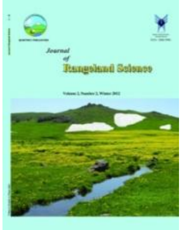
Contents available at ISC and SID

Journal homepage: www.rangeland.ir



Full Paper Article:

Using Post-Classification Enhancement in Improving the Classification of Land Use/Cover of Arid Region (A Case Study in Pishkouh Watershed, Center of Iran)

Jalal Barkhordari[A], Trahel Vardanian[B]

[A]Ph.D Student and Faculty Member of Agriculture And Natural Resources Research Center of Yazd. Email: jbarkhordary@yahoo.com. (Corresponding author).
[B]Associate Professor of Geography & Geology Department, Yerevan State University.

Manuscript Received: 11/09/2011
Manuscript Accepted: 28/01/2012

Abstract. Classifying remote sensing imageries to obtain reliable and accurate Land Use/Cover (LUC) information still remains a challenge that depends on many factors such as complexity of landscape especially in arid region. The aim of this paper is to extract reliable LUC information from Land sat imageries of the Pishkouh watershed of central arid region, Iran. The classical Maximum Likelihood Classifier (MLC) was first applied to classify Land sat image of 15 July 2007. The major LUC identified were shrubland (rangeland), agricultural land, orchard, river, settlement. Applying Post-Classification Correction (PCC) using ancillary data and knowledge-based logic rules the overall classification accuracy was improved from about 72% to 91% for LUC map. The improved overall Kappa statistics due to PCC were 0.88. The PCC maps, assessed by accuracy matrix, were found to have much higher accuracy in comparison to their counterpart MLC maps. The overall improvement in classification accuracy of the LUC maps is significant in terms of their potential use for land change modeling of the region.

Key words: Image classification, Land sat, Arid region, Accuracy, Iran.

Introduction

Land use/cover classification in heterogeneous landscapes is challenging, e.g. arid central Iran. Digital land use/cover maps are needed at an appropriate cost, spatial and temporal coverage. Central Iran is appropriate for exploring the use of Land sat ETM imagery in land use/cover delineations as its biogeography zones are very diverse and heterogeneous (Barkhordari and Khosroshahi, 2006). The varied spatial frequency of the landscape is a particular problem for mapping arid and semi arid land cover. Major problems include the variety of spatial patterns, highly fragmented features and variable vegetation cover in arid landscapes. Additionally, the high reflectance from calcareous and/or very dry soil can overwhelm the relatively small component reflected from sparse vegetation (Abdollahi *et al.*, 2007; Barkhordari and Khosroshahi, 2006; Khajedin, 1995; Berberoglu *et al.*, 2000). However, classifying a remote sensing imagery still remains a challenge that depends on many factors such as complexity of landscape in a study area, the choice of remote sensing data, and image processing and classification approaches etc. (Manandhar *et al.*, 2009). This has led to questioning the spectral and radiometric suitability of remotely sensed data sets for thematic mapping. This means that specific types of change must be identified using aerial photography and ground reconnaissance (Stow *et al.*, 1994). Wilkinson (2005) based on a review of 15 years of peer-reviewed experiments on satellite image classification, observed that there has been no demonstrable improvement in classification performance over 15 years period though a considerable inventiveness had occurred in establishing and testing new classification methods during the period. This raises some doubts about the value of continued research efforts to improve classification algorithms in remote sensing.

In this study, the Land sat TM data were classified with the most widely used parametric classifier, maximum likelihood decision rule and some ancillary data (e.g. DEM and knowledge of the locality, Land use data, vegetation index and textural analysis of the Land sat images) were combined through an expert (or hypothesis testing) system to improve the classification accuracy so that these classified maps could be used for detailed post-classification change detection. The aim of this paper was therefore to assess the hypothesis that the use of Post-Classification Correction (PCC) to improvement of land use classification. This aim is particularly pertinent because good quality satellite imageries of the study region for specific periods of interest to us were not available due to cloud cover and atmospheric haze, a common phenomena in the study region.

Study area

The Pishkouh watershed has area about 69235.4 ha which is located in eastern of Yazd city, center of Iran and this mountainous watershed is more important from ground water recharge of Yazd and Taft city. This area has been extended between the longitudes of 53° 42' to 54° 09' and latitudes 31° 33' to 31° 50'. This area is surrounded by mountains and the general slope is from East to West (Fig. 1). The region climate is dry and cold, in way of modified Domartan method.

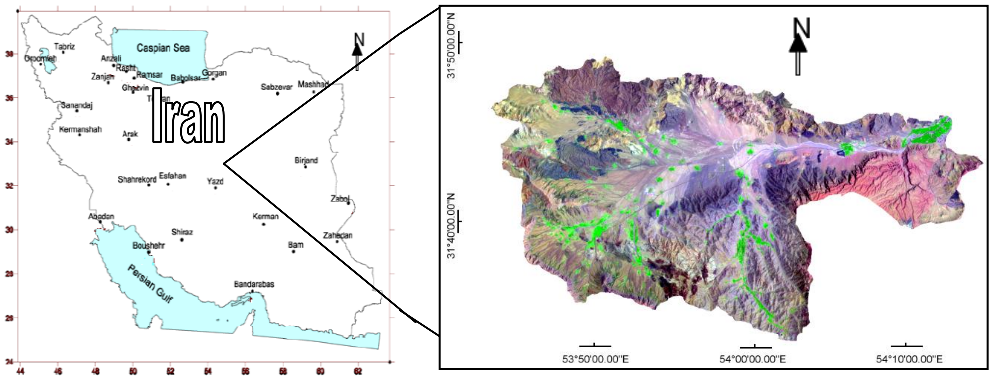


Fig. 1. Location of Pishkouh watershed area

Material and Methodology

For the purpose of this study, the autocorrected Land sat images of following were procured:

Land sat ETM of 15 July. The geo referenced rectified image was re-projected to UTM projection zone 39 and WGS 84 datum. All six bands (ETM 1–5 and 7) with a spatial resolution of 30×30m were used in this study. The aerial photographs were mainly used as reference data and the Singleton Land use geo database and DEM were utilized as ancillary data for post-classification correction using knowledge base. Maximum likelihood classifier (MLC) is the most widely adopted parametric classification algorithm. For this reason, we used MLC for the spectral classification of the Land sat images. Taking into account the spectral characteristics of the satellite images and existing knowledge of land use of the study area, six LUC categories (Table 1) were respectively identified and classified. Accuracy of the two classification schemes (PCC-MLC and MLC) were determined based on a stratified random sample of 248 points with at least 20 points for major classes and at least 8 points for minor classes. Producer’s accuracy (a measure of omission error) and user’s accuracy (a measure of commission error) and Kappa index were calculated for each class and for each classification scheme.

Post-Classification Refinement Using Ancillary Data and Logic Rule

As the LULC maps were noisy due to similarities of the spectral responses of certain land cover categories such as shrub land, river and Urban, a post-classification refinement was developed and applied using ancillary information using a hypothesis testing framework of Knowledge Engineer (Manandhar *et al.*, 2009) to reduce classification errors. The hypothesis framework was constructed by using the Singleton land use map, DEM, textural analysis and NDVI (Normalized Difference Vegetation Index) derived from the Land sat images. The framework was further augmented by the use of the other rectified aerial photographs. Through this framework the misclassified pixels of MLC were re-evaluated and correctly reclassified. The different post-classification procedures adopted for the mix-classified LULC categories, namely, Urban and River, are described as follows.

Results and Discussion

As would be expected classification using the classical MLC algorithm did not produce satisfactory results especially in the case of urban, Agriculture land and orchard LUC categories. Table 1 shows the mean DN (Digital Number) values of training pixels of the various LUC categories over band 1–5 and band 7.

The difficulty with these signatures is that the mean DN among the LUC categories are quite similar for bands 1 to 3, while there is significant difference among the LUC categories for bands 4, 5 and 7.

Table 1. The mean DN values and standard deviation of training pixels of the various LUC categories over band 1–5 and band 7

Categories		Band 1	Band 2	Band 3	Band 4	Band 5	Band 7
A.L*	Mean	77.43	75.02	87.95	80.63	91.15	74.02
	Std	18.18	22.25	32.81	31.82	34.41	34.27
Orchard	Mean	86.84	79.69	94.34	78.74	98.21	77.91
	Std	28.29	25.09	32.71	29.53	38.02	31.74
S.L**	Mean	81.12	76.47	94.94	81.22	91.25	78.68
	Std	20.36	22.51	32.37	28.27	35.44	31.84
River	Mean	82.04	78.48	99.00	104.00	87.49	102.03
	Std	20.14	19.37	20.06	20.06	41.43	20.11
rock	Mean	76.61	93.02	81.50	75.54	141.50	81.50
	Std	13.60	31.76	13.42	29.56	13.42	13.42
Urban	Mean	115.06	87.70	103.90	76.58	103.25	77.37
	Std	41.16	30.43	33.66	32.98	38.66	36.48

*A.L=Agriculture Land, **S.L=Shrub Land

Agriculture land and orchard have relatively larger DN for band 5 followed by Urban, while orchard has distinctly lower DN for bands 4, 5 and 7. The poor performance of the MLC classification algorithm is confirmed by the accuracy assessment, which indicated high commission error (i.e., low user’s accuracy) for the orchard and Agriculture categories, meaning that there is a probability (proportionate to the error) that pixels classified. On the other hand, urban category had high omission error (i.e., low producer’s accuracy), meaning that there is a probability (proportionate to the errors) that ground reference points for this category were classified incorrectly. Also most of the time, the traditional approach for classification (such as MLC) only distinguishes clearity between urban and orchard land use and land covers. Similar findings were recorded in this study. The MLC classification accuracy for Orchard and Agriculture land use was good, but for LULC categories, it was quite poor.

Table 2. Summary of accuracy (%) and Kappa index of MLC and PCC maps

Lu/ Category	MLC map		PCC map	
	Producer Accuracy	User Accuracy	Producer Accuracy	User Accuracy
Agri	81	87	80	92
Orchard	85	90	83	90
Shrub land	41	86	68	89
River	69	72	76	78
Rock	89	53	91	91
Urban	51	74	88	83
Overall Accuracy	72		91	
Kappa Index	0.71		0.88	

Upon post-classification correction that involved integrating ancillary information in hypothesis testing framework of Knowledge Engineer, the commission errors of the Urban and river categories and omission error of the shrubland categories were largely reduced (Table 2). These results were quite encouraging. The identification of urban category was improved as indicated by increased user's accuracy from less than 51% to greater than 88% accuracy in all of the three time steps of our analysis. Similarly, the user's accuracy of river category increased to above 91%, and producer's accuracy of shrub land improved to above 89%. The overall accuracies of all three PCC maps were above 91%, and Kappa statistics are well above 0.88, indicating a strong agreement or accuracy between the classification map and the ground reference information. It is obvious that the misclassified patches of vineyards in the western forest as well as in the military reserve have disappeared in addition to the reduction of overly estimated Urban patches resulted from MLC classification.

Conclusions

Although the MLC is a widely used classifier, it could not perform satisfactorily in deriving accurate and reliable classification of Urban and shrubland LULC categories. In this study, we were able to significantly improve MLC maps by incorporating additional data, such as land use, DEM, spatial texture and NDVI value of the Land sat imagery using a hypothesis testing framework based system of classification. The resulting PCC maps can be satisfactorily used for detailed post classification change detection. This study has demonstrated the usefulness of integrating ancillary data and knowledge-based rules into a classification scheme to improve accuracy of LULC classification.

References

Abdollahi, j., Rhimiazn, M. H. & Savaqebi, M. H., 2007. Limitation of Land sat ETM+ employment for mapping of vegetation cover in drought conditions, Iranian jour. range and desert Reaserch, Vol. 14 No. (3). (In Persian).

Barkhordari, J. & Khosroshahi, M., 2006. Land cover change detection in Minab watershed using RS & GIS techniques, Map Middle East 2006 Conference, Dubai. (In Persian).

Berberoglu, S., Lloyd, C. D., Atkinson, P. M., Curran, P. J., 2000. The integration of spectral and textural information using neural networks for land cover mapping in the Mediterranean. Compute. Geo Sci. 26, 385–396.

Khajedin, S. J., 1995. Asurvey of the plant communities of the Jazmorian, IRAN, using land sat data. University of Reading, Ph.D thesis. (In Persian).

Manandhar Ramita, Odeh Inakwu O. A. and Ancev Tiho, 2009. Improving the Accuracy of Land Use and Land Cover Classification of Land sat Data Using Post-Classification Enhancement. Remote Sens. 1, 330-344.

Stow, D. A., Collins, D. & McKinsey, D., 1994. Land use change detection based on multi date imagery from different satellite sensor systems. Geo cart. Int. 5, 3–12.

Wilkinson, G. G., 2005. Results of implications of a study of fifteen years of satellite classification experiments. IEEE Trans. *Geo Sci. Remote Sens.*, 43, 433–440.