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Comparison of Remote Sensing Soil Electrical Conductivity from PlanetScope and Ground Measured Data in Wheat and Beet Yields

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Abstract: Soil salinity is a major threat to the continuity of sustainable agriculture and food provision and the soil structure deterioration. In this context, determining, reducing, and managing soil salinity is very important for creating sustainable modern agriculture. Determining soil salinity is generally carried out in the laboratory environment and devices used in land plots. Remote sensing is one of the important methods used for precise estimation and mapping of salinity. With remote sensing technology, soil salinity maps for large areas can be obtained with low cost and low effort. This study aims to compare remote sensing soil electrical conductivity from PlanetScope and ground measured data in wheat and beet fields in the farming areas of Alpu, Turkey. For that reason, electrical conductivity was measured at several points in wheat and beet fields using in-situ measurements and compared with various soil salinity indices from Planetscope imagery acquired on the same day. Linear regression analysis was carried out to correlate the electrical conductivity data with their corresponding soil salinity spectral index values. The results show a high correlation (R^2 = 0.84) between soil salinity in wheat fields and some of the used indices. This study strengthens the idea that soil salinity maps can be obtained fast and accurately for large areas using remote sensing technology.

Keywords: remote sensing; soil salinity; electrical conductivity; Planetscope; salinity index

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1. Introduction

The soil is a building block that forms the basis of life. The evolution of humanity from the understanding of the hunter community to the agricultural society has led to the strengthening of humanity's connection with the soil and the study of the soil. The modern agricultural process, which has emerged today with developing technology and increasing population, focuses on increasing crop yields rather than soil. However, environmental issues, such as climate change, food and water security, land degradation, and the impact of habitat loss on species, have shown that soil characteristics other than crop yields also need to be studied (Arrouays et al., 2017). Therefore, soil characteristics evaluation is crucial in terms of soil sustainability on a local and regional scale (Ludwig et al., 2018).

It is estimated that 20% of the world's total cultivated areas and 33% of irrigated agricultural land are negatively affected by high salinity (Shrivastava and Kumar, 2015; Gorji et al., 2015). Besides, an estimated 1 million hectares of agricultural land in the European Union, including Mediterranean countries, are affected by soil salinity, one of the biggest causes of desertification (Stolte et al., 2016). In semiarid and arid areas, low rainfall, high evaporation, high water table, and a high amount of water-soluble salt cause soil salinity formation (Wang et al., 2019). For this reason, restoration and land reclamation of soils facing the salinity problem is significant in terms of increasing Eco-Environmental Quality and ensuring regional sustainable development (Wang et al., 2020). In this context, determining the spatial and temporal distribution of soil salinity and dynamic monitoring in ensuring soil sustainability can provide a quantitative assessment (Ivushkin et al., 2019).

Since traditional laboratory analyses generally carry out soil characterization, the process is both costly and time-consuming. The difficulty of dynamically monitoring the temporal and spatial change of the salinization process of soils with large areas and determining the regions inclined to salinization (Seifi et al., 2020) recently has been aided with remote sensing data and methods. In some studies, salinity indices were created using Landsat and Sentinel-2 satellite images, and salinity mapping was performed using several indices (Jiang & Shu., 2019) (Wang et al., 2020). However, high spatial resolution maps could not be created because Landsat satellite images' spatial resolution is 30 m. Planetscope consists of more than 120 nano-satellites manufactured by Planet Labs, Inc. The Planetscope system provides daily, high resolution (3 m) and 4-band (red, green, blue, and near-infrared) satellite images (http-1).

Considering that not many studies can be found in the literature for soil salinity mapping using high-resolution imagery such as PlanetScope, this study aims to compare remote sensing soil electrical conductivity from PlanetScope and ground measured data in wheat and beet fields in the farming areas of Alpu, Turkey.

2. Materials and Methods

The study was carried out in the Alpu district of Eskişehir, Turkey. Alpu has an area of 1.059.130 decares and an altitude of 700 m. 400.490 decares of the region are used as agricultural land, 389.640 decares as forest land, 220.700 decares as meadow-pasture, and 48.300 decares non-agricultural land. In agricultural production, 150.320 decares are used as irrigated agricultural land and 250,170 decares as barren agricultural land (http-3). In this study, soil sampling was carried out using a random sampling method from the fields where the beet and wheat were cultivated in the Alpu region on 6 October 2020 and 7 October 2020. The coordinates of each measurement point were recorded using handheld GPS. The study area, together with in-situ measurements and the used PlanetScope image, is given in Figure 1.

The electrical conductivity (EC) at the measurement points was measured with PNT 3000 COMBI + device. Three measurements were made by immersing the electrical conductivity probe 10 cm below the soil surface.

PlanetScope image of 7 October 2020 was used in the study. Planetscope consists of more than 120 nano-satellites manufactured by Planet Labs, Inc. The Planetscope system provides daily, very high resolution (3 m) and 4-band (red, green, blue, and near-infrared) satellite images (http-1). Various spectral indices have been developed for detecting and mapping salinity. The spectral indices used in this study are given in Table 1. Linear regression analysis was carried out to correlate the electrical conductivity data with their corresponding soil salinity spectral index values.

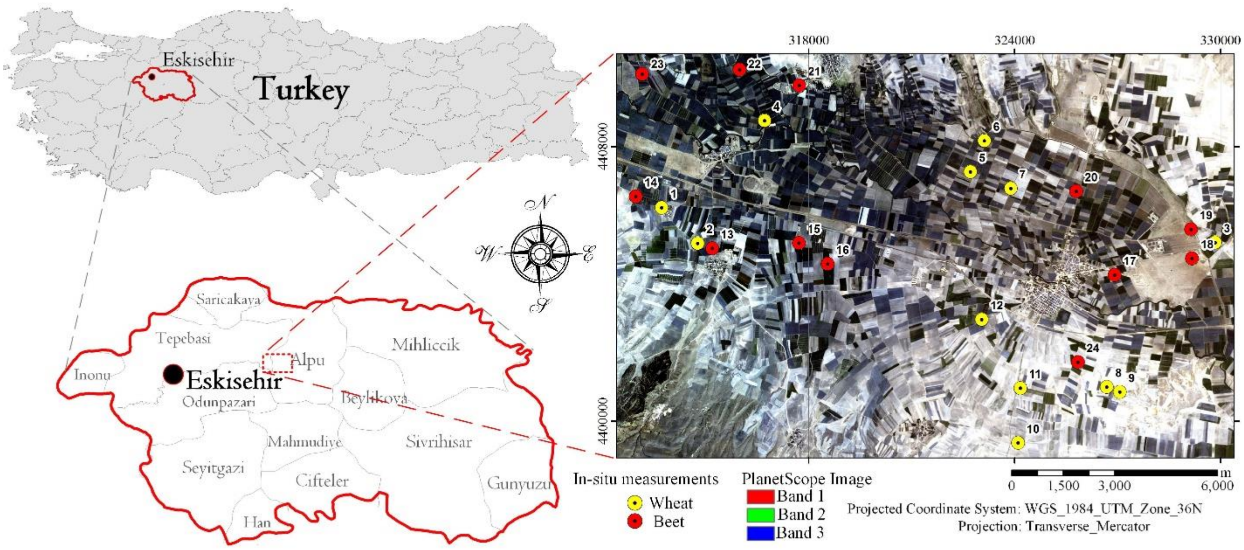

Figure 1. Study Area, in-situ measurements, and PlanetScope imagery.

Table 1. Spectral indices used in this study.

Spectral Indices	Formula	Reference
Salinity Index—1	SI = $\frac{B}{R}$	Bannari et al., 2008
Salinity Index—2	SI = $\frac{B-R}{B+R}$	Bannari et al., 2008
Salinity Index—3	SI = $\frac{G \times R}{B}$	Bannari et al., 2008
Salinity Index—4	SI = $\frac{B \times R}{G}$	Abbas and Khan, 2007

3. Results and Discussion

The four investigated salinity indices (Table 1) and the wheat fields' in-situ measurements showed a significant correlation. In contrast, the beet fields' measurements did not show a significant correlation with the field measurements. While the correlations of the wheat fields ranges $R^2 = 0.66 - 0.84$ ($p < 0.05$), the correlations for the beet fields were $R^2 > 0.1$ (Figure 2). Taking into consideration the high correlation between the salinity in the wheat fields with the investigated indices. Furthermore, we have investigated the potential for a linear regression model between the given variables. The results showed that, with the exclusion of SI-4, there is a significant relationship described with Equation (4).

$$\hat{Y} = 8.76SI1 - 79.64SI2 - 0.001SI3 \quad (4)$$

where $\hat{Y}$ is the predicted salinity, and SI are the investigated spectral indices (Table 1). The model showed significant regression statistics ($R^2 = 0.95$; Adjuster $R^2 = 0.83$; $p < 0.05$) in the study area with prediction power of 95% for the wheat fields. However, further investigation is needed for the accuracy assessment as the number of in-situ measurements is limited.

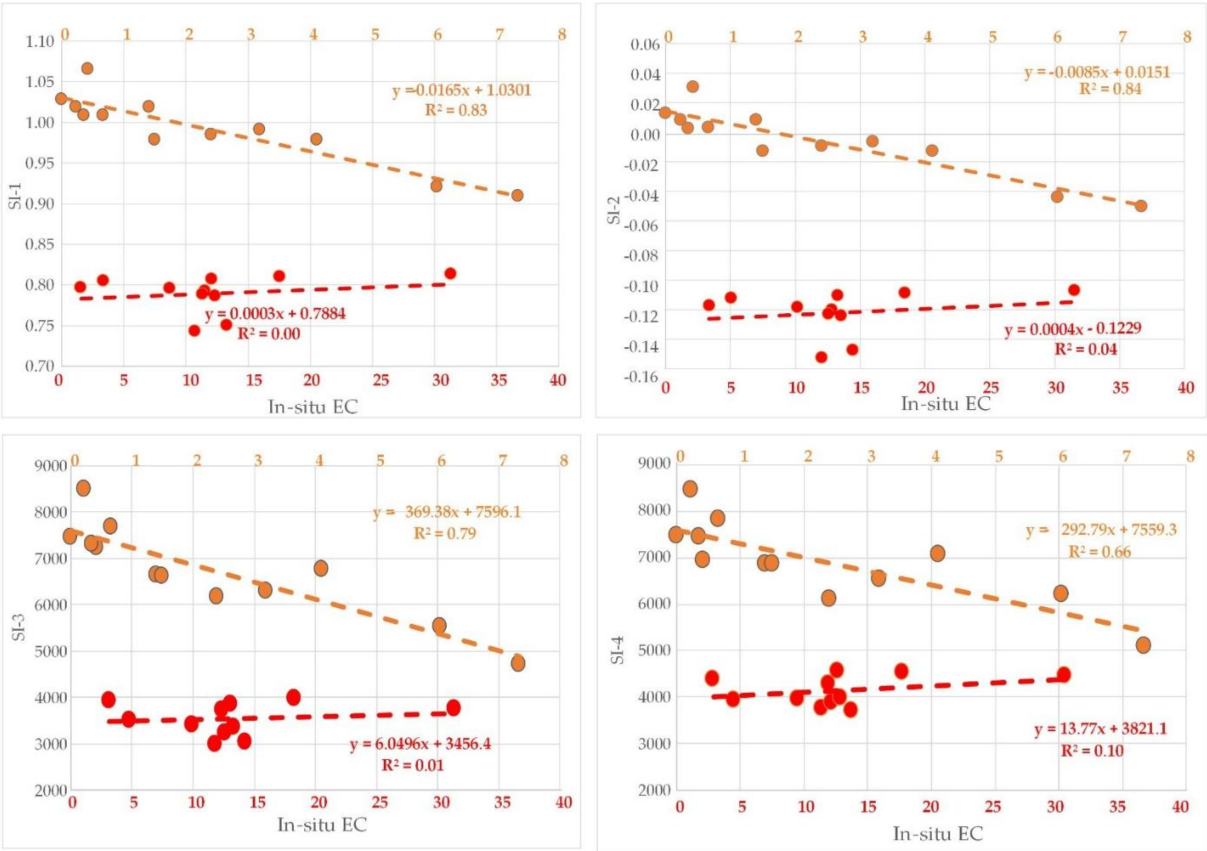

Figure 2. Correlation between in-situ measurements and the investigated SI (orange—wheat; red—beet).

4. Conclusions

The conducted study aimed at investigating the correlation between in-situ salinity measurements and spectral indices retrieved from PlanetScope satellite imagery in Alpu, Eskisehir, Turkey. After a significant correlation was established between wheat field measurements and satellite data, a regression model was developed with a prediction power of 95%. No significant correlation was found in the beet field measurements. The results are significant as they point out that not all agricultural fields can be predicted with the same model. For future studies, we recommend adding other indices to the investigated spectral indices, as well as increasing the field measurement points.

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Conflicts of Interest:

References

1. Abbas, A.; Khan, S. Using remote sensing techniques for appraisal of irrigated soil salinity. In *Int. Congr. Model. Simul.(MODSIM)*; Modelling and Simulation Society of Australia and New Zealand: Christchurch, New Zealand, 2007; pp. 2632–2638.

2. Arrouays, D.; Lagacherie, P.; Hartemink, A.E. Digital soil mapping across the globe. *Geodarma Reg*. **2017**, *9*, 1–4.
3. Bannari, A.; Bannari, A.; El-Battay, A.; Rhinane, H. Sentinel-MSI VNIR and SWIR Bands Sensitivity Analysis for Soil Salinity Discrimination in an Arid Landscape. *Remote Sens.* **2018**, *10*, 855.
4. Bannari, A.; Guedon, A.M.; El-Harti, A.; Cherkaoui, F.Z.; El-Ghmari, A. Characterization of slightly and moderately saline and sodic soils in irrigated agricultural land using simulated data of advanced land imaging (EO-1) sensor. *Commun. Soil Sci. Plant Anal.* **2008**, *39*, 2795–2811.
5. Douaoui, A.E.K.; Nicolas, H.; Walter, C. Detecting salinity hazards within a semiarid context by means of combining soil and remote-sensing data. *Geoderma* **2006**, *134*, 217–230.
6. Farifteh, J.; Farshad, A.; George, R.J. Assessing salt-affected soils using remote sensing, solute modelling, and geophysics. *Geoderma* **2006**, *130*, 191–206.
7. Gorji, T.; Sertel, E.; Tanik, A. Monitoring soil salinity via remote sensing technology under data scarce conditions: A case study from Turkey. *Ecol. Indic.* **2017**, *74*, 384–391.
8. Available online: https://www.planet.com/products/planet-imagery/ (accessed on 9 January 2021).
9. Available online: https://eskisehir.tarimorman.gov.tr/Belgeler/2019_Faaliyet_Raporu/2019_Yili_Brifing.pdf (accessed on 9 January 2021).
10. Available online: http://bebka.org.tr/admin/datas/sayfas/198/alpu-ilce-raporu_1568787633.pdf (accessed on 9 January 2021).
11. Huete, A.R. A soil-adjusted vegetation index (SAVI). *Remote Sens. Environ.* **1988**, *25*, 295–309.
12. Ivushkin, K.; Bartholomeus, H.; Bregt, A.K.; Pulatov, A.; Kempen, B.; De Sousa, L. Global mapping of soil salinity change. *Remote Sens. Environ.* **2019**, *231*, 111260.
13. Jiang, H.; Shu, H. Optical remote-sensing data based research on detecting soil salinity at different depth in an aridarea oasis, Xinjiang, China. *Earth Sci. Inform.* **2019**, *12*, 43–56.
14. Khan, N.M.; Rastoskuev, V.V.; Sato, Y.; Shiozawa, S. Assessment of hydrosaline land degradation by using a simple approach of remote sensing indicators. *Agric. Water Manag.* **2005**, *77*, 96–109.
15. Li, H.Y.; Webster, R.; Shi, Z. Mapping soil salinity in the Yangtze delta: REML and universal kriging (E-BLUP) revisited. *Geoderma* **2015**, *237*, 71–77.
16. Ludwig, M.; Wilmes, P.; Schrader, S. Measuring soil sustainability via soil resilience. *Sci. Total Environ.* **2018**, *626*, 1484–1493.
17. Major, D.J.; Baret, F.; Guyot, G. A ratio vegetation index adjusted for soil brightness. *Int. J. Remote Sens.* **1990**, *11*, 727–740.
18. Metternicht, G.I.; Zinck, J.A. Remote sensing of soil salinity: Potentials and constraints. *Remote Sens. Environ.* **2003**, *85*, 1–20.
19. Seifi, M.; Ahmadi, A.; Neyshabouri, M.R.; Taghizadeh-Mehrjardi, R.; Bahrami, H.A. Remote and Vis-NIR spectra sensing potential for soil salinization estimation in the eastern coast of Urmia hyper saline lake, Iran. *Remote Sens. Appl. Soc. Environ.* **2020**, *20*, 100398.
20. Shrivastava, P.; Kumar, R. Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. *Saudi J. Biol. Sci.* **2015**, *22*, 123–131.
21. Stolte, J.; Tesfai, M.; Oygarden, L.; Kvaerno, S.; Keizer, J.; Verheijen, F.; Panagos, P.; Ballabio, C.; Hessel, R. Soil threats in Europe: Status, methods, drivers and effects on ecosystem services: Deliverable 2.1 RECARE project. European Commission DG Joint Research Centre: 2016.
22. Wang, F.; Shi, Z.; Biswas, A.; Yang, S.; Ding, J. Multi-algorithm comparison for predicting soil salinity. *Geoderma* **2020**, *365*, 114211.
23. Wang, J.; Ding, J.; Li, G.; Liang, J.; Yu, D.; Aishan, T.; Zhang, F.; Yang, J.; Abulimiti, A.; Liu, J. Dynamic detection of water surface area of Ebinur Lake using multi-source satellite data (Landsat and Sentinel- 1A) and its responses to changing environment. *Catena* **2019**, *177*, 189–201.
24. Wang, J.; Ding, J.; Yu, D.; Ma, X.; Zhang, Z.; Ge, X.; Teng, D.; Li, X.; Liang, J.; Lizaga, I.; et al. Capability of Sentinel-2 MSI data for monitoring and mapping of soil salinity in dry and wet seasons in the Ebinur Lake region, Xinjiang, China. *Geoderma* **2019**, *353*, 172–187.

25. Wang, J.; Ding, J.; Yu, D.; Teng, D.; He, B.; Chen, X.; Ge, X.; Zhang, Z.; Wang, Y.; Yang, X.; et al. Machine learning-based detection of soil salinity in an arid desert region, Northwest China: A comparison between Landsat-8 OLI and Sentinel-2 MSI. *Sci. Total Environ.* **2020**, *707*, 136092.
26. Zhang, T.T.; Qi, J.G.; Gao, Y.; Ouyang, Z.T.; Zeng, S.L.; Zhao, B. Detecting soil salinity with MODIS time series VI data. *Ecol. Indic.* **2015**, *52*, 480–489.