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Investigation of Land Use Changes in North of Iran Using Remote Sensing and Geographical Information System (1986-2015)

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Abstract

Deforestation in Iran has been more rapid in the past 50 years than at any time in Iran's history, and Neka basin located in the north of Iran has been subjected to severe deforestation problems. Detection of ecosystem changes may help decision makers and planners to understand the factors in land use and land cover changes in order to take effective and useful measures. Using remote sensing and GIS technologies are used as efficient tools for monitoring and evaluation land use change. In recent years, a considerable land use changes have occurred in in the Neka basin. This paper presents findings of an evaluation study that focused on the changes in land use changes in a great basin of Neka. The study was based on a spatial analysis of historical Landsat images (1986–2015) and several field measurements and observations. First, geometric correction and contrast stretch are applied. In order to detect and evaluate land use changes, image differencing, vegetation change analysis, principal component analysis and classification comparison have been applied. Finally, the results of land cover classification for three different times are compared to reveal land use changes. Relatively, agriculture, range and urban developed areas increased, respectively 84.70, 31.88 and 54.52 % from 1986 to 2015, while forest decreased 44.35%. With the greatest decrease occurring from 1991 to 1999. The overly analysis of the four land cover maps revealed that there is an imbalance in the spatial distribution of deforestation areas. The west and central part of the study area has mostly changed and deforestrated.

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From 1986 to 2015, forest, which covered 1245.53 km2 (47.79%) of the total area in 1986 had decreased to 693.60 (25.60.7%) in 2015. However, the rangelands increased from 1120.42 ha in 1986 to 1477.69 km2 in 20015.

Keywords: Land use; Deforestation; Remote Sensing; Classification; Neka.

1. Introduction

Land-use/ cover changes (LUCC) have been more rapid in the past 50 years than at any time in Iran and are expected to continue or accelerate in the future [13]. Although this change has many interacting components, land use/land cover change or land conversion probably represents the most important factor affecting ecological systems [35]. Because of increasing population and a strong rise of the living standard, the need to intensify agricultural production has increased; this situation has putted pressure on other natural resources especially forest and range lands. The natural forests in Iran have been decreased from 19 million hectares in the 1950s to 12.4 million hectares in the 1990s [11, 24]. During the past 50 years, the amount of Iran's cultivated land has grown by more than five times, increasing from 2.6 million hectares to 24.5 million hectares [11].

There are a long histories of landuse changes, mainly as a result of increasing pressure of humans in terms of deforestation and agricultural expansion [6, 28]. Much of the research studies have assessed the patterns of land use change [28]. Such large-scale changes in land use and land cover can have significant consequences such as the depletion of valuable ecosystem goods and services. For example, forests are the source of fiber and valuable pharmaceutical products, and provide important services such as the regulation of climate and surface water, and protection of the soil. Furthermore, tropical rainforests provide a valuable habitat for an enormous number of plants and animals on this planet.

Land use changes have many faces, and these changes are often not carried out in a sustainable way. Land use change is important for social, economic and regional development and environmental changes [2, 8, 9, 22, 41].

Today, there are several ways and methods for monitoring environmental changes for evolution of land use change, traditional methods and large-scale precision land surveying on the ground is expensive and time-consuming and, in some cases, impossible [25]. Remote sensing is the major source of data that used in the study of areas with urban or manmade characteristics, landscapes and natural environments [5, 14, 29]. Remote sensing technology offers high spatial resolution and is valuable mechanism for the monitoring, diagnosis, identification and zoning of natural resources, especially in land-use mapping [1, 34]. Remote sensing digital images provide updated information and comprehensive views and use different parts of the electromagnetic spectrum to record characteristics of the area under study [3, 16, 23]. As a result, techniques such as remote sensing, geographic information system (GIS) is useful for the early identification and evaluation of land changes and it can be useful tool for planning and management environment. Yanli and his colleagues (2012) using GIS techniques and remote sensing to monitoring land changes and the processes of desertification in the province of Basra in southern Iraq during 1990-2003 [39]. The processes of desertification, urbanization, salinization, destruction of vegetation and the destruction of wetland eco-environmental degradation of the region have identified as main factors of land use changes.

Assessment of land use changes is a process that leads to correct understanding of the interaction between humans and the environment. This is more important in environmental sensitive areas of aquatic ecosystems, especially wetlands and lakes [17, 23]. Planning for the conservation and development of wetlands and lakes need to monitor their changes during the time. Using remote sensing is one of the new and efficient technologies in the area of monitoring and evaluation land use changes of lakes and wetlands, which can help administrators to provide a better solution to prevent destruction of these valuable ecosystems [7, 10, 12, 19, 26, 27, 30, 37, 40]. Therefore, monitor and assess the fluctuations of the wetland area and these changes impact on their environment according to the high threshold of environmental sensitivity in these habitats is very important.

According to studies about this issue and the importance of Bakhtegan and Tashk lakes in the province of Fars in southern Iran, in this study, assessment of the land use changes in these lakes and its related phenomena will be discussed by using satellite images [14, 15].

The changes in land use and land cover have accelerated over the last three centuries, since the onset of the Industrial Revolution. Land use is one of the most obvious and major drivers of global change. With this recognition, there have been an increased number of studies of the causes and consequences of land use and land cover change. In this paper a summary is given on the current understanding of historical changes in land use and land cover.

Information on land cover/land use (LCLU) plays a key role in natural resource management [33, 36]. LCLU maps are preliminary inputs for planning and modeling ecosystem activities [7, 32, 38]. LCLU mapping using satellite images has become widely popular in the last decades [8, 18, 31, 33].

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 [20, 21]. 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.

2. Materials and Methods

2.1. 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 to the 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 indicates 53º,17',54'' E to 54º,44',03'' E and 36º,28',50'' N to 36º,42',42'' N, based on Neka topography map published by the Iranian Geographical Organization (Fig. 1).

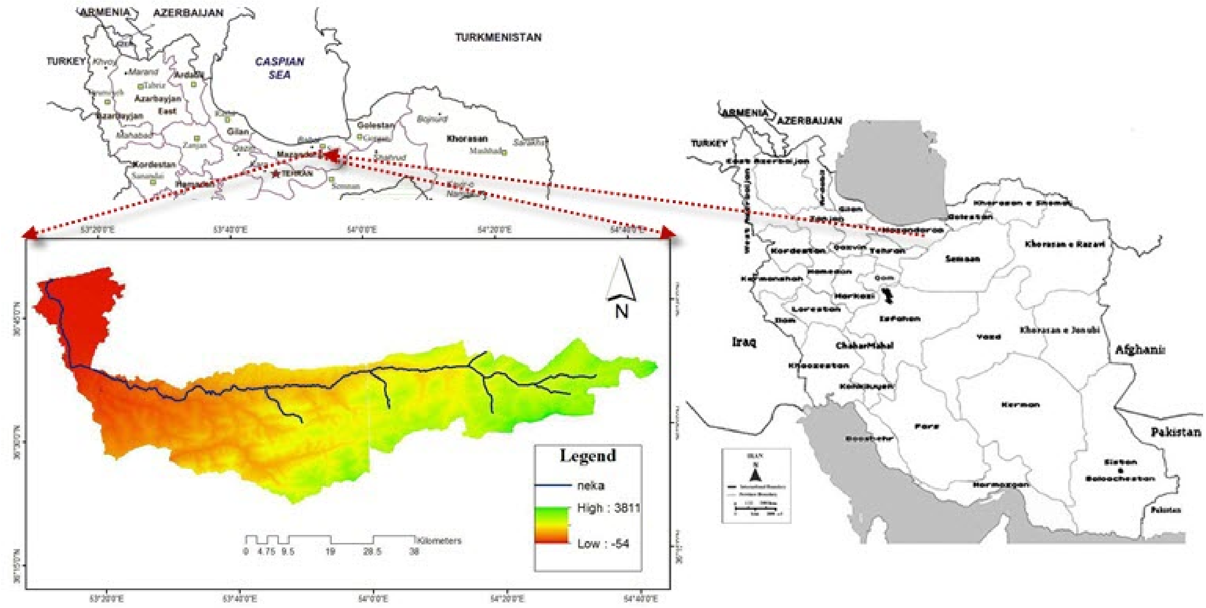


Figure 1: Location of the study area in Iran

2.2. Methodology

2.2.1. Utilized satellite sensors

Remote Sensing images used in this study include the Landsat-5 Thematic Mapper (TM) Image, Landsat-7 Enhanced Thematic Mapper Plus (ETM+) image and Landsat-8 Operational Land Imager (OLI). These images are for years 1986, 1999, 2011 and 2015. Also, date of registering these images is month June of every year with two or three difference days.

2.2.2. Pre-processing of satellite data

Raw images of remote sensing have always some errors in geometry and also registered amounts for pixels. The first errors are named geometric errors and the second are named radiometric errors. Some of these errors are corrected in ground receiver stations but the images should be finally assessed by users in terms of such errors and corrected if necessary. Generally, corrections can be divided to two groups including geometric corrections and radiometric corrections.

2.2.3. Geometric corrections

Geometric corrections are the first step for preparing satellite data. It can be done by using ground control points, measured by GPS or maps that have been corrected geometrically. Such maps could be satellite images of the region that are taken in the past years or air images taken from the region with high precision that have been georeferenced by using ground region data. In that case, geographical position of each point in image is like its position on the ground. 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 (40N) all images resampled to a 30 m pixel grid.

2.2.4. Radiometric corrections

Radiometric corrections are used for decreasing or deleting two types of main atmospheric and machine errors. Atmospheric errors are the result of atmosphere effect (absorption and scattering) on electromagnetic energy. Such correction takes place in two steps:

Conversion of numeric value to spectral radiance

Conversion of spectral radiance to spectral reflectance

By carrying out radiometric corrections, the effect of sunlight angle difference due to time difference among used data is removed. Likewise, spectral reflectance may correct the difference in spectral ranges that are rooted in various spectral bands. 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 were 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, 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.

The image classification in this study is used to provide a base map of the land use in Neka river basin north of 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.

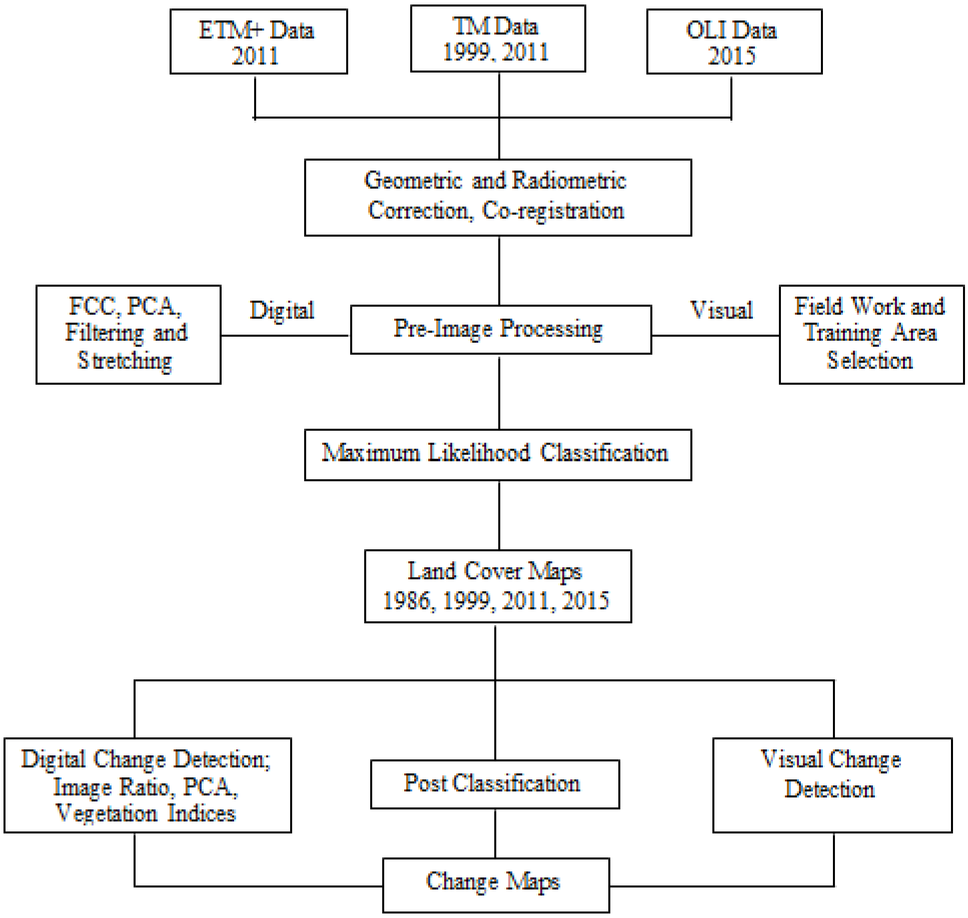
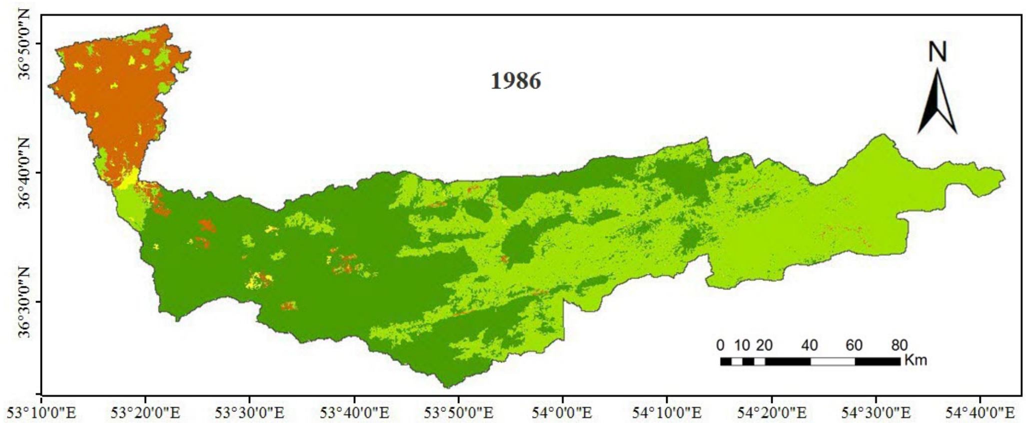


Figure 2: Flowchart of the research methodology

3. Results

In this study, in order to evaluate area changes of land uses in Neka river basin, the land use map based on supervised classification method was by Maximum Likelihood Classification Analysis. Classification maps were generated for all four years; Figures 3 shows the illustrations extraction of the land use map for the years of 1986, 1999, 2011 and 2015.



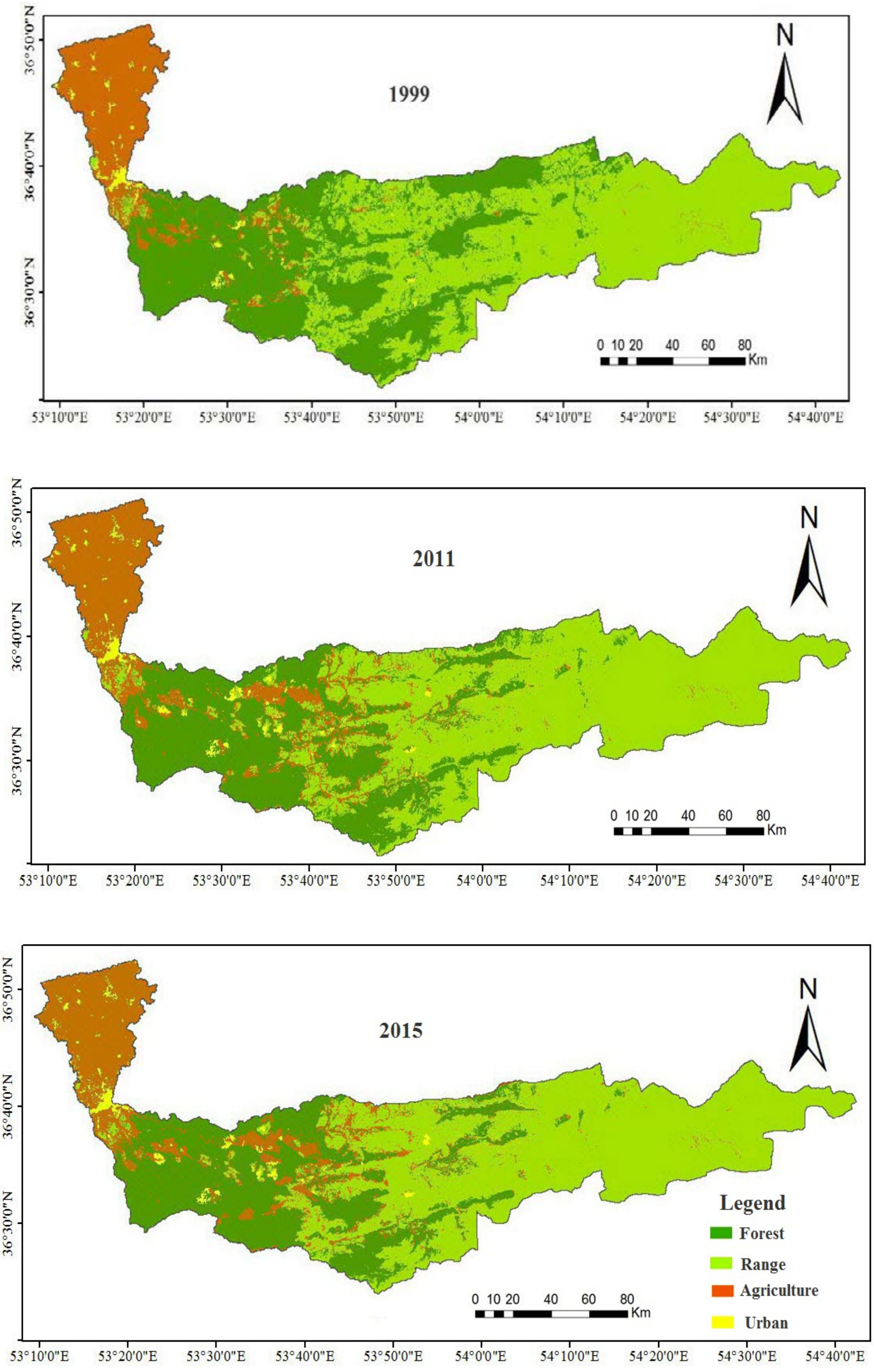


Figure 3: Land use maps of Neka basin for 1986, 1999, 2011 and 2015

The individual class area and change statistics for the four years are summarized in Table 1. Relatively, agriculture, range and urban developed areas increased, respectively 84.70, 31.88 and 54.52 % from 1986 to 2015, while forest decreased 44.35%. With the greatest decrease occurring from 1991 to 1999.

Table 1: Summary of Landsat classification area statistics for 1986, 1999, 2011, and 2015

Land cover class	1986		1999		2011		2015		Relative change, 1986–2015 (%)
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	
Forest	1245.53	47.79	985.74	37.82	765.44	29.37	693.16	25.60	- 44.35
Range	1120.42	42.99	1312.77	50.37	1432.77	54.97	1477.69	56.70	31.88
Agriculture	212.35	8.15	274.48	10.53	365.97	14.04	392.21	15.05	84.70
Urban	27.95	1.07	33.26	1.28	42.07	1.61	43.19	1.66	54.52

The general landuse changes trend of forest, range lands, agriculture and urban area have been shown in figures 3. Based on these curves the rage land, agriculture and urban area have been increased but the forest has been increased from 1986 to 2015.

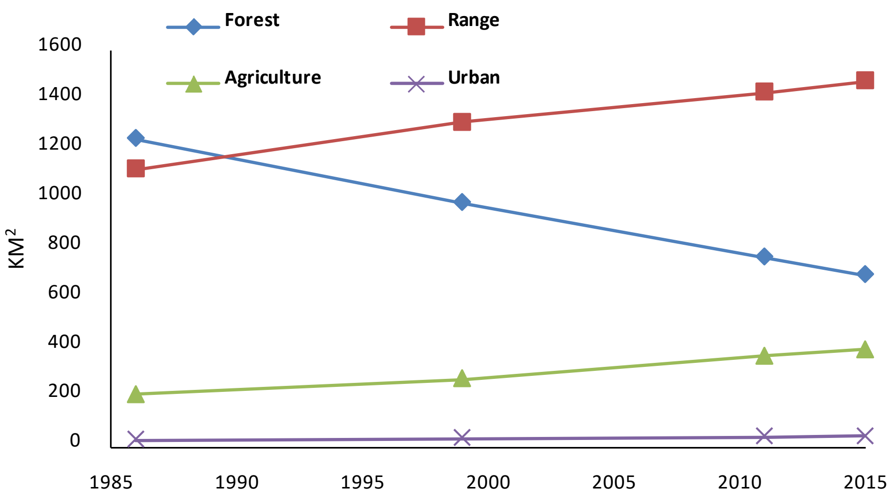


Figure 4: The landuse trend of Neka basin from 1986 to 2015

4. Dissection and Conclusion

Land use change is a process by which human activities transform the landscape. Today, destruction of lands and land use change are occurs in all the big cities, daily. There are many evidences that show a lot of transformation in various fields of land has created due to the demands and needs of civil society. However, conversion of different land and villages reduces the amount of lands available for food. Land use changes are different human activities occurring in a different area, the human activities and behaviors create theirs that they will be affected on the environment. However, these activities take place at the local level; they can also contribute to global processes, such as climate change.

In recent decades, we are seeing significant changes in land use, with the population growing and industrialization of human societies. Land use change and land degradation can effect to organic matter and physical and chemical properties of soil. Knowing the proportion of land use and how it changes over time is one of the most important indicators in planning. Detect and predict of land use changes are evaluated ecosystem changes the needs of and natural resource management. To inform the user of changes can predict future changes and appropriate measures taken.

The results demonstrate that Landsat classifications can be used to produce accurate landscape change maps and statistics. General patterns and trends of land-use change in Neka basin were evaluated by: (1) classifying the amount of land in Neka river basin that was converted from forest to rangeland, agriculture, urban use during four periods from 1986 to 2015; (2) quantitatively assessing the accuracy of change detection maps. In addition to the generation of information tied to geographic coordinates (i.e., maps), statistics quantifying the magnitude of change. The deforestation land in Neka basin was mapped from 1986 and 2015. The overly analysis of the four land cover maps revealed that there is an imbalance in the spatial distribution of deforestation areas. The west and central part of the study area has mostly changed and deforestrated. From 1986 to 2015, forest, which covered 1245.53 km^2 (47.79%) of the total area in 1986 had decreased to 693.60 (25.60.7%) in 2015. However, the rangelands increased from 1120.42 ha in 1986 to 1477.69 km^2 in 20015.

The results quantify the land cover change patterns in Neka basin and demonstrate the potential of multi temporal Landsat data to provide an accurate, economical means to map and analyze changes in land cover over time that can be used as inputs to land management and policy decisions. The use of multi temporal Landsat TM, ETM+ and OLI data in conjunction with GIS provides an opportunity for environmental monitoring, surveying and change detection, which can help in monitoring deforestation and save considerable efforts, time and cost compared with traditional surveying and mapping methods. The integrated land-use/cover maps have shown not only the temporal changes that occur in the forest cover but also in the other land covers between 30 years period. The forest cover maps based on satellite remote sensing data and GIS techniques can supplement existing conventional ground based sources of information for monitoring changes in the forests cover on a regular basis, which can be helpful for forest resource management and future planning for the development of the areas.

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. 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, and 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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