Application of satellite data for soil salinity assessment in the Sirdarya province, Uzbekistan

ウズベキスタン国シルダリヤ州における衛星画像を用いた塩類集積の解析

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1. Introduction

Soil salinity is a major concern in arid and semi-arid regions, often caused by water resource mismanagement and inadequate irrigation and drainage systems. Advanced technologies such as GIS and RS data are effective tools for assessing and monitoring soil salinity, including spatial and temporal variations. This study aims to use GIS and RS techniques to develop a risk assessment of soil salinization in Syrdarya, Uzbekistan, where soil salinity is a significant challenge.

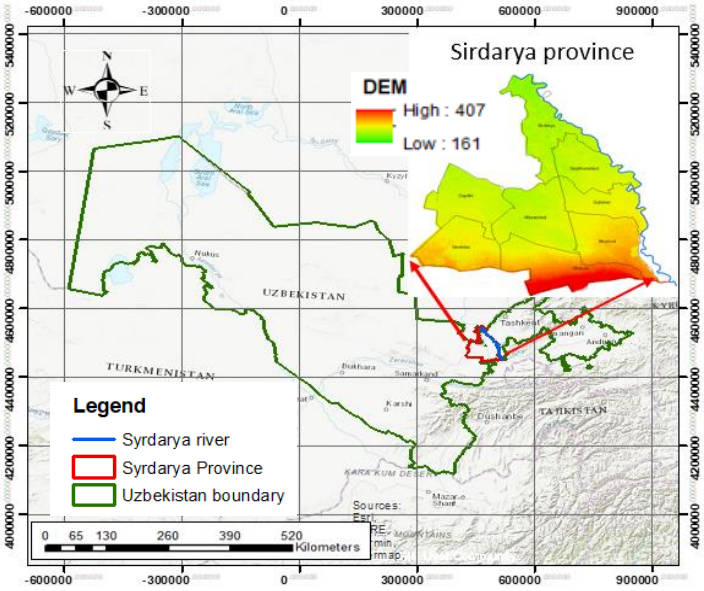

Fig.1 The map of Sirdarya province, Uzbekistan

2 Study area and methods

The study area is Sirdarya province of Uzbekistan (Figure. **1**), and its located on the left bank of the Syr Darya River, bordered by Kazakhstan and Tajikistan. The province's average annual air temperature was 15°C in 2020 and, the average annual precipitation is 310 mm. The climate of the province is a semi-arid and continental climatic zone with hot and dry summers.

2.1 Satellite Imagery and statistical analysis

This study aims to present a simpler method for assessing soil salinity using satellite imagery analysis. This method takes into account the digital number of the objects captured by remote sensing, as well as their spectral scale. To assess soil salinity, two satellite images were used in this study. The images were captured by the Landsat 8 OLI and Moderate Resolution Imaging Spectroradiometer (MODIS – MOD09) sensors on August 16 and 18, 2022. Previous studies have suggested that mid-August is an ideal time to use remote sensing imagery for soil salinity assessment as cotton biomass is at its highest, making it a good indicator for analyzing soil salinity patterns, Table 1. We used ArcGIS and QGIS to map soil salinity and validated our findings using statistical packages in R software, specifically Structural Equation Modeling

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(SME) using Lavaan statistics. The accuracy assessment of these satellite image-based maps was evaluated by comparing ground truth data (EC values). Two data series were compared in this study.

Table.1 Metadata of the employed satellite images

Sensors	Bands	Wavelength	Resolution
Landsat 8 OLI	B1-Coastal Aerosol, B2-Blue, B3-Green, B4-Red, B5-NIR-Infrared, B6-SWIR 1 and B7- SWIR 2	from 0.43 - 0.45 µm to 2.11 - 2.29 µm	30 x 30 m
MODIS – MOD09	Surface Reflectance (SR) B1-Red, B2-NIR, B3-Blue, B4-Green, B5-NIR, B6-SWIR 1 and B7-SWIR 2	from 0.62-0.67 µm to 2.105-2.155 µm	500 x 500 m

3.Result and Discussion

Figure 2 displays maps of soil salinity created using Landsat 8 OLI Bands. According to the visual comparison, we found that the Landsat 8 OLI Band 4 and Band 7 data can be used to locate the exact soil salinity locations or the risk being posed by soil salinization in the study area. On the basis of spectral correlation between various bands, false color composite has been employed as training and sampling points. Based on these findings, it was determined that MODIS-MOD09 Band 1 and Band 6 and Landsat 8 OLI Band 4 and Band 7 had the positive modest (R = 0.5…0.6) and strong (R ≥ 0.8) correlation, respectively. As a result, to properly distinguish soil salinity, the satellite-based soil salinity maps created using this method had an overall accuracy of 72% and a Kappa value of 81%. The next step in this study will involve estimating an SEM (structural equation modeling) model to assess the risk of soil salinity in the Sirdarya province of Uzbekistan.

4.Conclusion

Our findings imply that while MODIS Band 6 may have a lesser connection with EC values, MODIS Band 1 can be a somewhat good predictor of EC values. However, the EC values in Sirdarya Province can be predicted using Landsat 8 OLI Bands 4 and 7. The processes behind this link and the possible applicability of these results in other drylands, land management, and environmental monitoring require continuous investigation. However, to fully realize this potential, a collaboration between researchers, policy-makers, and land managers is crucial. SEM could be used as a more accurate assessment tool for future research analysis.

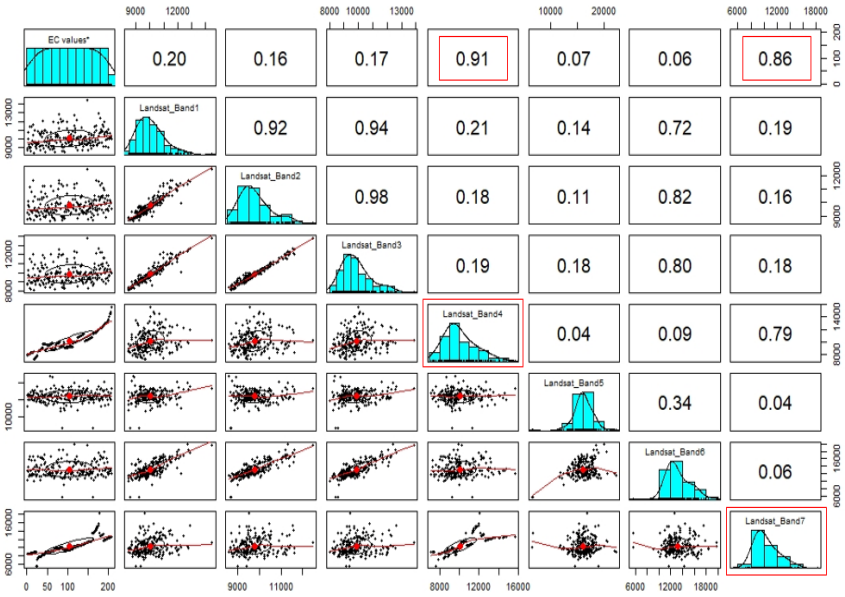

Fig.2 Pairs and panels statistical output for the EC values and Landsat