The Use of Landsat Thematic Mapper Data for Mapping the Marginal Playa Soils in Damghan Playa ,IRAN

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Key words:

ABSTRACT

Having notice that playa and arid lands have a harsh condition, studying and field observation in these areas face some limitation and difficulties and even in some cases is not possible. Therefore in order to overcome some of these problems, remote sensing and landsat satellite data can be very useful to study such areas, especially because of absence (or near-absence) of vegetation cover, usually clear sky, a shortage of rainfall and thus low soil moisture contents. (Escadufal and Puget 1986, Mulders and Epema 1986, Abd El-Hady et al. 1991). Soil is one of the most important parts of this environment, which always has been considered for researchers. Many researches were interested to study relationship between soil surface characteristics and soil spectral behaviors. Gossense et al. (1991) in Ismailia province of Egypt using TM1, TM3, TM5, TM6 bands, that were obtained from OIF calculation, detected gypsiferous soils. They have used another bands combination including TM6, TM7, TM5, TM3 in order to separate gypsiferous soils from other soils. Metternicht and et al. (1997) using an integrated approach of digital image classification including field observation and laboratory analysis discriminated salt and sodium affected soil surfaces. Alavipanah et al. (1997) have studied soil salinity in Ardakan area, Iran, based on the field observations and remotely sensed data. They concluded that behavior of the TM thermal and reflective TM bands is highly depended on the type of land cover.

The study area located in north Eastern of Iran Semnan Province and southwestern of Damghan Town with 35° 36′ 14″ to 36° 5′ 9″ latitudes and 54° 5′ 44″ to 54° 58′ 16″ longitude (Figure 1) which covers 46600 ha.

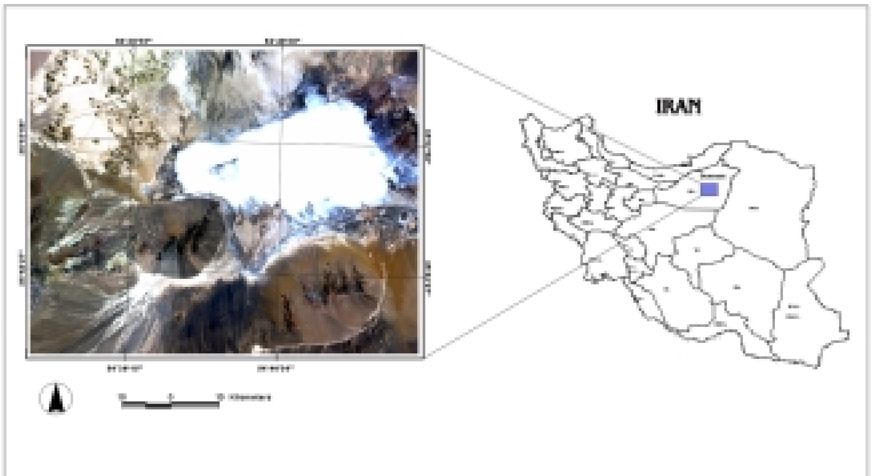

Figure 1. The location of studying area.

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1. INTRODUCTION

Having noticed that playa and arid lands have a harsh condition, studying and field observation in these areas face some limitation and difficulties and even in some cases is not possible. Therefore in order to overcome some of these problems, remote sensing and landsat satellite data can be very useful to study such areas, especially because of absence (or near-absence) of vegetation cover, usually clear sky, a shortage of rainfall and thus low soil moisture contents. (Escadufal and Puget 1986, Mulders and Epema 1986, Abd El-Hady et al. 1991). Soil is one of the most important parts of this environment, which always has been considered for researchers. Many researches were interested to study relationship between soil surface characteristics and soil spectral behaviors. Gossense et al. (1991) in Ismailia province of Egypt using TM1, TM3, TM5, TM6 bands, that were obtained from OIF calculation, detected gypsiferous soils. They have used another bands combination including TM6, TM7, TM5, TM3 in order to separate gypsiferous soils from other soils. Metternicht and et al. (1997) using an integrated approach of digital image classification including field observation and laboratory analysis discriminated salt and sodium affected soil surfaces. Alavipanah et al. (1997) have studied soil salinity in Ardakan area, Iran, based on the field observations and remotely sensed data. They concluded that behavior of the TM thermal and reflective TM bands is highly depended on the type of land cover.

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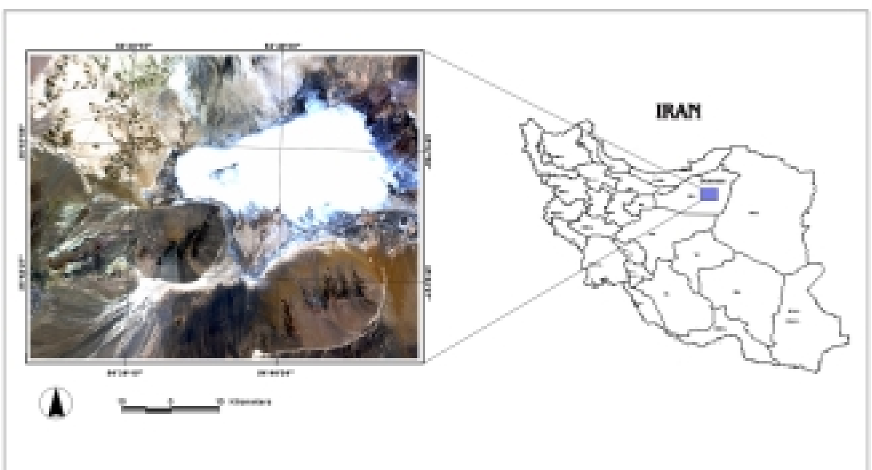

The average rainfull of the area is 147.3 mm and according to the report and cencus of Iran Meteorological Organization, the climate of the area is a cold arid.

2. MATERIALS

2.1 Material Inputs:

The materials used for this study are as follows:

1) 8 spectral bands of the enhanced thematic mapper (landsat 7) recorded July 20th 2000 (1790 * 2660 pixel).
2) Topographic maps on 1:50/000 scales.
3) Land use map on 1:100/000 scale
4) Geological map on 1:100/000 scale.

The hardware used were IBM PC Pentium III 433MHZ, scanner A3 Mustek, color printer 1125 c professional DeskJet.

Software used were Ilwis 3, Arcview 3.1 and Excel.

2.2 Methods

The methods used have been showed in figure 2. The most important stage of this flowchart is in the following way.

I- *<u>Image processing:</u>* The applied methods of image processing are including

– Georeferencing
– Principal components analysis
– Spatial filtering techniques
– Linear streaching
– Studying the colour compositions (natural and false colour).

	ETM+1	ETM+2	ETM+3	ETM+4	ETM+5	ETM+6	ETM+7	ETM+8
ETM+1	1							
ETM+2	0.97	1						
ETM+3	0.93	0.98	1					
ETM+4	0.87	0.94	0.97	1				
ETM+5	-0.01	0.08	0.13	0.15	1			
ETM+6	-0.63	-0.6	-0.56	-0.57	0.55	1		
ETM+7	-0.19	-0.11	0.06	-0.04	0.96	0.7	1	
ETM+8	0.91	0.97	0.98	0.98	0.13	-0.57	-0.06	1

Table 1: Correlation matrix between ETM + bands

Table 1 shows the correlation matrix between ETM + bands. Figure3 also shows correlation curve between the bands.

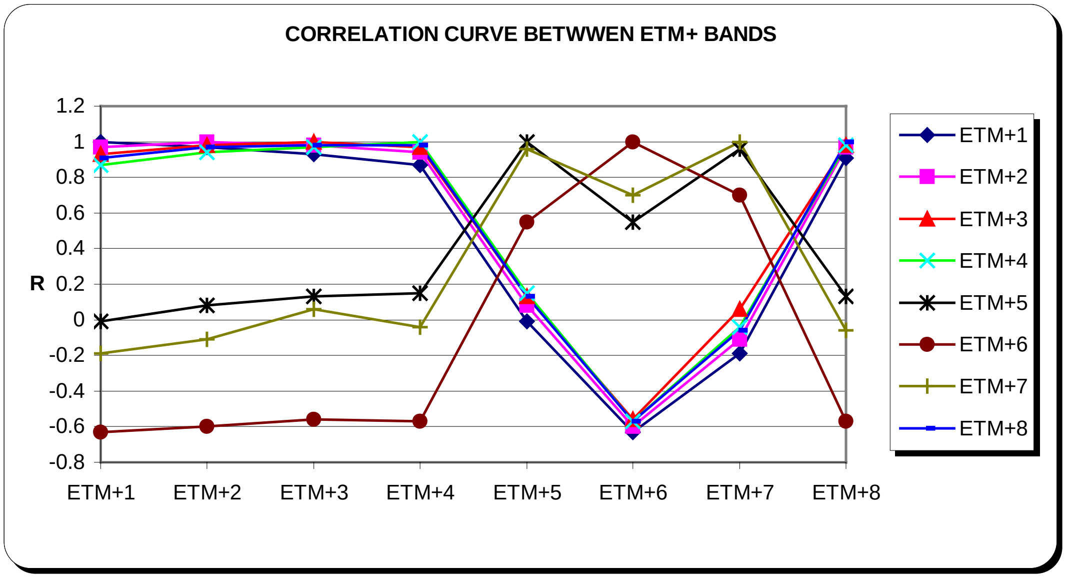

Figure 3: Correlation curve for ETM + bands

Although studying the correlation curve and matrix between ETM+ bands can remarkably help know of bands correlation but we can not obtain a quantitative result to select the best bands combination for information extraction. In order to overcome this problem chavez et al. (1982) introduced optimum index factor (OIF) which provide optimum band selection based on the variances and correlation of bands.

In this research two set OIF were calculated. In first calculation all bands were used and in second one thermal band (ETM+6) was neglected. Table 2 and 3 show the result of these calculations.

Table 2: OIF INDEX HIGHEST RANKING WITH ETM+6

ORDER OF	ETM+ BANDS		VALUE OF OIF
ETM+1	ETM+4	ETM+7	275.42
ETM+1	ETM+7	ETM+5	261.26
ETM+1	ETM+8	ETM+7	238.69
ETM+1	ETM+2	ETM+7	232.89
ETM+2	ETM+4	ETM+7	225.71
ETM+1	ETM+3	ETM+7	224.57

Table 3: OIF INDEX HIGHEST RANKING WITHOUT ETM+6

ORDER OF ETM+ BANDS			VALUE OF OIF
ETM+2	ETM+5	ETM+6	4559.12
ETM+6	ETM+7	ETM+8	2775.14
ETM+4	ETM+6	ETM+7	1977.39
ETM+3	ETM+6	ETM+7	1877.26
ETM+5	ETM+6	ETM+8	1673.48
ETM+4	ETM+5	ETM+6	1315.9

Using image processing technique and Digital-visual interpretation the homogeneous spectral unites based on the Tone, Colour, Pattern and Texture were determined. With field observation and using GPS 19 training areas were defined and condition of each unites were studied.

At second step by studying the feature spaces of training area and spectral signatures and based on the OIF calculations, the best bands combination were selected for classification.

II- Image classification:
Based on the information obtained from image processing technique, visual interpretations, OIF calculations, feature space analysis , spectral signature analysis, and in order to study the efficiency of ETM+ bands to detect the marginal playa soils four below bands combination selected and maximum likelihood classification was carried out..

A. Using all Bands

B. *B:* Using the first and second bands combination ranking of OIF calculation with thermal band (ETM+2, ETM+5,ETM+6, ETM+7)

C. Using the ETM+2, ETM+5, ETM+7 combination (excluding thermal band)

D. Using the first and second bands combination ranking of OIF calculation excluding thermal band (ETM+1, ETM+4, ETM 5, ETM+7).

Table 4 illustrates the characteristic of these unites.

3. CLASS	4. CLASS DESCRIPTION	Soil Classification (U.S.D.A)
soil (1)	hard brown soil, weak vegetations, saline and, poorly infilteration, milde slope	Typic salorthids
soil (2)	Alluvial, Silty loam soils, suitable vegetation, milde slop	Typic camborthids

soil (3)	Hard salin soil with salt crust, without any vegetation	Typic salorthids
soil (4)	Torrential saline clay soils, very saline, without gravel at soil surface	Aquollic salorthids
soil (5)	sandy loam desert soil with weak vegetation	Psaments
soil (6)	Brown saline soil with dense hallophyte vegetation	Typic salorthids
soil (7)	Brown puffy soil, weak vegetation, very saline and sodic, milde slope, ground water table is close to surface (0.5-1m)	Typic salorthids
soil (8)	Brown salin silty clay soils, ground water table is closed to the surface (less than 0.5m)	Aquollic salorthids
soil (9)	Sandy loam desert soils including sand dunes with dense vegetation	Psaments
soil (10)	Puffy saline soil, low infiltration, very saline	Typic salorthids
soil (11)	Microyardang with gypsiferous crystal at surface	Typic salorthids
Desertcrust1 (soil12)	Polygon crust, ground water table is close to surface (less than 0.5m), slightly poorly drained soils	Aquollic salorthids
Desert rust2 (soil13)	Salt crust and salt blisters, slitly poorly drained soils, at the whole of year the salt crusts and salt blisters covers the playa	Aquollic salorthids
Fan(1)	Desert pavement with low varnish and small gravely soil surface	Typic camborthents and Typic xerorthents
Fan(2)	Desert pavement with high varnish and big granely soil surface	Typic camborthents and Typic xerorthents
Fan(3)	Desert pavement including sandy soils	Typic camborthents and Typic xerorthents
Fan(4)	Desert pavement with moderat varnish and gravely soil surface	Typic camborthents and Typic xerorthents
Farmveg	Farm vegetation including crops, tomatos and other healthy vegetation	
Pistachio	Pistachio trees	

Table 4: Summary illustration of characteristic of training area

Figure 4 illustrates the result of each approach. Then with merging the similar classes the landcover map was provided (Figure5). The post classification procedure including iterative majority filtering to remove small patches were used. To evaluate the classification performance, 4 confusion matrixes using reference data were elaborated and overall accuracy, average reliability, average accuracy and Kappa Index were determined.

Average reliability indicates the probability of correct classification of a reference data, while Average accuracy refers to the probability that a pixel classified on an image is in reality representative of that class on the ground.

5. RESULT AND DISCUSSION

5.1 Feature Space Analysis

The feature space for training area of both band combinations clearly show different clusters corresponding to different soil types. The feature space between red (ETM+3) and near infrared (ETM+4) bands indicate the presence of a so-called "soil line". (Figure6)

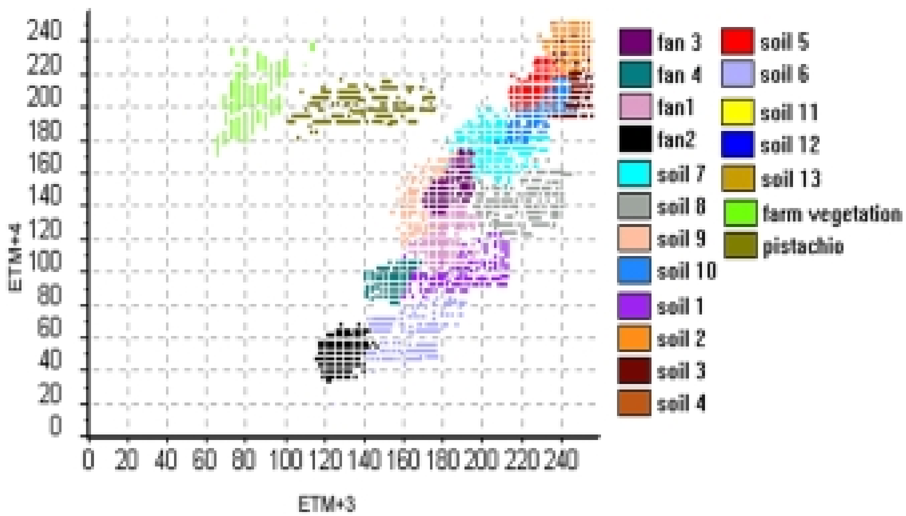

Figure 6: 2D-feature space between ETM+3 and ETM+4

In this feature space because of the nature and different spectral response of the farm vegetation and pistachio farm classes, they were clearly separated from soil classes and situated upper the soil line also the farm vegetation situated upper the pistachio indicating higher spectral response. The vegetation is not interfering with the different soil types.

The soil classes are located side by side. The class fan 2 (desert pavement with high verni) located in lower left part of the feature space and also class Soil 2 (Alluvial silty loam) located in upper right part of the feature space.

5.2 II Spectral Signature Analysis

In order to determine the relationships between spectral response and characteristics of playa soils spectral signature for each lasses have been determined using averaging over 500 random pixel sampling in each bands. Figure 7 illustrate the spectral signature graph for the classes soil 2, soil 4 and soil 8.

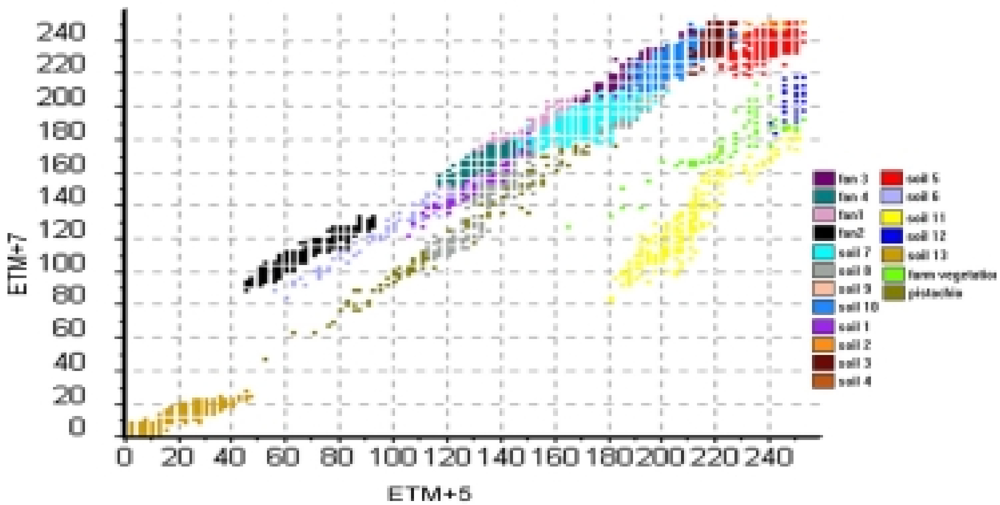

Figure 7: Spectral signatures soil 2, soil 4 and soil 8

Class soil 2 (Alluvial silty loam soil) and soil 4 (torrential saline clay soi1s) have a near spectral signature trends in all ETM+ bands but the only difference of them occurs in thermal band. This is important because it can be deduced that the soil 4 warm-up more rapidly than soil 2 thus the classification with combination bands ETM+2, ETM+5, ETM+6, ETM+7 separated as well these two soil types but ETM+2, ETM+5, ETM+7 combination bands was unable to do so. (Figure 4). The class soil 8 (brown saline silty clay soil) is clearly separated from both classes.

Figure 8 illustrates the spectral signature graph of polygon crust (soil 12) and salt blister crusts (soil 13) that covers the playa. This graph clearly indicates those polygon crusts having high reflectance in ETM+5 and ETM+7 bands. But the salt blister crusts (soil 13) have a low reflectance in these bands.

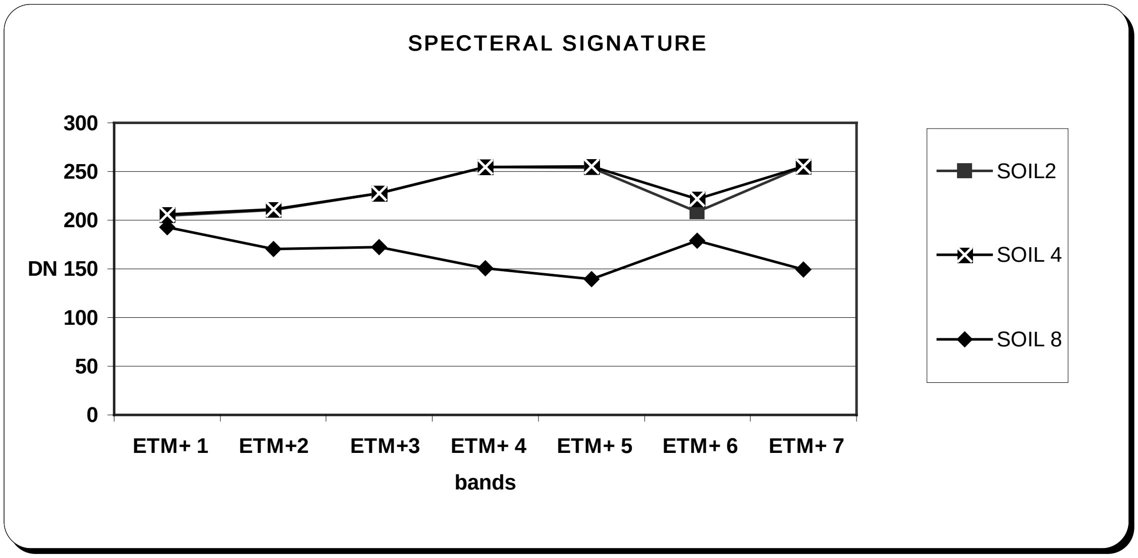

Figure 8: Spectral signature of soil 12 and soil 13

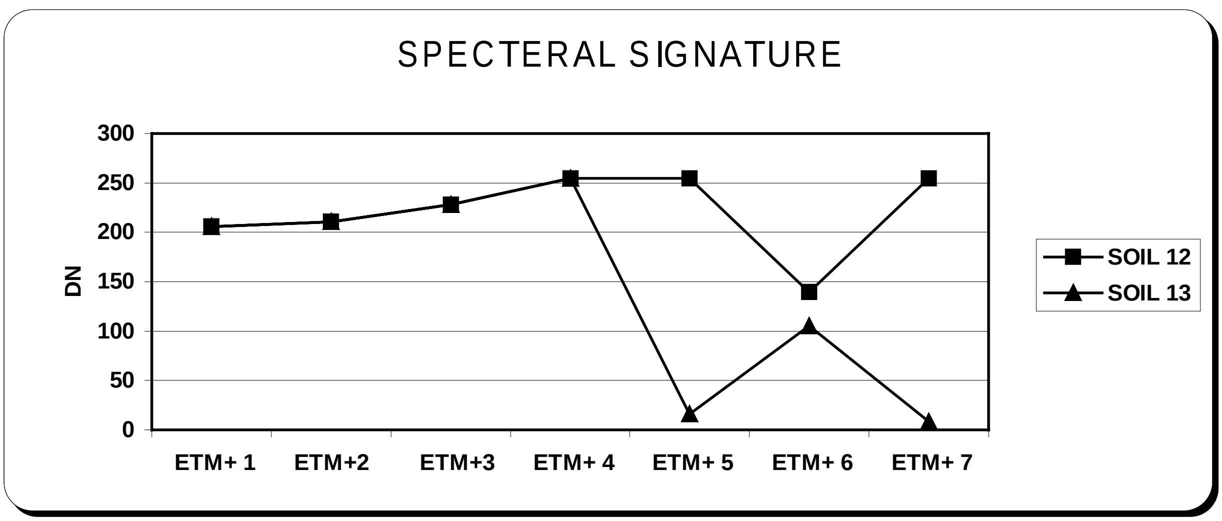

Figure 9: Spectral signature of the farm vegetation and pistachio farm

It can thus concluded that both ETM+5 and ETM+7 band have a key role in studying the polygon crusts and salt crust that covers the playa. Figure 9 illustrates the spectral signature of farm vegetation and pistachio. This graph shows that farm vegetation in all bands has a higher reflectance than pistachio farm.

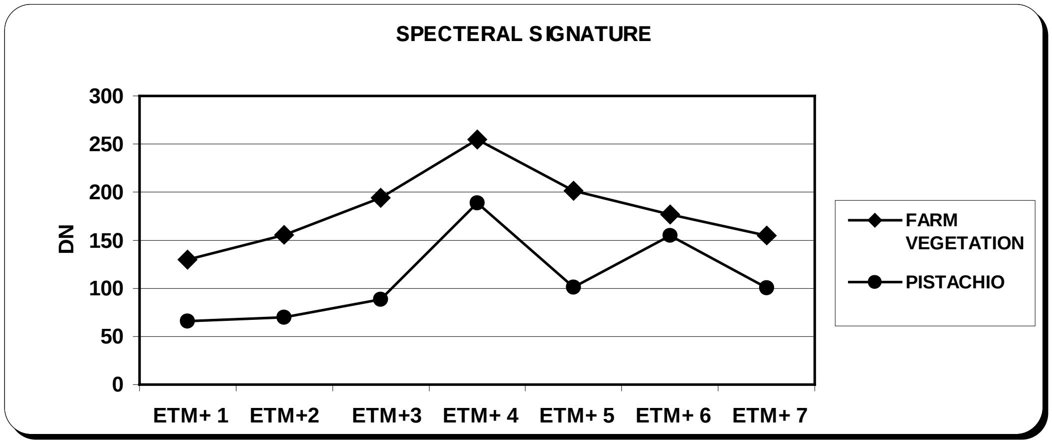

Figure10: Spectral signature of the farm vegetation and pistachio farm

The result of the classification showed that the highest accuracy was related to the first approach (93.97%).The obtained accuracy for the second approach (2, 5, 6, 7 ETM bands) was 91.15%, third approach (2,5,7 ETM+ bands)was 72.02% and for the fourth approach (1, 4, 5, 7 ETM+ bands) was 64.19%.

6. CONCLUSION:

We can conclude that each enhanced thematic mapper bands offers possibilities for detect and differentiating marginal playa soil. Due to enhanced spectral resolution of thermal bands in landsat 7 (60 meter) and temperature difference this band has a key role to detecting some classes. Infrared ETM+ bands (ETM+5, ETM+7) in studying the salt crust and salt blisters from different classes were also very efficient. This information can be used to increase the efficiency of soil survey procedure and make it easier to delineate soil map boundaries and soil profiles.

REFERENCES

Alavi panah, S.K., Goosens, R., De dapper, M., 1999, “Study of soil salinity in the Ardakan area, Iran based upon field observation and remote sensing”. operational remote sensing for sustainable development, Bolkema, Rotterdam, PP419-426.

Bryant, R.G., 1996, “Validated linear mixture modeling of landsat TM data for mapping evaporite mineralson playa surface methods and applications”. INT.J. Remote sensing, Vol. 17, No. 2. PP315-330.

Chavez P.S. et.al, “Statistical method for selecting landsat MSS Ratios”, Journal of applied photographic engineering., Vol 8, 1982.

Escadafal, R. and Pouget, M., 1986, lminace spectral et carasteres de la surface des sois en region arid Mediterraneene (sod Tun, sien), ITC Journal 1, 19-23.

Gossense. R. and Van Ranst, E. 1999, The use of Remote Sensing and GIS to detect gypsiferous soils in the Islamia province Egypt Nieuwenhvis Balkema, Rotterdam, PP 97-102.

Metternicht, G., Zink, J. 1997, “Spatial discrimination of salt and sodium affected soil surface”. INT. J. Remote Sensing Vol. 18, No. 12, PP 2571-2586.

Mulders, M.A. and Epema. G.F. 1986. “The thematic mapper a new tool for soil mapping in arid area”, ITC Journal, 1, 24-29.

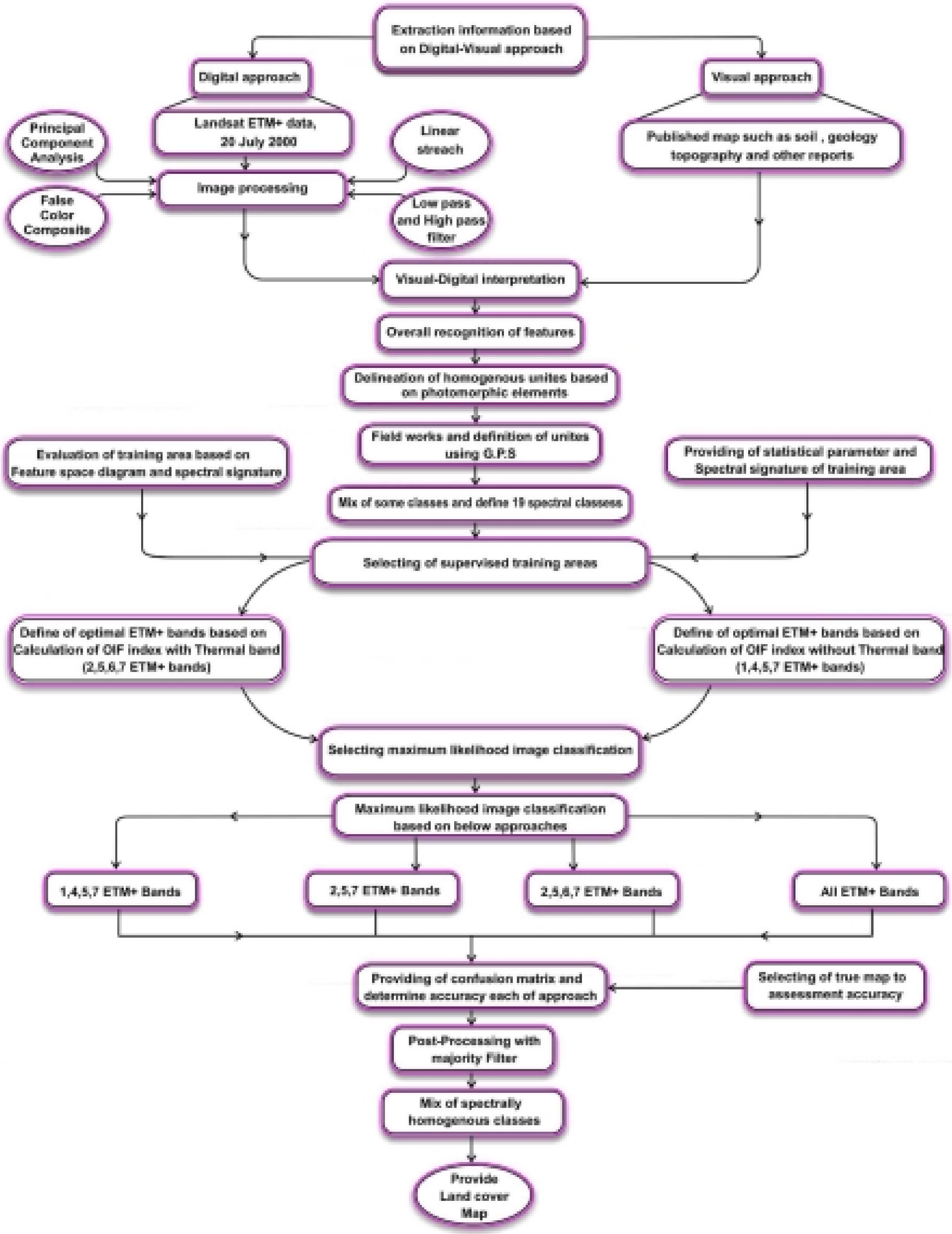

Figure 2: ***METODOLOGICAL APPROACH FOR DIFFERENTIATE PLAYA MARGIN SOILS***

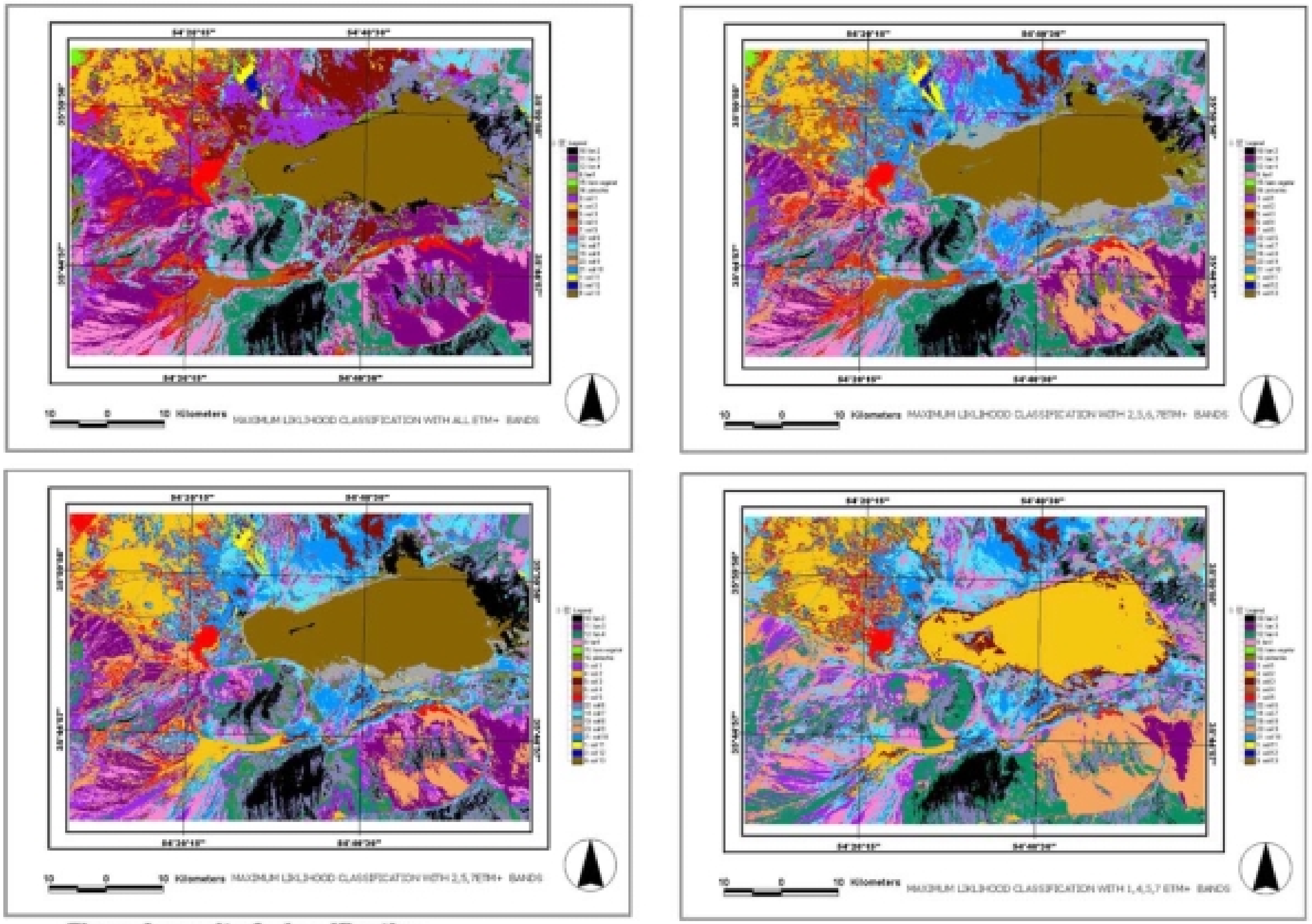

Figure4: result of classification

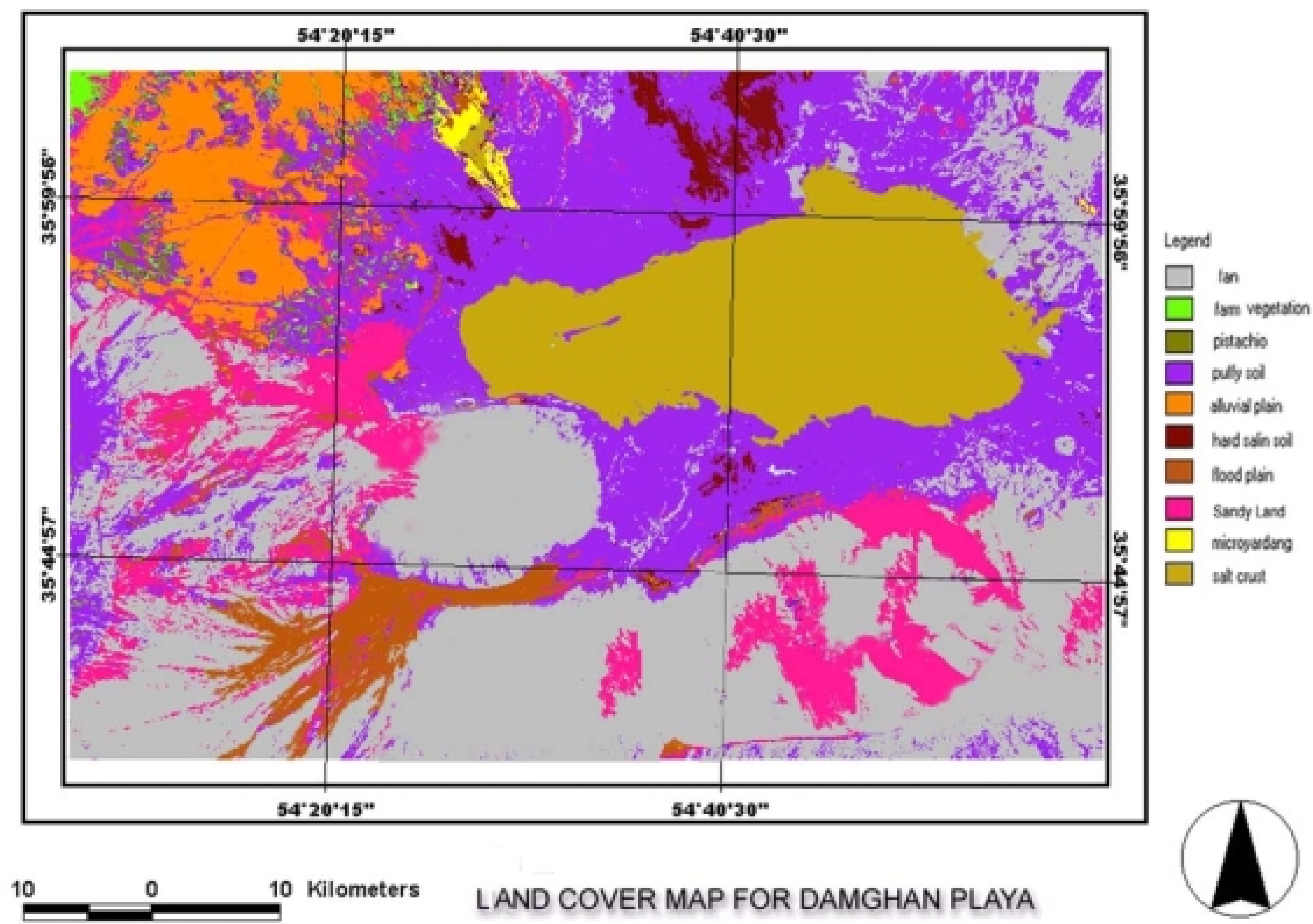

Figure 5: Land cover Map