Characterization and modelling of salt-affected soils properties using VNIR hyperspectral data

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INTRODUCTION

Soil salinization and alkalinization are soil degradation processes in arid and semi-arid regions of India impacting crop production. Conventional methods of detecting salt-affected soils (SAS) based on saturation extract SAS parameters entails additional time, labour and capital.

The study aims to characterize SAS based on hyperspectral data and to estimate the SAS properties using multivariate modelling approach for rapid and cost effective assessment of SAS.

METHODOLOGY

The study was carried out on SAS of five villages, situated in Ghaghar basin of Kaithal district of Haryana, India (Fig. 1), where the use of poor quality sodic (with high RSC) groundwater is a common practice for irrigated agriculture.

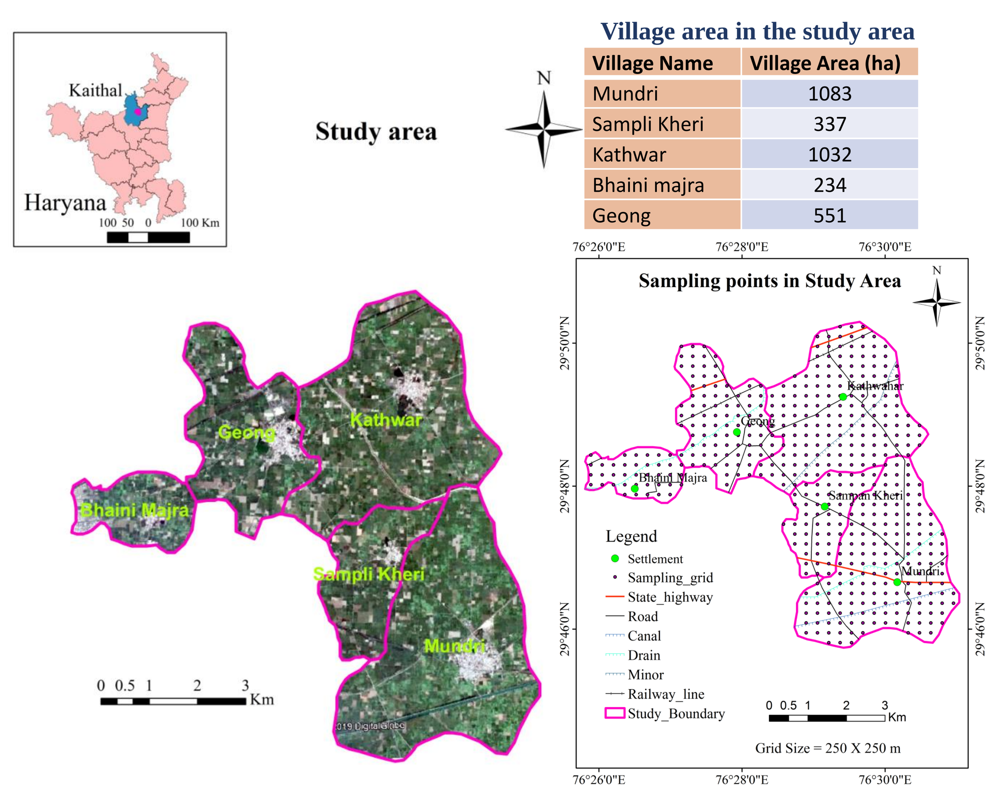

Fig 1. Location map of study area and GPS marked soil sampling points

Soil sampling was done based on 250×250m grid basis after rice harvesting during October, 2019. Then samples were processed for spectroradiometer data recording and chemical analysis. The whole data set was divided into calibration and validation sets for PLSR model using Unscrumbler-V.10.1 software. Prediction accuracy was tested based on R^2, RMSEP and RPD value. The proposed methodology was found useful for delineating and characterizing SAS using hyperspectral data (Fig. 2).

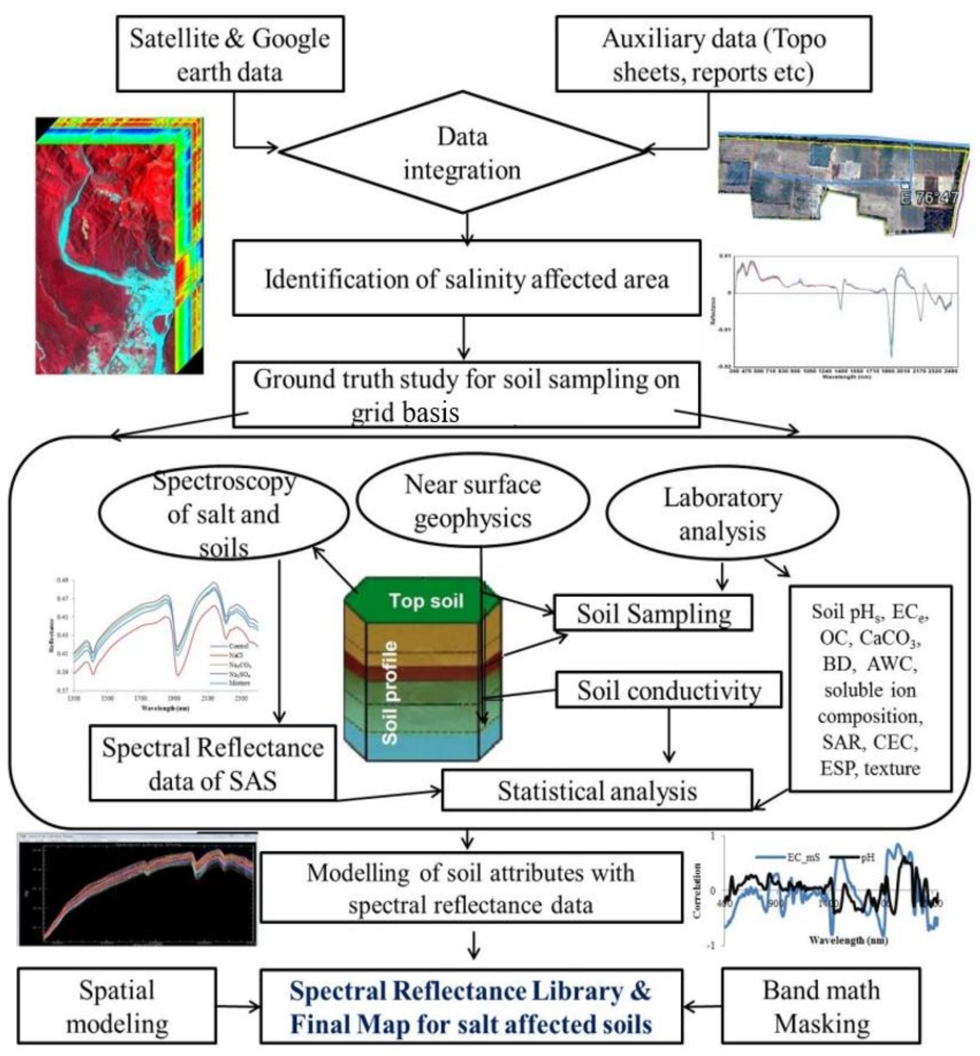

Fig 2. Methodology for characterizing SAS using spectral data

RESULTS

The spectral reflectance value from the soil reduced with increase of soil pH_s value from 6.2 to 9.6 and EC_e value from 0.1 to 5.5 dS m^{-1} (Fig. 3).

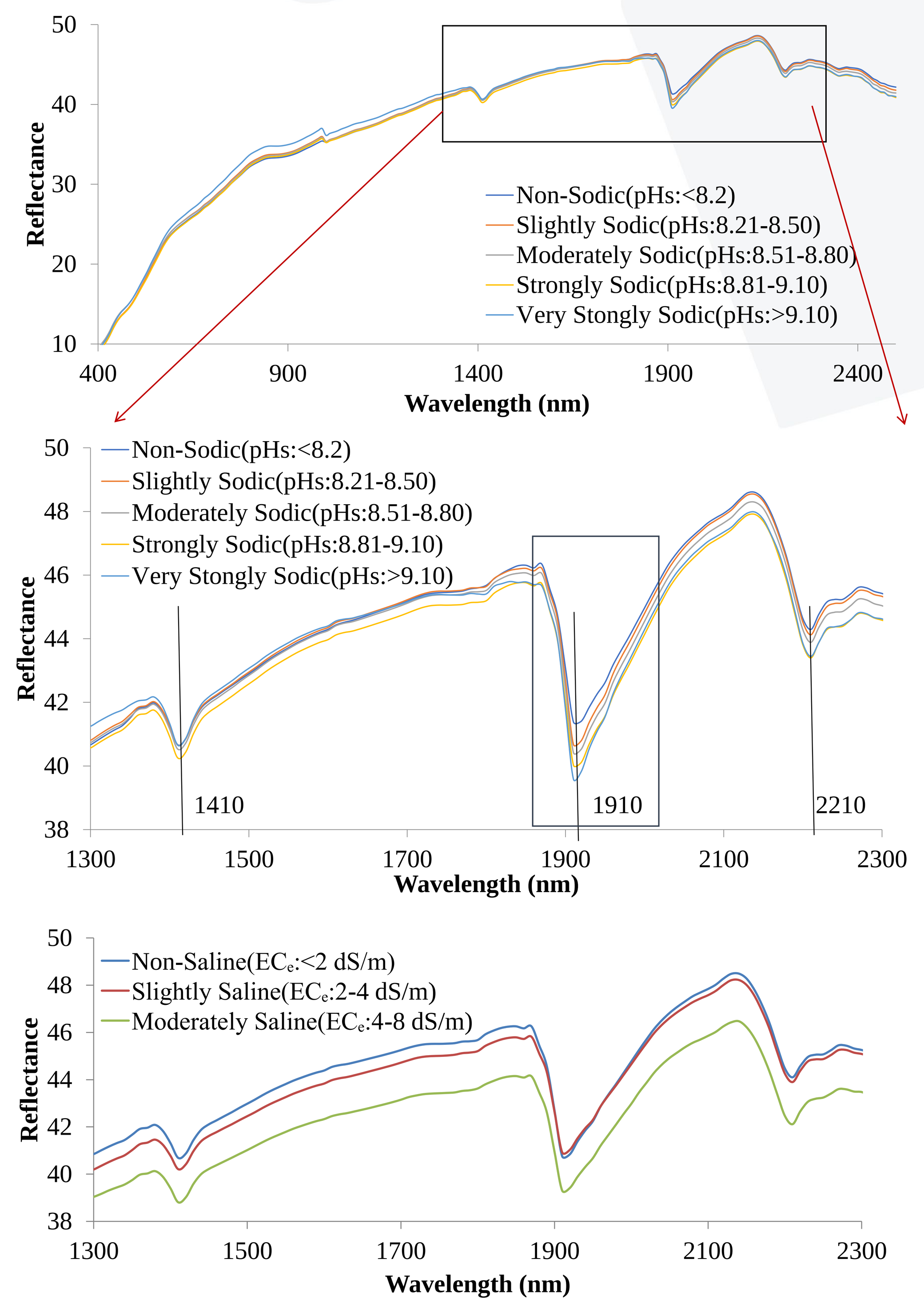

Fig 3. Mean representative spectra of soils with different Sodicity and Salinity levels

High ESP and SAR value decrease the spectral reflectance, whereas, high organic carbon (OC) content reduces the reflectance value (Fig. 4).

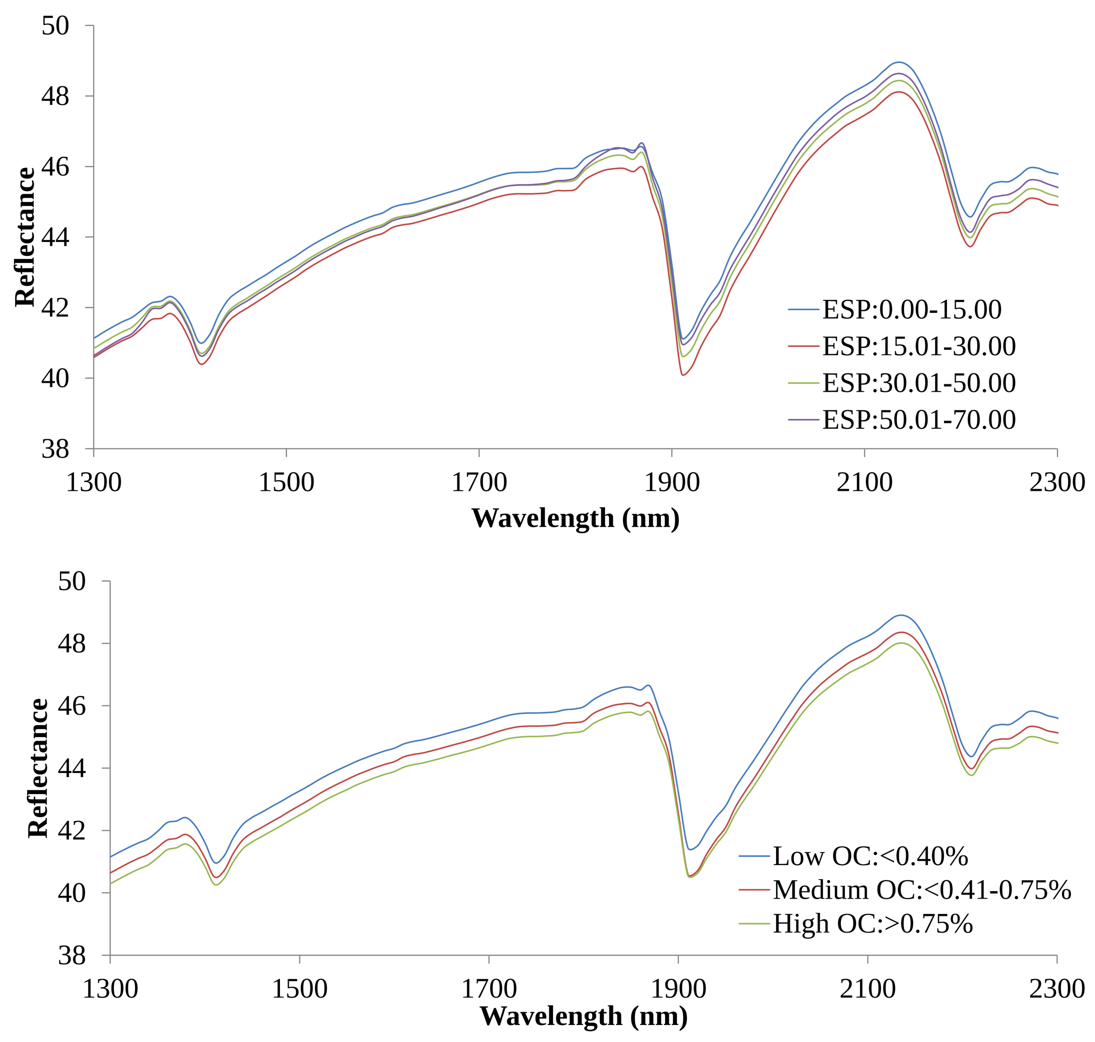

Fig 4. Mean representative spectra of soils with different ESP and OC levels

Summary statistics for the spectral models developed by PLSR was presented in Table 1. The PLSR model performed excellent for K in soil solution (RPD=2.7) and ESP (RPD=2.1), whereas, the performance of OC, $CaCO_3$, Cl, CO_3^{2-}+HCO_3^- and SO_4^{2-} in saturation extract were acceptable (2>RPD>1.4). Scatter plot of measured and predicted SAS parameters in validation datasets was presented in Fig.5.

The wavelengths 410, 490, 910, 1020, 1410, 1910, 2210 and 2350 nm showed peculiar absorption characteristics for different level soil pH_s (Fig.6).

Table 1. Summary statistics for the spectral models developed by PLSR

Soil parameters*	No. of Factors	Calibration set			Validation set				
		N	R^2	RMSE	N	SD*	R^2	RMSE	RPD
EC_e (mS m^{-1})	5	241	0.36	0.19	116	0.25	0.18	0.21	1.21
pH_s	8	258	0.53	0.24	125	0.36	0.30	0.28	1.30
SE Cl^- (meq L^{-1})	4	209	0.31	0.26	88	0.45	0.34	0.23	**1.95**
SE CO_3^{2-}+HCO_3^- (meq L^{-1})	4	243	0.27	0.14	94	0.20	0.35	0.13	**1.51**
SE SO_4^{2-} (meq L^{-1})	4	220	0.29	0.59	106	0.98	0.31	0.58	**1.69**
SE Na^+ (meq L^{-1})	5	244	0.33	0.69	108	0.98	0.26	0.67	1.47
SE K^+ (meq L^{-1})	4	242	0.28	0.05	83	0.08	0.36	0.03	**2.74**
SE Ca^{2+}+Mg^{2+} (meq L^{-1})	3	215	0.39	0.24	102	0.33	0.27	0.25	1.31
SAR ([meq $L^{-1}]^{0.5}$)	4	190	0.25	0.62	104	0.88	0.22	0.62	1.42
OC (%)	11	225	0.57	0.07	112	0.15	0.32	0.10	**1.51**
$CaCO_3$ (%)	9	228	0.57	0.17	96	0.28	0.50	0.17	**1.64**
CEC	6	131	0.54	0.49	72	0.71	0.51	0.50	1.42
ESP	4	111	0.55	0.78	45	1.47	0.43	0.70	**2.10**

*Square root transformation was applied on all soil parameters except OC and pH_s

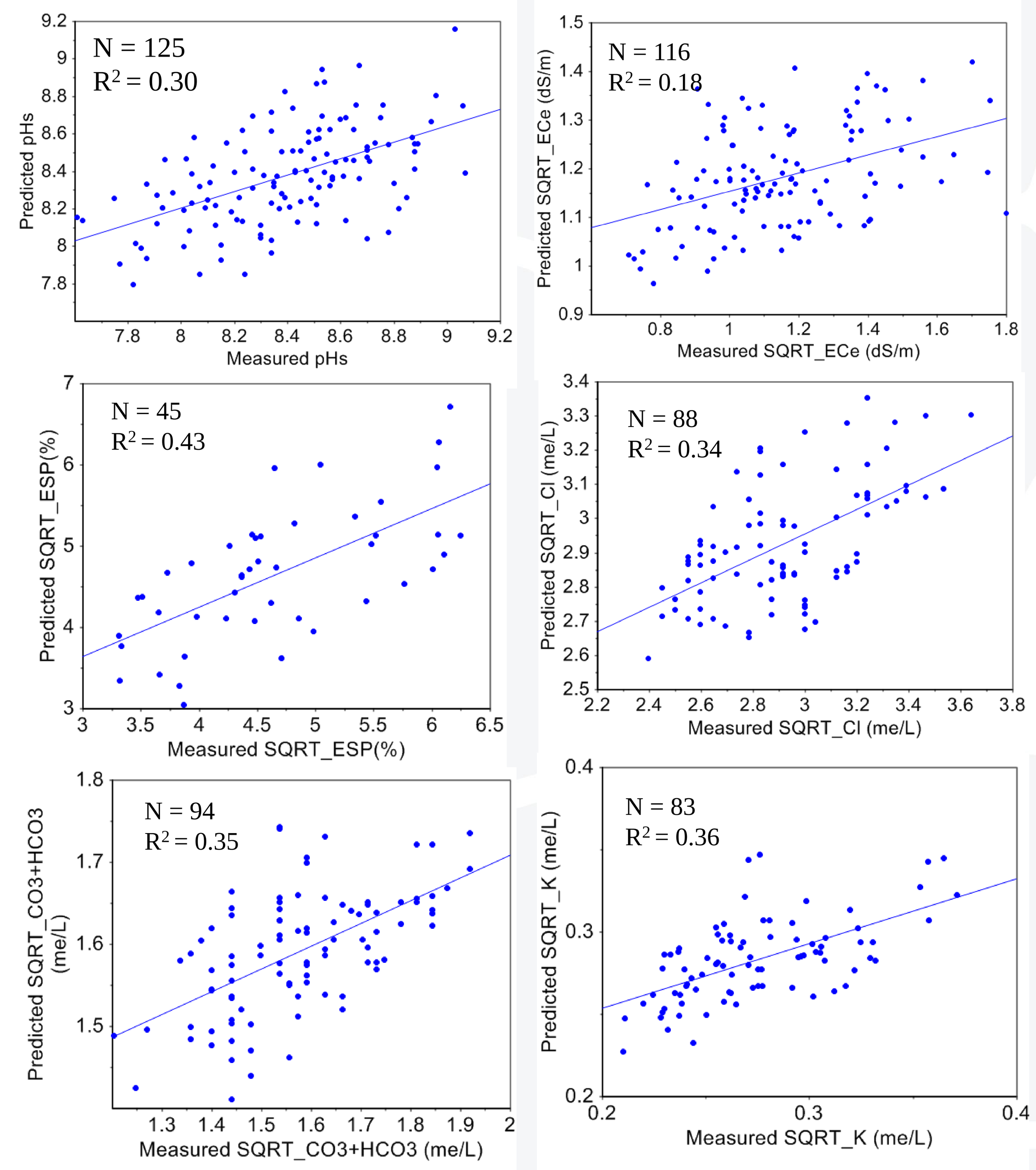

Fig.5. Scatter plot of measured and predicted SAS parameters in validation datasets

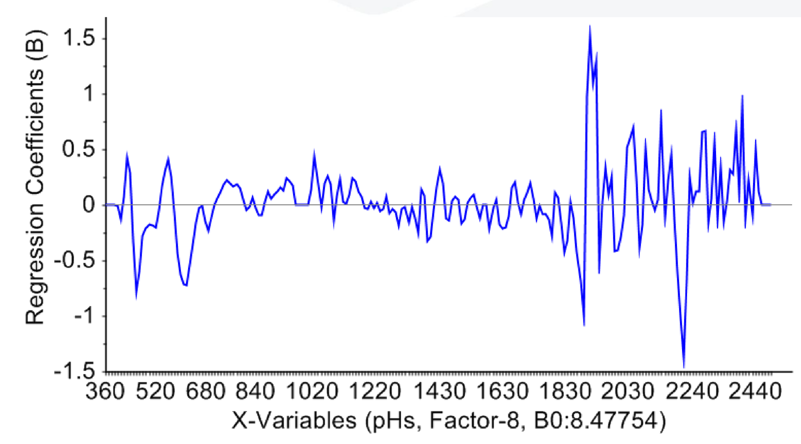

Fig 6. PLS regression coefficients for pH_s at different wavebands

CONCLUSIONS

The increased use and application of VNIR will aid in building a spectral library for SAS and in conjunction with developed model will provide real time monitoring as well as rapid information enabling the farmers to deal with salt degradation more effectively and efficiently.

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