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Comparison of remote sensing techniques to exploit irrigated agricultural lands from satellite images

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ABSTRACT

Knowledge of agricultural and horticultural land use percent is necessarily important for supplying human food and should be considered in agricultural planning. Remote sensing provides valuable data on land use classes. Mapping land use through remotely sensed images comprises various considerations, processes and techniques. In this research, four methods (ICA, Tasseled Cap, NDVI and supervised classification) have been utilized for extraction of irrigated land class in a part of Hablehrood watershed. The results of this investigation showed that among the studied techniques; ICA which uses the higher order statistical characteristics of multispectral and hyper spectral imagery such as skewness and kurtosis has the highest accuracy, whereas supervised classification has the lowest accuracy. Moreover; this research revealed NDVI accuracy is more than Tasseled Cap.

KEYWORDS

Remote sensing;
Tasseled cap;
NDVI;
ICA;
Supervised classification;
Irrigated lands.

INTRODUCTION

With the increase of population, as well as human activities, pressure on land has been intensified[14]. So, knowledge of agricultural and horticultural land use percent is necessarily important for supplying humans' food and should be considered in agricultural planning. Moreover; separating irrigated agricultural land from other land use such as rainfed farming or rangeland and determining this class area helps to appropriately water resource management. Remote sensing in conjunction with Geographic Information System (GIS) is the advanced tool for surveying vegetation cover. Remote sensing data provide valuable multi-temporal data on the processes and patterns of land cover and land use change, and GIS is a useful technique for mapping and analyzing these patterns[13]. Mapping land use through remotely sensed images comprises various considerations, processes and techniques. One of them is vegetation indices easy to understand and estimate[2,6,9,15,17] whereas; the Tasseled Cap transformation is another way to optimize data viewing for vegetation studies[4,5,7] and its algorithm provides the correct coefficient for MSS, TM4, and TM5 imagery. Also, Independent Component Analysis (ICA) is a high order extraction technique of vegetation cover can be utilized for improving the performance of land use classification[3,11].

In this paper, ICA, Tasseled Cap, supervised classi-

fication results and the simplest vegetation indices such as Normalized Difference Vegetation Index (NDVI) which has the most accuracy[6] have been utilized for extracting irrigated agricultural land class.

We made a comparison among the above techniques to determine their accuracies and realize the best method.

MATERIALS AND METHODS

Study area

The study area with 35611.59 hectares is a subwatershed of North Hablehrood watershed located in Tehran and Mazandaran provinces. The selected subwatershed lies between the 52° 36′ 00″ to 52° 49′ 30″ E and 35° 41′ 30″ to 35° 57′ 30″ N (Figures 1 and 2), which is composed of different land uses such as rangeland, agricultural land, residential area.

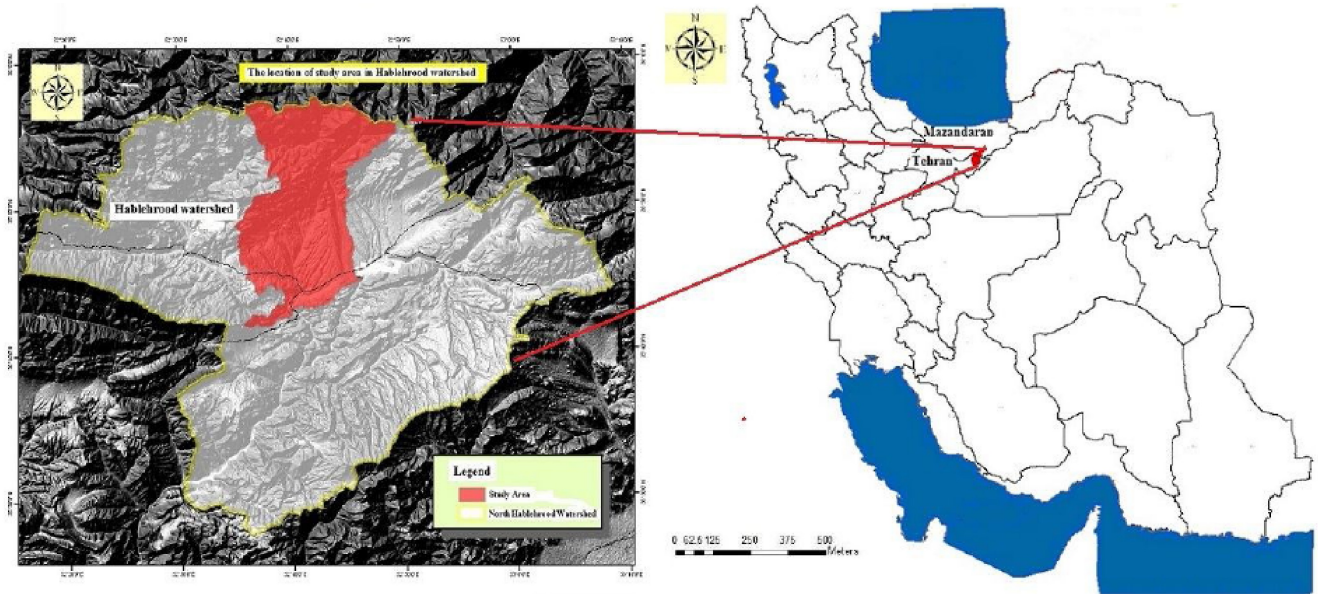

Figure 1 :

Satellite data

ETM+ image in 2002 was implemented in this research whereas the satellite image was georeferenced with 20 well distributed ground points using 1st-order and nearest neighbor resampling. So, the Root Mean Square Error (RMSE) of 0.84 Pixel was estimated for this image.

Methodology

Image fusion was performed using ETM+ image pan band (15 meters resolution) as high resolution whereas forward-reverse principal components transform[12], was applied for resampling low spatial resolution data to a higher spatial resolution. Clouds and shadows were removed with piecewise linear stretch using a poly line function to enhance the contrast. Moreover; unsupervised classification was carried out for generating a primary classification using Isodata Clustering algorithm (class number=5, Iteration=12, convergence threshold=%95).

In order to create training sampling points, stratified random algorithm was utilized. Sample points from various classes in the region and with suitable numbers were surveyed by GPS and 1:25000 topographic maps. Field surveying used 206 points located in the irrigated

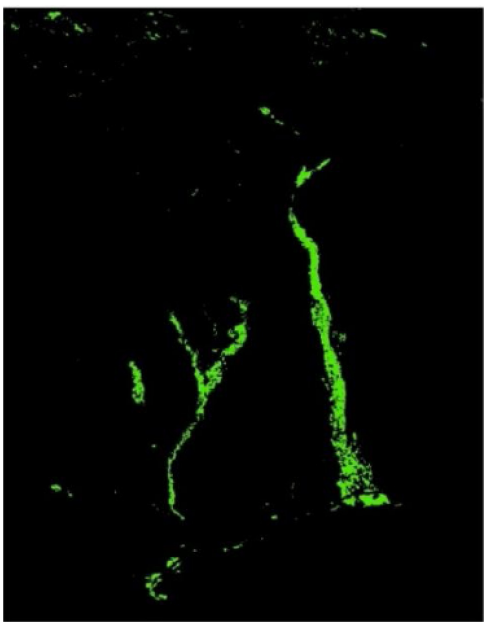

Figure 2 : NDVI result

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agricultural land class for investigating the accuracies of different enhancement techniques.

Among these 206 sampling points in irrigated area, 103 points were used for classification process and the rests were kept for accuracy assessment.

According to the pixel value range of sampling points in irrigated area, a non-parametric class fiction (Parallelepiped) was implemented on the enhanced images resulted from ICA and Vegetation index methods (Tasseled Cap and NDVI) at the base of 103 sampling points.

In supervised classification; 206 sampling points were used for classification, and the image was classified into two classes (irrigated area and rangeland).

For accuracy assessment, error matrices were used with overall accuracy, user's and producer's accuracies, and the Kappa statistic were then derived from the error matrices.

The Kappa statistic represents agreement obtained after removing the proportion of agreement that could be expected to occur by chance[1].

ArcGIS was applied for estimating the irrigated agricultural land area of each index performance.

RESULTS

The results of performing classification on ICA, vegetation index (Tasseled Cap and NDVI) and Supervised Classification were shown in Figures 2,3,4,5. Error matrices were applied to assess classification accuracy summarized in TABLE 1. Error matrix of NDVI indicated that 98 pixels were allocated to irrigated agricultural land class which all of them corresponded with ground truth whereas 4 of 5 pixels of other land uses class were categorized falsely. In supervised classification technique; all pixels of irrigated agricultural land (91 pixels) were classified well but 11 of 12 pixels of another class (class 2) were classified by mistake. Of 96 irrigated land pixels of Tasseled Cap; all of them were classified truly but 6 of 7 pixels of another class were categorized falsely.

Finally, in ICA; 102 pixels were classified as irrigated agricultural land which corresponded with ground truth and no pixel was attributed to other land uses class (class 2) falsely.

Also, as can be seen in TABLE 2, all users' accuracies were 100% whereas the producer's accuracies

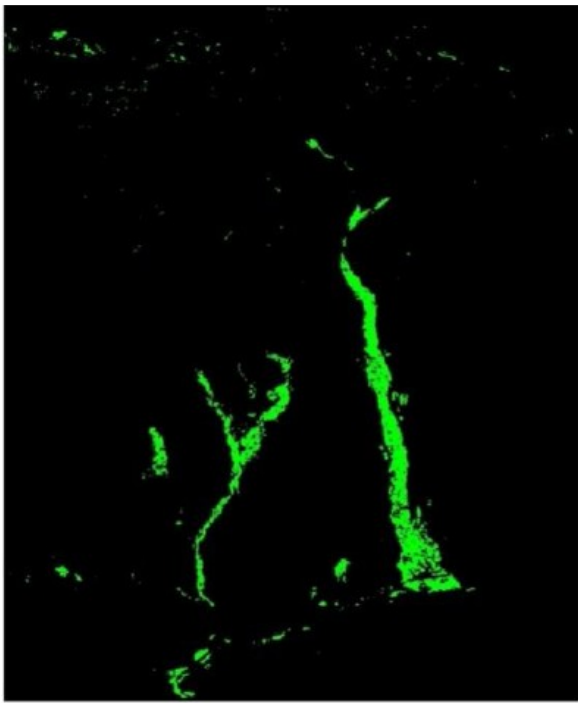

Figure 3 : ICA result

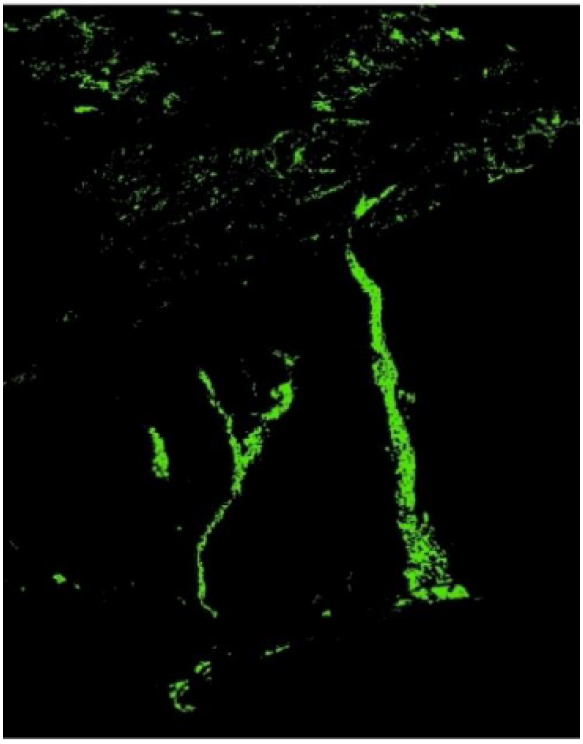

Figure 4 : Supervised Classification result

of NDVI, ICA, Tasseled Cap and supervised classification techniques were 96.08%, 100%, 94.12%, 89.22%. Furthermore; for NDVI, ICA, Tasseled Cap and supervised classification techniques, the overall accuracies were estimated 96.12%, 100%, 94.12%, 89.32%, respectively and Kappa statistics were 0.3224, 1, 0.2370 and 0.1384, respectively.

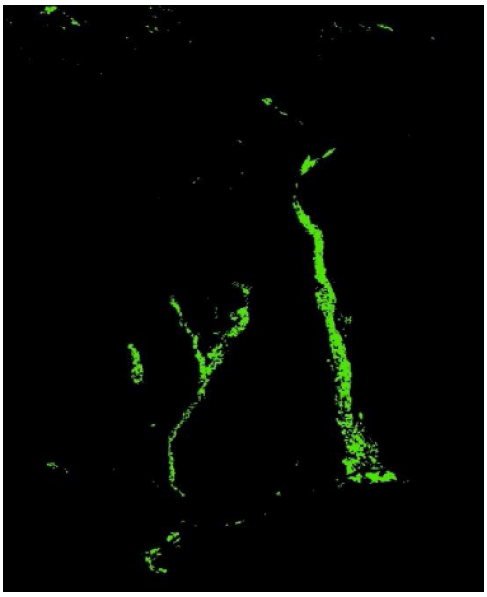

Figure 5 : Tasseled Cap result

TABLE 1 : Error Matrices by different enhancement techniques

Enhancement techniques	Class1 (Irrigated land)		Class 2 (Other land uses)	Total row
NDVI	Class1(irrigated land)	98	0	98
	Class 2(other land uses)	4	1	5
	Total column	102	1	103
Tasseled Cap	Class1(irrigated land)	96	0	96
	Class 2(other land uses)	6	1	7
	Total column	102	1	103
ICA	Class1(irrigated land)	102	0	102
	Class 2(other land uses)	0	1	1
	Total column	102	1	103
Supervised classification	Class1(irrigated land)	91	0	91
	Class 2(other land uses)	11	1	12
	Total column	102	1	103

However; the irrigated agricultural land area of each enhancement technique is shown in Figure 6 and the area values were listed in TABLE 3. The irrigated agricultural land areas exploited of NDVI, ICA, supervised classification and Tasseled Cap methods were 1006.759, 1272.37, 35611.89 and 882.8 hectares; respectively.

TABLE 2 : Summary of accuracies by different enhancement techniques

	Producer's	User's	Overall accuracy	Kappa statistics
NDVI	96.08%	100%	96.12%	0.3224
Tasseled Cap	94.12%	100%	94.17%	0.2370
ICA	100%	100%	100%	1
Supervised classification	89.22%	100%	89.32%	0.1384

TABLE 3 : Irrigated agricultural land area by different enhancement techniques

Enhancement Techniques	ICA	Tasseled Cap	NDVI	Supervised classification
Area(ha)	1272.37	882.85	1006.759	35611.89

DISCUSSION

Image enhancement is the process of making an image more interpretable for a particular application[10]. So, many algorithms were constructed as models to enhance the image by transforming each pixel values based on a multiband. In this study, the results of ICA which performs a linear transformation of the spectral bands such that the resulting components are decorrelated and independent[3], Tasseled Cap that Rotates the data structure axes to optimize data viewing for vegetation studies[4,5], NDVI that among various vegetation indices available, has shown best performance to classify vegetation cover[6] and supervised classification technique, were compared.

The results revealed that the Kappa statistic and overall accuracy of ICA which uses the higher order statistical characteristics of multispectral and hyper spectral imagery such as skewness and kurtosis is the highest among all techniques whereas supervised classification has the lowest accuracy in this investigation. Moreover; NDVI overall accuracy and Kappa statistic is more than those of Tasseled Cap but less than ICA results. ICA attempts to decompose the observed data into components that are as statistically independent from each other as possible, and can be viewed as a nonlinear generalization of Principal Components Analysis (PCA)[16]. ICA algorithm which enforces independence was the most accurate technique for determining Irrigated agricultural land area in current study. So, the Irrigated land class of the study area based on ICA technique with the most accuracy was 1272.37 hect-

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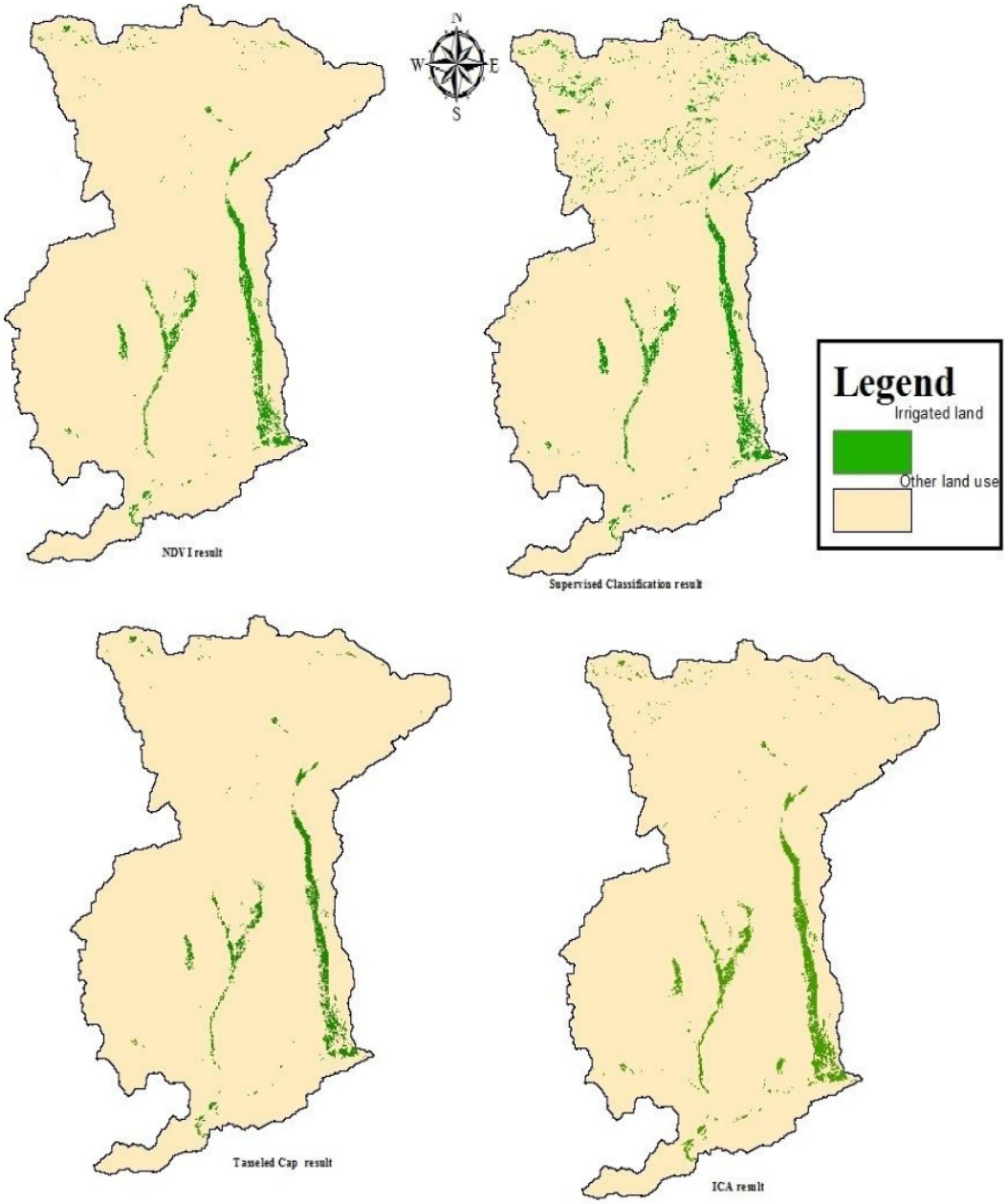

Figure 6 : Irrigated agricultural land area by different enhancement techniques

ares.

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