Vegetation Change Detection of Neka River in Iran by Using Remote-sensing and GIS

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Abstract

Land use change has transformed a vast part of the natural landscapes of the developing world for the last 50 years. Land is a fundamental factor of production, and through much of the course of human history, it has been tightly coupled with economic growth. On the other hand, bare soil has recently increased and has become one of the most important land degradation processes in the Mediterranean basins. The land use has changed rapidly within and near Neka River which is a fast growing agricultural river Basin. The land use changes in this region were analyzed based on Landsat data from 1977 to 2001. Supervised/unsupervised classification approach, coupled with RS and GIS analyses, was employed to generate the change over land use/cover maps. In order to analyze landscape fragmentation, land-use change was calculated using normalized different vegetation index(NDVI). Based on the results of the analysis, the range of NDVI has changed from the reflection of 0.9597 to 0.2876 in 1977 to the reflectin of 0.6420 to 0.187 in 2001, which indicates that an increase in bare lands led to a decrease in forest lands.

Keywords: Land use change, NDVI, Neka, Classification, RS, GIS

1. Introduction

In developing countries where a large proportion of human population depends almost entirely on natural resources for their livelihoods, resulting in land-use and cover changes. There are increasing concerns for sustainable management of the land resources (e.g., natural vegetation).

The political and economic condition in Iran after 1970s, favored a sudden increase in the application of scientific methods in agriculture and forestry. The exports of timber to Romania had taken a leap forward and there was a need for the application of quick and speedy production and exploitation of natural resources. It was at this time that the introduction of tractors and the use of machines in cutting trees were introduced in Iran. Due to the mechanization there was a rapid increase in the cutting of trees and disappearance of forest and reduction of the area under forest. The change in the temperature and rainfall began to be noticed from 2000 onwards, which the temperature and rains between 1977 and 2001 has remained constant. The vegetation has taken a noticeable decline, and the bare soil has suddenly increased. Due to these changes, the incidence of floods has also increased. The flood which occurred in 1998 was one of the most destructive causing a great damage to life and property. The impact of deforestation has led to an increase of barren land and soil erosion. These impacts have affected the water permeability of the soil. The rate of percolation has diminished, leading to the gushing of water into the Neka valley causing floods. It is in this context that the present study will aim to analyze the change in the forest area for a period of 25 years.

In this study, some change detection techniques, radiance/reflectance band differencing, NDVI differencing, tasseled cap (KT), change vector differencing and NDVI Rationing changes the north of Iran environment used image differencing, image rationing and normalized difference vegetation index (NDVI) differencing to detect land-use changes in a coral mining area of India and found that no significant difference existed among these methods in detecting land use change. Dhaka *et al*. (2002) Maximum value compositing (MVC) is the most common form of NDVI compositing used to produce NDVI time-series data sets with minimal effects from clouds and atmospheric scattering (Eidenshink and Faundeen, 1994; Holben, 1986). Frequent cloud cover in Arctic locations, a 14-day or half-monthly compositing period has been shown by Hope, Boynton, Stow and Douglas (2003) to produce NDVI images with little apparent bias or contamination due to clouds. A time series of these composited NDVI images is the basis for estimating vegetation production. Seasonally integrated NDVI values (SINDVI) correspond closely to vegetation above ground production (Goward and Dye, 1987).

The objectives of this study are to provide a recent perspective for land cover types and land cover changes that have taken place in the last 24 years; to integrate visual interpretation with supervised and unsupervised classification using Remote sensing; to examine the capabilities of integrating remote sensing and GIS in studying the spatial distribution of different lands and to assess the land affected by soil erosion and the barren land.

2. Study Area

Neka river basin, one of the largest watershed in Mazandaran Province is draining the northern flank of Alborz range to the Caspian Sea which divides Neka city as eastern and western parts. The tributaries of this watershed originated from mountainous and forest upland and geologically covered by Shemshak and Quaternary materials. Climate is temperate and seasonal; original land-cover was temperate hyrcanian mixed forest. Major land-uses in the area are rain-fed agriculture and cattle-grazing. The geographical location of the Southern Neka basin based on Neka topography map published by the Iranian Geographical Organization is located at 530, 07/, 57//E.-540, 09/, 03//E. and 360,19/,50//N.-360,32/,42//N. (Figure 1).

<<**Figure 1**. Geographic location of southern Neka basin.>>

3. Methodology

3.1 Data source and materials

Three sets of material were used here. First the Landsat imagery, MSS, WRS 82; PATH 175 row35 dated June 06 1977; all four bands have pixel size 57 m and a Landsat ETM WRS path 163 row 35 was in July 30, 2001 have eight bands. Band 1 is high resolution and the pixel size 14 m bands 1, 2, 3, 4, 5, 7 are 28.5 and band 6 is 57mts pixel size. Both 1977 and 2001 were obtained from Global Land Cover Facility (GLCF) used to classify land use/cover in the study area. Geo referenced to the UTM map projection zone 39 projection based on the WGS84 datum (this was used to rectify the 1977 and 2001 Landsat images using 40–45 ground control points (GCPs) with a root mean square error (RMSE) ranging from 0.5 to 0.7 pixels). Second, digital topographic maps digitized from hardcopy topographic maps with scale of 1:20,000 were used mainly for geometric correction of the satellite images and for some ground truth information. Finally, ground information was collected between 1977 until 2002 for the purpose of supervised classification and unsupervised classification and accuracy assessment (Table 1; Figure 2).

<<**Table 1**. Data source and materials>>

<<**Figure 2**: Flowchart of the land use and NDVI classification.>>

3.2 Procedure

3.2.1 Geometric Correction

Accurate per-pixel registration of multi-temporal remote sensing data is essential for change detection Change detection analysis is performed on a pixel-by-pixel basis; therefore any misregistration greater than 1 pixel will provide an anomalous result of that pixel. To overcome this problem, the RMSE between any two dates should not exceed 0.5 pixels (Lunetta and Elvidge, 1998). In this study geometric correction was carried out using ground control points from topographic maps with scale of 1:20000 produced in 1994 to geocode the image of 2001. This image was used to register the image of 1977. The Root Mean Square Error (RMSE) between the two images was less than 0.4 pixel which is acceptable. The RMSE could be defined as the deviations between GCP and GP location as predicted by the fitted-polynomial and their actual locations. The rectified Landsat images were resampled to a 100 mts pixel size using the nearest neighbor resampling. The change of resolution was necessary in order to gain better results.

Radiometric enhancement was done using low-pass filter because the sum of mean and standard deviation are equal to the original image in this study, while this is not the case with other filters. In other words, the sum of mean and standard deviation were not equal. This means that the number of image pixels is reduced in this filter (Saleh, 2004).

The color composites generated from bands 2, 3 and 4 (Figures 3 and 4) were visually interpreted through a screen digitizing. The visual interpretation gave a general idea about the forms of land cover changes over the period. Red colour represents forest and blue colour represents bare soil and low vegetation in Figure 4. In figures 4 and 5, forest area remains the same but the bare soil area changes.

<<**Figure 3**. False color composite image of Landsat MSS (June 1977) bands 2, 3 and 4.>>

<<**Figure 4**. False color composite image of Landsat ETM (July 2001) bands 2, 3 and 4.>>

The images in figure 3, and 4 vis-à-vis ETM and MSS data were used to produce Normalized Difference Vegetation Index (NDVI); which is defined as NDVI=(band4+band3)(band4–band3) where band4 and band3 are channels in the near infrared (NIR) and the red wavelengths of Landsat data, respectively. However, the three NDVI

data sets were derived from the same season and field work was performed to calibrate the NDVI classification.

Saleh emphasized that gray tone should be considered as microstructure of an image and texture as the macrostructure, image with high-spatial resolution is having the disadvantage of low-spatial coverage. To overcome this problem that indeed affects the accuracy of land cover, image must be resample to suitable low-spatial resolution (Saleh, 2004). In the current paper; landsat images with pixel sizes 14, 28, 57 m were resemple to 100 m.

4. Results

The result of NDVI has ranged from +0.9597 to − 0.2876 and +0.6420 to −0.187 in 1977 and 2001 respectively. This amount of change indicated the fact that the amount of bare soil has increased in the years 1977 and 2001. Based on the classification table, there has been an increment in the amount of bare soil while a decrease in the amount of land occurred in other classes. Further, as it is evident from Tables 2 and 3.

<<**Table 2.** Range of NDVI: MSS image of 1977 Neka basin of Iran>>

<<**Table 3.** Range of NDVI: MSS image of 2001 Neka basin of Iran.>>

As it is evident from Figure 5, in subtraction regions, those regions which have experienced more changes are shown by black color and those experienced little changes are specified as bright color.

<<**Figure 5:** NDVI change detection during 1977–2001.>>

It can be conclude that some factors may have a role in increasing the amount of discharge including an increase in dry-land and bare soil, and a decrease in forest size. Besides, there are other factors such as over grazing in the valleys which can also promote greater volume of discharge. However Change detection technique for 1977 and 2001 images has helped to identify change image (Figure 6) in the NDVI. Most of the sections in the study area have experienced a vegetation change (100%). In Figure 6, it is observed that there is a drastic change in the land use.

<<**Figure 6**. NDVI change detection between 1977–2001>>.

After calculating NDVI, two images of supervised and unsupervised classification using bands 3 and 4 were acquired on 6 June, 1977 and 30 July, 2001.Figs. 7 and 8 show the result of the classification

<<**Figure 7**. Land use/cover classification map of Neka Iran, using Landsat MSS1977.>>

<<**Figure 8**. Land use/cover classification map of Neka Iran, using Landsat ETM+ 2001>>

In order to increase the accuracy of land cover mapping of the two images, ancillary data such as data from Google earth, and the result of visual interpretation was integrated.

The area under the land use changes for different land cover classes are given in Table 4. Low Graze land, bare soil and dry land occupy 63532 ha in 1977 and 77905 ha in 2001. Grassland was 38333 ha in 1977 and 28053 ha in 2001. Low-density forest and vegetation was 25592 ha in 1977 and 20339 ha in 2001. Dense forest was 58261 ha in 1977 and 5940 ha in 2001.

<<**Table 4**. Area and percentage of land cover change of during 1977 and 2001 classified images Neka Iran >>

A standard overall accuracy for land-cover and land-use maps is set between 85% (Anderson, Hardy, Roach and Witmer, 1976) and 90% (Lins and Kleckner, 1996). In this study, the overall classification accuracy was found to be 99% for 1977 and 99.12% for 2001. Details of single class accuracy for both images of 1977 and 2001 can also be found in Table 4. This table shows that the highest accuracy is for all classes; this is due to the integration of the visual interpretation with the classified image in addition to the information obtained from the topographic map

<<**Table 5**. Accuracy statistics for the classification result>>

5. Conclusion

It is concluded from satellite images that most of the land use has changed from 1977 to 2001. If this process of change in land use continues at the same rate, there is a possibility that within no longer period of time there will be a severe mismanagement of land, and the impact could become severe especially on agriculture, and the environment. The problem increasing dry land and bare soil can lead to more destructive events such as floods and devastation.

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Table 1. Data source and materials

Satellite images	**Date**	**Spatial resolution**	**Source**
Landsat MSS	1977	57 m	GLCF
Landsat ETM	2001	28 m	GLCF
Topographical map	1955	1;55000	The Iranian Geographical Organization
Topographical map	1965	1:50000	The Iranian Geographical Organization
Topographical map	1994	1:20000	The Iranian Geographical Organization

Table 2. Range of NDVI: MSS image of 1977 Neka basin of Iran

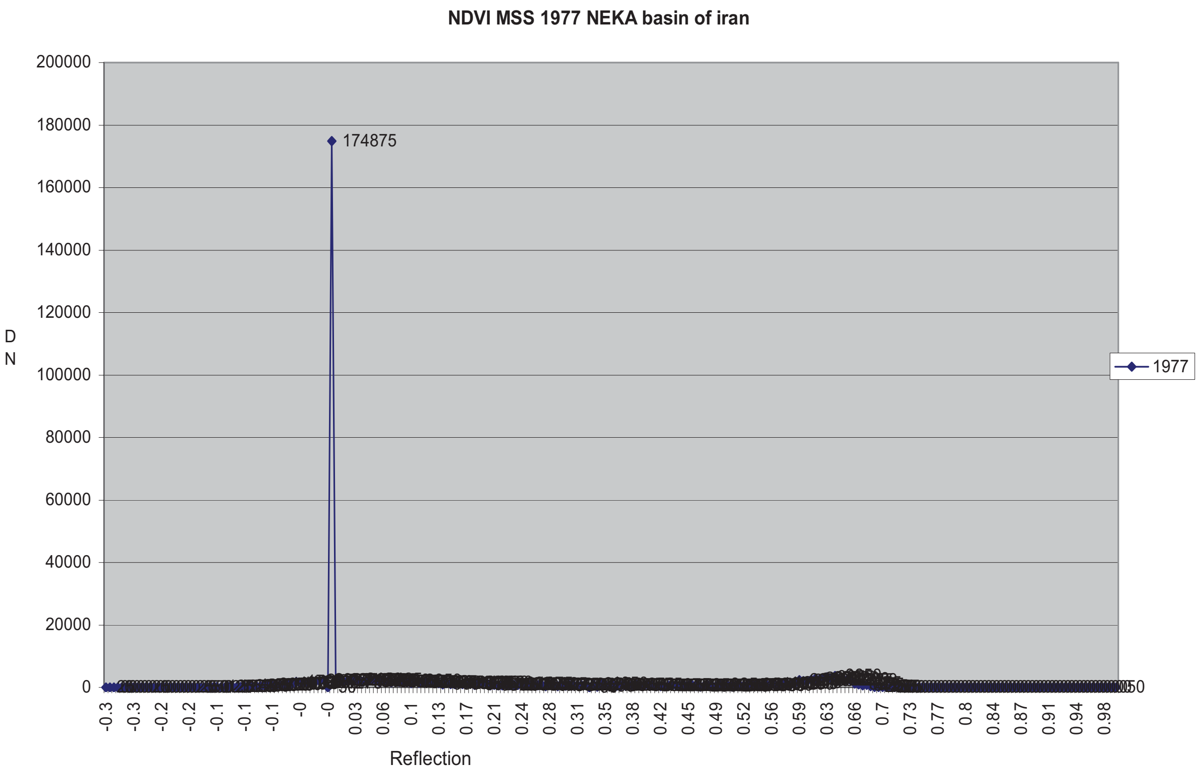

Table 3. Range of NDVI: MSS image of 2001 Neka basin of Iran

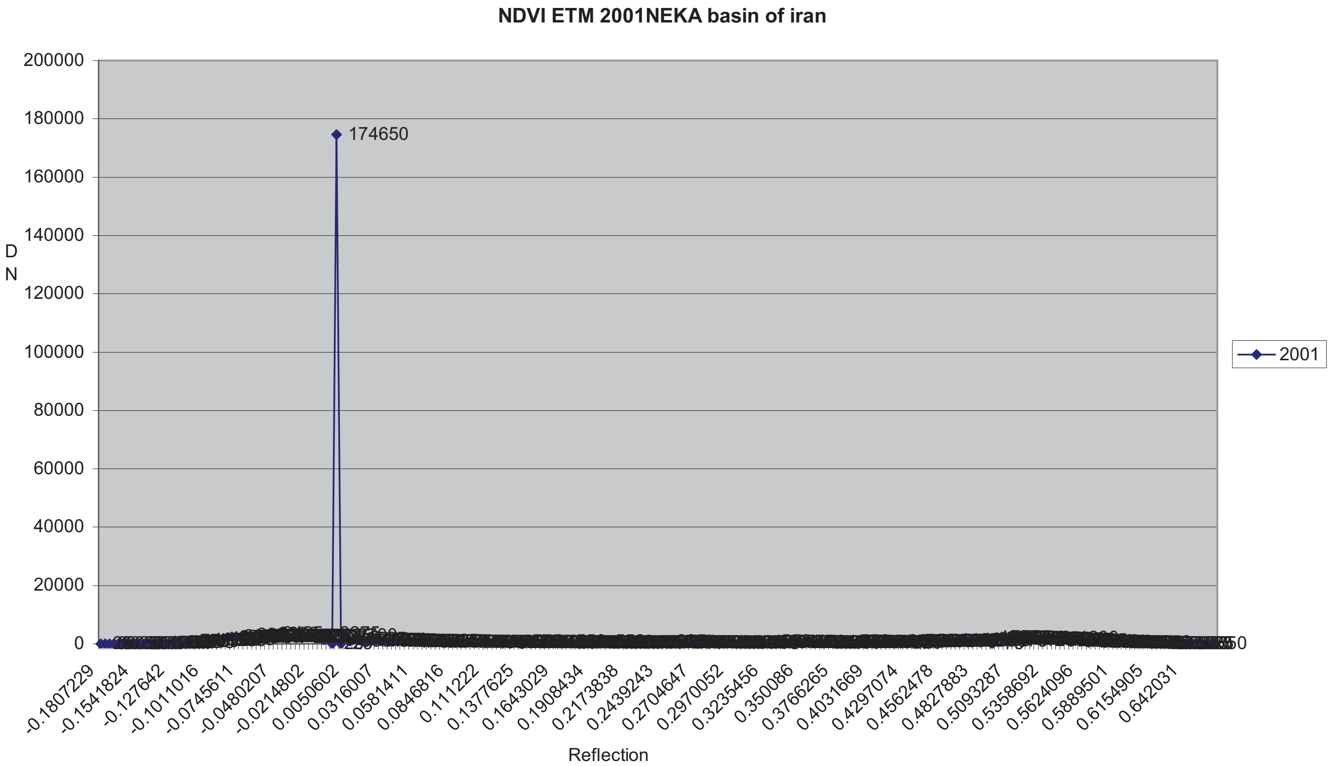

Table 4. Area and percentage of land cover change of during 1977 and 2001 classified images Neka Iran

Class name	1977 (area in ha)	Percentage	2001 (area in ha)	Percentage
Low grassland and bare soil and dry land	63532	34.20	77905	41.95
Graze land	38333	20.64	28053	15.10
Low forest and vegetation	25592	13.78	20339	10.95
Dense forest	58261	31.37	59401	31.98

Table 5. Accuracy statistics for the classification result

class name	Producer's accuracy (%)	Reference total	User accuracy (%)	Kappa statistic
(a) 1977 MSS image				
Low Graz land and bare soil, and dry land	100	26	96.67	0.96
Graze land	96.77	31	100	1
Low forest and vegetation	100	23	100	1
Density forest	100	91	100	1
(b) 2001 ETM Image				
Low Graz land and bare soil and dry land	100	31	100	1
Graze land	100	23	96	0.95
Low forest and vegetation	96	24	100	1
density forest	100	93	100	1

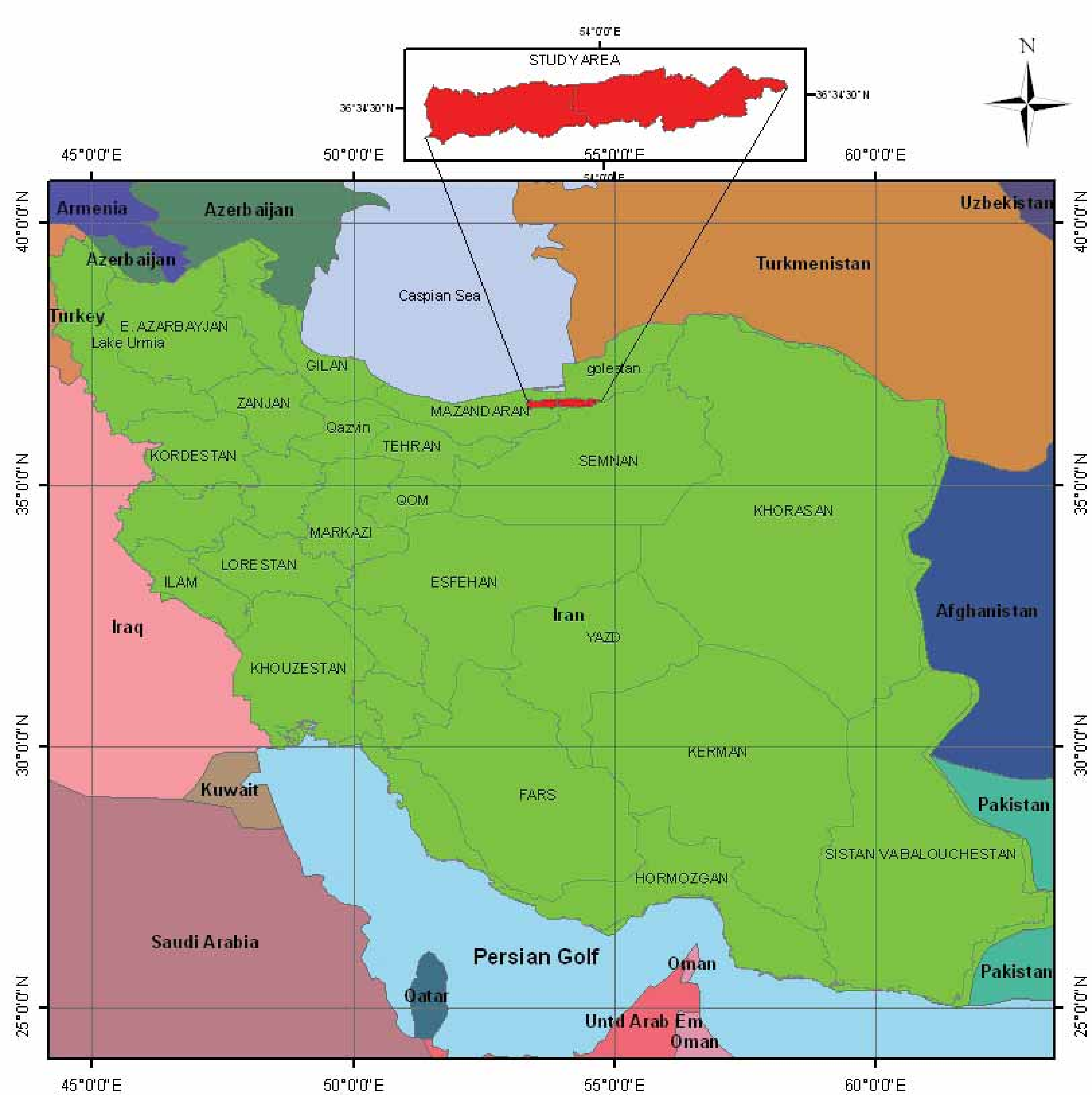

Figure 1. Geographic location of southern Neka basin

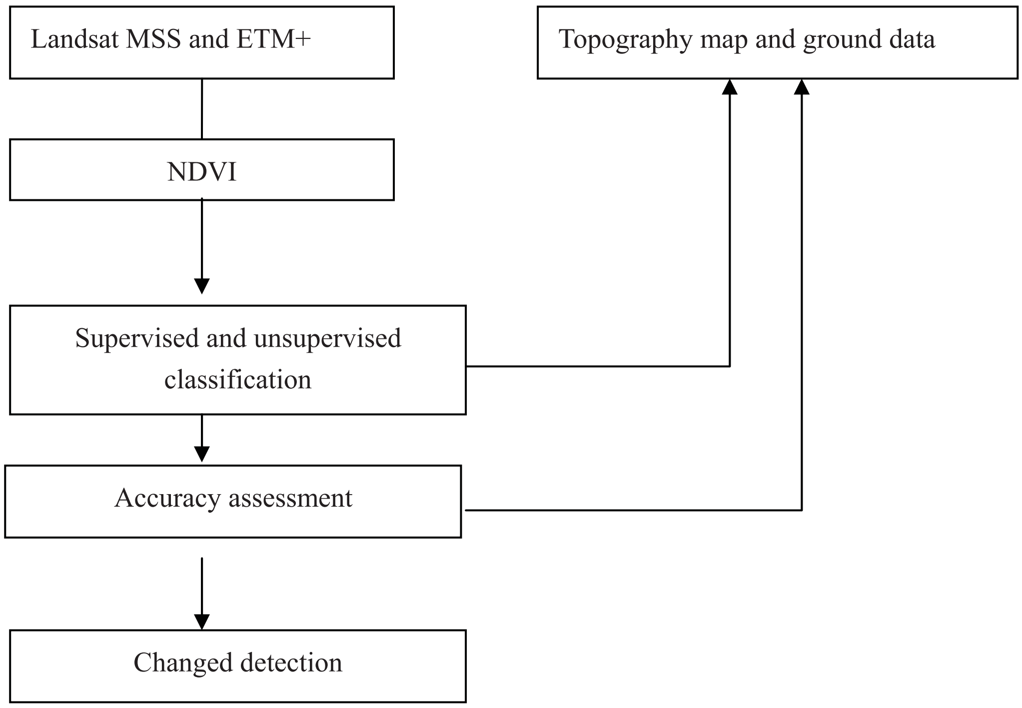

Figure 2. Flowchart of the land use and NDVI classification

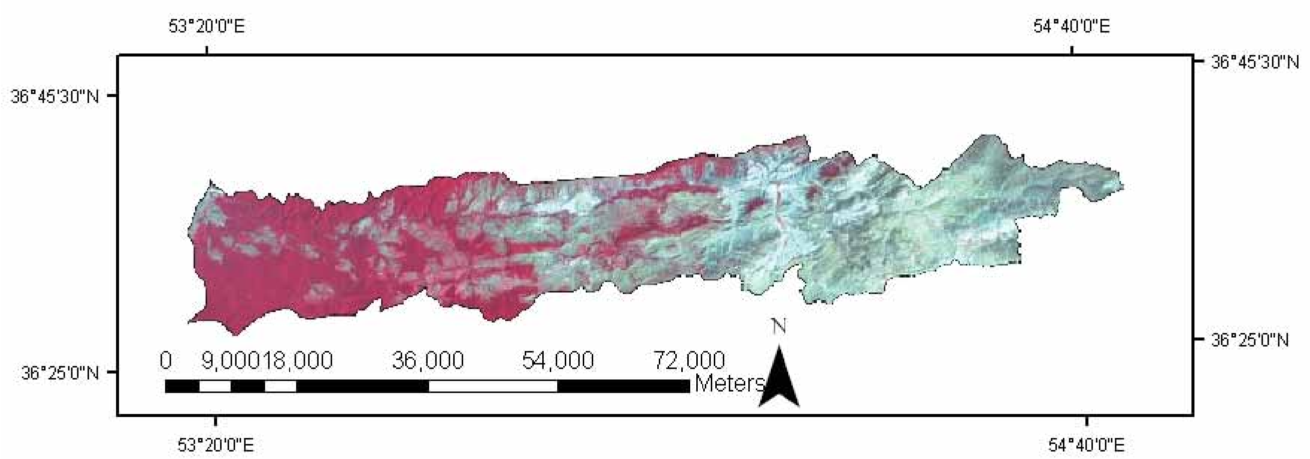

Figure 3. False color composite image of Landsat MSS (June 1977) bands 2, 3 and 4

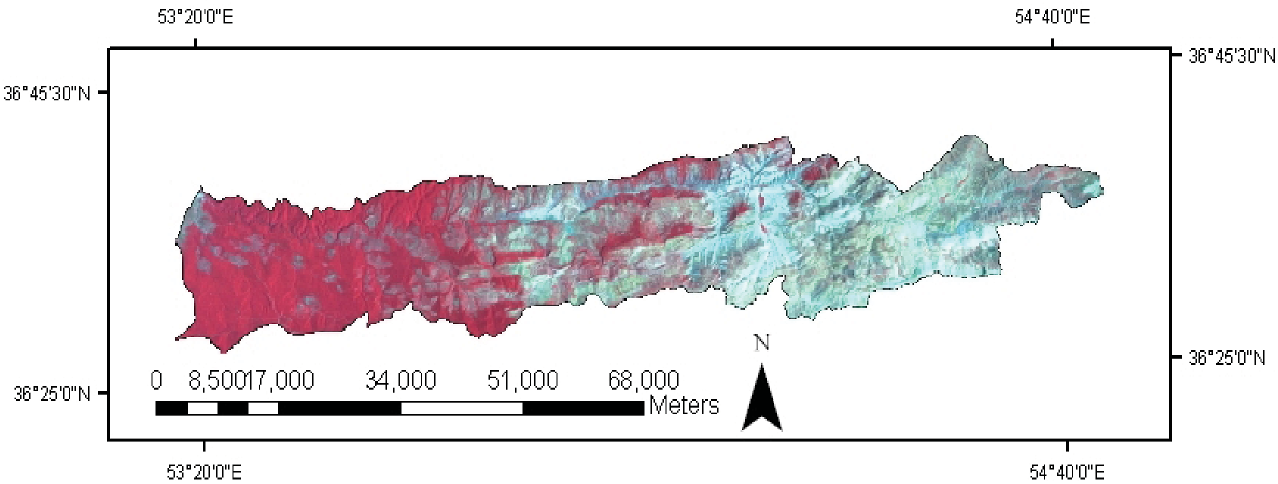

Figure 4. False color composite image of Landsat ETM (July 2001) bands 2, 3 and 4

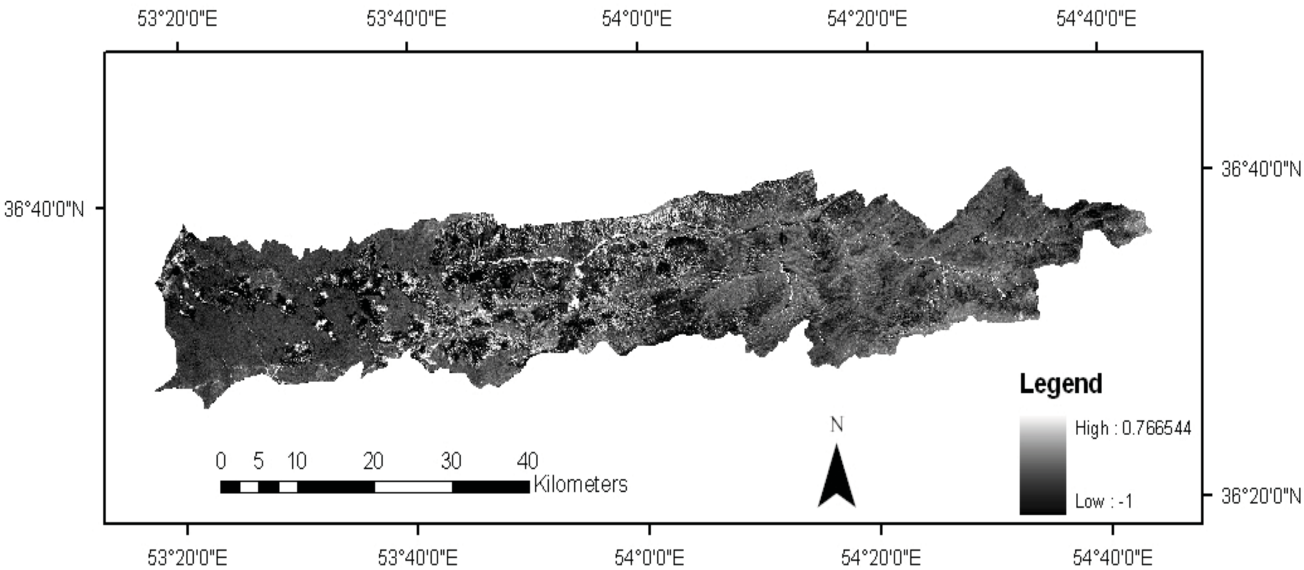

Figure 5. NDVI change detection during 1977–2001

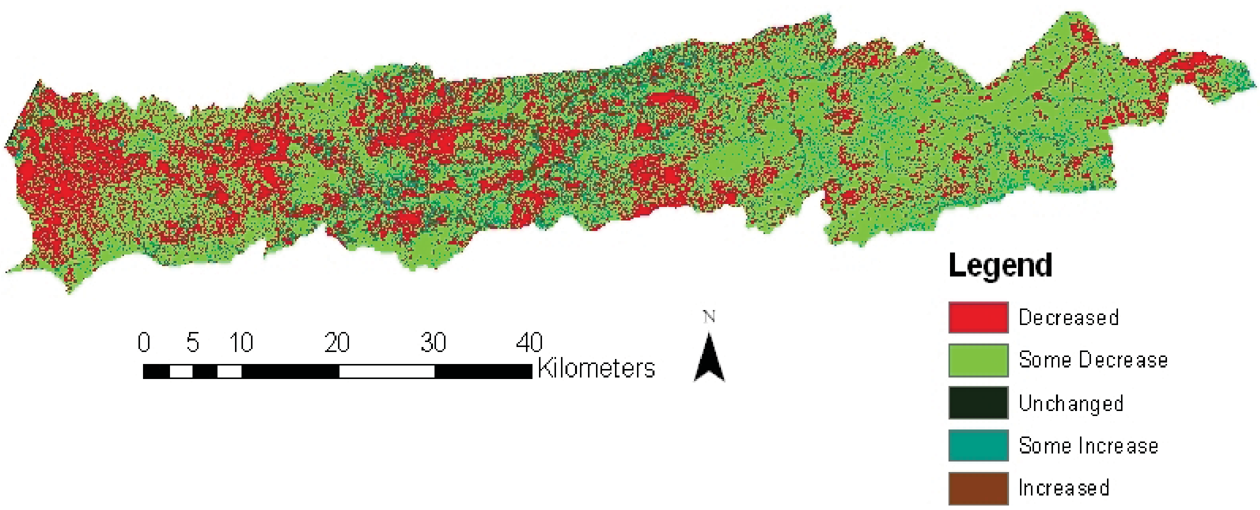

Figure 6. NDVI change detection between 1977–2001

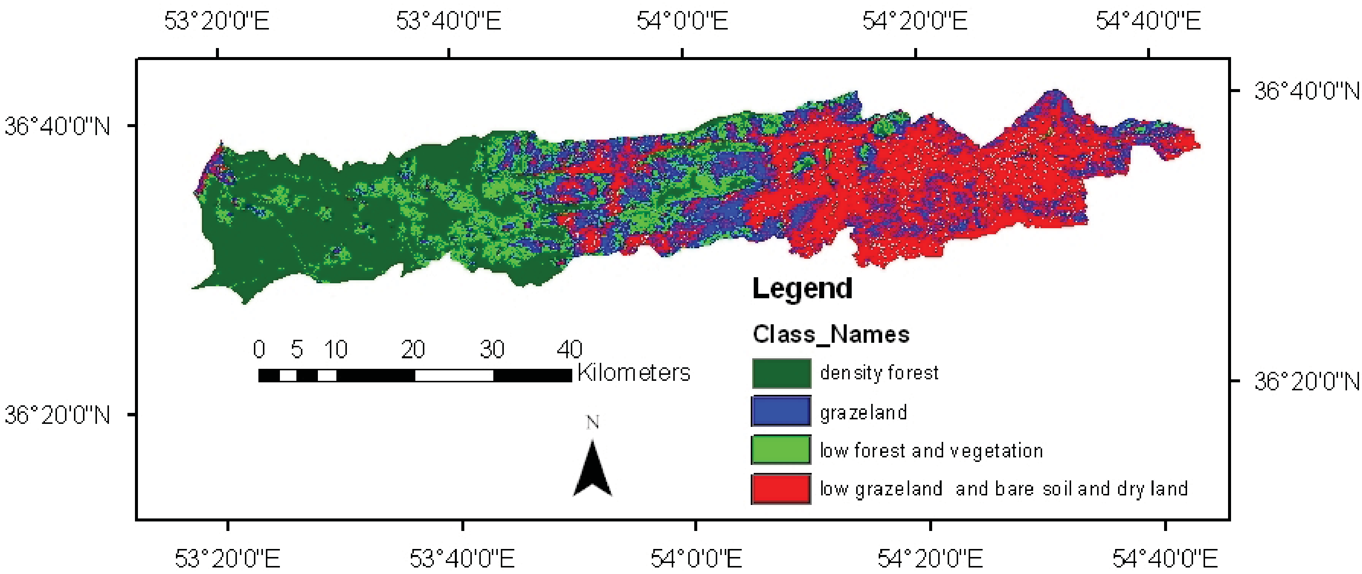

Figure 7. Land use/cover classification map of Neka Iran, using Landsat MSS1977

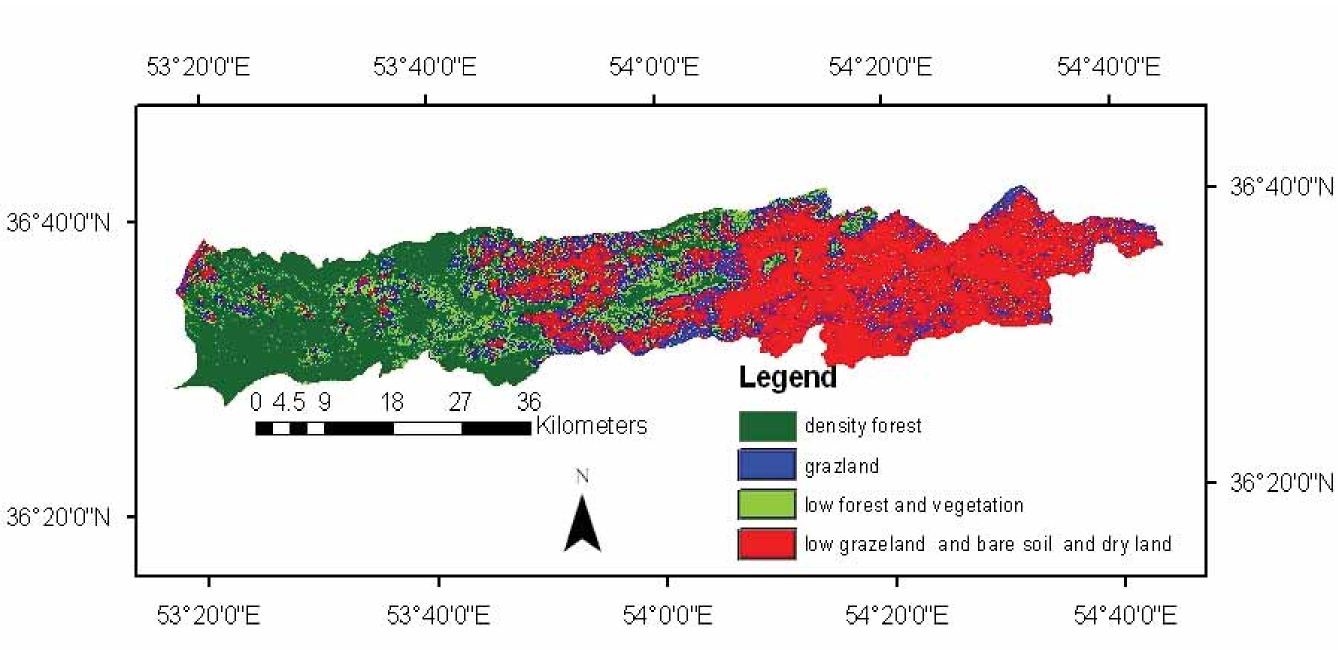

Figure 8. Land use/cover classification map of Neka Iran, using Landsat ETM+ 2001