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ARTICLE

# Sentinel-2 Satellite Imagery Application to Monitor Soil Salinity and Calcium Carbonate Contents in Agricultural Fields

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## ABSTRACT

The estuary tides affect groundwater dynamics; these areas are susceptible to waterlogging and salinity issues. A study was conducted on two fields with a total area of 60 hectares under a center pivot irrigation system that works with solar energy and belong to a commercial farm located in Northern Sudan. To monitor soil salinity and calcium carbonate in the area and stop future degradation of soil resources, easy, non-intrusive, and practical procedures are required. The objective of this study was to use remote sensing-determined Sentinel-2 satellite imagery using various soil indices to develop prediction models for the estimation of soil electrical conductivity (EC) and soil calcium carbonate ($CaCO_3$). Geo-referenced soil samples were collected from 72 locations and analyzed in the laboratory for soil EC and $CaCO_3$. The electrical conductivity of the soil saturation paste extract was represented by average values in soil dataset samples from two fields collected from the topsoil layer (0 to 15 cm) characteristic of the local salinity gradient. The various soil indices, used in this study, were calculated from the Sentinel-2 satellite imagery. The prediction was determined using the root mean square error (RMSE) and cross validation was done using coefficient of determination. The results of regression analysis showed linear relationships with significant correlation between the EC analyzed in laboratory and the salinity index-2 "SI2" (Model-1: $R^2$ = 0.59, $p$ = 0.00019 and root mean square error (RMSE = 1.32%) and the bare soil index "BSI" (Model-2: $R^2$ = 0.63, $p$ = 0.00012 and RMSE = 6.42%). Model-1 demonstrated the best model for predicting soil EC, and validation $R^2$ and RMSE values of 0.48% and 1.32%, respectively. The regression analysis results for soil $CaCO_3$ determination showed linear relationships with data obtained in laboratory and the bare soil index "BSI" (Model-3: $R^2$ = 0. 45, $p$ = 0.00021 and RMSE = 1.29%) and the bare soil index "BSI" & Normalized difference salinity index "NDSI" (Model-4: $R^2$ = 0.53, $p$ = 0.00015 and RMSE = 1.55%). The validation confirmed the Model-3 results for prediction of soil $CaCO_3$ with $R^2$ and RMSE values of 0.478% and 1.29%, respectively. Future soil monitoring programs might consider the use of remote sensing data for assessing soil salinity and $CaCO_3$ using soil indices results generated from satellite image (i.e., Sentinel-2).

## KEYWORDS

Electrical conductivity; modeling; soil indices; remote sensing; prediction