An Evaluation of ETM+ Data Capability to Provide "Forest-Shrub land- Range" Map (A Case Study of Neka- Zalemroud Region- Mazandaran- Iran)

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Abstract:

In order to evaluate the Capability of ETM+ remotely- sensed data to provide "Forest- shrub land- Rangeland" cover type map in areas near the timberline of northern forests of Iran, the data were analyzed in a portion of nearly 790 ha located in Neka- Zalemroud region. First, ortho-rectification process was used to correct the geometric errors of the image, yielding 0/68 and 0/69 pixels of RMS error in X and Y axis, respectively. The original and panchromatic bands were fused using PANSHARP Statistical module. The ground truth map was made using 1 ha field plots in a systematic-random sampling grid, and vegetative form of trees, shrubs and rangelands was recorded as a criteria to name the plots. A set of channels including original bands, NDVI and IR/R indices and first components of PCI from visible and infrared bands, was used for classification procedure. Pair-wise divergence through CHNSEL command was used, In order to evaluate the separability of classes and selection of optimal channels. Classification was performed using ML classifier, on both original and fused data sets. Showing the best results of 67% of overall accuracy, and 0/43 of Kappa coefficient in original data set. Due to the results represented above, it's concluded that ETM+ data has an intermediate capability to fulfill the spectral variations of three form- based classes over the study area.

Keywords: ETM+ Sensor, "Forest- Shrub land- Rangeland" classes, ML classifier, Accuracy assessment, Neka- Zalemroud

Introduction:

Original northern forests of Iran have been qualitatively and quantitatively being degraded during the last decades. Nowadays This kind of degradation is more concerning in term of vegetation and cover type changes from original old growth cover types into secondary- non commercial vegetative types, in the whole area, from coastal forests up to timberlines next to the rangelands, ranging from 0 to more than 2000 m in altitude. Cover type degradation in up land mountainous areas, from forested types into transactional shrub lands next to the range, due to human settlement and cattle over grazing, is now a critical issue. On one hand, a climatic limitation (e.g. wind, early chill etc) delays the original tree- type settlement over such areas. On the other hand, physiographic and topographic limitations (e.g. high slope and height variations, lack of accessible roads etc.) makes serious limitations over supervising such areas during short periods of time.

Meanwhile, using satellite remote sensing data has made a great potential to product quite reliable maps of vegetation through image analysis [2]. Using remotely sensed data, it's possible to separate different land cover types, considering user- defined criteria and features. Due to the importance of problems mentioned above, use of ETM+ satellite imagery in order to provide a map, showing forest (areas dominated by original tree types) - shrub lands (areas dominated by scrubs or short trees), and rangelands land cover classes was considered. Moderate spatial resolution of multispectral bands (30 meter) and existence of a 15 meter panchromatic band, enabling for image fusion techniques to carry out, and high spectral range of data set, using 6 multispectral visible to infrared bands, makes a feasible potential to use ETM+ data for the research.

Material and methods:

- Study area

The study area covers the area of approximately 800 ha located in Neka- Zalemroud mountainous region- Mazandaran province, in nearly highest altitude of northern

forests of Iran, ranging from approximately 1900 to 2400 m of altitude (Fig 1). The climate is wet and characterized by cold and long winter, and lower humidity, comparing to lower altitudes of the region [7].

- Satellite data and pre- processing:

Data set including a portion of an ETM+ scene, belonging to 2002, featuring 6 multispectral bands, and one panchromatic band was used for the research. First, the image was geometrically corrected, using Ortho- rectification process and DEM, extracted from 1/25000 topographic map of the area [1]. The Ortho- rectification method was selected due to high variation of altitudes inside the area, in yielded in 0/68 pixel of RMSE in X axis and 0/69 in Y axis. In order to apply the 15 meter spatial resolution to all multispectral bands and making a comparison over the classification process, 6 MS bands were fused to 15 meter panchromatic band, using PANSHARP statistical and automatic module [9].

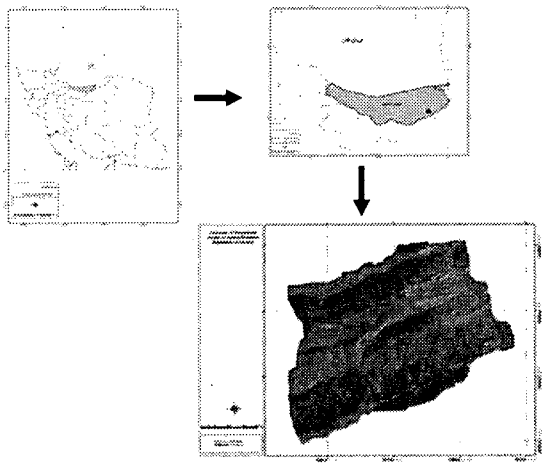

Figure 1. Location of the study area, illustrated in the map of Iran and Mazandaran province, featuring color composite (4,3,2) of the study site.

- Ground truth preparation:

Actually, the most common method for accuracy assessment of image classification is pixel by pixel comparison with a portion of area which is recognized correctly [4]. In this research, regarding to lack of ground information about vegetative over the area, ground truth preparation using field sample plots was considered. Therefore, almost 3% of the area was sampled using a systematic- random sampling grid, associated with 1 ha square field plots (Fig 2). The reason for selecting the area was that existence of three cover forms mentioned above enables to illustrate of adjacent types in the area selected from the scene. Meanwhile, two vegetation indices, including NDVI and IR/R were calculated and added to the data set used for the classification. Also in order to utilize the maximum information content of the channels, Principal component analysis (PCA) was carried out twice, for 3 visible and 3 infra red channels. Due to the most content of variance, ascisoated with the first component, the first components of PCA were used for the classification.

- Training site selection and classification:

Due to high variation of cover types inside each of three classes, resulting in heterogeneity of pixel values over the image, training area selection was performed using small and scattered sites, spreading all over the image. Then the areas were controlled using two separability measures including Bhattacharya distance and transformed divergence (TDV). These measures lead to correction of training sites locations and also merging some sub-classes with the lowest separability. Automatic channel selection command (CHNSEL) was utilized to appropriate band selection. Due to the relative low separability among classes, pair-wise divergence (PDV) measure was selected as a mean for the command to choose the best channel combination [6].

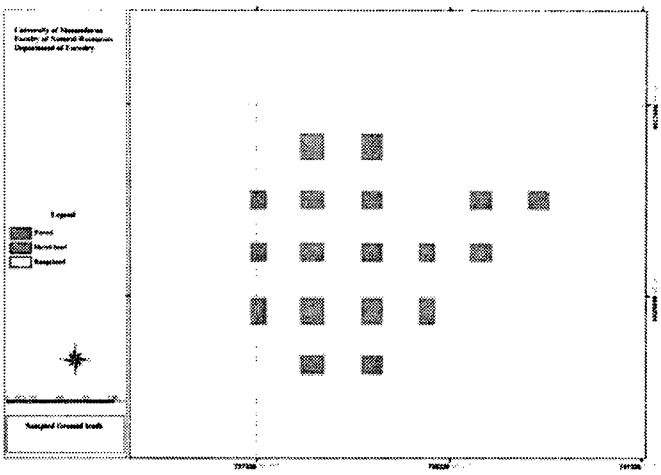

Figure. 2. Field samples showing forest- shrub land- range classes.

After the training area and band selection, both data sets, including original and fused data sets were classified using maximum likelihood supervised classifier. In order to compare the results of classification, same training sets were used for both data sets. A 3*3 pixel mode filter was carried out on classified images to reduce salt and pepper effect after classification [5]. After the procedure described above, accuracy assessment was performed utilizing overall accuracy, kappa coefficient, user and producer accuracy measures, to represent the results of comparison between classified images and ground truth of the area.

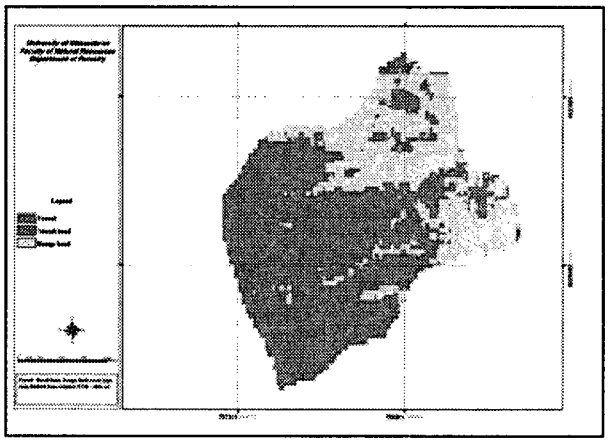

Fig. 4. Forest- Shrub land – Range cover type map derived from original ETM+ data set.

Results:

As mentioned above, both original and fused data sets were classified using maximum likelihood classifier and classified maps can be shown in Fig. 4& 5. Also, the results of accuracy assessment are presented in Table. 1.

As a result of the classification, the classified map derived from original data set showed the higher amount of overall accuracy and kappa coefficient comparing to the map derived from fused data set, presenting 67% and 0/43 respectively. As can be shown in Table.1, data set made by PANSHARP procedure showed 66% of overall accuracy and 0/42 of kappa, representing lower capability of this data set comparing to the original one.

The results of accuracy assessment using producer and user accuracy measures showed the same amount of producer accuracy for the classes concerning Forest and shrub land cover types, and higher user accuracy, related to Range land class, in original data set. As expected, results of both producer and user accuracies showed relative lower amounts in the fused image, representing 77% of producer accuracy, related to Shrub land class and 72% of user accuracy, belonging to Forest class.

Discussion:

As described above, in order to cover the variation of spectral responses, associated with different vegetation types in the study area, PANSHARP technique was used to spatially improve the potential of interpretability in multi spectral bands. Also, same set of training areas was used to classify both data sets. The results showed the relative higher amounts of accuracy measures in original multi spectral data set, comparing to spatially improved data set. One reason that can be mentioned regarding to the results achieved, is that enhancement of original pixel values with panchromatic values, during image fusion process, is much more aided in term of visual interpretation. But changes over basic multi spectral pixel values hamper spectral classification [3].

Meanwhile, the results show that traditional image fusion techniques can be more useful for improvement of visual interpretation [9]. The other reason that can be Mentioned can be using one set of training areas for both data sets. Due to the heterogeneity of 15 meter pixel values, as a result of image fusion procedure, utilizing the same areas as used for original 30 meter MS pixels will cause the relative lower separability, resulting in a lower accuracy measure. Totally, a major improvement can not be expected by applying image fusion techniques in a forested environment, dealing basically with variety of heterogenic spectral; categories [8].

In terms of original image classification, it can be seen that relative high amount of producer accuracy in Forest and Shrub land classes shows their better capability than Range class, to be classified comparing to the ground truth. Also higher user accuracy of Range class shows it's relatively better classification, comparing to the whole pixels classified in the image.

Conclusion:

Totally, regarding to accuracy assessment comparing to ground truth of the study area, it can be concluded that ETM+ remotely sensed data shows an intermediate capability to delineate three major cover types (due to vegetative forms which is used as a descriptive criteria) over the study area. Relatively moderate amount of overall accuracy proves that original ETM+ bands can perform as a tool for preparation of the cover type map described above.

it is suggested that biodiversity measures can be used as a feasible mean for description of three major cover types of Forest lands- Ecotone (transactional areas between forest and range) and range lands, for further studies. Also, due to interactions between vegetation and background radiation (e.g. soil, rocks etc.) some tools such as standardization of spectral responses can be used as a useful technique to purify the spectral responses of vegetation in such areas.

Dataset Name.	Classifier	Class Name.	Producer Acc.%	User Acc.%	Overall Acc. %	Kappa coef.
Multispectral (original)	ML	Forest	77	60	67	43
		Shrub land	77	66		
		Range land	46	76		
Pansharp (fused)	ML	Forest	58	72	66	42
		Shrub land	77	68		
		Range land	54	63		

Table.1. accuracy assessment results for original and fused data sets.

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