Evaluation of ASTER and LISS III Data in Identification of Saline Soils, Case Study: Regions of Iran

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Abstract

Salts tend to concentrate on the soil surface in dry and irrigated areas. As salinity increases, more salts will appear at the soil surface, favouring the use of conventional remote sensing tools. Rapid identification and large-scale mapping of salt-affected soils will help improve salinity management in watersheds and ecosystems. Potentiality of various sensors is important in detecting saline soils and salt crusts. Therefore, in this study we evaluated the data of ASTER and LISS III sensors in Playas of DAMGHAN, KASHAN and MAHARLOO regions, IRAN. The first, the imageries corrected and then we used PCA, NDVI and band ratioing in detecting of saline soils. In band ratioing method, two index were applied, NDSCI and RSCI. Investigation of feature space graphs in saline and non-saline soils indicated that NDSCI and RSCI had the best separatiability. Then, the maps of this soils prepaired. In this maps, saline soils with salt crusts were perfectly clear. Relative calibration of visible and near infrared in applied approach showed, band ratioing and using of these two indexes(NDSIC and RSCI) were very efficient. In addition, in general the ASTER data were better than of LISS III data in separation of saline soils and non-saline.

Keywords: ASTER Data; Calibration; DAMGHAN; IRAN; KASHAN; LISS III; MAHARLOO; NDSCI; RSCI; Salinity; Salt crusts.

2.Methods

2-1-Study area

In this research three desert area include DAMGHAN, KASHAN and MAHARLOO were chosen. Figure 1 shows the situation of these areas in IRAN.

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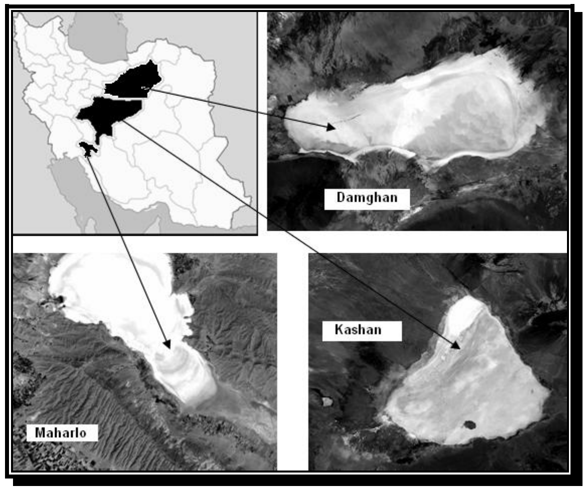

Figure 1. The location of study areas

2-2-Research methodology

2-2-1-Satellite images.

Tabe 1 shows the summery characteristics of sensors used.

Table.1 summery characteristics of sensors

Acquisition date	area	sensor
2007 NOV	DAMGHAN	
2007 JUL	KASHAN	
2006 JUL	MAHARLOO	LISSIII
2002 SEP	DAMGHAN	
2000 JUN	KASHAN	
2002 JUL	MAHARLOO	ASTER_L1B

2-2-2 Pre-processing of satellite data

In order to control the quality of used data and identify what extent of the systematic and non-systematic errors are fixed or remain after the systematic correction, the data were verified and determined all data used in this study, have standard corrections.

2-2-3 Alternative Calibration Method

For sensor calibration, due to the unavailability of sufficient information of study areas atmospheric conditions, the alternative method of relative calibration was devised. In this research the salt crusts of study areas were used for the relative calibration of LISSIII and ASTER sensors based on spectral reflectance method.

2-2-3-1 LISSIII sensor calibration

Using expression (1), the pixel DN of LISSIII sensor calibrated data convert to radiance:
(Slater, 1999). In this study, the following equation for the calibration of bands 2, 3 and 4 of LISSIII sensor were used:

$$L_\lambda = \left(\frac{L_{\max\lambda} - L_{\min\lambda}}{Q_{cal\max} - Q_{cal\min}} \right) Q_{cal} + L_{\min\lambda} \quad (1)$$

$$L_2 = \frac{148.005}{128} \times DN$$

$$L_3 = \frac{156.644}{128} \times DN$$

$$L_4 = \frac{164.543}{128} \times DN$$

2-2-3-2 ASTER sensor calibration

To convert from DN to spectral radiance of ASTER L1B calibrated data used equation(2):

$$L_\lambda = (DN-1).UCC \quad (2)$$

Where L_λ is the sensor spectral radiance in w/(m2.sr.µm), UCC is unit conversion coefficient in (w/(m2.sr.µm)) (Markham, 2005). In this study, the following equation for the calibration of bands 1, 2 and 3 of ASTER sensors were used :

$$L_1 = (DN-1) \times 0.676$$

$$L_2 = (DN-1) \times 0.708$$

$$L_3 = (DN-1) \times 0.862$$

After convert and calculate the radiations of visible and NIR bands of LISSIII and ASTER sensors, the equation (3) were used to convert the radiance to reflectance:

$$\rho_p = \frac{\pi . L_\lambda . d^2}{ESUN_\lambda . \cos\theta_s} \quad (3)$$

Where ρ_p is the amount of reflectance that is a quantity without unit, L_λ is the input spectral radiance of sensors (w /m2.sr.µm), *d* is the Earth-Sun distance in astronomic unit depends on Day, Year, Solar Zenith Angle, the time of image taking, latitude and longitude. $ESUN_\lambda$ is the solar exoatmospheric irradiance in the top of the atmosphere in band λ (w / (m2.sr.µm)), and θs is the Solar Zenith Angle at the image acquisition time in degree (Markham, 2004).

3- Results

3-1- Correlation of sensor bands LISSIII

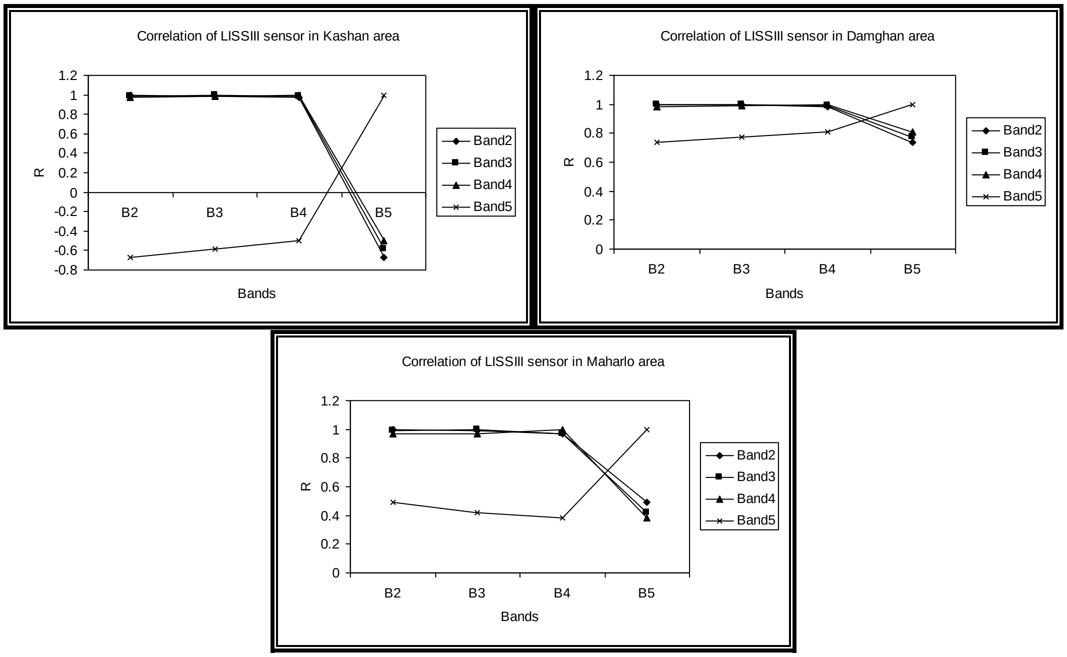

Figure 2. Correlation trend charts of LISSIII sensor in DAMGHAN, KASHAN and MAHARLOO area

As seen in figure (2), bands 2, 3 and 4 have a high correlation with each other. Band 5 shows less correlation with other bands, so this band has diverse information than others, thus band5 low correlation with other bands indicating the existence of fairly useful information on this band and requirement of its applications to identify the salt crusts.

3-2- Surveillance of bands correlation of ASTER sensor

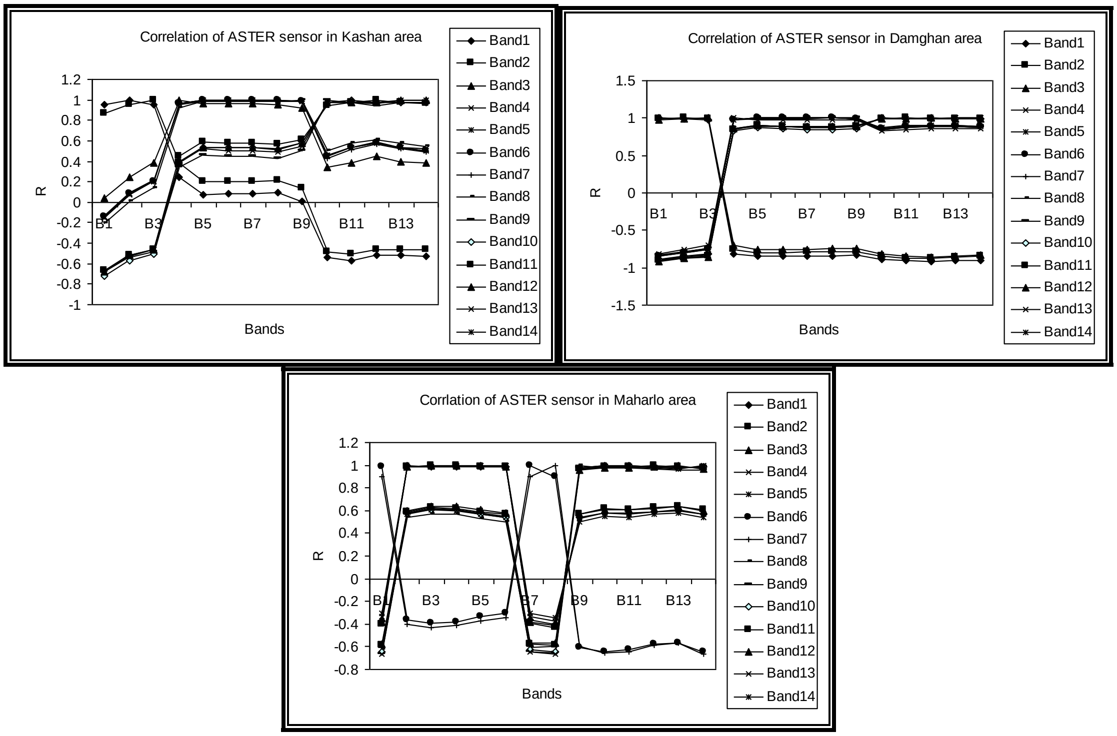

Figure 3. Correlation trend charts of ASTER sensor in DAMGHAN, KASHAN, and MAHARLOO area

As shown in figure 3, band1 and band 3 have a great correlation. Near infrared, middle infrared and thermal infrared bands have a great correlation too. Therefore low correlation between near infrared, middle infrared and thermal infrared bands with visible bands indicates existence of useful information in these bands and necessity of use this information to recognize salt crust.

3-3- Principal Component Analysis

Variance percentage of principal component analysis (Figure 4) shows that more than 90% of information is concentrated on first and second component, after compressing. Thus, first and second component have useful information about salt crusts which extractable in both form of visual and digital.

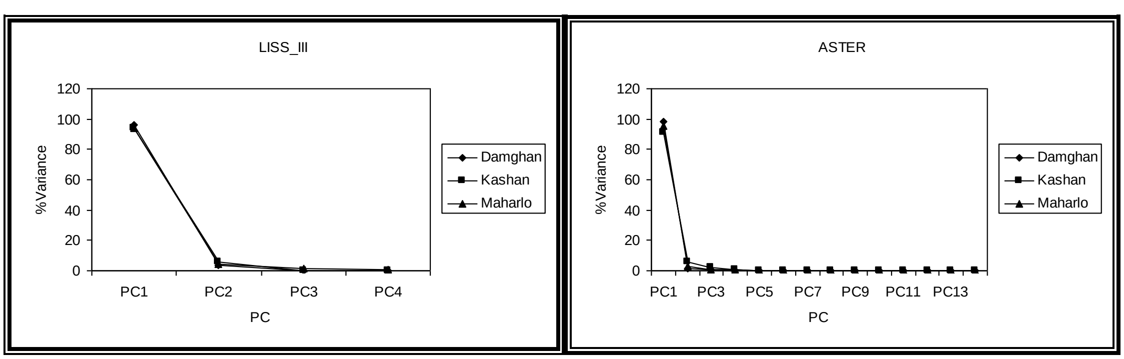

Figure 4. PCA Chart percent variance of LISSIII and ASTER sensors in DAMGHAN, KASHAN, MAHARLOO

3-4- Spectral Rationing

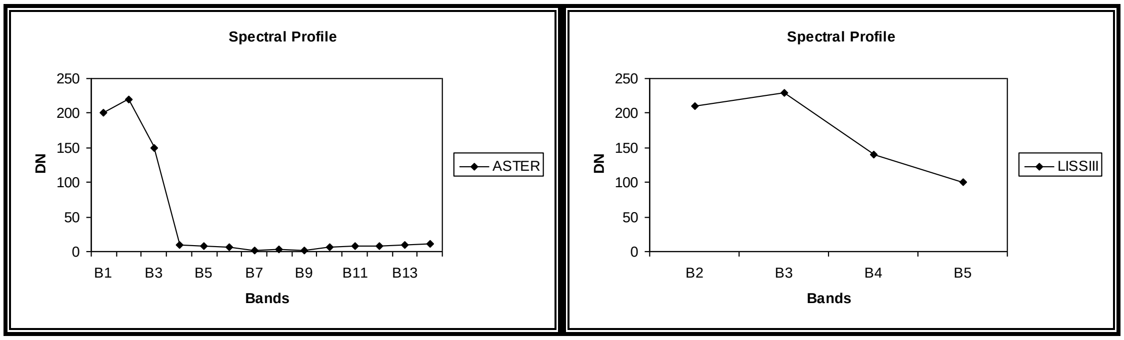

Figure 5. Average spectral reflection curves of DAMGHAN, KASHAN, and MAHARLOO salt areas in spectral band of LISSIII and ASTER sensor

On the basis of analysis of salt crusts spectral reflectance average curve, we can realize that difference value of salt crusts spectral reflectance in visible and middle infrared, is too high. In this research two new indices of salt crust have been introduced with regard to the characteristics of ASTER and LISS III sensors in arid and semi-arid condition of desert region.

3-4-1- Ratio Salt Crust Index

Ratio salt crust index is the simplest salt crust index and is defined as;

$$RSCI = \frac{LISSIII5}{LISSIII3} \cong \frac{ASTER4}{ASTER2} \tag{4}$$

This index, have a simple formula from the point of view of calculation and its values domain is between 0 and 1, so that the values toward 0, indicates salt crust.

3-4-2- Normalized Difference Salt Crust Index

Normalized difference salt crust index is defined as;

$$NDSCI = \frac{LISSIII3 - LISSIII5}{LISSIII3 + LISSIII5} \cong \frac{ASTER2 - ASTER4}{ASTER2 + ASTER4} \tag{5}$$

This index, have a similar treatment with RSCI salt crust index from the viewpoint of operation.

3-5- Thresholding

For evaluating separation capability of first and second component, NDVI vegetation index also RSCI and NDSCI indices, first, images of ASTER and LISS III sensor bands with images obtained from first and second component, also NDVI vegetation index and RSCI and NDSCI salt crust indices, were put into a map list and then pseudoscopic color image were produced. Through visual interpretation on pseudoscopic color image, training classes of salt crust and non- salt crust were selected and displayed on monitor by feature space diagram simultaneously. After samples were selected, feature space diagram of pixel dispersion were evaluated and at the end, samples were modified by evaluation of feature space diagram of training classes with regard to this issue that pure pixel of salt, must separate from other pixels, to identify salt crust. Therefore capability of images which obtained from first and second component, also NDVI vegetation index and RSCI and NDSCI salt crust indices, was evaluated by feature space diagram. After repetitious examination of feature space diagrams, specified that RSCI and NDSCI salt crust indices shows the best discrimination capability for salt crust and non-salt crust classes. (Figure 6 and 7). Thus, in final step, threshold values between 0 and 255 were used to have more certainty about RSCI and NDSCI salt crust indices discrimination values. Different thresholds for RSCI and NDSCI salt crust indices were determined by trial and errors and finally thematic maps that include salt crust and non-salt crust classes were obtained, in which salt crust discriminated perfectly. (figure 8 and 9)

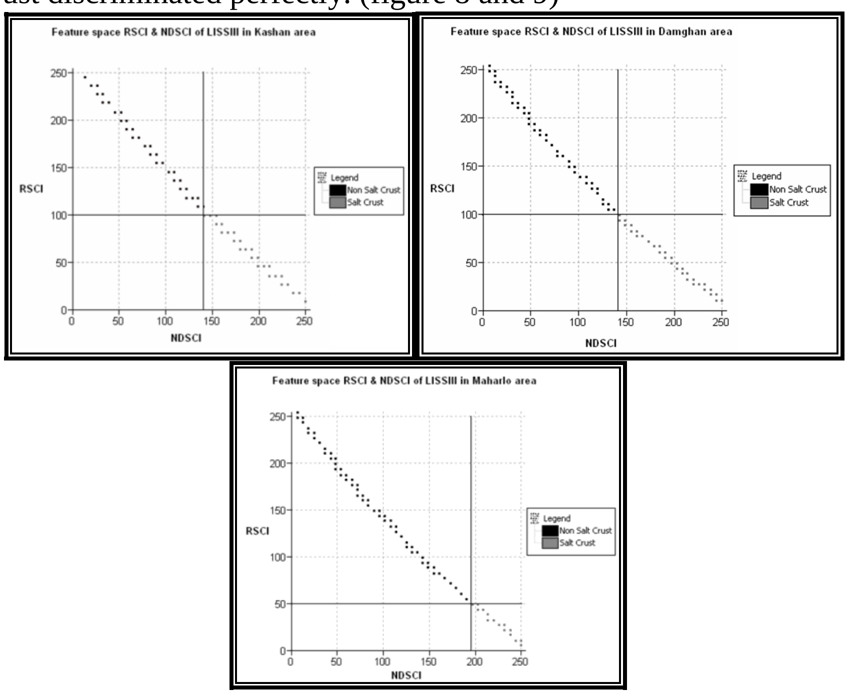

Figure 6. The scatter of pixels in two dimension space for RSCI and NDSCI indices of LISSIII in DAMGHAN, KASHAN, MAHARLOO areas

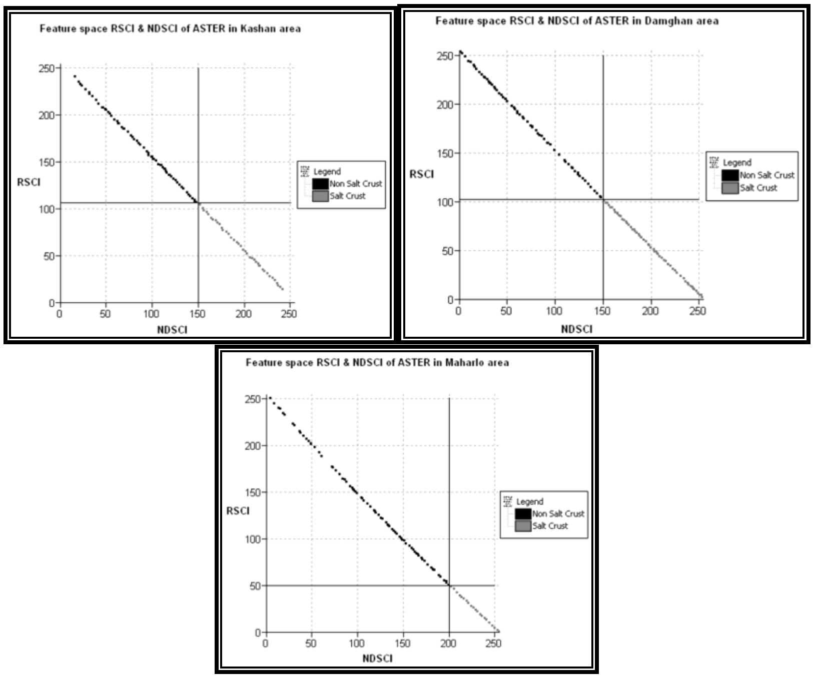

Figure 7. The scatter of pixels in two dimension space for RSCI and NDSCI indices of ASTER in DAMGHAN, KASHAN, MAHARLOO areas

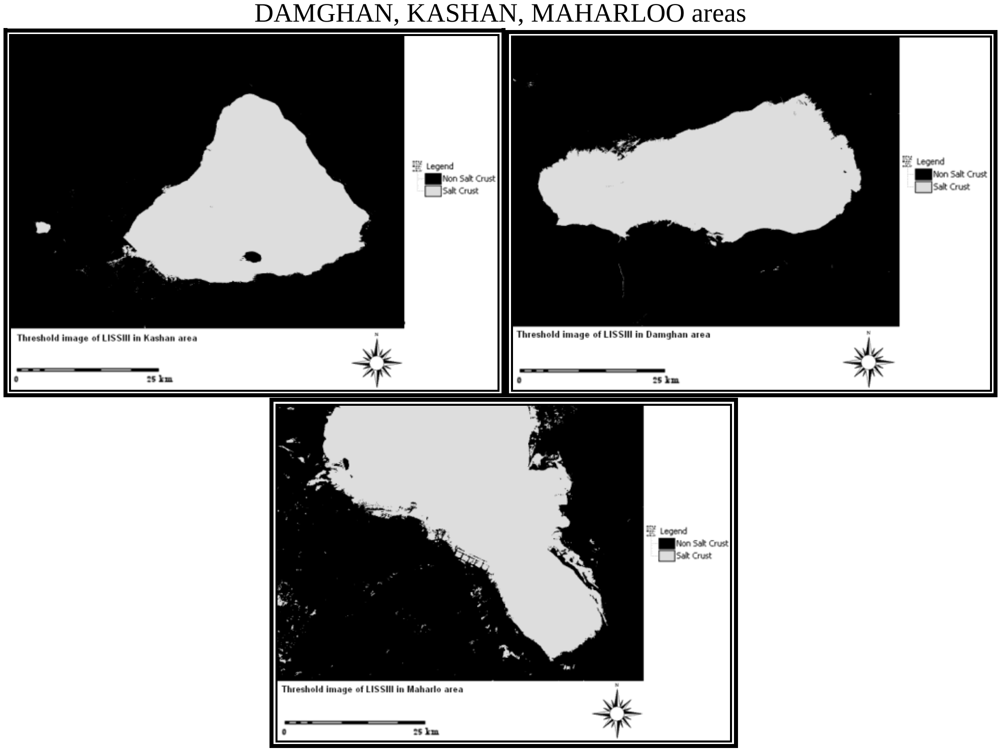

Figure 8. The image results of RSCI and NDSCI indices thersholding for LISSIII sensor in Damghan, Kashan and Maharloo area

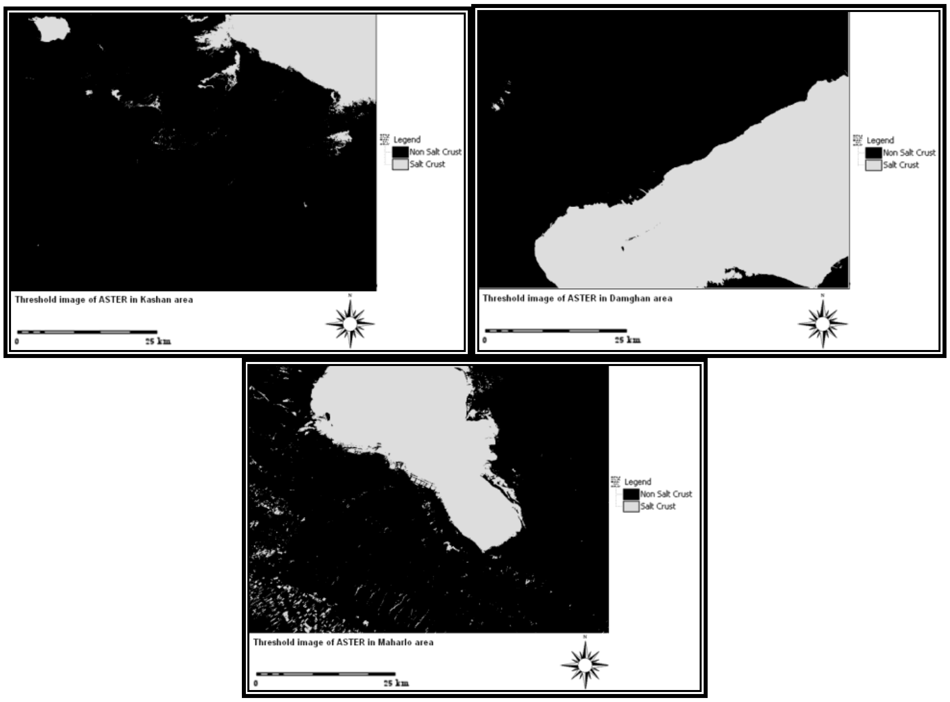

Figure 9. The image results of RSCI and NDSCI indices thersholding for ASTER sensor in Damghan, Kashan and Maharloo area

3-6- Superseding Calibration of ASTER and LISS III Sensors

After evaluation of salt crusts in studied areas, brightness value according to 1 and 2 equations, converted to receiving spectral radiation of satellite sensor. Correlation between brightness value and spectral reflectance was evaluated by calibration curve through overlaying of information layers of brightness value and calculated spectral reflectance for each visible and near infrared bands of ASTER and LISS III sensors, also performing cross instruction in ILWIS software. Figure 10 shows calibration curve of each visible and near infrared bands of LISS III sensor and Figure 11 shows calibration curve of each visible and near infrared bands of ASTER sensor in Damghan region. Calibration curve of Kashan and Maharlou, are the same with Damghan calibration curve.

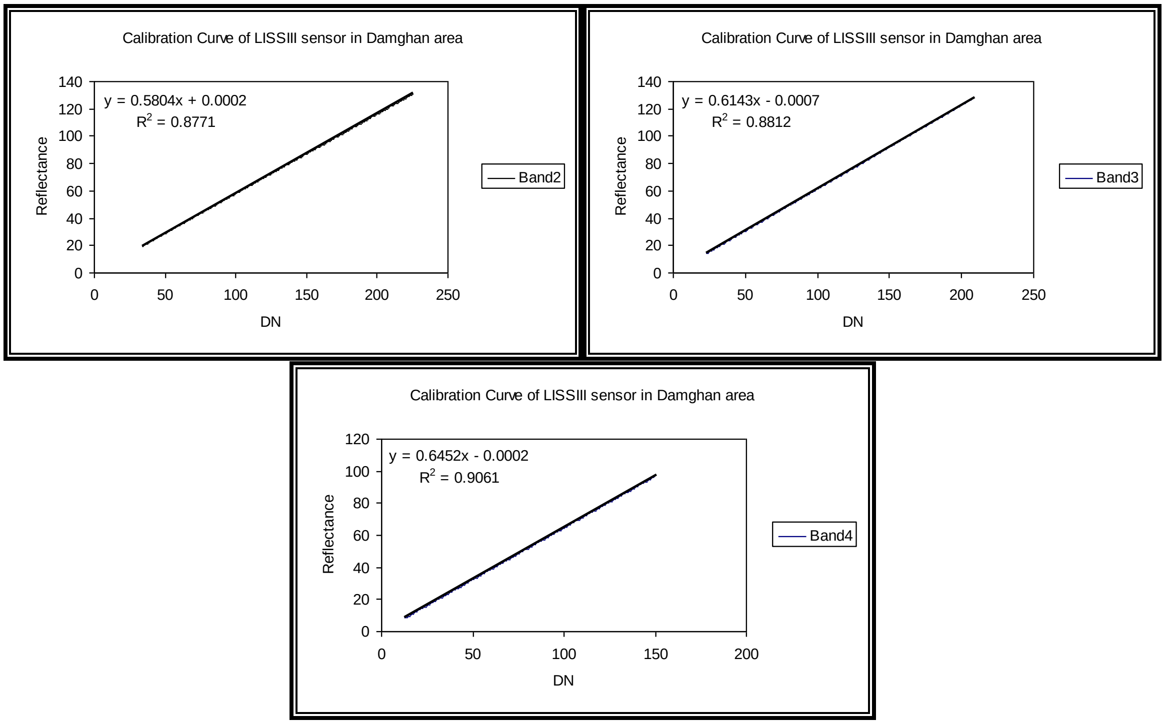

Figure 10. Calibration curve of visible and NIR bands for LISSIII sensor in Damghan area

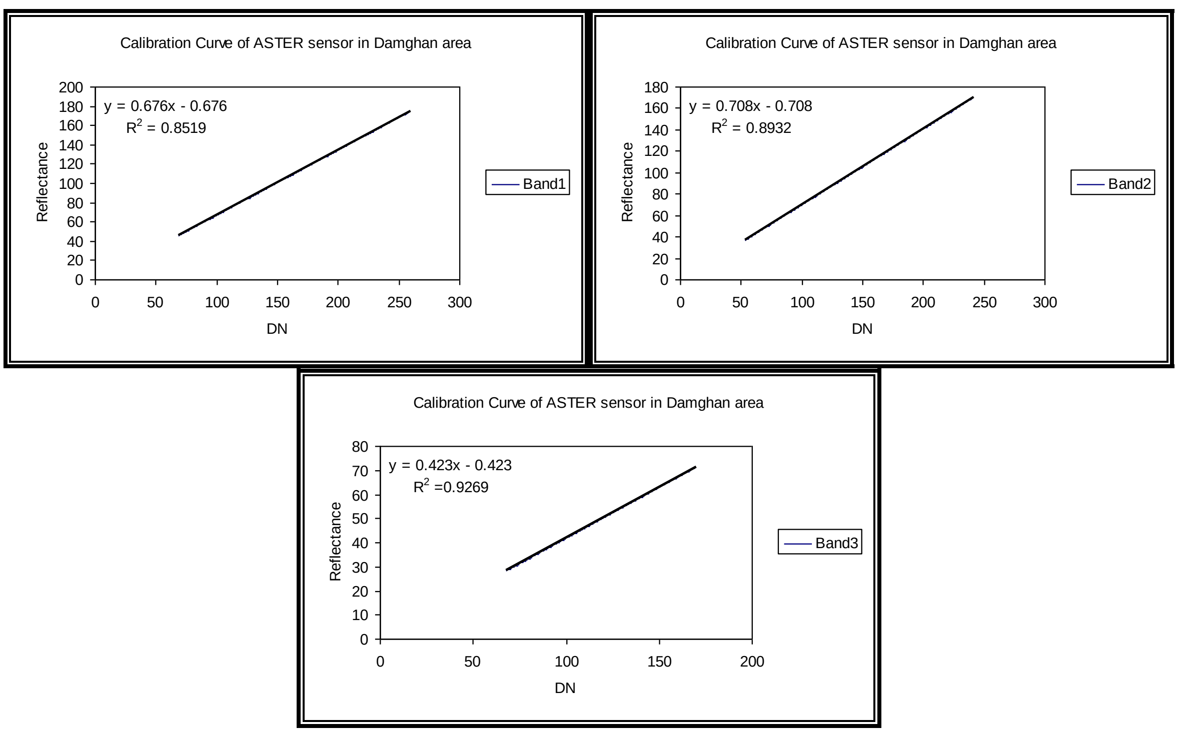

Figure 11. Calibration curve of visible and NIR bands for ASTER sensor in Damghan area

4- Conclusion

1- Analyzing the result of information obtained from ASTER and LISS III sensors shows that every three groups of ASTER bands have different band width and brightness value with respect to LISS III sensor .Thus the information of ASTER does not compare with the information of LISS III. In addition to, correlation process between the bands of LISS III and ASTER sensors is different with regard to geographic situation and salt marsh conditions of Damghan, Kashan and Maharloo, such as salt type, humidity, density of vegetation coverage and etc. Different status of salt marshes condition in different months or different seasons of the year is one of the effective parameters on band correlation.

2- Evaluating spectral reflection of salt marshes in different sensor bands can help us to study and identification of those. Optimum selection of bands is an important factor to salt marshes identification in spectral rationing method. In this method, reliable land data and information or personal experiment is important and required. Beside of complementary information requirement, much dependence on used sensor and its characteristics such as number of bands, band width in electromagnetic spectrum and its resolution, is one of the weak points of spectral rationing method. Also, accuracy of the results, depend on bands combination which is used for spectral rationing. Visible and middle infrared parts of spectral bands are suitable for identification of salt marshes. The reason of this circumstance, is, high reflection of salt marshes n visible and high absorption in middle infrared parts of electromagnetic spectrum. We can enhance and recognize the regions that have high percentage of salt by generate ratio between visible and middle infrared parts of electromagnetic spectrum. Therefore with accurate selection of visible and middle infrared spectral bands and generating ratio between them, salt marshes are recognized better. In this research by definition of salt marshes indices such as RSCI and NDSCI with regard to the characteristics of ASTER and LISS III sensors, salt marsh recognized better. The importance of salt marsh indices, RSCI and NDSCI, depend on the data type which used and salt covering surface. These indices can be use to study of the salt marshes of desert regions.

3- Thresholding is an information exploitation method to identify salt marshes which assign the amplitude pixel value to the desired class. Although accurate determine the desired amplitudes are not possible easily and always performed by trial and error. For perform thresholding, quantities of amplitudes are determine by user with regard to situation of the area, complementary information, science and adequate experiment. The best and optimum quantities are usually obtain in a trial and error process and examination of pixel dispersion in two-dimension diagram.

4- Comparison the correlation between brightness degree and spectral reflection of calibration diagram of each bands of visible and near infrared which obtained from ASTER and LISS III sensors, shows that use of salt marsh in maximum spectral reflection quantities, will reduce errors arising from atmospheric effects and sensor calibration. Existence of linear relation and high specification index in each visible and near infrared bands of ASTER and LISS III sensors, indicate that high percentage of changes (more than 80%) depend on spectral reflectance of salt marsh and low percentage of changes (less than

20%) impressed by unwanted parameters such as atmosphere and etc. therefore salt marshes can be use to calibration of satellite sensor in visible and near infrared bands.

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