# Evaluating the capability of satellite images in Recording the thematic information: with a focus on the SPOT5 Satellite images

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***Abstract***

*In a cooperative program, France, Belgium and Switzerland launched the SPOT Satellite with two HRV image capturing systems in1986. Having 3000 multi-spectrum detectors and 6000 panchromatic detectors, the SPOT5 received images without requiring mechanical scanning. Moreover, having efficient time for scanning enables these detectors to have a high resolution power per each pixel. In the panchromatic status, the energy reflected from the earth between wavelength ranges of 0/48 – 0/71 and 0/49- 0/69 micrometer are recorded by HRG and HRS sensors, respectively. Another advantage of SPOT lies in its significant visibility which is normally observed in the common coverage area of adjacent images. In this research we study the ability of SPOT5 Satellite images in recording thematic information. Analyzing Remote Sensing data and extracting instrumental thematic information from SPOT5 images are possible. Multi-spectrum classification is one of the most common approaches used for extracting information. The multi-spectrum classification approach puts its basis on this assumption that an image from a specific area has reflections from various parts of an electromagnetic spectrum. Also this image is completely Geo-referenced. The majority of information extraction techniques focus on analyzing the spectral features of such images. Numerous spatial algorithms have been designed to perform such spectral analyses. The current study implements a number of theses algorithms on images and represents the results.*

**Keywords**: *Satellite images, classification algorithms, SPOT5, image processing.*

**Introduction**

Information receiving systems in various spectral bands records the amount of energy reflected from the earth phenomenon. Photo or analogue sensors record spectral information directly in a two dimensional manner (film) but the multi- spectrum scanners normally record energy on magnetic tapes and then make it two dimensional to generate pictures and represent them. This two dimensional information is represented as a matrix including spatial information such as size, form, texture and linear phenomena. Regarding the principles of interpreting satellite images, the above-mentioned information is greatly significant. Recognition of the spectral features of plant species, different soils, water and the other ingredients on the earth is considered as a basis for analyzing and interpreting the telemetry data. It is obvious that the spectral features of various phenomena on the earth are not permanent rather they are continuously changing as a result of complex temporal and local conditions. In other words the spectral features of earth phenomena are changeable according to changes in time and place.

The influence of seasonal changes on vegetation activities is a good illustration of this fact. Changes in the biologic system and consequently spectral variations may originate from the seasonal changes of the vegetation and human activities such as deforestation, construction and etc. howsoever, such changes bring about spectral variations in different areas of the earth. So considering the temporal and local characteristics of the earth phenomenon during data gathering and interpreting processes seems essential. Also an appropriate interpretation necessitates incorporation of all the effective parameters. Therefore considering the characteristics of each region and essential information of a project or research, the appropriate time for gathering data must be determined in order to obtain desired results. On the other hand, the spectral change procedures of different geographical places may be studied and analyzed through applying multi-temporal spectral data during a year or a certain period of time. Changes in the spectral features of phenomenon are measureable through change interpretation techniques in any specific geographical place.

**Review of literature**

Numerous studies in Iran and other countries can be mentioned in literature and research background. In his studies, Dr. Gharagozlo_ the director of International Relations of the Topography Organization_ aimed to design an urban planning model through RS and GIS environmental models. He represented a developmental plan for the north-west of Tehran. In this plan, he studied the spatial features of urban uses including: construction, green space, agriculture and open space from 1984 up to 2001. Then he proposed a model for urban development (south-west of Tehran). In his studies, Dr. Gharagozlo realized an irregular increase in construction activities and a greatly significant decrease in open spaces and agriculture from 88/81 to 74/00 and 3/52 to 2/96, respectively from 1984 up to 2001. Also he mentioned an increase in green spaces from 11/76 to 12/50 (Ghragozlo, 2004). Using the Landsat photos, Ahadnezhad modeled the use changes in Maraghe considering the detrimental index. He argued and modeled that destroying gardens and agricultural areas around Maraghe as a consequence of the physical development of the city will damage its environment (Ahadnezhad, 2000). In his study, Ashtiani relied on the principle that the spectral-spatial information of TM sensor are high and low, respectively, and the spatial information of SPOT sensor is more than TM while its spectral information is less than it. So for optimal use of the sensors' information, image merging approaches are applied. Ashtiani applied an approach for transforming wavelet in order to combine Landsat TM and SPOT SPAN images. His purpose was to synthesize the high spectral resolution of TM with the high spatial resolution of PAN. The approximate images of TM and the slight PAN photos are synthesized and synthetic images are obtained. Results indicated that the wavelet transformation approach simultaneously maintained the spatial-spectral information of primary images and provided better results comparing other approaches (Karimi and Ashtiani, 1999). Karami used a multi-factor analysis approach to model the land uses in Khoramabad applying telemetry data and GIS information. After modifying satellite data, he represented land uses maps, vegetation and humidity index (Karami, 2000). Buiten (1993) stated that recognizing a distributive model of vegetation is one of the applications of telemetry which can be used for studying vegetation changes in different times. In this research he studied vegetation indices (e.g. vegetation changes index and changes in vegetation pattern and etc.) considering some advantages and disadvantages of telemetry regarding sciences such as traditional and manual topography and cartography. He recommended vegetation categorization techniques and approaches for interpreting images and studying reflective features of plants. Bektas (2002) represented a number of techniques for changing vegetation of land uses such as vegetation difference index and Chain Vector analysis. He applied these techniques in ETM and TM Landsat images. In his research, Bektas aimed to recognize the vegetation changes in a steppe area in the Gobi Desert during a twelve-year period since 1990 to 2002.

**Statement of the problem**

Information gathered by the satellites regarding to the spectral reflection of various land covers are numeral. Numeral data incorporates a single pictorial element called pixel, and each pixel has certain lighting degrees. Therefore, an image is composed of pixels with lightning level values in different bands and numeral images in form of a matrix and is generated from putting together the pixels as rows and columns in which each pixel possesses specific characteristics of its matrix (row and column). For this purpose, information of each different spectral band is considered as a feature of each pixel since its value varies according to the various spectral bands. In other words a pixel shows different characteristics in various bands.

**Significance of the Study**

In the current cities with specific complexities, we may not rely on the traditional approaches for optimal use of available resources and awareness of the environmental changes. Only approaches which continuously process changes in land resources may meet our needs. Analyzing and recognizing land covers and land uses are considered as the most significance of the telemetry data. The SPOT Satellite images are used for recognizing land uses. Among the SPOT5 series satellites, SPOT has a spatial resolution of 10 meters in different spectral bands and 2/5 -5 meters in panchromatic band. The high spatial resolution establishes SPOT as a universal sensor for generating land use and land cover maps.

**Materials and methodology**

**1. Numeral data**

In the current research, the following data and software have been used:

1.1. SPOT5 multi-spectral satellite images: these data incorporate four spectral bands including Green, Red, NIR and SWIR, respectively, which have been obtained from the target area (Hashtroud County) during May and Jun of 2001. These data were obtained with a resolution of 10 meters in various spectral bands and 2/5- 5meters in panchromatic bands.

1.2. Satellite image processing software: PCI Geomatics, ERDAS 9.1 and ENVI4.8 image processing software were used for performing pre-process, process and post-process activities and providing output data of maps obtained from categorization and final analysis of GIS software such as ARCGIS10.1.

**2. Training Sampling**

In this research, 11 land use and land cover classes were recognized through studying images of the target region (Hashtroud County). For recognizing these classes, we primarily studied the false colored image of the region and finally sampled land uses and land covers through GIS field sampling. The use level is a synthesis of levels 1 and 2 of the Mishigan classification system. In some land uses such as cultivation we studied uses of lands under dry and irrigated farming.

**Types of vegetation and land-uses in the target region (Hashtroud County)**

**1. Constructed areas**

1.1. Urban and rural regions: Hashtroud city, villages, rural districts and suburbs of Hashtroud County. Twelve samples were obtained from these centers by GPS.

1.2. Communication and transportation lines: these areas include roads and communicational lines in the county. This type of land use is easily observable in images. Therefore the number of samples obtained from this type in sampling stage was 3.

**2. Agricultural areas**

2.1. Gardens and woodlands: gardens and woodlands around cities and villages are put in this category. In the target area, gardens and woodlands are mainly located in valleys and around rivers as a result of the affluence of seasonal and permanent rivers. 9 samples were gathered from these areas by GPS.

2.2. Lands under cultivation: include lands under cultivation of wheat, pea, grain and other products which are mainly cultivated in such regions. The major product of this region is wheat which is cultivated based on dry farming. The number of samples gathered by GPS was 168, 12, 20, 4 and 2 for dry farming wheat, pea and grain, irrigated farming wheat and alfalfa, respectively. Cultivated areas include two main categories: 1. Irrigated lands and 2. Dry lands

2.3. Other agricultural lands which include shifting lands of the target region (Hashtroud County). About 28 samples were gathered from these areas.

**3. Pasturage**

Pasturage: grasslands which have been distributed along the county. Gathering training samples from lands covers is greatly important as a result of having similar variations with agricultural lands which troubles the classification stage. 14 samples were obtained from grasslands

**4. Water**

4.1. Rivers and rivulets: these areas include rivers in the county. As these areas are recognizable in the images, no sampling was done.

4.2. Lakes: seasonal lakes and artificial ponds in areas which are recognizable in the images.

**5. Unutilized lands**

5.1. Sandy areas other than sabulous: bare lands of the region with no cultivation in them. 5 samples were gathered from bare lands through GPS.

5.2. Bare rocky lands which include rocky heights and geological effects which are uncultivable. The training samples of this type of land cover were obtained from images.

The major problem in interpreting available images obtained from the target area is differentiating dry and irrigated lands and also cultivated areas (wheat, barely, pea and etc.) from unutilized lands and grasslands which show similar spectral values in the images. Therefore numerous samples were gathered from these areas.

**Drawing the distribution of classes based on training samples in the two dimensional space of selected bands**

Considering the selected training samples for each class, their scatter diagrams in various bands for the categories of 1, 2 and 4 were drawn. As these diagrams suggest the lake class exist separately from other training samples in all band compositions. The least separation and disjunction are observed in the training samples of constructed and shifting lands.

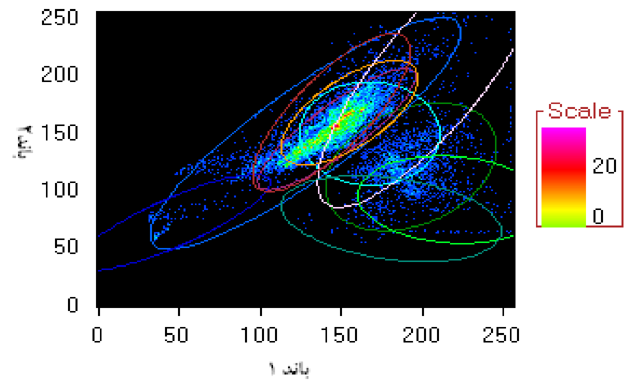



**Image1.** Scattering of training samples in the band 1

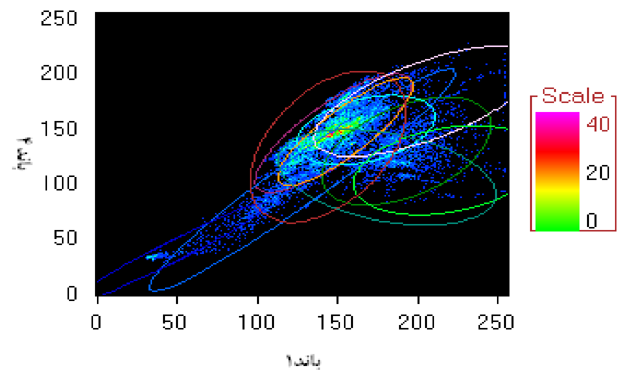



**Image2.** Scattering of training samples in bands 1 and 4

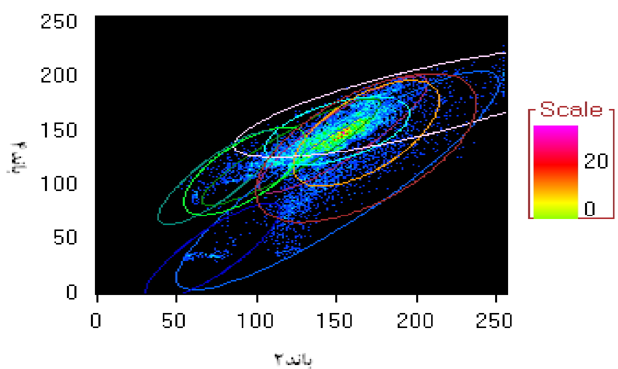



**Image3.** Scattering of training samples in bands 2 and 4

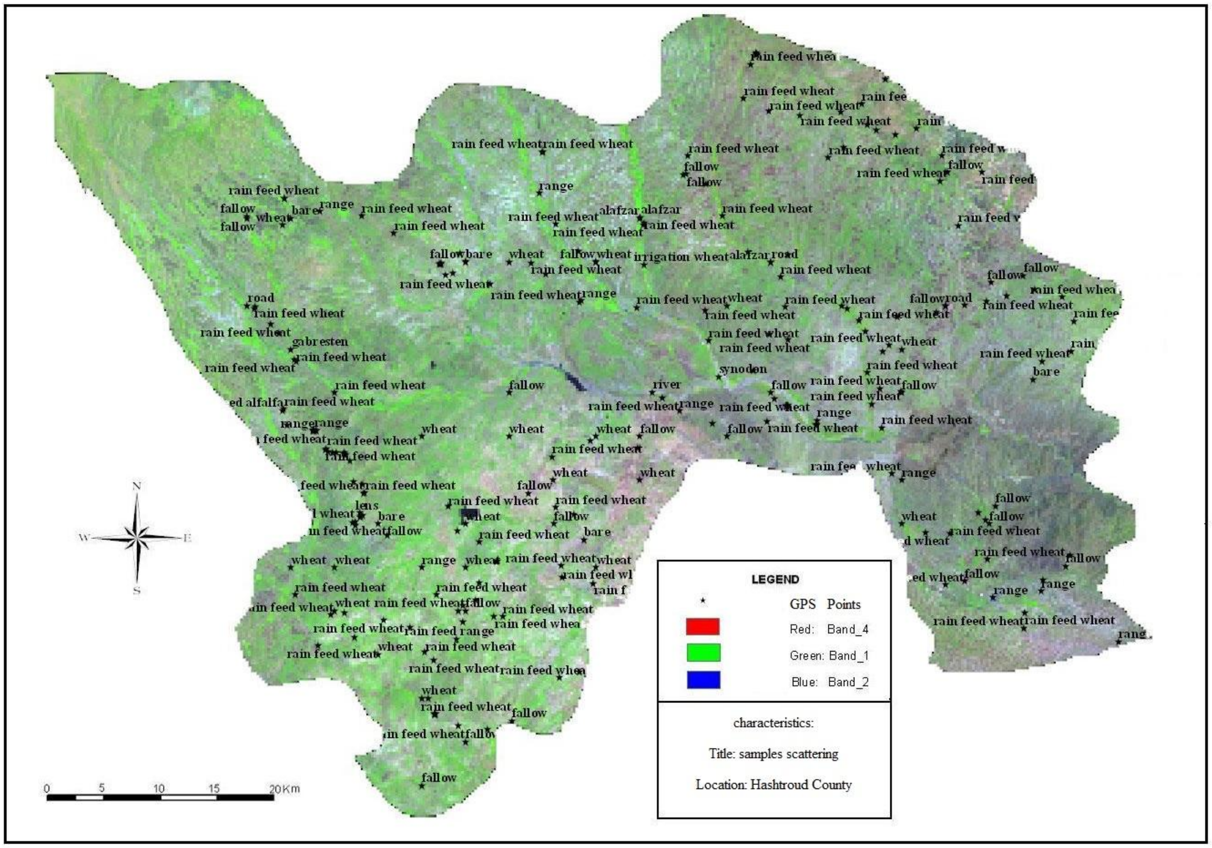
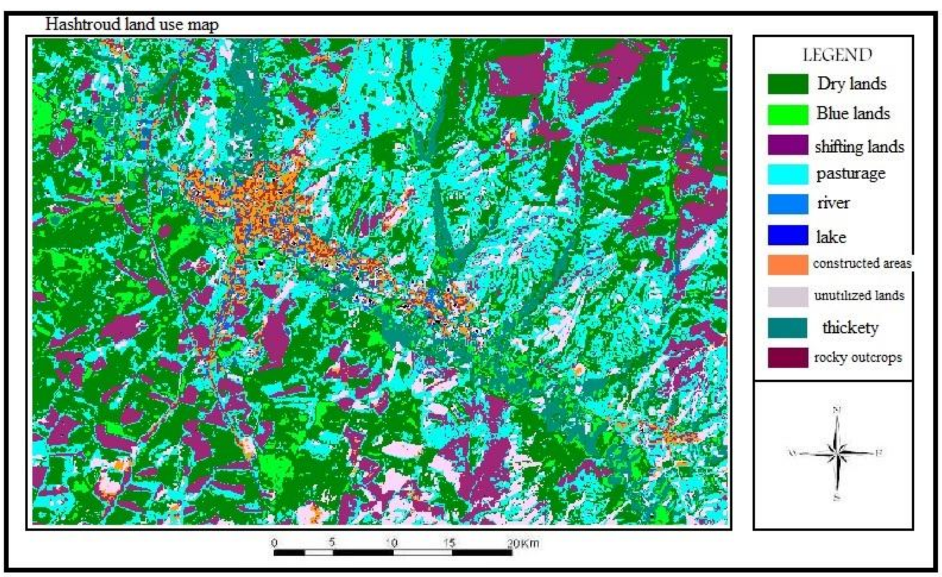
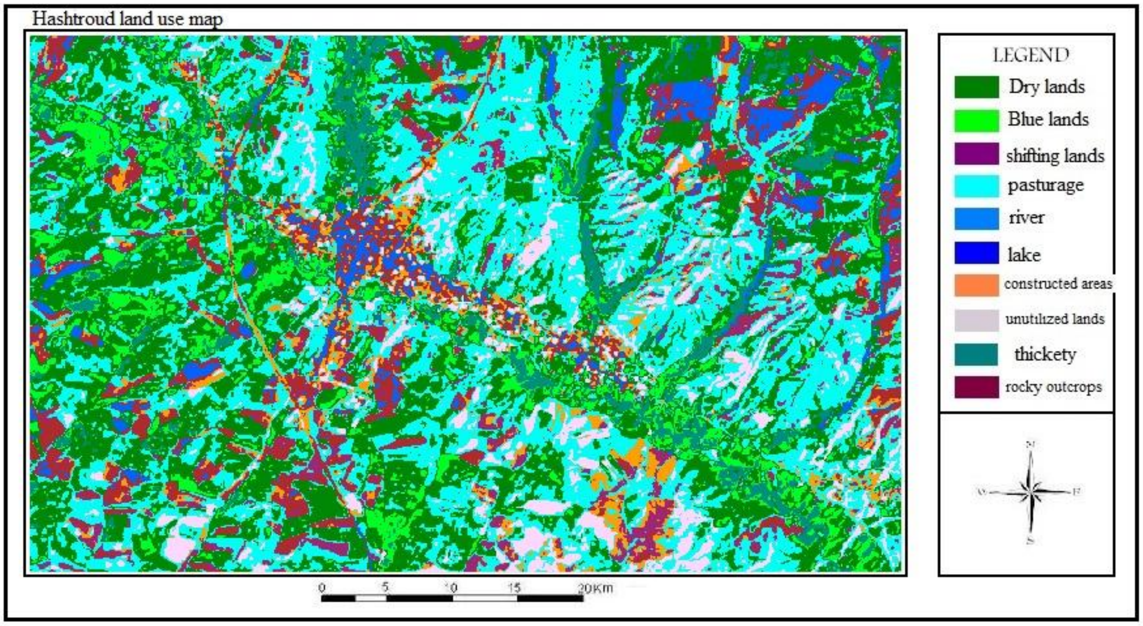



**Image4.** Scattering of samples gathered from the land uses and covers of the target region (Hashtroud Country) by GPS




(Dry lands_ Blue lands_ shifting lands_ pasturage_ river_ lake_ constructed areas_ unutilized lands_ thickety_ rocky outcrops) Hashtroud land use map

**Image5.** Land uses and land covers map and in the parallelepiped classification algorithm




(Dry lands_ Blue lands_ shifting lands_ pasturage_ river_ lake_ constructed areas_ unutilized lands_ thickety_ rocky outcrops) Hashtroud land use map

**Image6.** Land cover and land use map in the distance classification algorithm

**Discussion and conclusion**

**_Applying the vegetation index in classification**

Results obtained from the maximum likelihood algorithm demonstrated that the least separability was between classes 2 (shifting lands) and 6 (constructed areas). Therefore class 2 pixels were categorized in class 6. For improving classes 2 and 6, we used the vegetation index obtained from the ratio of bands 2 and 3 in the target region image (Hashtroud County). The results are represented in image 7 and table1.

Status of class 2 and 6 after applying NDVI

Status of class 2 (shifting lands) and class 6 (constructed areas) in bands 1, 2 and 4)

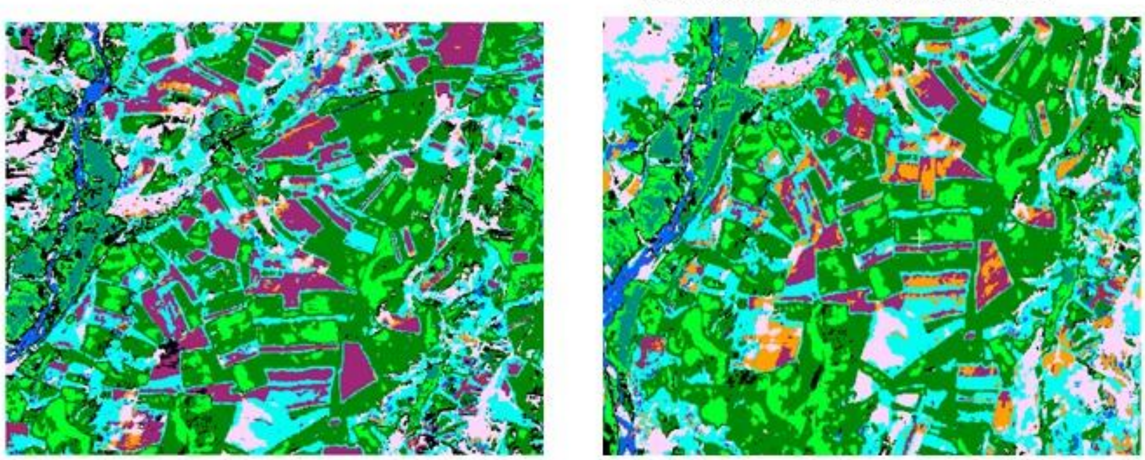


**Image7.** The effect of using vegetation index in separating classes 2 (shifting lands) and 6 (constructed areas)

**Table1.** The statistical results of using vegetation index in classes 2 and 6.

| Name of category | Category code | The number of pixels in the category before NDVI | The number of pixels in the category after NDVI | Percentage in the image before NVDI | Percentage in the image after NVDI |
|---|---|---|---|---|---|
| shifting | 2 | 2046106 | 2623668 | 4/87 | 6/25 |
| Constructed areas | 6 | 1148349 | 486654 | 2/37 | 1/16 |

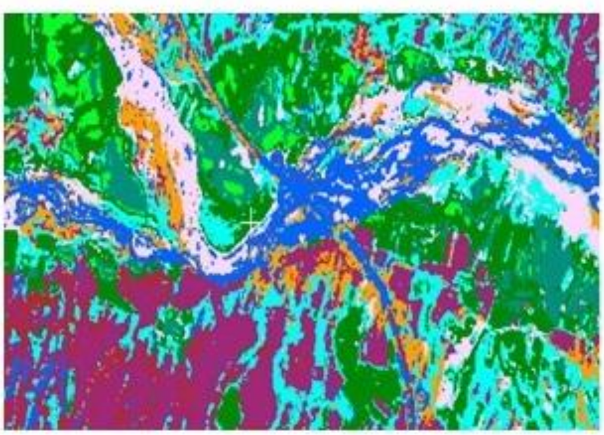
**Using the ratios of bands for improving riverbeds and waterways:**

The process of dividing pixels of an image on the corresponding pixels of another image is called rationing. Rationing is one of the most common transformations which are done on the telemetry images. Its popularity generates from two reasons: first some aspects of the spectral reflection diagrams for various land covers can be recognized through the rationing approach. Second, some undesired effects of the recorded radiance including the effects of topography on radiance may be decreased (Najafi Disfani, 1998). In this study we applied the first reason of rationing to detect riverbed more efficiently. In the multi-spectrum images captured by the TM sensor the ratio of band 2 to 5, and in the multi-spectrum images of SPOT sensor the ratio of band 1 to 4 will be beneficial in recognizing blue areas (John. R. Jensen, 1996). To extract the band of blue areas from Geomatics Modeling Software we used the following formula:

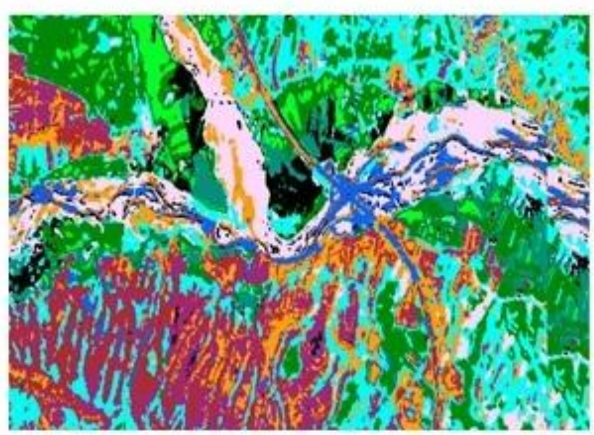
Relation 1: %8= (%1/ %4)

We used the resulted band in the classification process and its influence on classification output has been demonstrated in image 8 and table 2.

River bed AFTER using the band resulted from band 1 to 4 ratio



River bed BEFORE using the band resulted from band 1 to 4 ratio



(River bed after using the band resulted from band 1 to 4 ratio) (river bed before using the band resulted from band 1 to 4 ratio)

**Image8.** Using the ratio of band1 to 4 in the classification process of SPOT image of the target region (Hastroud County).

**Table2.** The results of band1 to 4 ratio in the SPOT5 sensor in the target region (Hashtroud County).

| Class name | Class code | Number of pixels in classification before rationing band1 to 4 | Number of pixels in classification after rationing band1 to 4 | Percentage in the image before rationing | Percentage in the image after rationing |
|---|---|---|---|---|---|
| river | 4 | 699271 | 1044182 | 1/55 | 2/49 |

**Accuracy evaluation**

Using the samples obtained by GPS and implementing the training samples on the target region image (Hashtroud County) generated a reference map for evaluating the accuracy of classification map. The results of accuracy evaluation of the classification map are represented in the following tables:

$\phi$ : Total accuracy

$\sum_{n=1}^{m} nij$ : Sum of numbers on the main diameter of classes in the reference and classification map

$\sum_{i,j}^{m} nij$ : Sum of reference and classification map classes

Relation 2:

$$\phi = \frac{\sum_{n=1}^{m} nij}{\sum_{i,j}^{m} nij}$$

**Table3.** Statistical characteristics of generator and user accuracy and calculated kappa for all land-uses and land-covers

| | Generator accuracy | User accuracy | kappa |
|---|---|---|---|
| Dry lands | %93.814 | %91.919 | ./8669 |
| Shifting lands | %82.759 | %88.889 | ./8741 |
| pasturage | %77.857 | %80.357 | ./7431 |
| river | %77.778 | %100 | 1 |
| Constructed areas | %100 | %87.500 | ./8714 |
| Unutilized lands | %85.714 | %78.261 | ./8624 |
| Waterway | %72.222 | %86.667 | ./8524 |
| woodlands | %100 | %62.500 | ./6173 |
| Rocky outcrops | %100 | %75 | ./7469 |

Relation 3: $k = \frac{\phi 1 - \phi 2}{1 - \phi 2}$

In this relation

$\phi 1$ : Total accuracy

$\phi 2$ : Calculated from the following relation

$$\phi 2 = \frac{1}{N^2} = \sum Ci * Ri$$

The final total accuracy is calculated based on kappa index. Kappa index calculate the classification accuracy in relation to an accidental classification. Total accuracy is usually bigger than final accuracy (kappa index). A kappa index of 1 shows that classification have been done correctly. If it equals zero, classification has completely been accidental and the negative values of kappa show a weak classification.

Regarding to the total accuracy and kappa index calculated for each class and category we can conclude that most of classes have been correctly classified. Among the available land covers and land uses in the image, only the river class had no result in accuracy evaluation because the river class had the highest amount of separability. Also none of the systematic samples of the image belonged to river class. Therefore we did not consider the river class as it had a unique separability in the accuracy evaluation process and no overlap with other classes and covers.

Relation 4: $$PAJ = \frac{Xjj}{\sum_{I} ij}$$

$$Ce = 1 - UA \quad UAi = \frac{Xii}{\sum_{j} ij}$$

$PAj$ : Generator accuracy

$UAi$ : User accuracy

$\frac{Xjj}{\sum_{i} ij}$ : The number of main diameter in the error matrix for each class on sum of classification map classes

$\frac{Xii}{\sum_{j} ij}$ : The number of main diameter in each category on the sum of each class in the reference map

: Commission error

$Oe = 1 - PA$ : Omission error

**Table4.** Calculating the commission and omission error of land cover and land use classes

| | Commission error | Omission error |
|---|---|---|
| Dry farming lands | % 8.81 | %6.14 |
| Shifting lands | % 11.11 | %17.24 |
| pasturage | %19.64 | %22.14 |
| River | 0 | %22.22 |
| Constructed areas | %12.5 | 0 |
| Bare lands | %21.73 | %14.27 |
| Blue lands | %13.33 | %27.77 |
| woodlands | %37.5 | 0 |
| Rocky outcrops | %25 | 0 |

**Table5.** The amount and percentage of pixels in land use and land cover class images in the distance classification

| Class name | Class code | Number of pixels in image | Percentage of pixels in image |
|---|---|---|---|
| Dry farming lands | 1 | 6483134 | 15.43 |
| Shifting lands | 2 | 1469202 | 3.50 |
| Pasturage | 3 | 6347757 | 15.11 |
| River | 4 | 1389010 | 3.31 |
| lake | 5 | 14007 | 0.028 |
| Constructed areas | 6 | 601153 | 1.43 |
| Bare lands | 7 | 2825831 | 6.73 |
| Blue lands | 8 | 1738065 | 4.14 |
| Woodlands | 9 | 452400 | 1.08 |
| Rocky outcrops | 10 | 1424819 | 3.39 |

**Table6.** The number and percentage of pixels in land use and land cover class images in the parallelepiped classification

| Class name | Class code | Number of pixels in image | Percentage of pixels in image |
|---|---|---|---|
| Dry farming lands | 1 | 7974991 | 18.98 |
| Shifting lands | 2 | 2808320 | 6.68 |
| pasturage | 3 | 5481182 | 13.05 |
| River | 4 | 918525 | 2.19 |
| lake | 5 | 14687 | 0.03 |
| Constructed areas | 6 | 687372 | 1.64 |
| Bare lands | 7 | 2449942 | 5.83 |

| | | | |
|---|---|---|---|
| Blue lands | 8 | 946185 | 2.30 |
| Woodlands | 9 | 710109 | 1.69 |
| Rocky outcrops | 10 | 690719 | 1.64 |

**Research findings**

Considering actions performed during the current research, we elicited that SPOT5 Satellite images possess a great capability in generating land use and land cover maps.

To improve the accuracy and resolution of land cover and use maps generated from SPOT5 images, we may implement ground samples on the region's image during the classification process. In this research GPS was used to collect training and experimental samples regarding land uses and land covers. Applying high resolution satellite images seems essential to study land use and cover types of a specific region. Based on research findings we may claim that using high resolution satellite data provides accuracy acceptable by universal standards in generating land cover and use maps. To be mentioned that even data such as SPOT5 images can differentiate cultivated areas regarding types of cultivation. Doing such accurate and minor work requires gathering cultivation samples from cultivated areas. However the above-mentioned ability was not used as this study aimed to extract land use and cover. Also applying image processing and information analysis techniques in GPS provide the possibility of representing locational models aimed to decrease land use issues. Types of algorithm used for classifying images influence on the results. Real samples are gathered from the target area and used in the classification process to improve the accuracy of classification map generated from telemetry images. Doing so we can claim that traditional approaches of generating land cover and use maps may be substituted by the final map resulted from telemetry images. Assuring the accuracy of generated map, it may be submitted to urban managers and programmers to perform required programs regarding environmental potentials.

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