

[Research]

IRS-1C image data applications for land use/land cover mapping in Zagros region, Case study: Ilam watershed, West of Iran

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ABSTRACT

In land use planning, mapping the present land use / land cover situation is a necessary tool for determining the current condition and for identifying land use trends. In this study, in order to provide a land use/ land cover map for Ilam watershed, the IRS-1C image data from 25th April 2006 were used. Initial qualitative evaluation on data showed no significant radiometric error. Ortho-rectification of imagery was accomplished using ephemeris data, digital maps of topography and 45 ground control points with RMSe less than 0.7 pixels. Different suitable spectral transformations such as rationing, PCA, Tasseled Cap transformation were performed on the images in ILWIS software to enhance and produce new artificial images. Image classification was done using supervised classification maximum likelihood and minimum distance classifier utilizing original and synthetic bands resulted from diverse spectral transformation. Unsupervised classification was used to determine strata for ground truth. The results were assessed using a sample ground truth map through systematic random sampling and samples were designed in circle form and 1000m² area. Finally, nine main classes of land use / land cover (Rangeland, Forest (dense, semi-dense, sparse, very sparse), Agriculture, gardens, settlements and bare lands) could be determined. For representing accuracy, the rate was used from some criteria of accuracy such as overall accuracy and Kappa coefficient with 83% overall accuracy and 0.78 kappa coefficient.

Keywords: IRS-1C, Land use / land cover maps, Zagros, Ilam.

INTRODUCTION

Land use is the human modification of natural environment or wilderness into built environment such as fields, pastures, and settlements. Land cover is the physical material at the surface of the earth included grass, asphalt, trees, bare ground, water, etc. (Lex *et al.*, 2005). These two terms are often used simultaneously to describe maps that provide information about the types of features found on the earth's surface (land cover) and the human activity that is associated with them (land use) (Shetty *et al.* 2005). Up to date information about the existing land use patterns and changes in land use / land cover through time is one of the prime prerequisites for the preparation of an integrated development plan and

economic development program of a region. For this regard, mapping the land use is a necessary tool for determining the current situation and for identifying land use trends. In fact, land use / land cover maps will provide the basis for improving land management practices in order to achieve sustainable management of lands (Singh and Roy, 1989).

The benefits of satellite-based remote sensing in land use / land cover mapping, monitoring and change detection as well as providing up to date information within short time at less cost and efforts were recognized long ago by several researchers. Many studies and surveys have used remote sensing techniques to acquire land use / land cover information during the past 40

years and this technique has become now the only most effective tool for land cover / land use data acquisition. (Gautam and Channaich, 1985; Karteris, 1990; Lillesand and Kiefer; 1994, Kelarestaghi *et al.* 2006).

Decreasing of forest and degradation of other natural resource lands in west of Iran is one of the critical issues for the management of lands in this region. As Rao *et al.*, 1996 mentioned "the growing pressure of population coupled with increasing demands made on land resources, have brought extra pressure on the available land", in west of Iran also we have the same problems in land uses. Management and planning for the land uses in this region have faced many challenges of which that one is the shortages in studies and surveys for collecting required information for sustainable management and planning.

Remote sensing and satellite data have also been used for land use/land cover mapping and change detection by many researchers In Iran (Shataee & Abdi, 2007; Amini *et al.*, 2008; Rezaii banafshe *et al.* 2008, Daryokvandy *et al.* 2009). Rafiian in 2002 evaluated the applicability of ETM+ image data in providing forest maps and investigated the changes in forest cover in the north of Iran. The result of study showed that ETM+ image data are useful

tools for land use/land cover mapping. In addition, about 8.2 % of forest cover in the study area has been reduced during 7 years. Amini *et al.*, 2008 used aerial photographs, ETM+ and IRS-1C image data for land use and land cover change detection in Zagros forest in the west of Iran. Based on the results of change detection in this study, about 953 hectares of forest area have been increased and 4853 hectares have been reduced during 47 years. The study mainly focused on the evaluation of the present status of land use/land cover in Ilam watershed using digital satellite data of IRS-1C, topographic maps and field observations data. The study also tried to evaluate the potential of the IRS-1C, LISS-III data for delineation of various land use/land cover classes.

MATERIALS AND METHODS

Study area

The research was carried out in the Ilam watershed in west of Iran. The study area is located between latitude 33° 19' to 35° 54' N and longitude 38° 45' to 30° 52' E that covers about 219972 hectares (Fig 1). The climate in the study area is classified as semi humid cold, characterized by annual rainfall 630.1 mm and average annual temperatures 18.19°C.

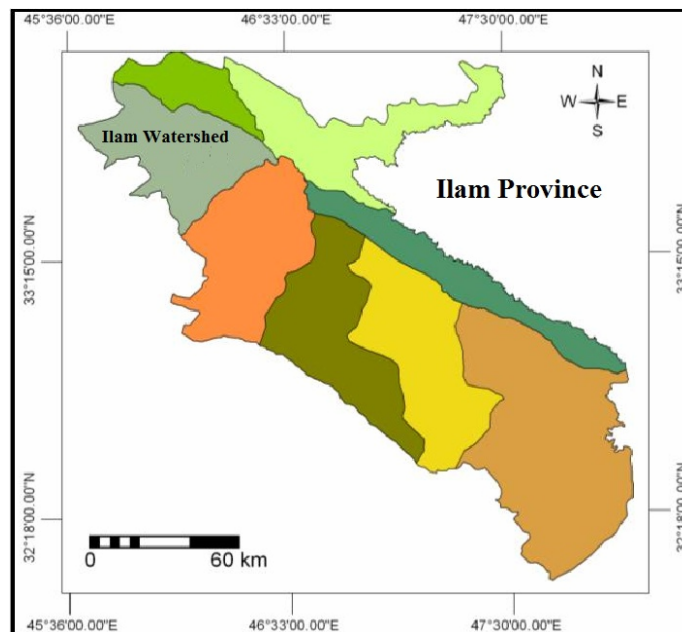


Fig 1. The location of study area in Ilam province of Iran

Data Sources

Data in this study are composed of digital topographic maps dated 1994 at the scale of 1:50000 (from National Cartographic Center (NCC)) and IRS-1C satellite data from 25th April 2006 were used to generate land use map.

Satellite image processing and classification

It was preferred to use IRS-1C data after 1G level processing (geometrically and radiometrically corrected). Note worth the data were for growth season under clear sky. IRS-1C image data were geo-referenced to avoid geometric distortions. It is achieved by transforming image coordinates into projected geographic coordinates, which is also known as coordinate transformation. The Integrated Land and Water Information System (ILWIS) software was used to geo-reference image data. 45 ground control points (GCP) taken at road crossing and waterways using GPS and maps (set in UTM) were used to check accuracy of the geo-reference. Different appropriate transformations namely rationing, PCA, Tasseled Cap were performed on the images in order to improve information extraction. Visual interpretation of satellite images was enhanced through the use of linear stretching and principal component analysis in ILWIS software.

Land use / cover mapping

Two main steps were followed for the land use/cover mapping; Firstly, an unsupervised image classification performed prior to field visit, in order to determine strata for ground truth. Then the final land cover / land use map of 2006 was produced by combining supervised image classification techniques and on screen digitizing of some land use classes based on their textural characteristics. Supervised classification based on the

maximum likelihood algorithm and minimum distance classifiers were used with original and synthetic bands (false color composite generated using different bands) in the classification of satellite images. This was based on 65 training sets on image which are representative of each desired land cover category. Expert knowledge was used in selecting 65 points on spots at suitable distances away from those visited during field work. When an image analyst has knowledge of the geography of a region and experience with the spectral properties of the cover classes then he/she can delineate different land cover / use in most effective form (Skidmore, 1989). The sample points collected during fieldwork were all used for validating classification results. Land use classes which showed on overlap in spectral information could be discriminated based on textural characteristics were digitized on screen, polygonized, rasterized and merged in ILWIS. Finally, the 2006 land use map was produced at a scale of 1:50000.

Field sampling design

Validation of image classification was based on a set of 325 field samples in form of circle with 1000 m² area. Field sampling was necessary for validation land use interpretation results from satellite images, for qualitative description of the characteristics of each land use class. The sampling technique used in this research was systematic random sampling. During fieldwork however, some adjustment were made where it was impossible to access some systematic randomly selected samples (Fig. 2). The information collected during the field survey consists of the type of land use / land cover, writing down species composition of each field site and canopy closure in the forest area.

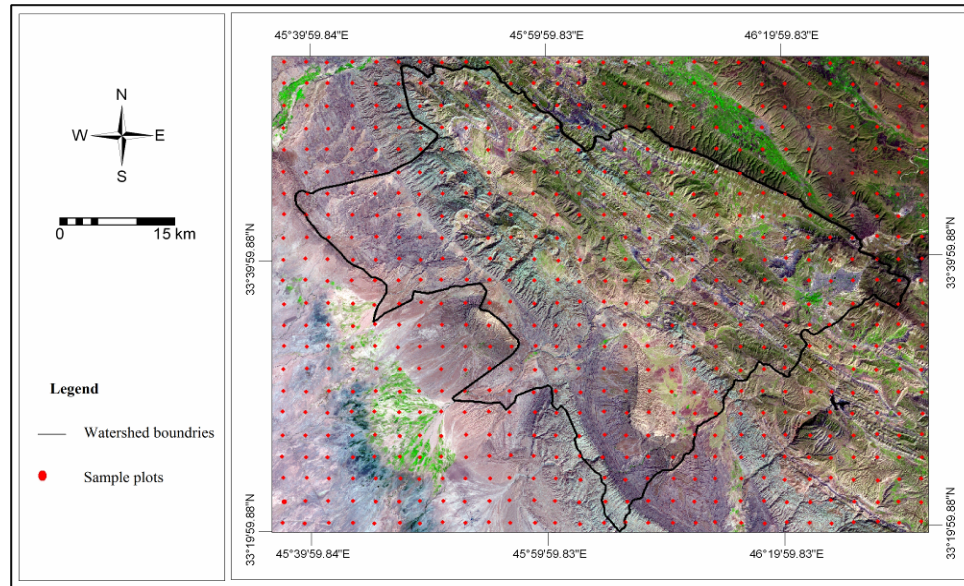


Fig. 2. The location of sample plots in the study area

Results

Post classification

A majority filter in ILWIS was used for smoothing the classification results. The accuracy of classification was carried out by means of a confusion generated through GIS overlay of the classified maps and test

samples. The image classification accuracy was further assessed by calculating the kappa coefficient 'K'. The confusion matrix gave an overall accuracy of 83% and calculation of kappa statistics (K) gave accuracy 0.78 from bands 3,4,5 (Table 1).

Table 1. Accuracy of different band composites in classification process

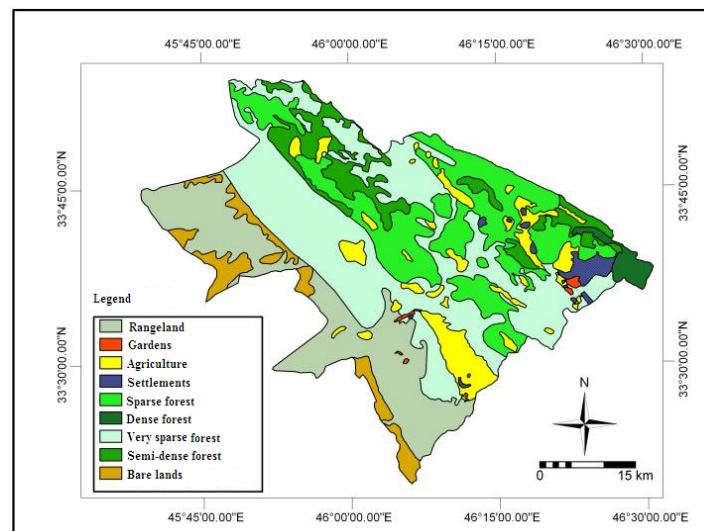
User accuracy of non-forest class	User accuracy of forest class	Producer accuracy of Non-forest class	Producer accuracy of Forest class	kappa coefficient	Overall accuracy	Algorithm	Bands
65.45	82.01	77.15	71.16	0.68	73.54	Max-likelihood	Bands 2,3,5
61.19	80.32	71.52	70.92	0.57	69.98	Min-likelihood	Bands 2,3,5
68.27	82.42	78.77	77.37	0.61	77.67	Max-likelihood	Bands 2,3,4
56.67	79.31	73.45	68.78	0.55	70.88	Min-likelihood	Bands 2,3,4
77.46	85.48	79.91	86.89	0.78	83.21	Max-likelihood	Bands 4,5,3
64.92	79.48	76.57	71.52	0.61	74.27	Min-likelihood	Bands 5,3,4

The visual interpretation of satellite data with strong ground truth was used to draw the map of different land cover / land use classes. Fig. 3 shows the main result of this study namely the land use / land cover map of Ilam watershed. Nine land use /land cover classes were discriminated based on

spectral characteristics of satellite images. These included: dense, semi-dense, sparse forest and very sparse forests and also, rangeland, agriculture, gardens, bare lands and settlements. A brief area statistics of such land use /cover classes is given in Table 2.

Table 2. Area details of land cover / land use data in Ilam watershed

Class names	Area (ha)	% of total Area
Rangeland	44696.4843	20.4
Gardens	683.2458	0.31
Agriculture	17099.3574	7.7
Settlements	3249.595	1.47
Dense forest	3344.5007	1.52
Semi-dense forest	17820.9447	8.1
Sparse forest	45987.4307	20.9
Very sparse forest	75907.2693	34.5
Bare lands	11184.1409	5.1
Total area	219972.9691	100

**Fig. 3.** Land use / land cover map of Ilam watershed

Discussion and Conclusion

The different land use / land cover classes like settlements, gardens, agricultural, rangeland, bare lands and forest (accounting for 65.01 % of study area) could be determined in the study area based on spectral values and textural characteristics. However, sometimes it was difficult to separate different forest classes based on their spectral characteristics. Also, sometimes it was not easy to separate rangeland from bare land in the unsupervised classification. This difficulty to separate these two classes is possibly due to poor vegetation cover of rangeland in some areas. The very sparse forest class with 75907.26 ha (34.5 %) area, sparse forest class with 45987.43 ha (20.9 %) and rangeland land cover class with 44697 ha (20.4%)

represented the dominant land cover classes within the study area.

Based on the land use / land cover mapping, it can be concluded that the major land cover class was very sparse forest that covers about 34.5 % of the study area. The study shows that a considerable forest area is degraded, so it merits attention of planners and administrators. Undertaking massive afforestation in degraded forest and more control on livestock would seem to be better land management options. Agricultural lands are mainly noticed near the villages. Similarly bare lands like stony waste and scrub lands are found in the uplands and along the timberline of the forest and rangeland area.

The present study showed that digital classification techniques through systematic

random approach with limited ground truth could be used for mapping broad categories of land uses / land covers classes. The overall accuracy of the classification results from the confusion matrix and the calculation of the kappa coefficient were 83 % and 0.78, respectively. These values fall within the range described by Congalton (1996) as strong agreement. These high accuracy results demonstrate that the combined use of the spectral and textural characteristics increased the number of classes in the field classification and also with a good accuracy. The availability and use of time series remote sensing data permit the detection and quantification of land use changes and improve our understanding of past and present status of Zagros forest ecosystem. The results of the study state that IRS-1C image data are an important source of data for mapping the dynamics of land use and land cover in west of Iran. In addition, the main focus of the study was to map the different land use/land cover classes in Ilam watershed. Therefore, for the first time, the study could provide the status of land uses / land covers of the study area in 2006 with details of different forest types and density classes along with statistical data on the area of each category of forest as well as non-forest classes. The availability and use of time series land use / land cover map would be of immense help to the natural resources officials (general natural resource office and

other related offices in all over the province of Ilam) in assessing, change detection and quantification of land cover / land use dynamics in the study area. In this study some problems were found such as low number of samples and difficulty to access some sample plots because of hard topographic conditions. But in general, the methodology explained can be used to assess the resource availability in similar areas using remote sensing / GIS technique with extensive ground truth. Note worthy, it is necessary to formulate a national land use development policy in Iran for planning and sustainable development. For this regard, a continuous monitoring system to understand and identifying the land use changes is necessary. Therefore, more studies in land use / land cover mapping can be recommended to detect the changes in land use /land cover in Ilam watershed and other areas in this province.

Knowledge of the place and amount of probable change offer a better basis for decision which intervention measures an appropriate and how much the efforts must be accelerated.. Hopefully, this produced land use / land cover map is useful contribution towards management and planning for the Ilam watershed.

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