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Land Use Change Detection Using Remote Sensing and GIS

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***Abstract*—**In recent decades, rapid and incorrect changes in land-use have been associated with consequences such as natural resources degradation and environmental pollution. Detecting changes in land-use is one of the tools for natural resource management and assessment of changes in ecosystems. The target of this research is studying the land-use changes in Haraz basin with an area of 677000 hectares in a 15 years period (1996 to 2011) using LANDSAT data. Therefore, the quality of the images was first evaluated. Various enhancement methods for creating synthetic bonds were used in the analysis. Separate training sites were selected for each image. Then the images of each period were classified in 9 classes using supervised classification method and the maximum likelihood algorithm. Finally, the changes were extracted in GIS environment. The results showed that these changes are an alarm for the HARAZ basin status in future. The reason is that 27% of the area has been changed, which is related to changing the range lands to bare land and dry farming and also changing the dense forest to sparse forest, horticulture, farming land and residential area.

***Keywords*—**HARAZ Basin, Change Detection, Land-use, Satellite Data.

I. Introduction

INCREASED population and human activity increases the demand on limited water resources and agricultural land, forest, range and urban land-uses and industries. With the population growing, lands under cultivation can no longer provide the needs of people and therefore, more lands are needed to be cultivated which in long terms will result in a decrease in quality and quantity of natural resources [1]. Today, unplanned land-use change is a major problem. Changing the land-use has direct effect on hydrological cycles. In addition, hydrological processes like interception, penetration, evapotranspiration, soil moisture, runoff, and ground water are affected by the characteristics of land-use and land cover of the basin [2]. Changing the land-use and land cover is a surface dynamic process. Spatial distribution of changes in a time period is important issue in studies related to natural resources [3]. The sustainable management of watersheds needs monitoring, understanding the dynamics of changes, ecosystem response to social and natural pressures, information providing on planning for natural resource conservation [4].

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Nowadays, various natural hazards such as flood, landslide, and erosion have been seen in many areas of the country, especially its north part that researchers consider the destruction of plant vegetation and changes in forest area as the most important factors enhancing the probability of these events [5]. Haraz basin has a high potential for such phenomena, too [6]. In order to tackle such problems, natural resources and land-use of the above mentioned basin and its changes in recent years should be studied in order to have a close and timely glance for changing, adjusting and planning of water resources, natural resource protection and decrease the soil erosion in accordance with basin correct management and achieving the sustainable development with low time and cost. On the other hand, providing a land-use map using field work method is so expensive and time consuming. Therefore, we should continue methods like remote sensing so that in a short period of time and with less cost, we can provide maps with reasonable accuracy.

Nowadays, remote sensing is one of the advanced tools for mapping land cover and land-use in different levels of planning [7]. In addition, remote sensing is an appropriate tool for providing information [8]. According to [9], remote sensing and geographical information system are useful in analyzing the land cover changes in basins. In fact, multi-temporal data which is obtained from remote sensing are so effective in mapping and detecting changes of landscape in order to planning and consistent managing. Furthermore, using remote sensing and incorporating it with GIS can be used to obtain environmental data [10]. By mixing the data obtained from remote sensing and GIS, analyzing and categorizing the land cover changes pattern during time will be possible and changes would be detectable [11]. Various researchers of inside and outside of the country have been done numerous studies about the land-use change detection using satellite data and different analyzing methods [12]-[17]. Therefore, the purpose of this study is land-use mapping and detecting temporal and spatial changes during 15 years (1996-2011) in Haraz basin using LANDSAT data.

II. Material and Methods

A. Study Area

The study area is Haraz basin, which covers almost 677000 ha in Mazandaran Province (Fig. 1). This area is used mostly for different grades of range, forest, farming and horticulture land-uses and bare lands.

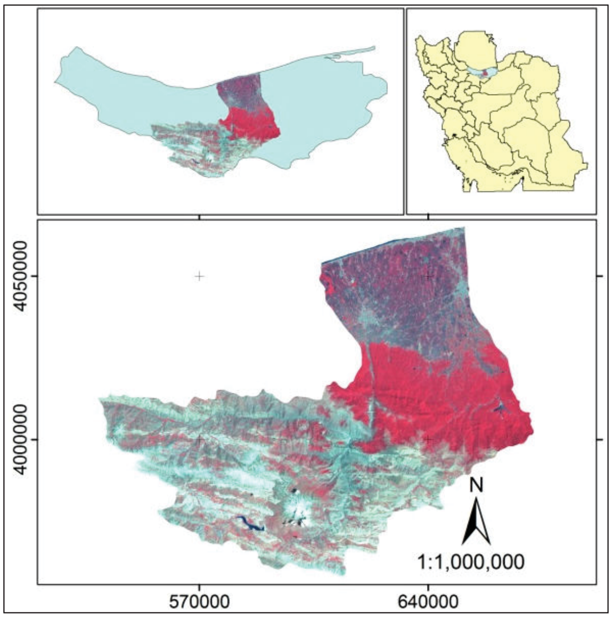

Fig. 1 Location of study area within the Mazandaran province, Iran

B. Methods

1. Image Corrections

Before using satellite data, they should be authenticated in quality, not having radiometric and geometrical errors and if there were any, they should be corrected. In this study, observing of all the bands and its different color composites of each year showed the striped error and cloudy areas. Therefore, the classes of cloud and shadow were included in classification. For solving the geometrical errors, Ortho-rectification method was used. The process of this method was done using rivers, roads and DEM maps in PCI software and image of each year with RMS error under one pixel were corrected.

2. Enhancement of Images

In this study, according to the aim of it, the results and suggestions of other studies, PCA and rationing methods and (SAVI & NDVI indices) were used. As PCA method has high correlation between visible bands (1-3) and infra-red (4-7), it was used separately on these groups and their first components were used as artificial bonds in classification. Also, a colour composite (RGB 432) of each year image was used for better recognizing of area and making training sites.

3. Classification and Land-Use Mapping

After authenticating the radiometric and geometric accuracy of images and appropriate processing on them for a better extraction of information, images are analyzed. In this study, according to its aim, results, and suggestions of other studies, supervised classification method and maximum likelihood algorithm were used. Before selecting the best band combination, training sites were chosen. For selecting training sites of each year image, RGB (432) colour composite, field control points and also Google Earth images (because of its timely and accuracy) were used. Training sites were selected for 9 classes in 1996 image and 11 classes (because of cloud and shadow classes) in 2011 image. classes are: 1- residential 2-farming 3- water 4- horticulture & sparse forest 5- dense forest 6- first grade range 7- second grade range 8- dry farming 9- bare lands. Then, classification was done using supervised classification method and maximum likelihood algorithm on each year's image. Therefore, an appropriate land-use map for each year was provided. For removing the mono pixels and smoothing the classified images, a mode filter with 3*3 window was used.

4. Extracting of Changes Map

This stage of research was done using comparison method after classification. For doing, the land-use map of each year was converted to vector format and polygons of cloudy and striped area was processed in GIS environment and converted to its correct class. Thus, the final land-use map was provided. By overlying maps of 2 periods and using Dissolve function, the position and the percent different land-uses and changed and unchanged areas for a period of 15 years were identified.

III. Results and Discussion

A. Image Corrections

Geometric correction of images with remove topographic error was done using Orthorectification method (with RMS error less than one pixel). Fig. 2 is corrected image of 1996 that complete adoption to rivers of the area shows its accurate geometric correction.

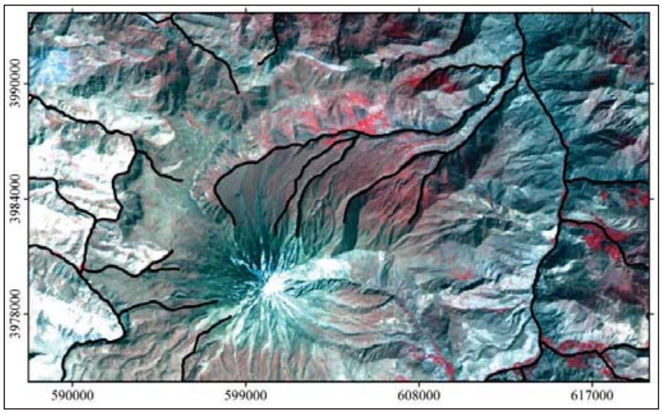

Fig. 2 Situation of the image geometric matching

B. Enhancement, Artificial Bands and Color Composites

To decrease the negative effects of inappropriate factors which exist in almost every bands (with different quantities) and increase the separation capability of the phenomena and selecting the training site from the images of each period, artificial indices and bands and colour composites were generated. Colour composite (RGB 432) of each area and some bands and artificial indices are shown in Figs. 3-6. As colour composites indicate, the most general and land-uses of area consists of: range, dry farming, forest, horticulture, and water sources.

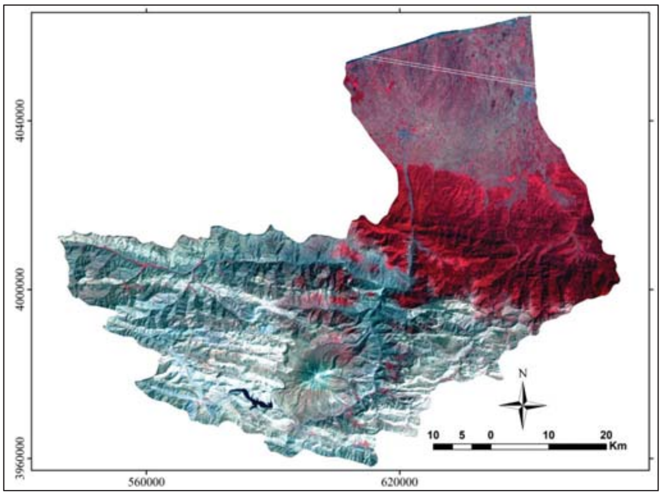

Fig. 3 RGB432 of 1996 image

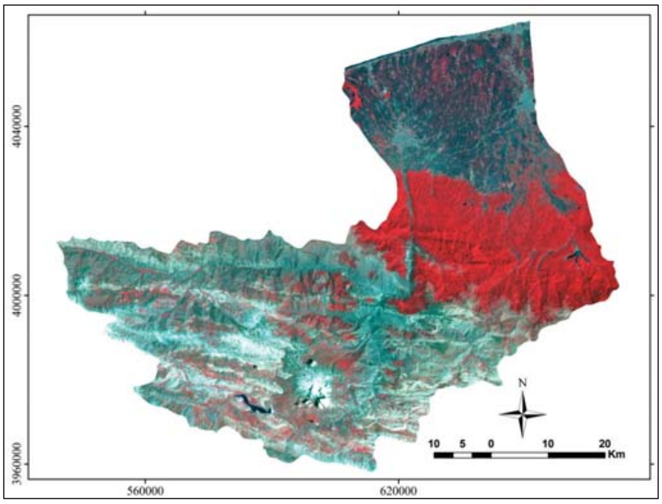

Fig. 4 RGB432 of 2011 image

C. Land-Use Maps

Land-use map of each period have shown in Figs. 7, 8, Tables I and II. As these tables and figures indicate, the area land-uses are residential, farming, water resource, horticulture, forest, range, and bare lands. In 1375, percent area of different land-uses including residential, farming, water bodies, horticulture & sparse forest, dense forest, first grade range, second grade range, dry farming and bare lands were 0.87, 20.8, 0.38, 1.68, 20.46, 9.86, 8.5, 35.3 and 2.1 respectively. The percent area in 1390 were 5.04, 16.5, 0.76, 7, 14.4, 1, 7.5, 39 and 8.6 respectively.

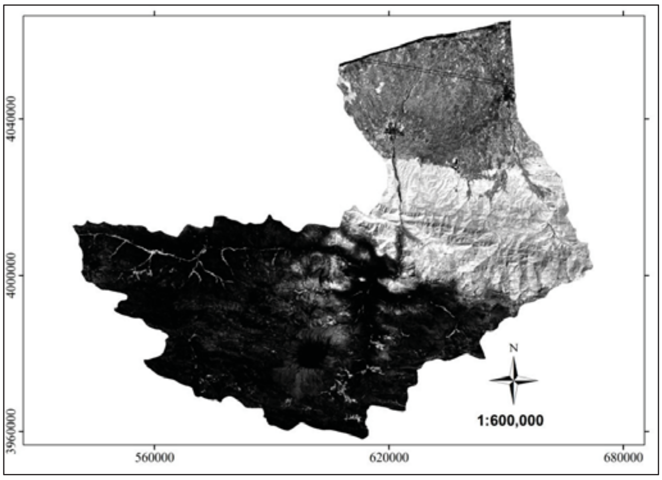

Fig. 5 SAVI index of 1996 image

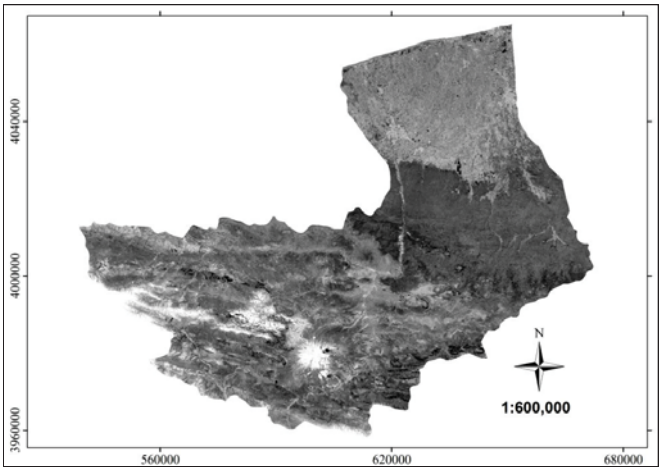

Fig. 6 PC1 (4567) of 2011 image

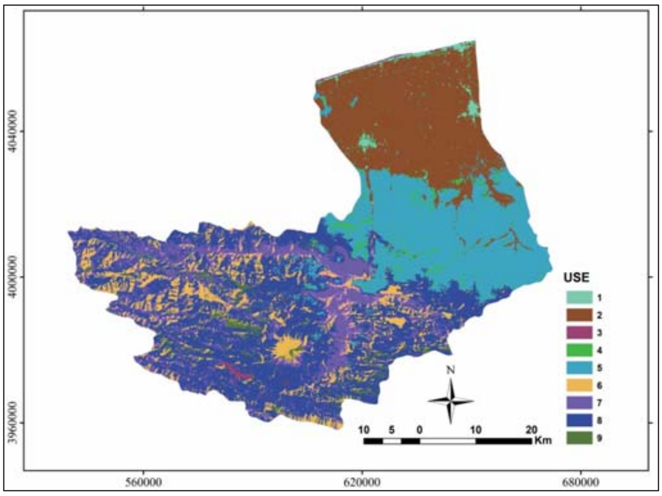

Fig. 7 Land-use map of 1996

TABLE I
LAND-USE CLASSES AREA OF 1996

Class	Land-use 1996	Area (Ha)	Area (%)
1	Residential	5895.931028	0.870386
2	Farming Lands	140991.441	20.813843
3	Water Resource	2575.294254	0.380177
4	Horticulture & Low Density Forest	11443.45214	1.689338
5	Dense Forest	138636.3678	20.466175
6	First Grade Range	66807.17997	9.862401
7	Second Grade Range	57480.99581	8.485624
8	Range-Dry Farming	239283.772	35.324235
9	Bare Lands	14278.19849	2.107817

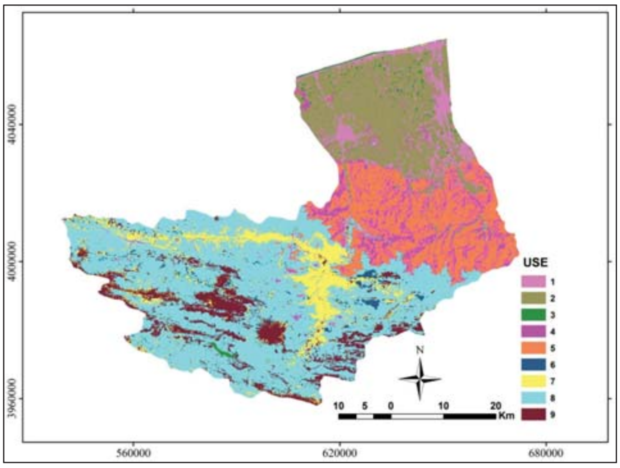

Fig. 8 Land-use map of 2011

TABLE II
LAND-USE CLASSES AREA OF 2011

Class	Land-use 2011	Area (Ha)	Area (%)
1	Residential	34192.2555	5.047627
2	Farming Lands	111564.8884	16.469752
3	Water Resource	5176.763136	0.764218
4	Horticulture & Low Density Forest	47746.27049	7.048537
5	Dense Forest	97501.7859	14.393688
6	First Grade Range	7202.241924	1.06323
7	Second Grade Range	51109.25297	7.544996
8	Range-Dry Farming	263999.2077	38.972848
9	Bare Lands	58899.96656	8.695099

D.Changes during 15 Years

15 years change map of land-uses and different classes area have been brought in Fig. 9. Also, for better understanding of spatial changes, map of changed and unchanged area have shown in Fig. 8. During this period, 72.5% of the area is unchanged and 27.5% is changed. 16% of these changes is related to change and conversion of range and its different grades to other land-uses (especially dry farming and bare lands), 6% of it was the conversion of dense forest to horticulture, sparse forest, farming land and water resources and 5% was the conversion of farming land to residential area, horticulture and water resources and 0.4% was the conversion of low density forest and horticulture to farming lands and residential area (Fig. 10). In addition, it should be mentioned that, according to recent droughts, water resources area should be shown decrease but in this study, an increase in 1390 was observed which is due to the construction and exist of a dam in the period of 1390.

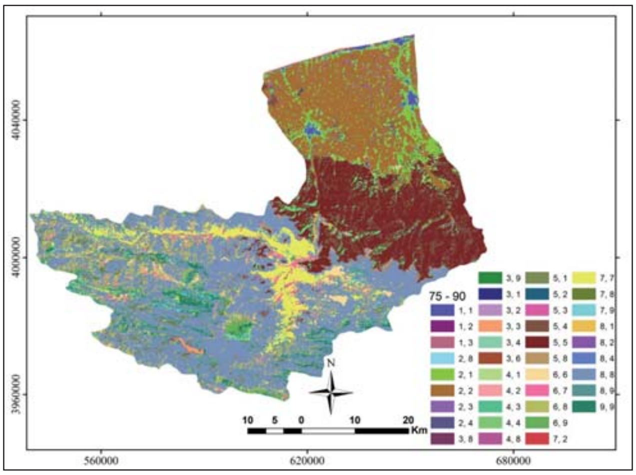

Fig. 9 Land-use changes map of 1996-2011

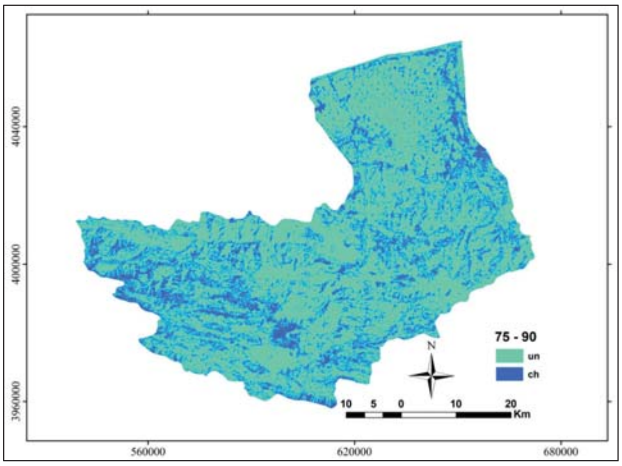

Fig. 10 Map of changed and unchanged area

IV. CONCLUSION

The results of this study show a warning alarm for HARAZ basin, because during 15 years, 27% of study area has been changed. The reason of these changes can be due to the population increase and human activities which result in increasing demands for natural sources and converting them into farming lands, horticulture, residential and industrial areas. In addition, climate changes are effective on these conversions which its most part is due to human interference in natural ecosystems. Finally, it is important to mention that this procedure can aggravate the environmental damages and decrease the level of ranges and forests in the above mentioned basin and other similar parts of the country. Therefore, studying the area of changes and degradation of natural resources during recent years can help in prediction the upcoming changes and can help in planning and optimal use of resources and controlling and inhibiting the unsystematic changes in future.

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