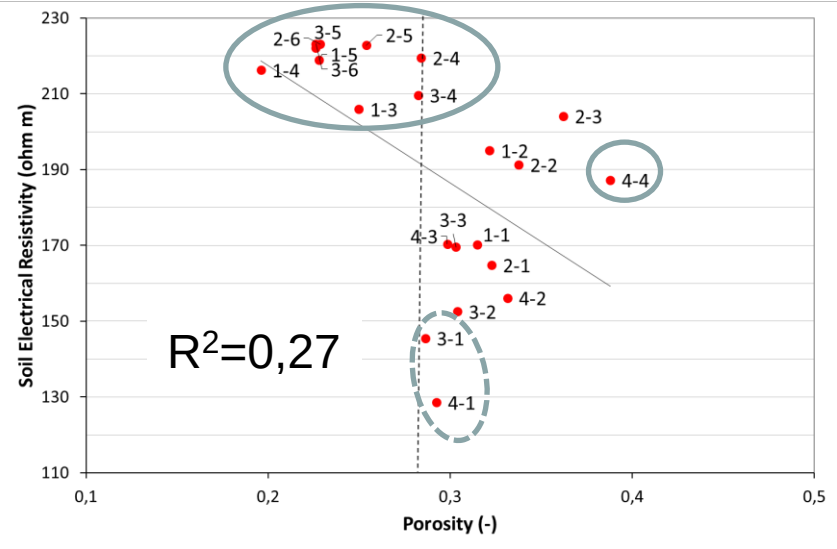
Results: porosity and ER



Porosity profile



Correlation Porosity - ER

The behavior of porosity along the profile 4 is quite anomalous: the porosity presents the highest value at 45 cm depth (bulk density 1.63 g/cm^3) and a very low value at 25 cm depth. Moreover, the compaction along this profile is not remarkable, due to the bulk density values always less than 1.63 g/cm^3 (except for point 4-4)

Along profile 3, the decrease of porosity due to the soil compaction (bulk density up to 1.90 g/cm^3) is not significant

Compacted soils correspond to the cluster of points with the highest ER values and the lowest porosity (except for point 4-4) less than 0.28

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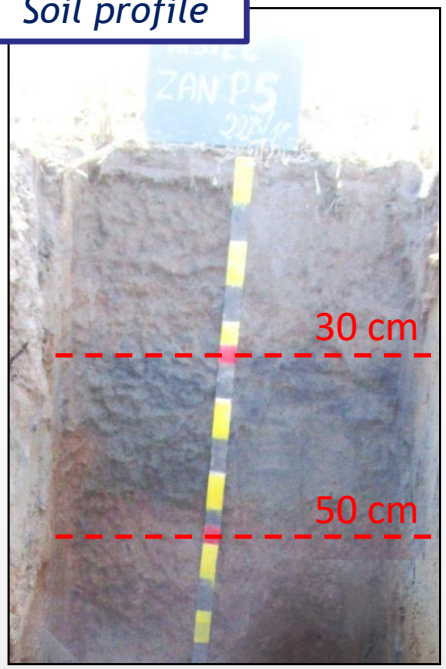
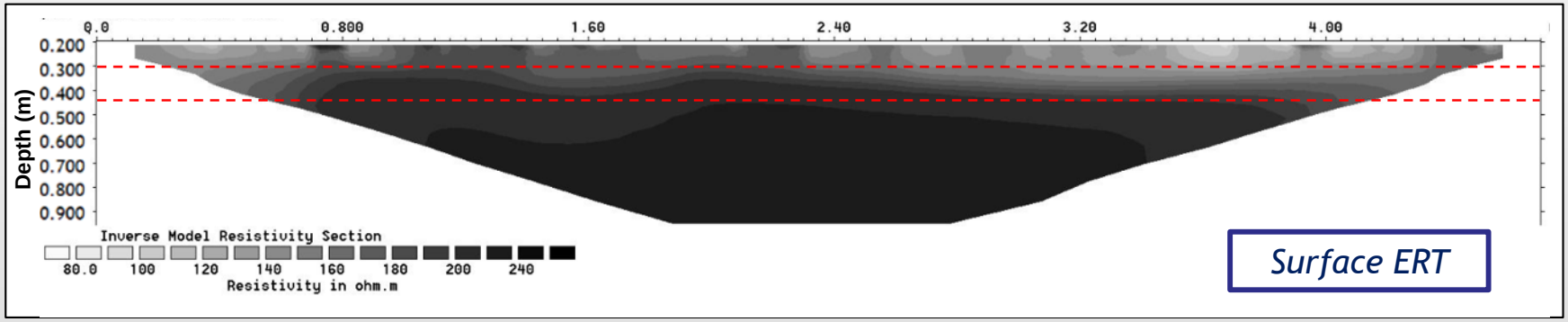
Results: soil profile and ER

Soil profile



The soil profile trench dug in proximity of the ERT transect was analysed through traditional method
The analysis revealed a compacted layer from 30 cm to 50 cnm depths

The compacted layers in a ERT section correspond to the depths where the ERT image shows the highest ER values and a greater ER gradient.
These depths well corresponds to the compacted layer observed during the investigation of soil profile with traditional methods.



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Conclusions

Data points in the scatter plots (porosity-ER; SWC-ER) are clustered based on the bulk density values, showing that in soil water condition near to saturation, the compacted soil are characterized by the highest ER values

For paddy soils with a relatively homogeneous soil texture and water condition near to saturation, compacted layers can be effectively detected in ERT images by identifying depths characterized by higher ER gradients and the highest ER values.

An integrated approach combining surface ERT and soil sampling with a hand auger at a few depths to check the texture homogeneity and eventually collect a few soil samples for further analysis (e.g., bulk density, volumetric water content, soil hydraulic conductivity) could be used to assess the presence and continuity of compacted layers in paddy soils, instead of intensive and extremely invasive surveys

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