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Change detection and desertification based on multi-temporal satellite data (case study; kashan playa, Iran)

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ABSTRACT

Kashan playa, Located in the west of Central Desert of Iran, has been subjected to severe desertification problems. Most of these problems are due to human activities, overgrazing, sand dune mobility, soil salinity and ground water depletion. Monitoring desertification, land degradation and land cover requires rapid and accurate procedures. Remotely sensed satellite technology allows land degradation processes to be monitored over time. Two Landsat TM/ETM+ satellite images for 12 years period (1990-2002) with field observations were provided basic information for mapping of the extend and monitoring of the Kashan playa in central desert of Iran. Several change detection techniques such as image differencing, vegetation change analysis, principal component analysis and classification comparison have been applied to the data. Maximum Likelihood classification analysis showed a kappa coefficient accuracy of 86% and 82% for the TM and ETM+ images. Results revealed that about 35 % of the study area mostly salty lands and fixed sand dune has been rapidly changed. The overall rate changes of the desert lands and vegetation are about 7275 and 62 ha $year^{-1}$ respectively.

Introduction

Desertification refers to the creation of new deserts through the degradation of dry lands, which cover 40% of the world's land surface. Remote sensing provide significant contributions to desertification assessment and monitoring, particularly by providing the spatial information needed for regional-scale analysis of the relationships between climate change, land degradation and desertification processes. To study land use change, It is necessary to create land use maps in two or more than two dates (Mapedza et al., 2003; Pirbavaghar et al., 2003; Dountree, 2003). In land use researches, remote sensing (RS) and Geographic Information System (GIS) could provide useful information for land use planning and watershed management (Cropper et al., 1999; Tipaniat & Nitin, 2003; Rasul et al., 2004). Using satellite data, the various, up to date, cheaper and repetitious information can be extracted (Richards &. Xiuping, 1999; Darvishsefat, 2000).

Remote sensing is a major source of data and information which is used in different fields. To prepare a land use map using satellite data, image classification is a powerful method of information extraction (Karteris, 1990; Kelarestaghi et al, 2006). Successful use of satellite remote sensing for land use/cover change detection depends upon an adequate understanding of landscape features, imaging systems and information extraction methodology employed in relation to aims of analysis. Desert lands due to their fragile characteristics and human activity are changing. Human population growth and associated demands are exerting an accelerated pressure on soil and water sources (Verburg et al., 1999; Dountree, 2003; Rasul et al., 2004). Reliable up-to-date information on the arid lands changes can provide important decision tools for monitoring the areas at risk.

Masoud and Koike (2006) analyzed the arid land salinization over span of 16 years by remotely-sensed data. Bayarsaikhan (2009) have studied the Land cover types of Hustai National Park (HNP) in Mongolia, a hotspot area with rare species, and their temporal changes were evaluated using Landsat MSS TM/ETM data between 1994 and 2000.

Karnieli (2008) performed a Change detection analysis, based on the kriging prediction maps to assess the direction and intensity of changes between the 1970-2000 periods. He found that degradation occurred in some areas are due to recent exploration and exploitation of the gas and oil reserves in the region.

Ostir (2003) used spots landsat and ERS data for identifying, estimating and monitoring at hazard zones like Elnino storm and combustible forest.

Decertified sandy land increased by 25,200km for the period from 1975-1987, about 40.5% of which was distributed in the semi-arid agro-pastoral regions of northern China (Zhu & Wang, 1993).

The purposes of this study area are as following:

1. To evaluate of TM/ETM+ images potential for land use mapping

2. Detecting various changes and land cover map

Materials and Methods

Study area

Kashan playa is located in west of Central desert of Iran between 51° 56' 51" to 51° 19' 34" E - 34° 00 06" to 34° 23' 27" N and covers about 2494 Km^2. The altitude ranges from 810 m to 1500m. Kashan playa is characterized by an arid climate with annual average precipitation 0f 133mm mainly falling in winter and mean annual temperature of 18.8°C.

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Figure1: location of study area in central desert of Iran, Kashan playa.

Methodology

Data and pre-processing

• Remote Sensing images used in this study include the Landsat-5 Thematic Mapper (TM) Image and Landsat-7 Enhanced Thematic Mapper Plus (ETM+) image, which were acquired in 27 September 1990 and 10 July 2002, respectively, the pre-processing of this dataset included geometric corrections. All images were geometrically corrected not only to eliminate geometric distortions present in the images but also to register the satellite images to ground data. The nearest-neighbor resampling method was used in datum WGS 84 and projection UTM (39N) all images resampled to a 30 m pixel grid. In order to remove or normalize the reflectance variation between images acquired at different times, relative radiometric correction was performed to yield normalize radiometric data on a common scale. Here, the histogram normalization, a simpler and more effective technique, was used to carry out the relative radiometric correction. Figure2 shows the methodology used in this study. The image processing and change detection techniques used in this study are band ratio, vegetation indices (NDVI, RVI, DVI, SAVI and TSAVI), image enhancements, image differencing, principal component analysis and classification comparison. Image classification is defined as the extraction of differentiated classes or theme categories from raw remotely sensed digital data.

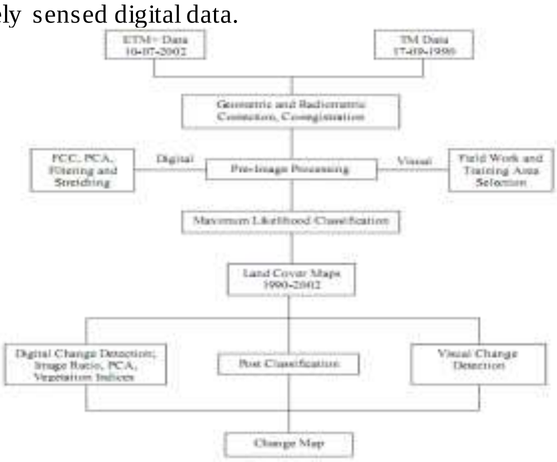

Fig. 2: Flowchart of the methodology.

The image classification in this study is used to provide a base map of the land use in Kashan Salt Lake, Iran. Parametric Maximum Likelihood Classifier (MLC) was used as a decision rule. The MLC rule is based on the probability that a pixel belongs to a particular class and the input bands have normal distributions. In the classification, the signature reparability functions were used to examine the quality of training site and class. The importance of using this panel is to determine how well each class is separated from each of the other classes. This function allows the operator to use statistical analysis to increase the accuracy of the very subjective process of classification. The final output (post classification) of the classified image was filtered using majority filter pass to produce a better, smooth view by aggregate and avoiding the isolated individual pixels. Accuracy assessment is an important step in the classification process. The goal is to quantitatively determine how effectively pixels were grouped into the correct feature classes in the area under investigation. Briefly, Kappa statistic considers a measure of overall accuracy of image classification and individual category accuracy as a means of actual agreement between classification and observation.

Change detection analysis

Two maps of land use in 1990 and 2002 were compared using change detection extension of ILWIS3.3 software. Thereafter the land use change detection was accomplished and analyzed.

Results

The Figure3 and Figure4 show land cover maps 0f 1990 and 2002 produced from the ML classification. Maximum Likelihood Classification Analysis showed Kappa coefficient accuracy (Congalton et al., 2008) of 86% and 82% for the TM and ETM+ images respectively.

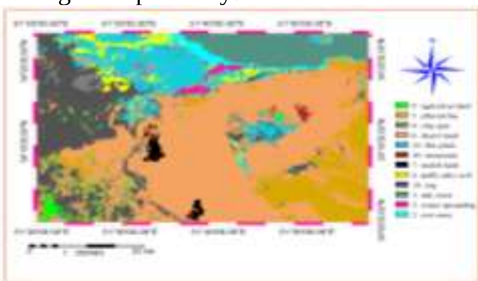

Figure 3: Land cover map of the study area in 1990

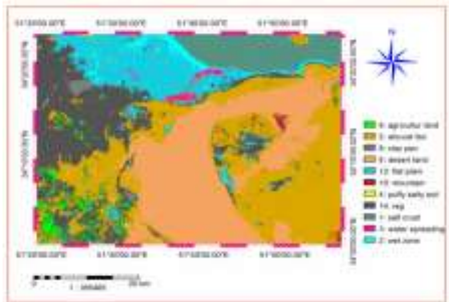

Figure4: Land cover map of the study area in 2002

The results of land cover changes detection in (Table1 and Figure5)) show diverse land cover in Kashan region during the studied period.

Spatiotemporal changes in different land cover classes, monitored for the study area are shown in Figure6. Generally, from the 1990s to the 2002, there was a remarkable ecological change occurred in the study area land cover during the studied period (12 years). The land cover changed significantly and desertified land has expended rapidly.

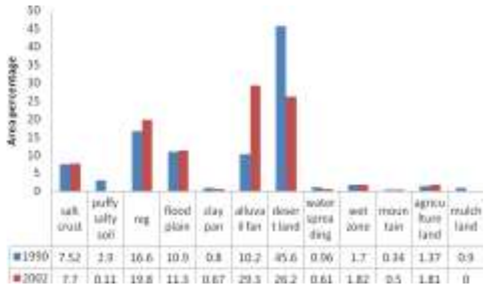

Fig 5. Area percentage of the land covers in 1990 and 2002

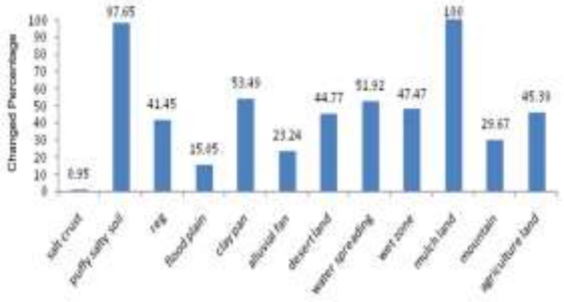

Fig6. Land cover changes situation in the 1990-2002 periods

Finally the changes map (Figure7) was produced Using change method and post classification comparison. Comparison of changes matrix showed detection that about 35/18% (8775/19 ha) of 249434/9 ha have been changed.

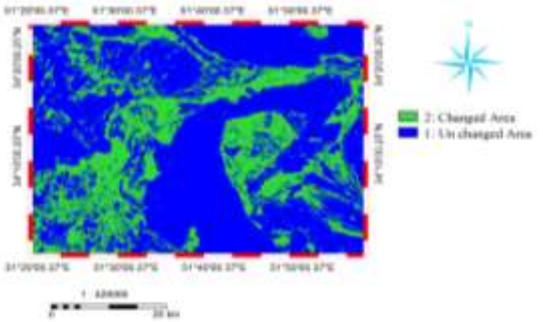

Fig 7: Map of change area

Conclusion

In this study desertified land in Kashan playa was mapped from 1990 and 2002. The overly analysis of the two land cover maps revealed that there is an imbalance in the spatial distribution of desertified areas. The central part of playa is mostly changed and desertified. By comparison its part is better covered by vegetation. The changed land in desertified land is closely correlated with changes in salt and sand.

From 1990 to 2002, the salt crust, which covered 18757.77 ha (7.52%) of the total area in 1990 had increased to 19215.23 ha (7.7%) in 2002 with a growth rate of 38.12 hayear-1. However, the puffy salty soil, decreased from 7234.87 ha in 1990 to 275.5 ha in 2002. The clay pan, desert lands, water spreading and mulch land, following the same trend as the puffy salty soil, from 2003.9, 113832, 2387.7 and 2234.33 hectare in 1990 to 1680.87, 65452.54,1515.49 and 0 hectare in 2002, with a decreasing rate of 26.91, 4031.7,72.69 and 186.19 hayear-1 respectively. Reg, flood plain, alluvial fan, wet zone, mountain and agriculture land following the same trend as the salt crust with an increasing rate of 664.78, 58.05, 3959.5, 25.86, 32.23 and 91.66 hayear-1 respectively.

The analysis of the vegetation indices showed a gradual increase of the vegetated area with rate of 91.66 ha/year. This improvement and rehabilitation is mainly resulted by combating desertification started in 1970, proper vegetation management, fixation of sand dunes and biosphere reservation. However the most changes are occurred in the puffy salty soils and wetlands near the playa where the water table fluctuations occurred. Moreover extent of the playa also decreased during 1990-2002. The Intra-playa activities e.g. salt and evaporate mineral extraction, have changed the hydrologic characteristics of the playa and contributing to these changes.

In addition to the need for high accurately classified scenes the detection of changes and hence the monitoring capability and landsat is dependent on change is the spectral characteristics of various habitats through times. The reflectance characteristics of land and water surface are influenced by a number of factors. Additional factors that can influence the change are reflectance between two different.

From the above results, we may conclude that there are some problem in relation to the resolution for a multi- temporal analysis based on landsat TM and ETM+ images, but these problems can be mainly solved by regrouping the finer TM to ETM+ spectral classes. These post classification processes are not only necessary to obtain the same meaningful classes in TM and ETM+ classified images, but are also useful to increase the accuracy of classification and consequently the accuracy of change detection. Therefore we concluded that the land sat TM and ETM+ images are useful tools for change detection. From the result of multi temporal analysis we concluded that some drastic land cover changes took places in the area in period 1990-2002.

Arid land changes over time are due to human activities, climate, economic, social and environmental forces. Monitoring, research and modelling are closely inter- related and are required for arid management systems. Understanding and prediction the nature of changes with rapid and reliable tools is essential to facilitate proper planning, management of land resources. Therefore remote sensing and multi-spectral and multi-temporal satellite data particularly supported by ground data are very useful for monitoring of arid lands. about 35 % of the study area mostly salty lands and fixed sand dune has been rapidly changed. The overall rate changes of the desert lands and vegetation are about 4031.7 and 91.66 ha year-1 respectively.

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