Evaluations of vegetation cover and soil indices for saline land classification in Neyshabour region using ETM$^+$ Landsat

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Abstract

Remote sensing technology is a useful tool in obtaining information with respect to soil characteristics and land degradation aspects. This work considers the possibilities of using band ratios (plant cover and soil indices**)** for classification of saline lands in a part of Neyshabor plain region in Khorasan Razavi State in which ETM land satellite data of July 10 2002 was also used. Satellite images was reviewed and due to primary and radiometric corrections, the study area was selected from complete frame image. A Selection of sampling points with uniform distributions was performed and soil samples from 0 -10 cm of the studied point were collected and their geographical positions were recorded by GPS. 39 soil samples were analyzed for EC, pH, soluble Ca, Mg, Na, Cl, CO_3, HCO_3, SO_4 ions. The position of samples was determined on each image, and Digital Number (DN) in each point was detected. Results indicated that the regression coefficients obtained for main and composite bands were very low, but revealing that the use of composite bands (plant cover indices) compared to main bands resulted to an increasing in the regression coefficient in the equations. In addition, when statistical analysis is limited to Data of higher EC, regression coefficients increase compared to when total sample parameters was statistically analyzed. All in all, it was realized that, due to very low regression coefficients among numerical vales obtained from main bands and plant indices and EC of soils, the classification of satellite images on the bases of a suitable regression model is not possible and also these coefficients for classification of the images are not sufficient.

Keywords: Vegetation index, GIS**,** Soil salinity, Remote Sensing

Introduction

Soil degradation due to salinity and sodicity is increasing at an alarming rate of endangering the environment, agricultural ecosystems and human life. Soil salinity resulted in limiting natural resources and agricultural land use. Knowledge about soil salinity changes and forecasting land degradation is a key in safe guarding future management practices and correct decision making in improving and or reclaiming saline soils by making use of survey and classification of saline soils.

Land satellite data is in use for two decades as a new source of information for survey and classification of saline lands. Fernandaes *et al*. (2006) used numerical data of ETM and aerial photographs for soil mapping of Texcoco region in Mexico and proposed a new index spectrum named as (COSRI) by modifying plant cover index (NDVI) . Due to high correlation between soil characteristics (EC and SAR) with spectrum rates (0.885 and 0.857 , respectively) this composite band was introduced as a regression model for estimating salinity soil map.

Khodadadi *et al*. (2007) used different indices of NDSI, SI, SAVI, PVI, SRVI, NDVI and BI for preparing soil map under the influence of dissolved salts in a part of Gazvin plain, and concluded that among the indices used, SI and BI had more efficiencies compared to others.

Khavaninzadeh and Khajeadin (2001) studied soil physical and chemical properties of Neer region of Yazd by using land satellite data of 1992 TM Landsat. They proposed that for estimating physical and chemical properties of soil surface when variation ranges are optimum and high, the estimated numerical data of TM have good and valuable potential.

Westine (1978) studied the interaction effect of plant cover and soil on data from reflected bands and concluded that different types of plant cover provide difference on soil reflection behavior. This is because, changes in soils cover can change the appeared spectrum signals by means of specific plant specie in the image.

Darvishsefat *et al.*(1997) studied the possibility of saline lands classification of Hosealsoltan region – Ghom by land satellite numerical data of TM Landsat. Their results showed higher correlation coefficient for TM4 and TM3 bands compared to other main and composite bands. The correlation coefficient obtained for saline lands were not enough for the image classification.

Saha *et al*. (1990) studied the soil map for salt affected waterlogged soils by using TM images. They proposed that for preparing the images it is possible to use 3, 4, 5 and 7 bands as digital numbers with the accuracy of 95%.

Material and Method

The study area is Neyshaboor plane located in Khorasan Razavi province, North of Iran, (between 58°, 34' to 59°, 08' latitude and 35°, 51' to 36°, 15' longitude) which is shown in figure 1. An image from Landsat ETM$^+$ taken in 10th of July 2002 in row 160 and column 35 was used for this study. The image was revised in each of the reflectance bands (1-5 and 7) before any other geometric and radiometric corrections. For collecting soil samples from the field random classification method was considered. In each random sampling point 3 points were considered in 100 meters apart. Soil samples were collected from surface to nearly 15 centimeters in depth.

Geohraphical position of the sampling points was recorded by using a Garmin E-Trex GPS. In this study 39 soil samples were analyzed. For making the soil samples ready for laboratory tasks they were dried in an open air condition and were الك by a 2 milimeters. The soil samples then were garbled with a 2 mm garble.

Digital Numbers (DN) for the correspondence sampling points were extracted from the image by using different filters (3*3, 5*5 and 7*7 pixels). This was done for 19 different vegetation indices, 2 salinity indices and 6 reflected bands of the ETM$^+$. This was done for all of the data including salted soils and semi-salted soils and then by using only the averages of sample data in two different methods. In method 1 the average data for the 3 points in each sampling point was calculated and was correlated to the DN derived from the geometrical center of the points in the image. In method 2 the inhomogeneous data was excluded from each set and then the correspondent DN was considered from the middle of geometrical position of the points. Jump statistical software was used for a linear regression analysis to find any relation between the data derived form the laboratory works for the sampling data and the correspondent DNs in the image. In this analysis soil salinity was considered as related variant and DN as independent variant.

Results

The regression analysis results between salinity and DN over all of the data collected for the study area show a low regression coefficient, though by increasing the filter size in the image the coefficient slightly increases. However, the coefficient is higher when the analysis is limited for only the homogenous data. Among the different spatial filter which were applied for the analysis the filter with 5*5 pixels increased more the regression coefficient than the others 3*3 and 7*7 pixels. This was the same when the DN of the pixel located in the geometrical position of the three sampling points was considered to represent the correspondent DN for the average value of the three sampling data. The results were exception for band 7 and 1. Using spatial filter of 5*5 for bands 1, 2, 5 and 7 also caused increasing in regression coefficient. A7*7 spatial filter also increased regression coefficient except for Band 3.

It was concluded that the highest R^2 which was 0.1 for the main bands was derived for bands 3 and 4. Applying the middle geometrical position of the homogenous data and using 3*3 spatial filtering can increase regression coefficient in relation to the other two previous mentioned methods. This is exception only for bands 3 and 4 which using 5*5 spatial filter that makes the regression filter higher.

The highest regression coefficient ($R^2 = 0.1$) for this method is derived only when 7*7 spatial pixel was applied. The regression coefficients for vegetation cover in sampling points with the correspondent pixels DN are also low for different spatial filtering size. For instance, the highest regression coefficient (R^2=0.14) was derived for MIRV2 and SII when spatial filtering of 7*7 pixels was applied for the image

The regression coefficient was slightly increased when homogenous data analysis was applied for vegetation indices. The highest regression coefficient derived by this analysis was R=0.22 when applying MIRV2 with a 7*7 pixels spatial filter in the image. Using different averaging spatial indices for total dataset did not increase the regression coefficients, neither for applying medium of geometrical location of the two sampling points nor for the three in homogenous sampling points.

Table1- Average filters results on complete set of TM bands

Mean filter	RSquare(R^2)					
	Band1	**Band2**	**Band3**	**Band4**	**Band5**	**Band7**
Filter3*3	0/0027	0/0036	0/00089	0/00019	0/0029	0/0025
Filter5*5	0/0070	0/0124	0/0162	0/0163	0/0196	0/0037
Filter7*7	0/0092	0/0209	0/040	0/051	0/050	0/0055

Table2- Average filters results on complete set of TM bands without average

Mean filter	RSquare(R^2)					
	Band1	**Band2**	**Band3**	**Band4**	**Band5**	**Band7**
Filter3*3	0/0444	0/0406	0/0106	0/0030	0/0124	0/0458
Filter5*5	0/0530	0/0553	0/0365	0/0041	0/0438	0/0507
Filter7*7	0/0444	0/0406	0/0106	0/0030	0/0124	0/0458

Table3-Average filters on complete set average based on the position of the center of gravity of TM bands

Mean filter	RSquare(R^2)					
	Band1	**Band2**	**Band3**	**Band4**	**Band5**	**Band7**
Filter3*3	0/0405	0/0407	0/0629	0/0360	0/0175	0/0061
Filter5*5	0/0277	0/047	0/0744	0/0819	0/0275	0/0042
Filter7*7	0/0321	0/0501	0/104	0/132	0/0672	0/0108

Table 4-Average filters on homogenous set average based on mid geometrical position of TM bands

Mean filter	RSquare(R^2)					
	Band1	**Band2**	**Band3**	**Band4**	**Band5**	**Band7**
Filter3*3	0/0797	0/0701	0/0233	0/0003	0/0201	0/0649
Filter5*5	0/0519	0/0603	0/0496	0/0084	0/0452	0/0509
Filter7*7	0/0663	0/0874	0/111	0/0659	0/113	0/0614

Average filer results ETM bands

Table 5-Average filters on complete set average based on the position of the center of gravity			
Index	R^2(3*3)	R^2(5*5)	R^2(7*7)
BI	0/0584	0/0576	0/0698
IR	0/0020	0/0051	0/0
IR2	0/0001	0/0029	0/0009
MINI	0/0001	0/0029	0/0009
MIR	0/0002	0/0016	0/0039
MIRV1	0/0013	0/0051	0/0010
MIRV2	0/0350	0/0281	0/0005
MND	0/0018	0/0001	0/0005
MSI	0/0008	0/0041	0/0
NDVI	0/0018	0/0001	0/0006
NIR	0/0017	0/0002	0/0006
PD311	0/0301	0/0747	0/135
PD312	0/0061	0/0343	0/0530
PD321	0/0334	0/0577	0/127
PD322	0/0063	0/0086	0/0188
RA	0/0	0/0022	0/0012
SI1	0/0207	0/0180	0/0291
SI2	0/0018	0/0001	0/0006
SIMPLE	0/0094	0/0035	0/0030
VNIR1	0/0	0/0077	0/0116
VNIR2	0/0	0/0012	0/0036

Table 6-Average filters on homogenous set average based on mid geometrical position			
Index	R^2(3*3)	R^2(5*5)	R^2(7*7)
BI	0/0500	0/0561	0/0500
IR	0/0079	0/0163	0/0079
IR2	0/0342	0/0258	0/0342
MINI	0/0342	0/0258	0/0342
MIR	0/0633	0/0352	0/0638
MIRV1	0/0418	0/0303	0/0412
MIRV2	0/0003	0/0068	0/0004
MND	0/0147	0/0146	0/0147
MSI	0/0095	0/0180	0/0075
NDVI	0/0140	0/0154	0/0140
NIR	0/0128	0/0128	0/0156
PD311	0/0024	0/0098	0/0024
PD312	0/0309	0/0014	0/0309
PD321	0/0112	0/0014	0/0112
PD322	0/0577	0/0150	0/0774
RA	0/0172	0/0172	0/0106
SI1	0/0008	0/0572	0/0626
SI2	0/0264	0/0154	0/0140
SIMPLE	0/0081	0/0285	0/0281
VNIR1	0/0207	0/0109	0/0272
VNIR2	0/0177	0/0180	0/0319

Average filer results on vegetation cover indices

Table 7- Average filters results on complete set			
Index	R^2(3*3)	R^2(5*5)	R^2(7*7)
BI	0/0015	0/0145	0/0275
IR	0/0009	0/0007	0/0001
IR2	0/0004	0/0	0/0007
MINI	0/0004	0/0	0/0007
MIR	0/0001	0/0	0/0029
MIRV1	0/0012	0/0	0/0930
MIRV2	0/0077	0/0037	0/146
MND	0/0001	0/0	0/0027
MSI	0/0015	0/0009	0/0002
NDVI	0/0	0/0	0/0028
NIR	0/0001	0/0	0/0028
PD311	0/0006	0/0110	0/0232
PD312	0/0048	0/0014	0/0161
PD321	0/0040	0/0056	0/0287
PD322	0/0123	0/0	0/0047
RA	0/0	0/0	0/0007
SI1	0/0011	0/0080	0/119
SI2	0/0	0/0	0/0028
SIMPLE	0/0	0/0012	0/00002
VNIR1	0/0007	0/0002	0/0083
VNIR2	0/0009	0/0	0/0039

Table 8- Average filters results on complete set of TM bands without average			
Index	R^2(3*3)	R^2(5*5)	R^2(7*7)
BI	0/0277	0/0516	0/0667
IR	0/0291	0/0296	0/0247
IR2	0/0429	0/0348	0/0212
MINI	0/0426	0/0348	0/0212
MIR	0/0459	0/0360	0/0175
MIRV1	0/0440	0/0375	0/0372
MIRV2	0/0061	0/0170	0/225
MND	0/0316	0/0224	0/0062
MSI	0/0303	0/0305	0/0252
NDVI	0/0325	0/0229	0/0060
NIR	0/0309	0/0232	0/0061
PD311	0/0041	0/0006	0/0087
PD312	0/0275	0/0111	0/0003
PD321	0/0170	0/0008	0/0078
PD322	0/0642	0/0339	0/0060
RA	0/0310	0/0250	0/0135
SI1	0/0380	0/0557	0/0651
SI2	0/0325	0/0223	0/0060
SIMPLE	0/0391	0/0350	0/0171
VNIR1	0/0400	0/0214	0/0019
VNIR2	0/0472	0/0283	0/0062

Conclusion

It can be concluded that if the analysis is restricted only to the area where salinity is high, the regression coefficient would be higher that using all of the data set. Applying different combinations of the bands in calculating of vegetation indices resulted to increasing of regression coefficient, in compare of using the individual original bands. However the highest regression coefficients derived from the analysis is still not valid for being used as a model for assessment of soil salinity from ETM + image in the study area. Therefore it can be concluded that in there are some limitations of using ETM^+ for soil salinity assessment. This is because soil salinity is one of the most complex soil features. On the other hand the reflection from soil surface is not related to only one soil feature in arid aria because of salinity soil is a complex phenomenon and some soil surface condition such as gravely surface, and also the vegetations which are resisted to salinity and crusted surface may influence on the reflectance of soils, so remote sensing potentioal are limited to detecting salt affected soils.

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