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An Evaluation of the Capability of IRS-P6 Data for Monitoring Pollarding Forest Areas of Northern Zagros (Case Study: Kurdistan, Pollarded Forests of Baneh)

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ABSTRACT

To evaluate the capability of IRS-P6 LISS-III data to be employed for monitoring the pollarding forest areas in Northern Zagros, some parts of pollarded forests located around Baneh city were selected as a case study area. The pollarding area was determined as the ground truth in a 3-year alternation period using a global positioning system (GPS). Radiometric and geometric corrections were applied to the image and then the data 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 the Intensity–Hue–Saturation Method (IHS). The obtained results were combined with the original bands. The separability of classes was studied using Bhuttacharrya Distance Criteria. The resulting data was classified using Maximum Likelihood Algorithm. Then the classified image was compared with ground truth on a pixel by pixel basis. In order to determine the 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 separated from Northern Koor class. The highest overall accuracy was 70% and a Kappa Coefficient of 60% obtained through a five-class classification of the bands combination PCA (4, 2, 3) -1, 4, 1. In this classification the resulted User accuracy and Producer accuracy were more than 50% for all classes expect for southern Khert. Results of the study revealed the high capability of the abovementioned image and methods to separate the pollarding areas and to prepare the map of the area.

Key words: IRS-P6, Northern Zagros, Pollarding, Vegetation index.

INTRODUCTION

Local communities of Baneh mainly depend upon ranching for their living due to the high population living per forest surface unit, rough topographic conditions of the area along with low water availability for agricultural purposes (Fatahi, 1994). Ranching in such a cold area (not following a seasonal migration system) has resulted in a serious forage shortage which is a crisis in ranching system of the area particularly 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. Starting with the end of August, ranchers cut leafy boughs of oaks at 3-4 years intervals. They pile the boughs either on the trees that have two or more branches remained on them or on the ground. These are called Gala or Luya Gala. The piled dried boughs are finally used to feed cattle (especially sheep and goats) (Fattahi, 1994).

Each forest area is divided among several local families. Then, each parcel (each part)

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is accordingly named, e.g. "Gala-jar of Mr. X" (Armarde forestry plan, 2004). Each Gala-jar is divided into 3 parts, each part being called a "Shan", with approximately equal aerial production. Every 3-year interval one of these Shans is pollarded. The Shan which is time for its being pollarded is called "Khert", the one being pollarded for its second turn is called "Koor" and the third pollarding area is named "Kurpe" (Mostafa, 2004). In these forests, each of the mentioned parts in northern aspects (Northern Khert, Northern Koor and Northern Kurpe) is denser than the ones in the southern aspects (Southern Khert, Southern Koor and Southern Kurpe).

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 resolution of these images, previously used methods are now being replaced with these kinds of data that take a lesser amount of time and labor to obtain the same up-to-date information (Shataee, 2003). 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 constituted of parts of pollarded forest areas in Kurdistan Province.

The capability of IRS-P6 data to produce up to date maps of pollarded forest areas is studied in this research via a comparison between the classified image and ground truth data using the classification accuracy criteria. Forest managers can use these maps as a device for a more efficient pollarded area management. No detailed studies have so far been conducted in this field, using Remote Sensing technique, however, some of the relatively similar researches could be cited as follows:

Joao *et al*. (2006) estimated tree crown closures in Dehesa region in 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*. (2003) 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.

Majani (2000) studied the capability of IRS-IC PAN sensors to produce forest maps related to North West of Guillan province. Results of accuracy assessment showed the highest overall accuracy of 67.6%, and kappa coefficient of 52% for fusion interpretation method. Similar reflectance of lower density forests with other such phenomena as rangelands and gardens were determined as the main error sources in classification activities. In conclusion, the use of multispectral data associated with high resolution could be suggested.

The applicability of ASTER images to provide density maps of Zagros forests is studied by Ahmadi Sani (2005). A classification of 3-classes using a 6-band collection and maximum likelihood algorithm showed the highest overall accuracy and Kappa coefficient (68.5 and 51.5, respectively). Furthermore, findings of this study indicated that the results of all the 3 algorithms namely the minimum distance, maximum likelihood and fuzzy algorithm were relatively close to each other within a 1-2% of difference.

Amini (2006), studied the capability of ETM+ and IRS-1C images to provide a forest map and to discover the changing rates and forest situation from 1955 to 2002 (Case Study: Armarde forests located at Baneh). According to the results of this study, the highest overall accuracy (81.3%) and Kappa coefficient (64%) accompanied related to the map resulted from the classification of 7 band collections with 2 classes performed using a maximum likelihood algorithm. Results of studying the forest changes in the study area demonstrated that 4,853 hectares of forest surface were diminished while 953 hectares

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superimposed to the forest surface during the study period.

Collecting accurate qualitative and quantative forest data via field surveys are very costly and time consuming. In contrast, multispectral remotely sensed data can be used to prepare updated thematic maps for pollarding areas. Furthermore, forest managers can receive precise comprehensive data on forest conditions using RS data. Thus, it seemed necessary to study the capability of RS imagery to assess the pollarded forest areas, provide thematic scatter maps and separate these areas over different year intervals.

MATERIALS AND METHODES

Study Area

Five hundred and four hectares of pollarding forests of the Armarde zone at southwest of Baneh town are studied in this research work. This area is located at longitude of 45º 47' 48" to 45º 48' 00" E and latitude of 35º 25' 41" to 35º 53' 57" N, (Figure 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 in late winter as well as in spring. More than 80% of trees in this area's forests are 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).

Images Employed in the Research

1- IRS-P6 LISS-III image, July, 14th, 2006, 23.5m spatial resolution (pixel)

2- IRS-1C PAN image, Octbre 23th, 2005, 5.8 m spatial resolution (pixel)

These images are both identified in the Global WGS 84 system and Zone 38.

Softwares Employed in the Research

PCI-Geomatica Ver. 9.1

This software formed the basis of processing in such areas of: geometric and

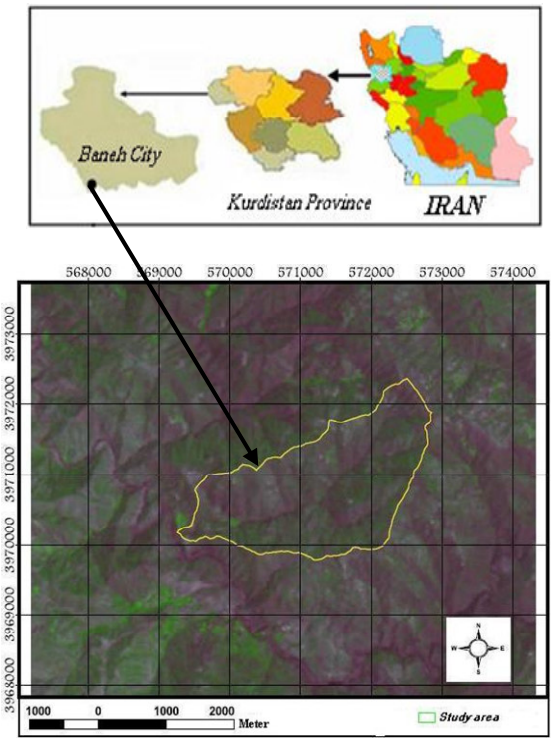

Figure 1. Location of the study area shown on Iran map and a perspective of the area in IRS-P6 image withinn a combination of bands 3, 2, 1

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radiometric corrections, creation of artificial bands and color combinations, creation and corrections of training sample, classification, and accuracy assessment.

Idrisi Ver. 2

This software was used to provide soil line and vegetation indices.

Erdas Ver. 8.5

This software was employed in data fusion.

ArcView 3.2 and ArcGis 9.2

For preparation of maps and processing of polygons and polylines.

Geometric Correction

The images employed in this research were already radiometrically corrected by their supplier companies. Images were geometrically corrected via a Polynomial Model using SPOT5 images which were geometrically corrected at the Ortho level by an image-to-image method. To do this, 20 points were selected on the IRS-P6 color image with their corresponding points determined on SPOT5 image. Root Mean Square Error (RMSE) of control points was equal to 0.38 pixel along *X* axis and 0.39 pixel along *Y* axis. With this method, also a panchromatic Image with RMSE equal to 0.54 pixel along *X* axis and 0.53 pixel along *Y* axis was geo-referenced.

Ground Truth Map Production

To evaluate the classification accuracy, the pollarded zones in the study area were identified as control points collected using a Global Positioning System (GPS). An area yielding in every 3-year interval and encompassing general characteristics of the region was selected for ground truth mapping. Then, Kurpe, Koor and Khert areas were identified using GPS. Furthermore, all bare parts, agricultural areas, gardens and pine thickets existing in 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 database. Finally, special codes were assigned to each vegetation class and the same codes given to each class in the classified image, and 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 (Alavipanah, 2006). The measured indices were added to the data. Soil line parameters were employed to measure the above mentioned indices (Sundison and Henley, 1999; Bart *et al.*, 1993). Using soil line parameters and vegetation indices, one can distinguish the spectral reflectances of plants crown closure from soil spectral effects (Lyblon, 1997). 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.

In order to obtain a high spectral and spatial resolution image, LISS-III image and pan image were merged using an IHS conversion method. Then all bands of color image fused with IRS-IC panchromatic image, and their pixel size changed to 5.8 m×5.8 m.

Finally, principal bands of color image, fused bands, synthetic bands resulted from vegetation indices and Principal Component Analysis as a combination with principal bands were separately classified.

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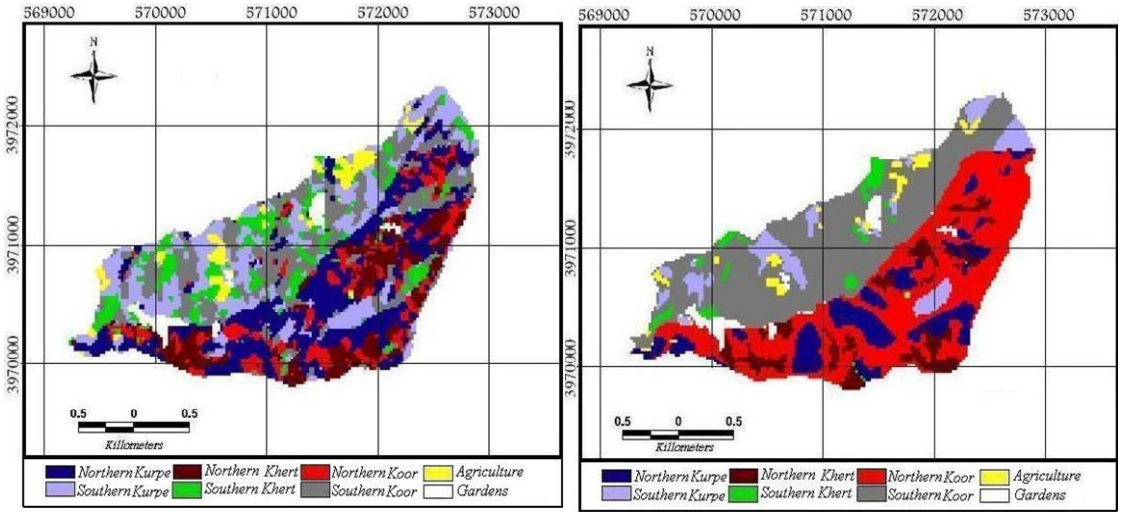

Figure 2. (a) A map resulted from the classification with 7 classes of the bands combination PCA (4, 2, 3) -1, 4, 1 and applying a mode filter (3×3), (b) Ground truth map.

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 Bhattacharyya 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 (Joshi, 2006).

Since Gala-jars of the study area had 3 yielding areas, on the other hand a significant difference existed between crown closure densities of two southern and northern ranges in the first place the area we classified into 7 classes of Northern Koor, Southern Koor, Northern Khert, Southern Khert, Northern Kurpe, Southern Kurpe and agriculture. Then, each range was separately classified into 3 classes of Koor, Khert and Kurpe. Likewise, due to the significant difference existing between two Khert and Kurpe classes, the classification was done again into 5 classes including Northern Kurpe, Southern Kurpe, Northern Khert, Southern Khert and agriculture. To improve the accuracy of data obtained for the study area, a mask was used over garden areas to prevent their being considered into the classification (Figures 2 and 3). 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 employed to evaluate the classification.

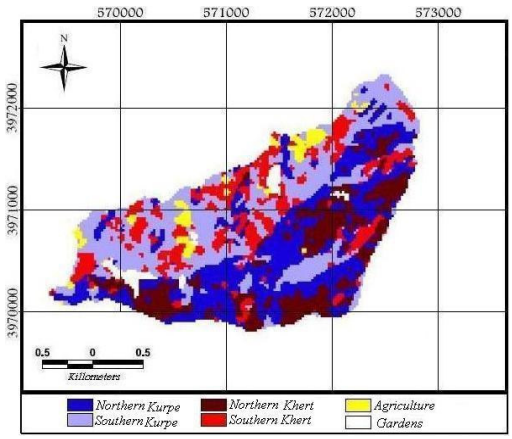

Figure 3. A map resulted from the classification into 5 classes of the bands combination PCA (4, 2, 3) -1, 4, 1 and applying a mode filter (3×3).

RESULTS

The results of separating between classes, Northern Khert class showed the highest

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separability as compared with other classes of: Koor, Khert, Kurpe (1.67 at Bhattacharyya distance Criteria). Agriculture classes with 1.5-2 separability at Bhattacharyya distance Criteria were fully separated from all other classes. The lowest separability was related to Northern and Southern Koor at both ranges. The classes in northern range were better separated as compared with the southern classes. The separabilities among the classes, when the images were combined with vegetation indices, were approximately similar. To achieve a better separable classification of the satellite images, 7, 3 and 5 class classifications were conducted as follows:

Seven Classes Classification

This classification was applied for original bands, fused images, vegetation indices and the first Principal Component Analysis (PCA) combined with original bands using a Maximum Likelihood Method. Combination of PCA (4, 2, 3) -1, 4, 1 presented the highest Kappa coefficient (26%) and overall accuracy (38%) among other data used in this study (Figure 2). All vegetation indices exhibited the same results. NDVI index had the highest Kappa coefficient (23%) and overall accuracy (36%) among all the other used vegetation indices. The lowest and the highest user accuracies were obtained for Southern Khert class and Southern Koor class, respectively. Two classes of Northern Kurpe and Southern Kurpe demonstrated the highest producer accuracy, while, the lowest one was obtained for the Northern Koor class.

Three Classes Classification

Different crown cover densities in northern and southern ranges, in addition to nonseparability of some classes, especially in southern range, resulted in a high spectral interference among classes in the 7 class classification process. Therefore, a new classification was separately done for each range of the three classes of Koor, Kurpe and Khert.

Based on the classification results, maps produced from southern range classification revealed a better accuracy in match with ground truth data. Furthermore, they showed a higher overall accuracy and Kappa coefficient rather than the northern ranges. A combination of PCA (4, 2, 3) - 1, 4, 1 of Southern ranges illustrated the highest overall accuracy (44%) and Kappa coefficient (20%). As for Northern ranges, the most desirable results were obtained using the original bands where Kappa coefficient was 17% and overall accuracy equal to 44%. This classification showed a better overall accuracy, but a lower Kappa coefficient, as compared with the classification into 7 classes. Results shown by all vegetation indices used in this study were relatively similar for overall accuracy, user and producer accuracies and Kappa coefficient in both northern and southern ranges

Five Classes Classification

As mentioned before, two classes of North and South Koor showed a poor separability from other classes and they had the lowest separability in terms of Bhattacharyya distance Criteria, as well. Thus, to obtain better results, a classification was done using 5 classes of North Kurpe, South Kurpe, North Khert, South Khert as well as agriculture. A higher Kappa coefficient and overall accuracy were obtained through this trend of classification.

Furthermore, a low level of difference between Kappa coefficient and overall accuracy indicates the optimal accuracy of the produced map in this classification. Results of vegetation indices were the same as what were obtained for the classification of original bands. Among all the used data combination, the fused image showed the lowest rates for overall accuracy, Kappa coefficient, producer and user accuracy

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Table 1. Accuracy assessment resulting from classification of the 5 classes.

Dataset	Classifier	Class name	Producer accuracy (%)	User accuracy (%)	Overall accuracy (%)	Kappa coefficient (%)
PCA (4, 2, 3) -1, 4, 1	**ML**	Northern Kurpe	76	76	70	60
		Southern Kurpe	73	69		
		Northern Khert	60	77		
		Southern Khert	62	49		
		Agriculture	86	73		

indices. PCA combination (4, 2, 3)-1, 4, 1 involved the highest Kappa coefficient (60%) and overall accuracy (70%). User and producer accuracies obtained via this classification are higher than 50% for all classes, except for Southern Khert, indicating the low omission and commission error as well as a reasonable separability among adopted classes. Figure 3 shows the classified image after applying a made filter with a window size of 3×3 pixels.

Results of this classification are presented in Tables 1 and 2.

DISCUSSION

The capability of remotely sensed data to produce update maps of pollarded forest area and to separate different map areas of alternative pollarding periods were studied in this research. As for classification into 3 and 7 classes, there has been a significant difference observed 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 reported by Latifi (2005) who studied the forest cover type classification.

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

The spectral reflectance of the Koor class is similar to the Shan and Kurpe classes leading in a high commission error and a low degree of user accuracy. Ahmadi (2005), who studied the density classes of Zagros forest, has also come up with the same results.

Different crown cover densities of Northern and Southern ranges and nonseparability of some classes especially in

Table 2. Error matrix derived from classification of the 5 classes.

Ground-truth data					
Classified data	Northern Kurpe	Southern Kurpe	Northern Khert	Southern Khert	Agriculture
Northern Kurpe	794	51	187	14	0
Southern Kurpe	88	481	49	65	19
Northern Khert	134	16	466	8	0
Southern Khert	32	78	75	184	7
Aagriculture	1	37	4	18	164

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southern range led to spectral interference of classes in the 7 class classification process. To obtain a better result, another classification was tried with 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, 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 the produced map.

The third classification method employed in this research included 5 classes which showed the higher overall accuracy and Kappa coefficient as compared with the 3 and 7 class classifications. In this classification, producer and user accuracies of all classes, except Southern Khert class, were more than 50% which demonstrated a good separability among different classes and lower degrees of commission and omission error. Obtaining a higher Kappa coefficient, the difference between Kappa coefficient and overall accuracy was decreased. Based upon these results, the produced map via this classification was more in match with ground truth data. Kappa coefficient measured for bands combination of PCA (4, 2, 3) -1, 4, 1 was 60% indicating 60% match between the produced map and the ground truth data (Figure 3). Using fusion bands with panchromatic image did not reveal acceptable results, due to different dates of acquisition of panchromatic and multi-spectral images (about 9 month). Acquisition of LISS-III data was acquired simultaneously with plant growth. But panchromatic image was acquired last autumn, one year before the LISS-II. At this time normally the trees do not keep their leaves and in this case the soils of the area were bare and devoid of any plant cover. With regard to the above mentioned reason, it can be concluded that for obtaining a better type of fused data from multi-spectral and panchromatic images, simultaneous images acquisition of no variations in the area of imagery coverage and as well in plant coverage are necessary.

Latifi *et al.* (2005) mentioned that applying this method (data fusion) or other similar methods can improve visual data interpretation which can be used in geometric correction. However, it is not yet more applicable than the original multispectral data due to the capabilities of digital image interpretation.

All images combined with vegetation indices had relatively reflected the same overall accuracy and Kappa coefficient. The vegetation indices did not show the desired results in separating different pollarding areas. The same result was reported by Hossini (2002) from his study of preparing landuse map using ETM data. Likewise, Abdollahi (1998) did not find a significant regression relationship between vegetation indices and vegetation cover percentages. According to the results obtained by Khvaninzade (1999) in a study to prepare the vegetation cover map of Nier region in Yazd Province, no significant difference was found existing between vegetation indices and vegetation cover.

The relatively high accuracy and lesser difference between user and producer accuracies of classification, comparing previous done studies (Sarouei, 1999; Naseri, 2003; Joao, 2006; Xu, 2003) showed that better results would be obtained using SPOT data with a higher spatial resolution. The high similarity between soil and tree reflectances in Shan and Kurpe pollarding areas are some of the main obstacles to this type of research work. This result is confirmed by Juffer (1993), Sarouei (1999), Naseri (2003), and Ahmadi (2005).

All in all, the overall accuracy of 65.3% and Kappa coefficient of 63% could be an acceptable result for separating the pollarding areas and as well in producing the map of these areas.

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ارزیابی قابلیت داده‌های ماهواره‌ای IRS-P6 در پایش مناطق جنگلی گلازنی شده در زاگرس شمالی (مطالعه موردی: کردستان- جنگل‌های گلازنی شده بانه)

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چکیده

به منظور ارزیابی قابلیت داده‌های ماهواره‌ای سنجنده LISS-III ماهواره IRSP6 در پایش مناطق جنگلی گلازنی شده در زاگرس شمالی، محدوده‌ای از جنگل‌های گلازنی شده شهرستان بانه انتخاب و مورد بررسی قرار گرفت. سطح محاوط گلازنی شده در دوره تناوب ۳ ساله با استفاده از دستگاه موقعیت‌یاب GPS، بعنوان واقعیت زمینی منطقه تهیه گردید. پس از بررسی خطاهای هندسی و رادیومتری مجموعه داده مورد استفاده تحت عملیات پیش پردازش نظیر نسبت‌گیری طیفی و تجزیه مؤلفه‌های اصلی قرار گرفت. همچنین باندهای چند طیفی با تصویر سنجنده PAN ماهواره IRS-1C به روش شدت-رنگ-اشباع ادغام (فیوژن) شد. نتایج حاصله با باندهای اصلی ترکیب و مورد استفاده قرار گرفت. بررسی تفکیک‌پذیری طبقات با استفاده از معیار فاصله باتاچاریا انجام شد. طبقه‌بندی داده‌ها با استفاده از الگوریتم حداکثر احتمال انجام شده و تصویر طبقه‌بندی شده با واقعیت زمینی بصورت پیکسل به پیکسل مورد مقایسه قرار گرفت. از چهار معیار صحت کلی، شاخص کاپا، صحت تولید کننده و صحت کاربر جهت بیان صحت طبقه‌بندی استفاده شد. نتایج حاصله نشان داد که تفکیک اکثر طبقات از طبقه کور شمالی به خوبی امکانپذیر است. بالاترین میزان صحت کلی معادل ۷۰٪ و شاخص کاپا ۶۰٪ با طبقه‌بندی ۵ کلاسه‌ای با ترکیب باندی ۱،۴، ۱- (۴،۲،۳) PCAحاصل شد. صحت کاربر و تولید کننده حاصل شده در این طبقه بندی برای تمامی طبقات به غیر از طبقه خرت جنوبی دارای مقدار بالای ۵۰ درصد می‌باشد. نتایج حاصل از این تحقیق گویای قابلیت مناسب تصاویر مورد استفاده و روشهای ذکر شده جهت تفکیک محاوط گلازنی و تهیه نقشه در این مناطق می‌باشد.

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