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Evaluating the Capability of SPOT5 Data to Monitor Pollarding Forest Areas of Northern Zagros

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Abstract: To evaluate the capability of SPOT5 HRG data for monitoring the pollarding forest areas in northern Zagros, some parts of pollarded forests located at Baneh city were selected. The Pollarding area was determined as ground truth in a 3-year alternation period using a Global Positioning System (GPS). Radiometric and geometric correction, were applied to the image and then the data was pre-processed, using 2 methods of spectral rationing and Principal Component Analysis (PCA). Likewise, multi-spectral bands were fused with IRS-1C PAN image, using a Principal Component transformation (PCT). The obtained results were combined with original bands. The separability of classes was studied using Bhuttacharrya Distance Criteria. The resulting data was classified using a maximum likelihood algorithm. Then the classified image was compared with ground truth on a pixel by pixel base. In order to the determine classification accuracy, four parameters encompassing Overall Accuracy, Kappa Coefficient, Producer Accuracy and User Accuracy were used. The results showed that most of the classes were completely separatable from northern Koor class. The highest overall accuracy was 65.3% and Kappa Coefficient equal to 63% was obtained through classification using four-classes of the fused image. Northern Shan class showed the highest user accuracy (71%) and producer accuracy (78%). Likewise, southern Koor class showed the lowest user accuracy in all methods. Results of this study show the high capability of above mentioned images and methods to separate the pollarding areas and to prepare the map of the area.

Key words: SPOT5 . Vegetation index . Data fusion . Pollarding . Northern Zagros

INTRODUCTION

Local communities of Baneh are mainly dependent upon ranching, due to the high population living per forest surface unit, rough topographic conditions of the area and low water storage for agricultural purposes [1]. Ranching in such a cold area, not following a migration system has resulted in a forage shortage which is a crisis in ranching system of the area in cold seasons. In a wise attempt, local people began pollarding the forest trees to adapt themselves to the shortcomings and limitations of their surrounding nature. Each forest area was divided among several local people. Then, each parcel (each part) was named as « Gala-jar of Mr. X » (Armarde forestry plan, 2004). Each Gala-jar was divided into 3 parts, each part called a « Shan », with approximately equal production amounts. In every 3-year intervals one of these Shans was pollarded. Therefore, The Shan which is the time for its pollarding was called « Khert », the one pollarding in the second period was called « Koor » and the third pollarding area was « Kurpe » [2].

Unique characteristics such as quick and nonstop coverage and frequent imagery have made multi spectral satellite images an efficient tool to continuously manage the natural resources. Due to the high spectral and spatial resolutions of these images, previously used method are now replaced with these kinds of data to conserve time and expenses and obtain updated information [3]. In this study, the possibility of separating the pollarding forest areas in different pollarding periods was assessed using HRG SPOT5 images. The study area is a part of pollarded forest areas in Kurdistan province. The capability of SPOT5 HRG data to produce updated maps of pollarded forest areas has been studied in this research via doing a comparison between the classified image and ground truth data using the classification accuracy criteria. Programmers can use these maps as a device for pollarded area management. No study has been already conducted on this field using RS technique; however, some of the relatively similar researches are as follows:

Joao *et al*. [4] estimated tree crown closures in Dehesa region located at southern Portugal. Results of this study showed that a mid to high accuracy would be obtained in crown closure measurement of these forest types (evergreen oak thicket) using satellite images.

Xu *et al*. [5] evaluated the capability of Landsat TM data to estimate the oak crown closure in Tular, California. According to the results, near infrared, red and blue bands are suitable for evaluating crown cover properties.

Darvishsefat [6] studied the capability of SPOT and TM images to prepare the map of forests and their composing plant types. The highest overall accuracy obtained using maximum likelihood classifier was 65.4%. Based on the results of this study, SPOT multispectral data have more advantages rather than TM data.

Sarouei [7] assessed the possibility of density classification of Zagros forests using TM data. The highest overall accuracy and Kapa Coefficient (45 and 25,

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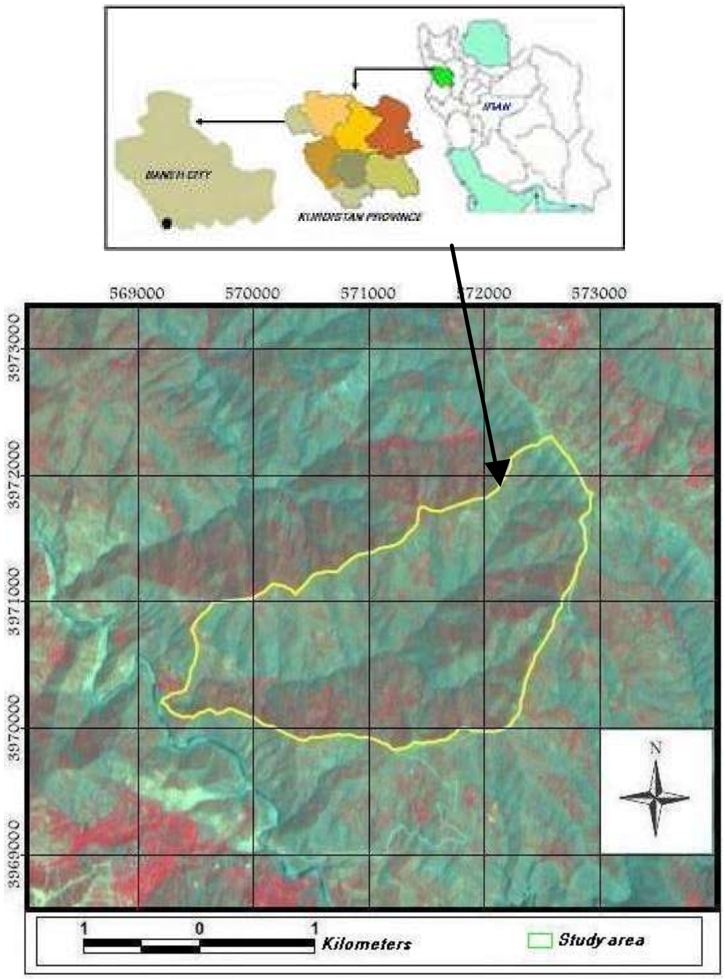


Fig. 1: Situation of the study area on Iran map and a prespective of the area in SPOT image with a combination of bands, 1-3

respectively) were obtained using a maximum likelihood classifier and a combination of TM bands of 2, 3 and 4. Results of this study showed a high spectral interference among soil and forest cover in TM data (particularly in classes with high density) which prevents achieving a higher accuracy.

MATERIALS AND METHODS

Study area: 504 ha of pollarding forests of Armarde zone at southwest of Baneh town is studied in this research. This area is located at east longitude of 45º 47' 48" to 45º 48' 00" and north latitude of 35º 25' 41" to 35º 53' 57" (Fig. 1). Bane basin is a mountainous area with a long cold winter and a mild summer. This area has a snowy winter; however, it is rainy at late winter and spring. More than 80% of trees in these forests are composed of various Oak types including Lebanon oak (Quercus libani oliv.), Gall oak (Quercus infectoria oliv.) and Quercus brantii Lindl. Var. Brantii.(Armarde forestry plan, 2004).

The images used in this research are as follows:

- SPOT5 HRG image, sep 30th, 2005, 10 m spectral resolution (pixel).
- IRS-1C PAN image, oct 23th, 2005, 5.8 m spectral resolution (pixel).

Both these images are identified in the Global WGS 84 system and Zone no 38.

Geometric correction: The images used in this study were geometrically corrected by their supplier companies. Likewise, SPOT images having a good adjustment with digital polygons of the study area, were compared with pan images via an image geometric correction.

Polynomial method of geometric correction which is a nonparametric method was used in this study. In this method, 20 points on the pancromatic image and their correspondents on SPOT image were selected. Then, Root Mean Square Error of 0/54 pixel along X axis and 0/53 pixel along the Y axis were geometrically corrected and the image was georeferenced.

Ground truth map production: To evaluate the classification accuracy, the pollarded zones of study area were determined using Global Positioning System (GPS). An area yielding in every 3-year intervals and encompassing general characteristics of the region was selected for ground truth mapping. Then, we determined Kurpe, Shan and Koor areas using a global positioning system. Furthermore, all bare parts, agricultural areas, gardens and pine thickets of the study area were yielded as polygons. After assigning each yielded area to its related class, polygons were transformed from vector to raster form and saved in a data base. Finally, special codes were assigned to each vegetation class and the same codes were given to each class in the classified image, then, the resulted file was saved to be used in next stages.

Pre-processing and data classification: Some vegetation indices were measured for better vegetation cover detection. Due to sparse tree coverage in the study area, there is interference between the spectral reflectance of soil and plant cover. To prevent these interferences, NDVI, WDVI, SAVI, MSAVI and TSAVI indices were calculated. These indices reduced the soil effects on vegetation spectral reflectance [8]. The measured indices were added to our data. Soil line parameters were used to measure the above mentioned indices [9, 10]. Using soil line parameters and vegetation indices, we can distinguish the spectral reflectance of plants crown closure from soil spectral effects [11]. Principal component analysis (PCA) was applied for visible and infrared bands to analyze the spectral information of various image bands. First components resulted from this analysis had the highest variance of spectral information; therefore, they were added to dataset.

A high correlation had been shown between Bands 1 and 2 of SPOT satellite. Panchromatic and multispectral bands were fused using principal component transformation method. First principal component resulted from this method include some information related to brightness intensity and it's loaded with data 1 and 2. The resulted image, which is corrected regarding its brightness values, had a high spatial resolution [12]. All bands of color image fused with IRS-IC panchromatic image and their pixel size had been changed to 5.8m×5.8m. Finally, principal bands of color imagery, fused bands, synthetic bands resulted from vegetation indices and principal component analyses as a combination with principal bands were separately classified.

Training areas were selected within the area of determined polygons. After several addition and omission of these training areas, the separability of classes was evaluated using Bhattacharrya Distance separability index. Data classification was done using maximum likelihood algorithm. This classifier determines the probability of each pixel incurrence in a given class and then the pixel will be assigned to the class with the highest probability [13].

Since Gala-jars of the study area had 3 yielding areas and on the other hand a significant difference existed between crown closure densities of two southern and northern ranges, we classified the area as 6 classes of Northern Koor, Southern Koor, Northern Shan, Southern Shan, Northern Kurpe and Southern Kurpe. Then, each range was separately classified into 3 classes of Koor, Shan and Kurpe. Likewise, due to the significant difference existing between two Koor and Shan classes, the classification was done again with 4 classes including Northern Koor, Southern Koor, Northern Shan, Southern Shan. A pixel by pixel comparison was made between the classified images and ground truth data. Four standards of overall accuracy, Kappa coefficient, producer accuracy and user accuracy were used to evaluate the classification. Results of this evaluation were shown as error matrix (Table 2).

RESULTS

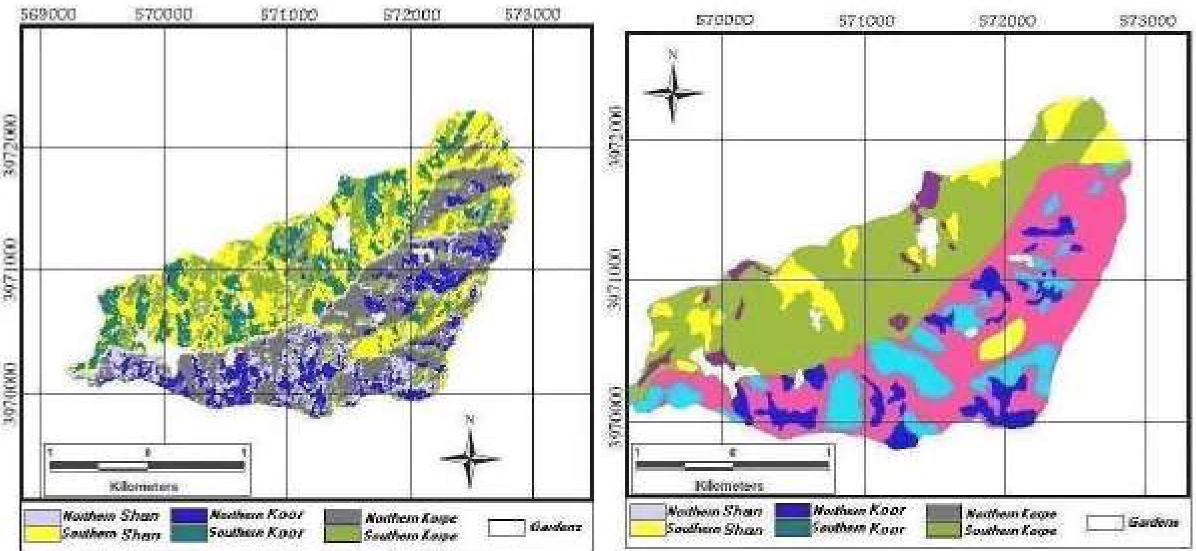
According to the results of this study, Northern Koor class is completely separatable from most other classes (1/34-2 separability in Bhattacharrya Distance Criteria). The highest separability was observed between Northern Koor and Southern Shan classes with average separability of 1/97 in Bhattacharrya Distance Criteria. Different classes are better separatable using synthetic band image rather original band image. Among the image combined with vegetation indices, the one with TSAVI index showed the highest separability. Likewise, a better separability was observed in northern rang rather than southern rang, so that separability level between some classes in northern range was near 2 according to Bhattacharrya Criteria, however due to a high spectral interference in southern range, a separability lower than 0.5 was observed in some cases according Bhattacharrya Criteria.To find a higher resolution image classification, we tried the classifications with 3, 4 and 6 classes.

Classification with 6 classes: This classification was applied for original bands, fused images, vegetation indices and the first principal component (PCA) combined with original bands using a maximum likelihood method. The highest kappa coefficient (21%) and overall accuracy (39%) were observed in fused images. Among the images combined with vegetation indices, the one combined with MSAVI index showed the highest kappa coefficient (19%) and the highest overall accuracy (34%). Likewise, the highest user accuracy and the highest producer accuracy were related to Northern Kurpe and Southern Kurpe (61%) and Northern Shan (61%), respectively.

Classification with 3 classes: Different crown cover densities in northern and southern ranges, in addition to nonseparability of some classes, especially in southern range, caused in a high spectral interference among classes classification with3 classes. Therefore, a new classification was separately done for each range 3 classes of Koor, Kurpe and Shan.

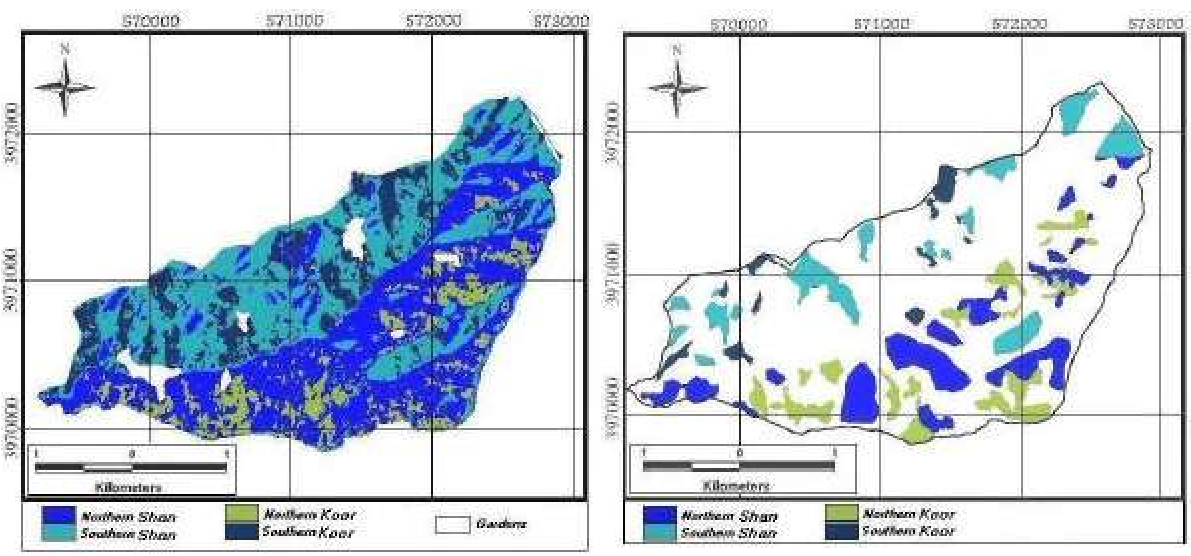
According to the results of this classification, the original bands with Kappa coefficient of 17% and an overall accuracy equal 49% in northern range and the fused image of south ranges with Kapa coefficient of 8% and an overall accuracy of 42% showed the best results. The highest user accuracy was obtained in Northern Kurpe classes in both Northern (87%) and southern (91%) ranges. On the other hand, Northern Koor class showed the highest producer accuracy in both northern range (74%) and southern range (56%).

Classification with 4 classes: Studying the separatability of the mentioned classes showed the low capability of Bhattacharrya Distance Criteria in separating Kurpe class from other classes. On the other band, a significant difference existed between Koor and Shan classes. Therefore, Northern



(a) (b)

Fig. 2: (a) A map resulted from the 6 classes classification using the fused bands and applying a mode filter (3×3), (b) ground truth map



(a) (b)

Fig 3: (a) a map resulted from the classification with 4 classes, using the fused bands and applying a mod filter (3×3) (b) ground truth map

Table 1: Accuracy assessment resulting from classification of the 4 classes

Dataset	Classifier	Class name	Producer accuracy (%)	User accuracy (%)	Overall accuracy (%)	Kappa coefficient
Fused data	ML	Northern Shan	78	71	65.3	63
		Southern Shan	65	75		
		Northern Koor	47	62		
		Southern Koor	56	34		

Kurpe and Southern Kurpe classes were omitted and another classification was done using 4 classes including Northern Koor, Southern Koor, Northern Shan and Southern Shan. Based on the result of this study, this kind of classification showed the highest Kappa coefficient and overall accuracy. Meanwhile, the best result was obtained using the fused image, with Kappa coefficient equal to 63% and overall accuracy of 65.3%. The lowest user accuracy was again

Table 2: Error matrix derived from the fused dataset classification of the 4 classes

	Ground-truthed data			
Classified data	Northern Shan	Southern Shan	Northern Koor	Southern Koor
Northern Shan	17773	769	6250	209
Southern Shan	922	10327	844	1662
Northern Koor	3800	10	6398	127
Southern Koor	175	4796	140	2593

related to Southern Koor class, i.e. most pixel of this class belongs to other classes. Results of this classification are shown in Table 1 and 2. Figure 2 shows the classified image after applying a mod filter with a window size of 3×3 pixel.

DISCUSSION

As it had been mentioned before, the capability of remotely sensed data to produce updated maps of pollarded forest area and to separate different map areas of alternative pollarding periods were studied in this research. As for classification to 3 and 6 classes, there has been a significant difference between Kappa coefficient and overall accuracy, due to the spectral interference among some classes, particularly in southern range, resulting in informational interference of training classes and obtaining a low Kappa coefficient. The same results were obtained by Latifi [14] who studied the forest cover type classification.

In all three classification types, Southern Koor class showed the lowest user accuracy, i.e. most of its pixels entered from other classes. Koor class covered a lower area in Southern range, due to the worse climatic condition of this range, as compared with the northern range. Therefore, a lower density of forest trees existed in this range. As the result, less pollarding is done by local people in this area.

The spectral reflectance of Koor class is similar to Shan and Kurpe classes leading in a high commission error and a low amount of user accuracy. Ahmadi [15], who studied the density classes of zagros forest, has also obtained the same results. Different crown cover densities of northern and southern ranges and nonseparability of some classes specially in southern range led to spectral of classes in classification with 6 classes. To obtain a better result, another classification was tried to only 3 classes. In this type of classification, heterogeneous northern and southern classes were separated, i.e., more similarity was obtained in the classified areas. Although a higher overall accuracy was observed in this classification, but the low Kappa coefficient caused by the high commission and omission error in each class of Northern and Southern ranges showed the unacceptable accuracy of produced map.

The third classification method used in this research included 4 classes which showed the higher overall accuracy and Kappa coefficient comparing the classifications with 3 and 6 classes. In this classification, producer and user accuracies of all classes, except Southern Koor class, were more than 50% which showed a good separability among different classes and lower amounts of commission and omission errors. Obtaining a higher Kappa coefficient, the difference between Kappa coefficient and overall accuracy was decreased. Based on these results, the produced map via this classification showed more accordance with ground truth data. Kappa coefficient measured for fused image was 63% which showed 63% accordance between the produced map and ground truth data (Fig. 3). Using combined bands and fused image resulted in obtaining acceptable results. This result is proved by many researchers [16-19]. Latifi *et al*. [20] mentioned that applying this method (data fusion) and other similar methods can improve visual data interpretation which can be used in geometric correction. However, it is not yet more applicable than original multispectral data due to the capabilities of digital image interpretation.

All images combined with vegetation indices had relatively shown the same overall accuracy and Kappa coefficient. The vegetation indices did not show a good result in separating different pollarding areas. The same result was obtained by Hossini [16]. In his study to prepare land use map using ETM data. Likewise, Abdollahi [21] had not found a significant regression relationship between vegetation indices and vegetation cover percentage. According to the results obtained by Khvaninzade [21] in a study to prepare the vegetation cover map of near region in Yazd province, no significant difference existed between vegetation indices and vegetation cover.

The result of this study had not been improved by using principal component analysis. Pourshakouri [18] had also obtained the same results in determining northern boundary of Caspian forest. The relatively high accuracy and less difference between user and producer accuracies comparing previous studies [4, 5, 7, 17] revealed the better results would be obtained using SPOT data with a higher special resolution. The high similarity between soil and tree reflectances in Shan and Kurpe pollarding areas is one of the main obstacles of doing these researches. This result is confirmed by some researchers [7, 15, 17, 23-27]. In total, the overall accuracy of 65.3% and Kappa coefficient of 63% could be considered as an acceptable result in order to separate the pollarding areas and to produce the map of these areas.

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