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An approach for land cover classification system by using NDVI data in arid and semiarid region

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ABSTRACT

Land use and land cover change play a pivotal role in global environmental change. They contribute significantly to earth-atmosphere interactions and biodiversity loss, are major factors in sustainable development and human responses to global change, and are important for integrated modeling and assessment of environmental issues in general The land cover map and land use map can be produced by field research and observation and interpretation of the large scale aerial pictures, but both of them are time and cost consuming. The main advantage of satellite images is that the classification is able to be repeatedly performed by simultaneous usage of multiple images during a short time. Applying the satellite data is a proper way in order to producing the land cover map and monitoring it especially in the vast geographical regions. The iterative self organizing data analysis technique (isodata) method used a set of rule-of-thumb procedures. Many of the steps used in the algorithm are based on the experience obtained through experimentation. According to evaluate signature file the optimal number of classes is 11.after determining of best classified NDVI map processed of spot NDVI maps for a new set of the hyper temporal. Drawinggraphs of mean digital number help to us for determined kind of classes. According to the graph of the spectral behavior of each class and fieldwork were determined land covers types. The optimum numbers of classes are 11 classes in the case study region based on the divergence of a minimum of separability. Spectral behavior shows the highest mean digital number in 11th class that starts in the spring season and finish in winter. First to fifth class has spectral behavior to each other. Mean of digital number of different years not same each other years and have different actions.

Introduction

Land cover applies to different forms such as vegetation, water, rock mass, and so on, while usage of land depends on the way of land use ofhuman beings. Although these two terms are conceptually different, they have common meaning and are used in many cases. Changes of land cover, as a result of time passing, are certainly natural and are slowly shaped consistent with ecological characteristics of a region. Land use and land cover are dynamic in nature and is an important factor for the comprehension of the interaction and relationship of anthropogenic activities with the Environment. Knowledge of the nature of land use and land cover change and their Configuration across spatial and temporal scales is consequently indispensable for sustainable Environmental management and development by turner. Land cover refers to the physical materials on the surface of a given parcel of land, while land use refers to the human activities that takes place on or make use of land e.g. residential, commercial, industrial and etc .(FAO, 2005).

Application of Remote Sensing

Does the human being interferences in the nature such as converting the rangelands to agricultural land, creation of installations and the road channels as well as climate changes, lead land cover to change? In studying these changes, there is a need for a tool which is readily accessible at different times; one of these affective tools is the remote sensing. Remote sensing can be named as the knowledge and the art of data gathering from the land surface without any physical contact with the earth which includes the application of aerial and satellite images.(Jensen,2005)

The main advantage of satellite images is the ability of their usage in a digital form which can be analyzed by computer. In addition they are accessible in different times. Another advantage of digital information is that the classification is able to be repeatedly performed by simultaneous usage of multiple images during a short time. (Lillesand and Kiefer,1994)Updated and accurate data about the land cover and land use have been needed for decision makers and researchers in all the levels.(Arastoo, 2009) The land cover map and land use map can be produced by field research and observation and interpretation of the large scale aerial pictures, but both of them are time and cost consuming. Applying the satellite data is a proper way in order to producing the land cover map and monitoring it especially in the vast geographical regions (Gibson and Power,2000).

The map of land cover is produced by using the remote sensing data and applying the digital classification. Nowadays from among the most common and accurate ways of

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classification that can be referred to, are statistical methods such as the classification of maximum of the probability. But newer techniques such as neural network have attracted the large amount of notification tothem.(Jensen and Gorte,2001)Because of the nonparametric nature of neural networks and their ability to benefit from examples and their ability to be generalized, they are considered as an appropriate method for supervised classification. In addition, among the many comparative studies, neural networks have classified land cover better than common methods of classification.(Foody and Boyd,1999).

Normalized difference vegetation Index (NDVI)

The Normalized Difference Vegetation Index (NDVI) is a simple graphical indicator that can be used to analyze remote sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not. The Normalized difference vegetation Index (NDVI) is used for monitoring and assessing the vegetation (Kaufman and Tanre,1992) .This index has generally a range of 0.5 and 0.7 respectively for scattered plants and dense vegetation. After this fixed range of densities (0.7) increase of the volume of green plant slightly increases the amount of NDVI.(Milich And Weiss,2000) The NDVI is a measure of the amount and vigor of vegetation on the land surface and NDVI spatial composite images are developed to more easily distinguish green vegetation from bare soils.

In general, NDVI values range from -1.0 to 1.0, with negative values indicating clouds and water, positive values near zero indicating bare soil, and higher positive values of NDVI ranges from sparse vegetation (0.1 - 0.5) to dense green vegetation (0.6 and above).

- The NDVI is also directly related to the:
- Leaf area index" (LAI), which is often used in crop growth models
- Herbaceous or total green biomass (tons/ha) for giving vegetation types,
- Photosynthetic activity of the vegetation
- Percent ground cover.

The NDVI is calculated from satellite imagery whereby the satellite's spectrometer or radiometric sensor measures and stores reflectance values for both red and NIR bands on two separate channels or images were the first to propose NDVI and it is calculated by subtracting the red channel from the near-infrared (NIR) channel and dividing their difference by the sum of the two channels, or:

NDVI= (NIR - RED) / (NIR + RED)

Where, RED = the red portion of the electromagnetic spectrum (0.6-0.7 μm) and

NIR = the near infrared portion of the electromagnetic spectrum (0.75-1.5 μm).

The long-term and short-term NDVI averages for AVHRR-GAC data, SPOT-VEG, and MODIS are processed by the Global Environmental Monitoring and Modeling Studies (GIMMS) group from the National Aeronautics and Space Administration (NASA) by calibrating all NDVI composites for changes in satellite-series sensors, radiometric sensor decay, atmospheric changes caused by volcanic eruptions, etc. Regional droughts and wet seasons can then be easily determined by comparing the current NDVI composites with the short-term or long-term NDVI averages from the same period.

The spatial correlation between this index and climate factors have been assessed by different researchers. Especially the high correlation between NDVI and the amount of precipitation in the dry regions have been gained, while the correlation between NDVI and temperature was lesser but significant (SARODJA,2011),(Schultz and Halpert,1993).

Many studies have been conducted for reaction of plantswith water and air fluctuations with NDVI index. For example, different researches have been conducted in the US, Africa and on the global scale.(SARODJA,2011) Generally it can be resulted from these studies that time changes of NDVI have a high correlation with precipitation which is reported by some of the scholars as linear or nonlinear way (Davenpor and Nicholson,1993).If precipitation is more than the specified threshold for example 500 millimeter for the range of 50 to 100 millimeter, there will be a high correlation between the precipitation and NDVI in Botswana (Kaufmanand Tanre,1992) 200 to 100 millimeter monthly in East African and 1000 millimeter annually in West African. In Africa the delay between the rainfall peak and the maximum NDVI can be seen and there are a higher correlation between NDVI and precipitation during the two past months (Davenport and Nicholson,1992),(Kaufmanand Tanre,1992) ,(Ji and Peters,2003) Estimated the correlation between NDVI and precipitation for the growth season about 250 to 500 millimeters. By studying the NDVI of the precipitation and soil moisture in Botswana, found that the correlation between NDVI and the precipitation is high, whenever NDVI is controlled by soil moisture. Furthermore temperature has a direct effect on the growth of the plants.Yang et al (1997) studied the correlation between NDVI in Nebraska in the US and found a high correlation between NDVI and the degree of growing degree days and soil temperature (Kriegler and et al,1969).Literature of the previous studies suggests that the effect of the delay in growth of the plant and precipitation is complicated. The delay fluctuates between several days to 1 year and even more (Ji and Peters,2003) .

Yu and et al, (2000) found that the initiation of greenness of a plant in interior steps of Mongolia is dependent on precipitation and temperature in the previous fall and winter, and the spring of the current year. Schultz, P. A., and Halpert, M. S., (1995) studied the spatial variability of NDVI correlation with temperature and precipitation and found that NDVI changes don't have a high correlation with the weather, but they described that a monthly delay of rainfall with NDVI, is normal and ordinary.(Milich And Weiss,2000)The effect of dryness on vegetation in Iran, regardless of region, in point form was studied. Some of the results are:

During the two past decades vegetation indexes were based on simple components of close and visible infra-red reflexes. These indexes such as NDVI and SR have been widely applied in monitoring the vegetation in small-scales to regional and global scales.

(Jensen and Gorte,2001)(Kriegler and et al,1969)

Methods and Material

Study area

Semnan province with an area of 96,815 km2, Semnan Province is 5.8 percent of the total area of the country .It is considered the sixth province of the country. Its area is almost quadruple of Tehran province. This Province is located between (Latitude: 34° 17' to 37° 30' N and Longitude: 51° 58' to 57° 58' E) which is surrounded from the north by North Khorasan, Golestan and Mazandaran provinces, from the south by Yazd and Isfahan provinces, from the east by Khorasan Razavi province and from south and southwest of Tehran and Qom provinces. The capital city of this province is Semnan

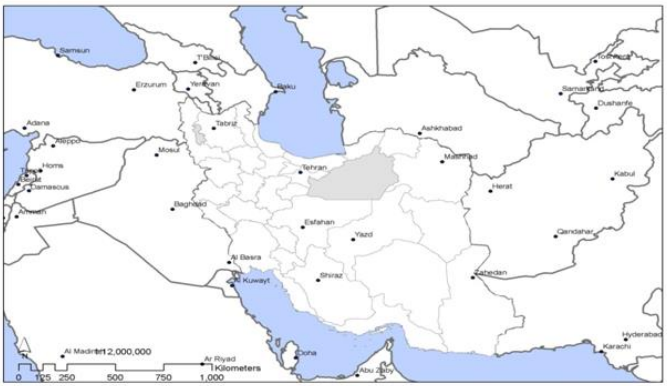

Figure1. Semnan province location

Raster data

The VEGETATION sensor is on-board the Spot 4 satellite which was launched on March 24, 1998. It provides global coverage on an almost daily basis at a spatial resolution of 1 kilometer.

The SPOT-VEG program is co-funded by the European Union, Belgium, France, Italy and Sweden and led by French space agency CNES. The SPOT-VEG spectral bands were designed specifically to study vegetation cover and its temporal dynamics; red (0.61 to 0.68 µm), near-infrared (0.78 to 0.89 µm), short-wave infrared (1.58 to 1.75 µm); with a blue band (0.43 to 0.47 µm) for atmospheric corrections. The red and near-infrared bands are used for making maximum value Normalized Difference Vegetation Index (NDVI) composites every 10-day (Arastoo,2012).

Data available for this part of the study concern Geo-referenced and de-clouded SPOT4 Vegetation 10-day composite NDVI images (S10 product) at 1km resolution from April 1999 till 2009 as obtained from www.VGT.vito.be. De - clouded means: using by image and pixel the supplied quality record; only pixels with a ‘good’ radiometric quality for bands 2 (red; 0.61-0.68 µm) and 3 (near IR; 0.78-0.89 µm), and not having ‘shadow’, ‘cloud’ or ‘uncertain’, but ‘clear’ as general quality, were kept (removed pixels were labeled as ‘missing’). NDVI indicates chlorophyll activity and is calculated from (band 3 - band 2) / (band 3 + band 2).

The NDVI data of the SPOT VGT were already converted from its original values (-1 to 1) into unsigned-8-bit integers. The conversion of NDVI from its original values in 0-255 digit number (DN) is based on the formula [80].

DN= (NDVI + 0.01) / 0.004

Vector data

Vector data that used for extract image data and determine boundary provide by official organization such as natural resources and agriculture.

Software used

ERDAS Imaging 2011 and ENVI 4.7 were used for the image processing .ArcGIS 9.3 was used Andes was used to determine of changes, transition and exchange in land covers. MS Word was used for documentation while MS Excel was used for statistical analysis.

The whole process is categorized into 5 steps as mentioned below:

- Pre-processing
- Change detection modeling
- Field data collection
- Pre-processing

Pre-processing is further divided into the following steps

Stacking of data

The SPOT 10 day NDVI MVC images were stacked in the study area. The stacked NDVI data had one time period. The time period corresponds to the duration from 1999 to 2009 and the “stack” is too data-rich. There are several questions that should be answered:

- Which pixels behave similarly?
- Can we put those in classes?
- How many classes do we need?
- Can we use un-supervised classification Techniques?
- How will the legend look like?
- How to get a ‘final’ legend?
- How to use the product for monitoring?

ISODATA clustering

Multispectral remote sensing is the collection and analysis of reflected, emitted, or backscattered energy from an object or an area of interest in multiple bands of regions of the electromagnetic spectrum (Jensen, 2005). Subcategories of multispectral remote sensing include hyper spectral, in which hundreds of bands are collected and analyzed, and ultra spectral remote sensing where many hundreds of bands are used .The main purpose of multispectral imaging is the potential to classify the image using multy spectral classification. This is a much faster method of image analysis than is possible by human interpretation (Eastman and Laney,2002).

The ISODATA algorithm used for Multispectral pattern recognition was developed by Geoffrey H. Ball and David J. Hall, working in the Stanford Research Institute in Meleno Park. They published their findings in a technical report entitled ISODATA, a novel method of data analysis and pattern classification ISODATA is defined in the as a novel method of data analysis and pattern classification, is described in verbal and pictorial terms, in terms of a two dimensional example, and by giving the mathematical calculations that the method uses. The technique clusters many variable data around points in the data's original high dimensional space and by doing so provides a useful description of the data. ISODATA was developed to facilitate the modeling and tracking of weather patterns. This step initially followed the methodology described by de Bie(De Bie and et al. 2010) The NDVI dataset from 1999 to 2009 were processed using the Iterative Self Organizing Data Analysis Technique (ISODATA) (Eastman and Laney, 2002).

An unsupervised classification method available in ERDAS-imaging software, called the Iterative Self-Organizing Data Analysis (ISODATA) technique, used to classify the 396 stacked images of NDVI. The classification runs to generate predefined classified maps from 10 to 100 classes. Each classification was set to 25 iterations and 1.0 convergence threshold. The ISODATA procedure is iterative; it repeatedly performs an entire classification and recalculates statistics. It is self-organizing regarding the way in which it locates the clusters that are inherent in the data and minimizes the Euclidian distances to form clusters (De Bie and et al. 2010). To define the best number of NDVI classes (between 10 and 100), the cluster separability results were examined. This separability was measured by the divergence between each pair of classes of the unsupervised classification result using the signature evaluator function in ERDAS (Leica Geosystem, 2005). The best number of classes to be chosen was based on the maximum values of average and minimum divergence statistics with a clear and distinct peak on the separability values of divergence. The minimum separability is considered less important, and may be ignored when it is lower than the value of 26, especially when gradients are part of the dataset .Furthermore; the lesser number of classes is chosen when more than one divergence combination is suitable (De Bie and et al. 2010)

Results and Discussion

Classification algorithm

The last step in supervised classification is selecting an appropriate algorithm. The choice of a specific algorithm depends on the input data and the desired output. Parametric algorithms are based on the fact that the data is normally distributed. If the data is not normally distributed, nonparametric algorithms should be used. The more common nonparametric algorithms are:

- One-dimensional density slicing
- Parallelepiped
- Minimum distance
- Nearest-neighbor
- Neural network and expert system analysis

Unsupervised classification

Unsupervised classification (also known as clustering) is a method of partitioning remote sensor image data in multispectral feature space and extracting land cover information. Unsupervised classification requires less input information from the analyst compared to supervised classification because clustering does not require training data.

ISODATA method

The Iterative Self Organizing Data Analysis Technique (ISODATA) method used a set of rule-of-thumb procedures that have incorporated into an iterative classification algorithm. Many of the steps used in the algorithm are based on the experience obtained through experimentation. The ISODATA algorithm is a modification of the k-means clustering algorithm. This algorithm includes the merging of clusters if their separation distance in multispectral feature space is less than a user-specified value and the rules for splitting a single cluster into two clusters. This method makes a large number of passes through the dataset until specified results are obtained (Rojas, 2007)

After unsupervised classification and storage legend in signature file the following steps do to select the optimal number of classes:

Step1. Evaluate the SIG-file

Use the SIG-file to generate Avg. Andmine. Divergence stats.

Table 1.Evaluate signature

Best Minimum Separability									
Bands	AVE	MIN	Class Pairs:						
			1: 2	1: 3	1: 4	1: 5	1: 6	1: 7	1: 8
			1: 9	1:10	1:11	2: 3	2: 4	2: 5	2: 6
			2: 7	2: 8	2: 9	2:10	2:11	3: 4	3: 5
			3: 6	3: 7	3: 8	3: 9	3:10	3:11	4: 5
			4: 6	4: 7	4: 8	4: 9	4:10	4:11	5: 6
			5: 7	5: 8	5: 9	5:10	5:11	6: 7	6: 8
			6: 9	6:10	6:11	7: 8	7: 9	7:10	7:11
			8: 9	8:10	8:11	9:10	9:11	10:11	
1 2 3 4	983	13	36	136	222	236	244	391	264
5 6 7			885	819	3741	29	69	104	154
8 9 10			327	238	1405	749	5276	13	49
11 12 13			120	381	257	1908	944	6921	22
14 15 16			91	452	211	1856	1357	8919	24
17 18 19			261	83	1097	981	6071	82	24
20 21 22			545	390	2882	70	154	50	604
23 24 25			166	232	1097	102	175	159	
26 27									
28 29 30 31									
32 33 34 35									
36									

Step2. .Evaluate the divergence stats.

Plot for each product the Avg. Andmine. Divergence

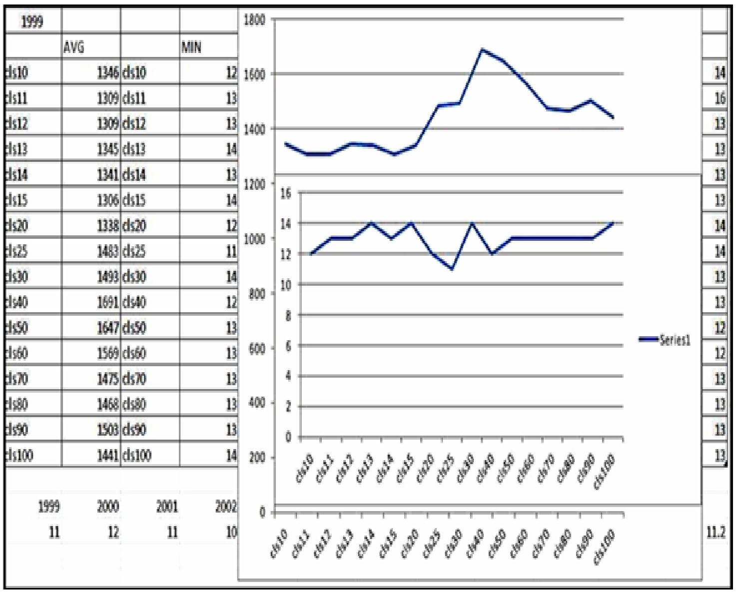

Figure 2.Evaluate the divergence stats

According to evaluate signature file the optimal number of classes is 11.After determining of best classified NDVI map processed of SPOT NDVI maps for a new set of the hyper temporal.

Drawing graphs of mean digital number help to us for determined kind of classes.According to the graph of the spectral behavior of each class and fieldwork were determined land covers types.

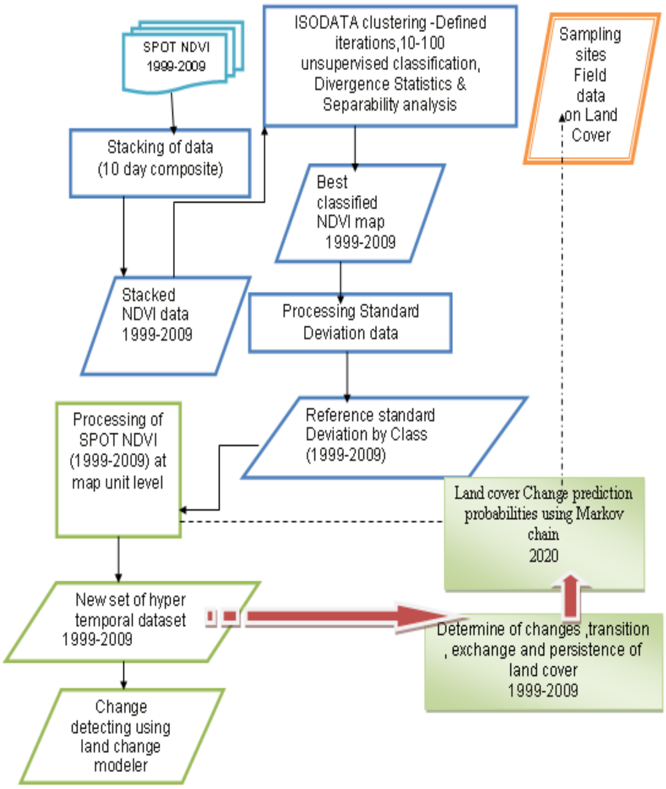

Figure 3. Flowchart of work process

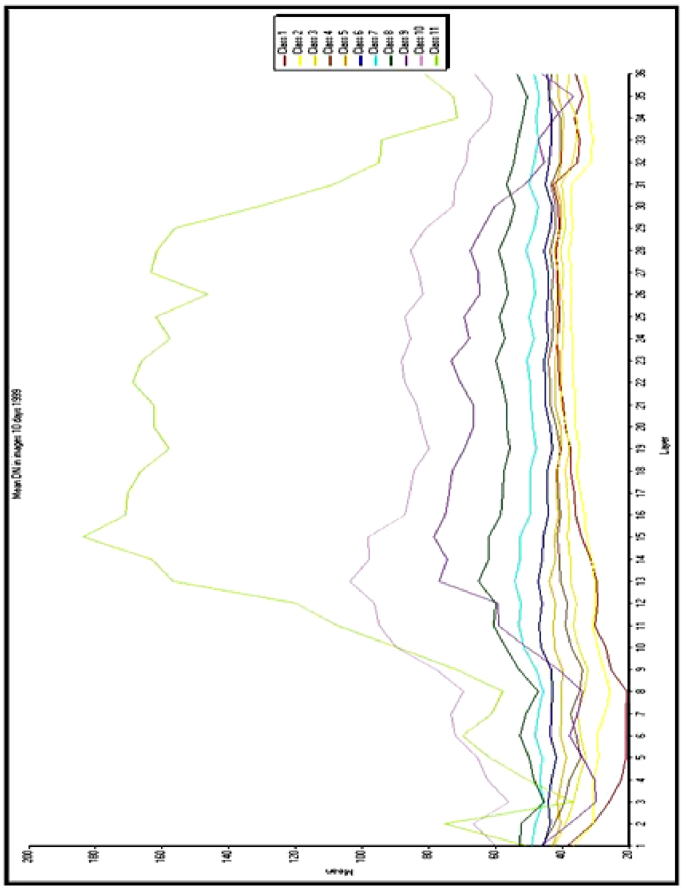

Figure 4. Mean DN in each class 1999

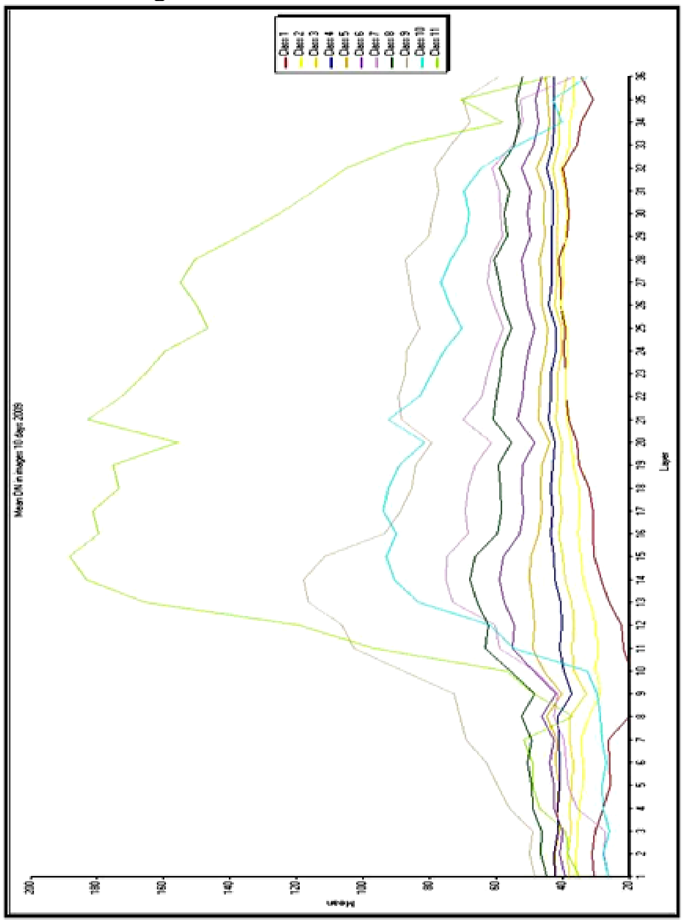

Figure 5. Mean DN in each class 2009

Table 2.Legend of land cover

Land cover	Legend
Kavir	Kavir
Salt land	Salt Land
Salt land and Bare Land	Mix Salt Land & Bare Land
Bare Land & desert rangeland	Bare Land & poor range
Rock & desert rangeland	Rock & poor range
Desert range land	A poor range
Semi steppe rangeland	Mix Rock & Mod rang
Agriculture land	Agriculture
Steppe rangeland	Good Range
Low forest	Urban & Low Forest
Dense forest	Dense Forest

After determining legend drawing a land cover map in 11 classes by a pixel base method for each year .

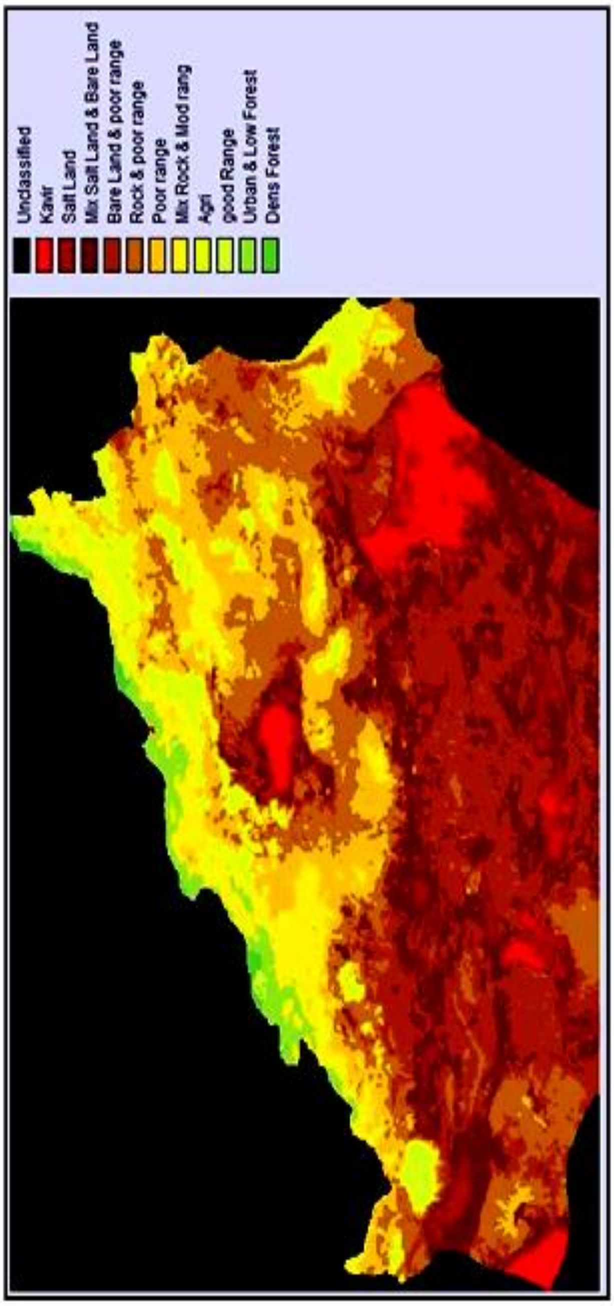

Figure 6.Map of land covers (1999)

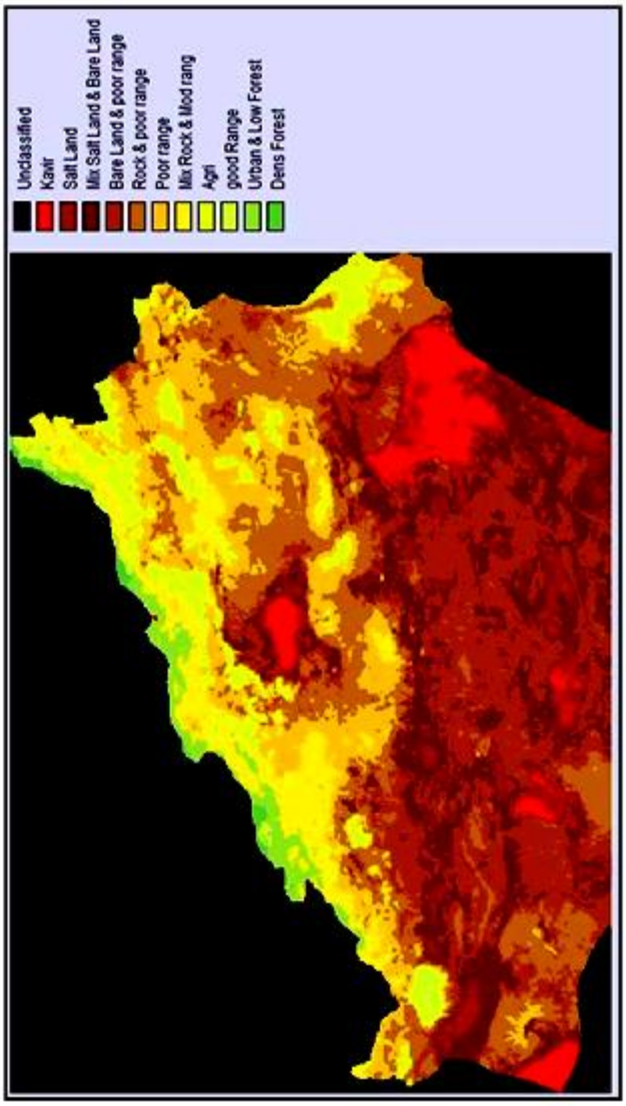

Figure 7.Map of land covers (2009)

Conclusions

- The optimum numbers of classes are 11 classes inthe case study region based on the divergence of a minimum of spar ability.
- Spectral behavior shows the highest mean digital number in 11th class that starts in the spring season and finish in winter.
- First to fifth class has spectral behavior to each other.
- Mean of digital number of different years not same each other years and have different actions.

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