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Research article

CAPABILITY LANDS AT SATELLITE DATA FOR DETERMINATE CHANGE DETECTION IN FOREST COVER (CASE STUDY: KHORRAMABAD FORESTS, IRAN)

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ABSTRACT: Large scale forest type mapping using current field methods is time consuming and cost-intensive. Satellite imagery capability in order to managing and mapping forest-covered area is a new useful tool. The purpose of this research was forest cover changes detection using satellite data from 1991 to 2003 and the assessment of capabilities different classification methods for Northern forests of Korramabad region located in Lorestan Province, Iran. In this research, the multi-spectral and panchromatic TM and ETM+ images has been used for forest area mapping. The images were geometrically corrected and orthorectified using GCP_s and DEM. For comparing change detection in the forest, two methods including Normalized Difference Vegetation Index (NDVI), and different supervised classifications methods were used. The classification including forest/non-forest classes were accomplished by maximum likelihood, parallelepiped and minimum distance classification method. The accuracy of classification results were assessed with ground truth maps. The ground truth maps including forest/non-forest and reforested area maps had generated by interpretation of digital orthophotomosaic and field check. The results showed that forest and non-forest areas classification based on supervised classification method was more accurate than other methods. Using maximum likelihood algorithm, the best results of the classification was obtained from TM with 90.08% overall accuracy and 0.78 Kappa coefficient and ETM with 90.05% overall accuracy and 0.87 Kappa coefficient. The change detection results showed that the forest cover area has been decreased about 8.097% during 12 years. In spite of high overall accuracy and regards to the moderate Kappa coefficient, this research showed that investigation on forest cover change detection using satellite images doesn't involve beneficial results.

Key words: Change detection, NDVI, Supervised classification, Zagros forests.

INTRODUCTION

Temporal effects as variation in spectral response involve situations where the spectral characteristics of the vegetation or other land cover type in a given location change over time is defined change detection [3] and based on Singh [9] description the change detection is a process that observes the differences of an object or phenomenon at different times [4]. Timely and accurate change detection of Earth's surface features, by providing the foundation for better understanding the relationships between human and natural phenomena is important in order to effectively manage and use resources [6]. In general, the change detection includes analysis of multi date data for finding the effects of time on phenomena, and because the data is stored digitally, the analysis can be done simply by computer. For this purpose, TM and ETM are the basic data that are used recent decades. The existing covers change detention techniques are categorized into three groups including, image enhancement, multi-date data classification, and comparison of two independent lands cover classifications [7]. The enhancement approach involves the mathematical combination of imagery from different dates [7]. The multi-date classification is based on the single analysis of a combined dataset of two or more different dates in order to identify areas of changes. The post classification comparison is a comparative analysis of images obtained at different moments after previous independent classification. Darvishsefat et al. [2] investigated north Iran forest cover changes to obtain a criterion for evaluation of these forests conservation program. They selected the forests in Chaboksar to Amlesh in the east of Guilan Province as study area. They used Landsat 7 and Spot 5 images for mapping the forest area. The forest classification was done using supervised method, integrated method (visual and on screen digitized interpretation) and field observation. Two-classed classification of forest with density higher than 10% and 5 to 10% was done. The quality comparison of Landsat and Spot images showed higher capability of Spot 5 images. The comparison of forest area extracted from 1994 topography map and recent maps (more than 10% density) extracted from satellite showed 2465 ha equal to 2.47% decreasing in forest area. The reason is expansion of rangelands, gardens and forest deforestation due to urban development particularly in the northern borders. Karami [5] investigated deforestation trend Zagros forest in Ilam province using TM and ETM+ for years 1990 and 2000. The study result indicated increase of 6.2 ha (1%) deforestation per year for that region because of road development.

Mas [7] tested six change detection procedures using Landsat Multi Spectral Scanner (MSS) images for detecting areas of changes in a coastal zone of the State of Campeche, Mexico. These six techniques were including image differencing, vegetative index differencing, selective principal components analysis (SPCA), direct multi-date unsupervised classification, post-classification change differencing and a combination of image enhancement and post-classification comparison. The accuracy of the results obtained by each technique was evaluated by comparison with aerial photographs through Kappa coefficient calculation. Post-classification comparison was found to be the most accurate procedure and presented the advantage of indicating the nature of the changes. Methods based on classification were found to be less sensitive at these spectral variations and more robust when dealing with data captured at different times of the year .

Ramachandra and Kumar [8] discussed the land use/land cover analysis and change detection techniques using GRDSS (Geographic Resources Decision Support System) for Kolar district in India by applying temporal multispectral data (1998 and 2002) of the IRS 1C/1D (Indian Remote Sensing Satellites). They analyzed change detection using different techniques including image rationing, image differencing and image regression. Land use analysis was done by both Supervised classification (accuracy 94.67 %) and unsupervised classification approach (accuracy 78.08 %) using Gaussian Maximum Likelihood Classifier (GMLC) to classify the data in to five categories (agriculture, built-up, forest, plantation and waste land). The Land use analyses indicated increase of non-vegetation area from 451752 ha. (54.84% in 1998) to 495238 ha (60.17% in 2002). The results of the change analysis based on two dates, spanning over a period of four years using supervised classification, showed an increasing trend (2.5 %) in unproductive waste land and decline in spatial extent of vegetated areas (5.33 %).

The purpose of this research is to compare different area change detection techniques for the Zagros forest in Khorramabad province using TM and ETM data.

MATERIAL AND METHODS

Study area

The study was carried out in the Khorramabad district located between $47^{\circ}48'$ to $48^{\circ}48'$ East longitude and $33^{\circ}14'$ to $33^{\circ}43'$ North latitude with the area of 251680 ha. The climate of region is semi-humid cold with very cold winter. The vegetation cover is Persian oak (Quercus persica), wild almonds (Amygdalus spp.), rangelands with annual and perennial grasses, and farmlands including irrigated and rainfed lands. Figure 1 shows the location of study area in Iran and Lorestan Province.

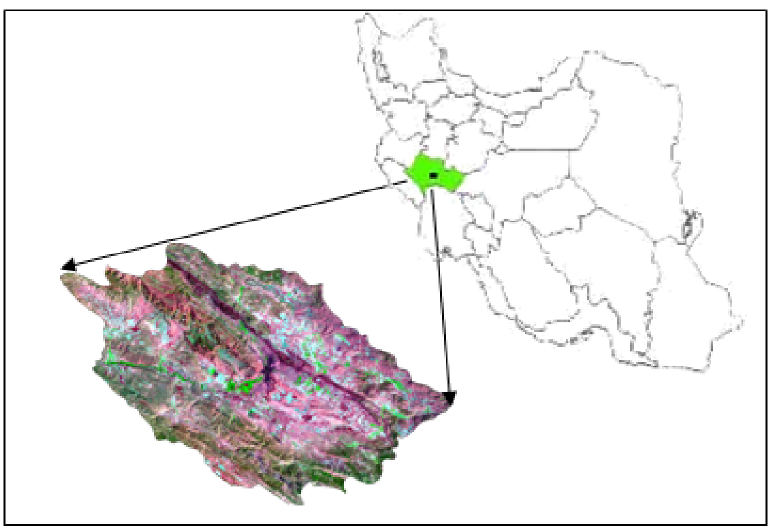

Figure-1. Location of the study area in Iran and Lorestan Province.

Data and softwares

Digitized topography maps 1:50000 (2D and 3D) was used for deriving resources and other required layers, ETM+ data of Landsat 7 for 2003 and TM data of Landsat for 1991 were used for the area land use, and GPS was used for positioning the field data. Also Microstation V8 was used for extracting necessary layers form digitized maps, ENVI for satellite images processing, ERDAS IMAGINE 9.1 for images classification and deriving current and past landuse maps, and Arc GIS 9.3 and ArcView for the spatial analysis of the area.

Methodology

After image preprocessing, area change detection techniques including normalized difference vegetation index (NDVI) and post classification changes were performed.

Normalized Difference Vegetation Index (NDVI)

The Normalized Difference Vegetative Index (NDVI) is a calculation, based on several spectral bands, of the photosynthetic output (amount of green stuff) in a pixel in a satellite image. It measures, in fact, the amount of green vegetation in an area. NDVI calculations are based on the principle that actively growing green plants strongly absorb radiation in the visible region of the spectrum while strongly reflecting radiation in the Near Infrared region. The concept of vegetative spectral signatures (patterns) is based on this principle.

The NDVI is calculated from these individual measurements as follows:

$$NDVI = \frac{(NIR - R)}{(NIR + R)} \qquad (1)$$

where R and NIR stand for the spectral reflectance measurements acquired in the visible (red) and near-infrared regions respectively.

Post-Classification Comparison

Post-Classification comparison was then employed to detect the differences between the two images. Change maps have been complied to display the specific nature of the changes between the two classified images. Traditional post-classification change analysis follows a straightforward methodology of image overlay where pixels have been unambiguously categorized into one of many alternative classes [1]. It is a comparative analysis of independently produced classifications of different dates via a simple mathematical combination pixel by pixel. Therefore using independent classification can show the locations and classes that have spectral changes in two different times and can be classified in the same land uses. Figure 2 shows the flowchart of the post classification image comparison in this research.

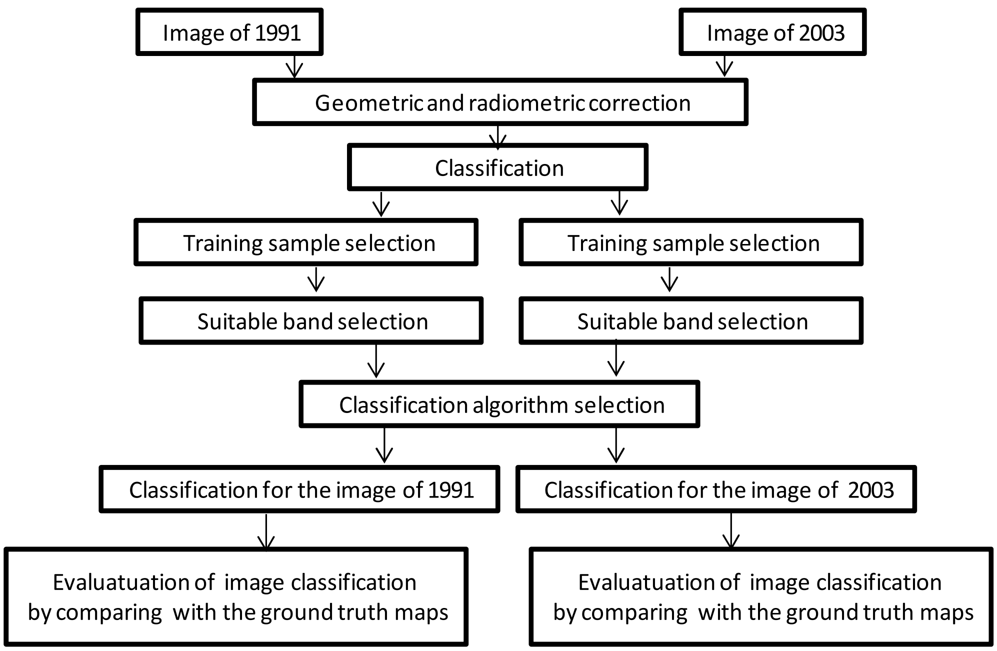

Figure-2. Post classification stages flowchart

Changes detection techniques comparison

For comparing the techniques applied in this research, two classed map of change and unchanged during a 12 year period was provided. For deriving this map, samples of change and unchanged using auxiliary maps, available reports, local information and high resolution pseudo color images were selected. Then, resulted maps were compared together using general accuracy and Kappa coefficient parameters, to derive the error matrix.

RESULTS

Normalized Difference Vegetative Index (NDVI)

NDVI changes between -1 to +1. NDVI derived from the TM image of year 1991 was between -0.24 to 0.67 while this parameter for the TM image of 2003 was between -0.21 to 0.56. The resulted images were classified in four classes of non vegetated area with NDVI less than 0.05, areas with low vegetation density with NDVI between 0.05 to 0.1, areas with average vegetation density with NDVI between 0.1 to 0.5 and areas with high vegetation density with NDVI higher than 0.5.

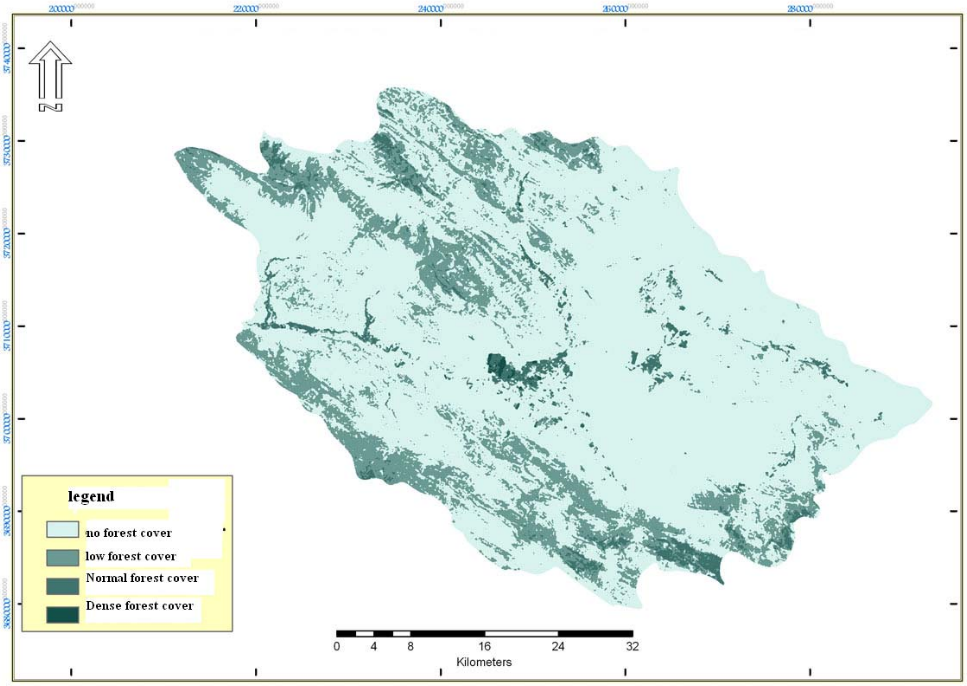

Figure-3. NDVI classification of 1991image

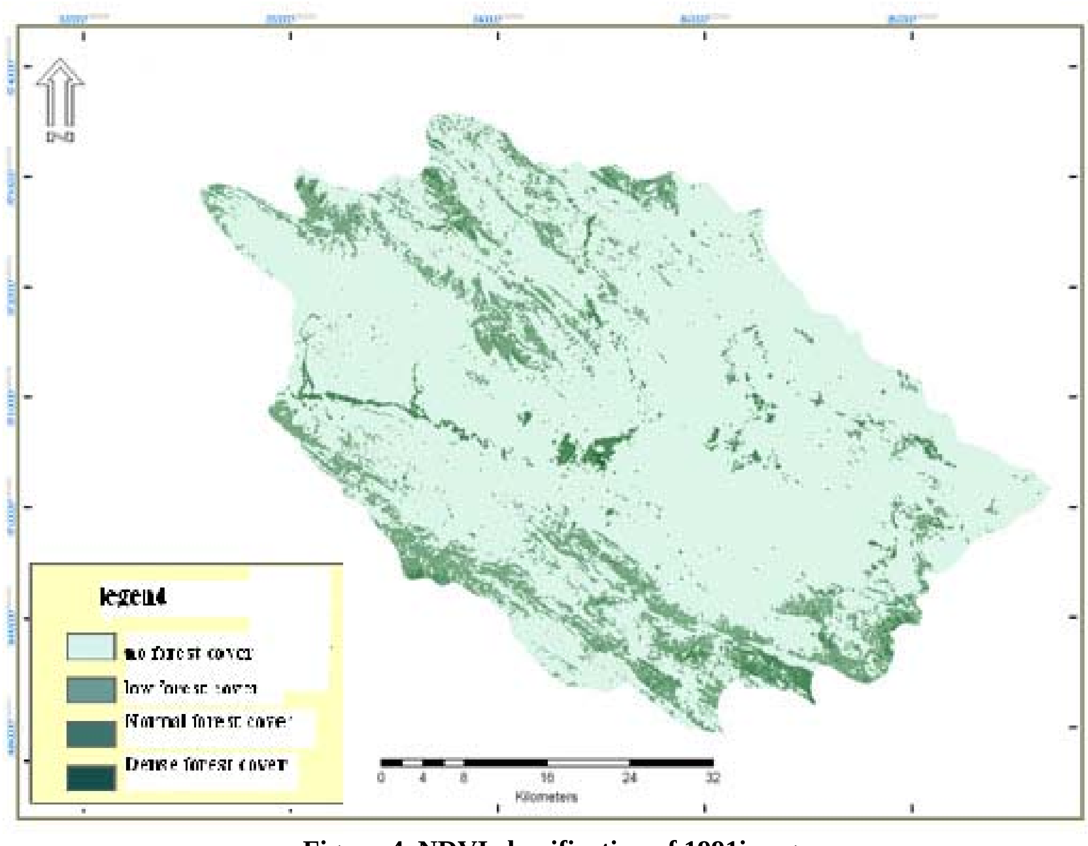

Figure-4. NDVI classification of 1991image

Post classification comparison method

For achieving the aim of change detection, image classification was done for 1991 and 2003 images. In this research supervised classification method was employed. Results of two periods of image classification using maximum likelihood indicate that forest area in year 1991 was 121508.45 ha and in year 2003 was 111669.76 ha. Also by comparing the maps derived from satellite images of years 1991 and 2003 forest and non forest classes during 12 years were assessed. In total 8.098% of forest area has changed and decreased (Figure. 5).

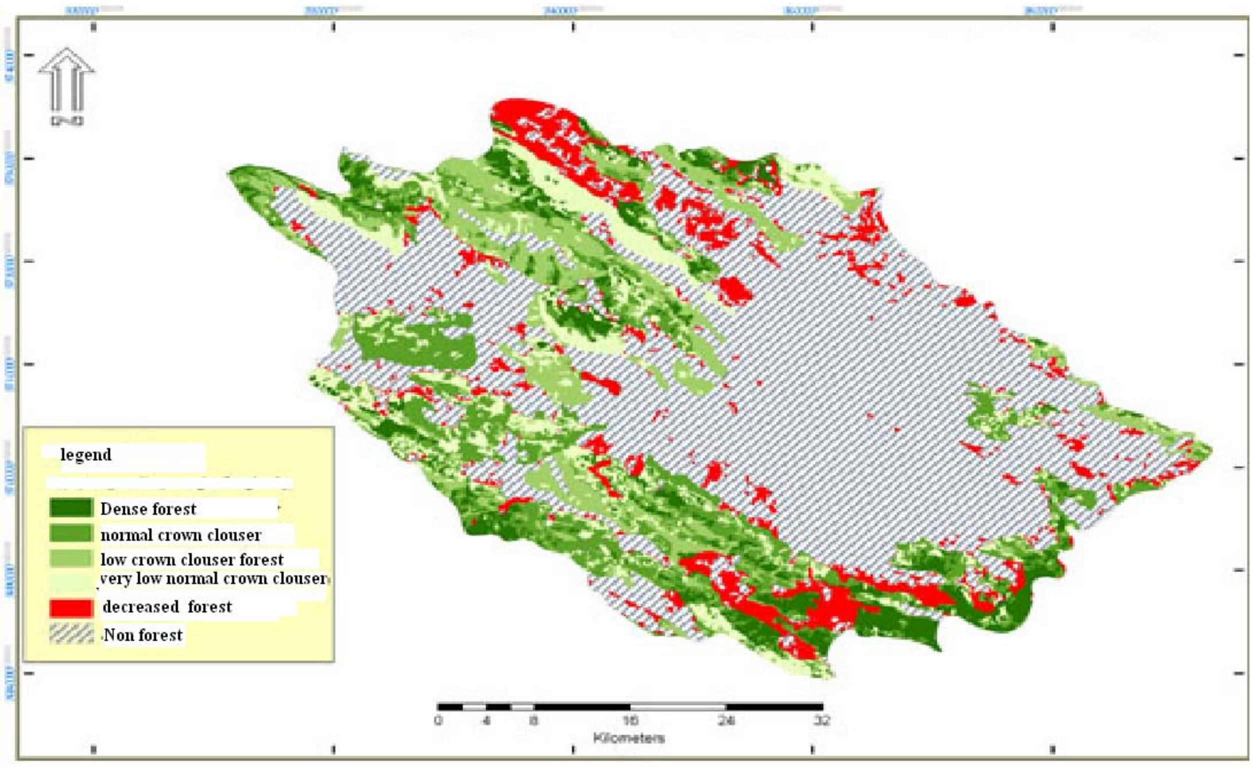

Figure-5. Forest area change map during 12 years

Evaluation of classification accuracy

For evaluating of the 1991 image classification accuracy, ground truth map was produced using topographic maps and aerial images of year 1991 within a systematic cluster sampling plan. Also the evaluation of image classification accuracy was done for the topographic maps and GPS images of 2003 using the aerial photos of year 2001 within a systematic cluster sampling plan. Then by calculation of the error matrix table, general accuracy, Kappa coefficient, user and producer accuracy for both two periods of the classified images were obtained.
The results showed that general accuracy of the classified images of year 1991 was 90.80% and 90.05% for the images of year 2003.

Comparison of change detection techniques

By overlying the images obtained from different change detection techniques used in this research on two changed and unchanged classified ground truth map, Kappa coefficient and general accuracy for comparison were obtained (table 1 and 2).

Table-1. Evaluation of the accuracy of different change detection techniques with the ground truth map (year 1991)

Technique	Kappa coefficient	General accuracy (%)
NDVI difference	0.71	83
Maximum likelihood	0.78	90.08
Minimum distance	0.75	87
parallelepiped	0.73	85

Table-2. Evaluation of the accuracy of different change detection techniques with the ground truth map (year 2003)

Technique	Kappa coefficient	General accuracy (%)
NDVI difference	0.53	80
Maximum likelihood	0.87	90.05
Minimum distance	0.80	86.32
parallelepiped	0.68	81

DISCUSSION AND CONCLUSION

Post classification comparison technique is used more than other forest area change detection techniques. Multi date NDVI and combined bands are rarely applied for the Zagros forests in Iran. For the change detection, the data for suitable seasons in a specific time of the year with the same spectrum reflectance should be available. In this research, the Landsat 1991 and 2003 imagaes for two seasons of spring and winter were used. The NDVI and SAVI are employed when the objective is change detection in the specific time period. Regarding the results obtained from the methods applied in this work, post classification method performs better than the other methods (Kappa coefficient and general accuracy were 0.78 and 90.08% for the year 1991 respectively and 0.87 and 90.05% for the year 2003.

The reason could be less sensitivity of this method to the radiometric changes between images and gives more suitable results when the data are for different months and from different sensors. Moreover, this technique was done based on supervised classification, in case of pay more attention to selection of samples and availability of auxiliary maps and documents the results can improve. Weak performing of preprocessing methods related to the plant phenological events in different times that effects on digital image analysis, are less sensitive to radiometric changes in the methods based on classification. For all change detection techniques, large changes due to urban development is easily traceable but small changes in this study with the pixel resolution of 28.5 m or 812.25 square meters area cannot be detected that is a limitation for these techniques. For example animal husbandry buildings could not be detected.

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