INVESTIGATION OF THE POSSIBILITY OF FOREST TYPE MAPPING IN ARID AND SEMI-ARID REGIONS USING LANDSAT ETM+ DATA

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ABSTRACT

Landsat ETM+ data from the National Park of Khabr in Kerman province, dating May 2000, were analyzed to investigate the possibility of forest type mapping in arid and semi-arid regions.Quality evaluation of the image showed any radiometric distortion. Orthorectification was implemented to reduce relief displacement. The RMS error obtained was less than half a pixel. The ground truth map allocating 50% of the total area was prepared by fieldwork, using strip sampling. Different forest types considering the density, were qualitatively estimated in the strips based on typology definitions,. The original and synthetic bands were obtained applying tasseled cap transformation, PCA, ratioing and bands fusion. Furthermore, the parameters of the soil line relation were applied to produce suitable vegetation indices to reduce soil reflectance. The best band set, based on the divergence between classes signatures, using sample areas were selected. Forest type classification utilizing ML, MD, PPD and SAM classifiers were performed to separate pure and dominant types of *Pistacia atlantica, Acer monspessulanum, Amygdalus elaeagnifolia, A. scoparia* and a mixed type. Because of spectral similarity between the pure and dominant types, these classes merged together and the classification was repeated. In this case the highest overall accuracy and kappa coefficient equal to 47% and 23% respectively, were achieved by MD classifier. Accuracy assessment and signature separability criterions showed undesirable separation between the whole forest types, except for *Amygdalus scoparia*. By merging all of the types but *A. scoparia* and performing the classification again, the highest overall accuracy and kappa coefficient equal to 92% and 68% respectively were resulted utilizing MD classifier. Based on the results, in such regions, low forest canopy, increases the role of background reflection and this makes undesirable results. Therefore high resolution sensors data and improved classification methods are advised.

1. INTRODUCTION

The forests in arid and semi-arid regions play an effective role in soil conservation and preventing destructive floods. These forests are ecologically important due to holding valuable genetic reserves and causing a rich biodiversity. Sothat it is necessary to image them based on comprehensive investigations. The starting point at this field is to achieve suitable and fresh information to recognize them. In this regard Satellite data with their own characteristics such as being able to cover large areas, their revisit frequency and their possibility of automatic analysis (Darvishsefat, 2002), can be considered to meet this aim. On the other hand, it seems obvious that these kinds of data have a great potential to diminish the fieldwork and cosequently, lowering the costs of forest data acquisition. These data are applied in different forest researches including typology studies (May *et al*., 1997; Mickelson *et al*., 1998; Huang *et al*., 2001). In arid and semi-arid regions also, various investigations have been recently carried out using satellite data (Satterwhite & Henly, 1987; Leprieur et al., 1996; Hurcom & Harrison, 1998; Todd & Hoffer, 1998). In this study the potential of ETM+ data for forest type mapping in the national park of Khabr as a part of arid and semi-arid regions was investigated.

2. STUDY AREA

The study area measuring 1818 hectares is a part of the national park of Khabr in Kerman province in the south east of Iran. this area extends from 28º 46' 00" to 28º 49' 30" N and from 56º 28' 30" to 56º 37' 30"E. The elevation ranges from 2000 to 2600 meters above sea level. The main forest species are *Pistacia atlantica, Acer monspessulanum, Juniperus excelsa*, and *Amygdalus* spp. Accompnied by secondary species like *Celtis caucasica, Cotoneaster persicus* and *Crataegus microphylla*.

3. DATA

In this investigation ETM+ data, including 7 spectral bands dated 19 may 2000, were applied. Furthermore, 1:25000 digital topographic maps were used to determine GCPs and also to evaluate the precision of geomatric correction.

4. Methods

4.1 Ground truth map

In this research, based on the present possibilities, a strip ground truth map, allocating 50% of the total area measuring 909 ha was prepared. Forest types were estimated qualitatively in the strips, based on typologic definitions (Gorgi Bahri, 2000). Large numbers of recognized forest types and small area of some of them, made the types to be generalized and consiquently 9 forest types including 4 pure types (*Pistacia atlantica*, *Acer monspessulanum, Amygdalus* spp., and *Am. Scoparia*), 4 dominant types (*Pistacia atlantica, Acer monspessulanum, Amygdalus* spp., and *Am. Scoparia*) and a mixed type were concluded. In these types if the canopy area of a species was more than 90% of the total, a pure type and if it was between 50% to 90% a dominant type was resulted. If the canopy area of the first species was less than 50% of the total and the second species' was less than the first species, a mixed type was obtained (Gorji, Bahri, 2000).

On the basis of the data, resulted from the fieldwork, a vector ground truth map possessing aforesaid forest types was prepared using a GIS approach.

In order to assess the accuracy of the maps resulted from forest classification, the vector GT was then rasterized. In this Process, cell size of the raster GT was decided to be 5 meters, to keep the details.

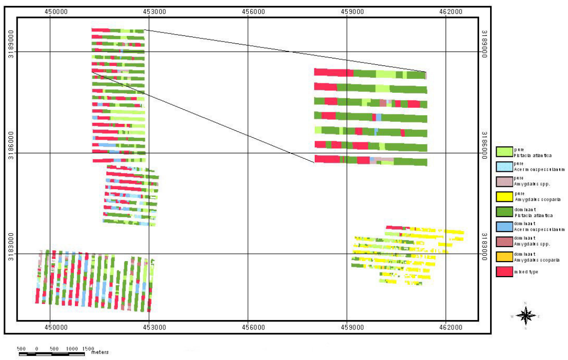

Figure 1. The ground truth map for 9 forest types

4.2 Digital image processing

It is necessary to be aware of geomatric and radiometric situation of the image, before performing digital processing (Darvishsefat, 1994). Therefore, different geomatric and radiometric distortions such as striping, banding, sweep error, duplicate pixels and also atmospheric error of existing clouds were inspected, while any noticeable distortion was found. Orthorectification was then implemented utilizing 14 GCPs, digital elevation model and ephemeris data using toutin model (Ann., 2001). In this regard while performing resampling, pixel size was distinguished to be 5 meters. In order to seperated forest types more efficiently, various synthetic bands were created applying band ratioing (Terrill, 1994; Sandison, 1999), principal component analysis, tasseled cap transformation and bands fusion (Darvishsefat, 2002).

In addition, different vegetation indices such as PVI, SAVI, MSAVI1, MSAVI2, TSAVI1, TSAVI2 and WDVI were produced using soil line parameters, to reduce soil effect (Terrill, 1994; Sandison, 1999; Jelenak, 2001).

The soil line relation was as below:

$$Y = 0.034937 + 0.999654\,X \qquad (1)$$

Where X= ETM3
Y = ETM4
r = 0.99

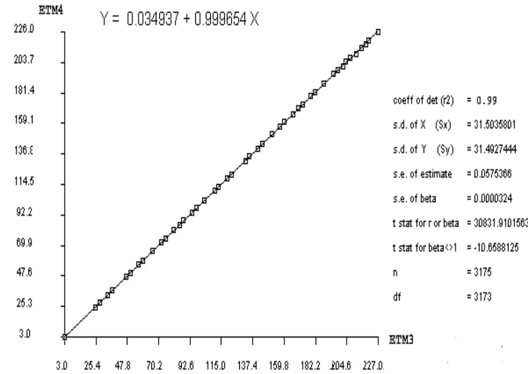

Figure 2. Scatter diagram of digital numbers of pixels containing bare soil ETM3 (X axis) and ETM4 (Y axis)

4.3 Image classification

Based on the divergence between class signatures which is calculated from the class sample means and the class covariance matrices, the best band set were selected (Richards, 1999; Ann., 2001), using training areas. A supervised classification was then implemented utilizing maximum likelihoo (ML), Minimum Distanct to Mean (MD), Parallelepiped (PPD) and Spectral Angle Mapper (SAM) classifieres. In order to eliminate single pixels deviating from the neighborhood a mode filter (7×7 pixels) was done on the resulted maps. Ultimately, accuracy assessment was carried out through a pixel by pixel comparison of the classified outputs by the ground truth map, considering overall accuracy, kappa coefficient, user and producer accuracies.

5. Results

1- The RMS error resulted from orthorectification was 6.9m (0.23 pixed) along with the X axis and 6 m (0.2 pixel) along with Y axis. Desired coincidence between the roads and rivers layers of digital topographic maps and the rectified image indicated high precision of the orthorectification.
2- The best result of classifying 9 forest types was obtained by MD classifier with overall accuracy and kappa coefficient equal to 18.45% and 11.05% respectively.
3- Because of undesirable separability between pure and dominant types, understood from Bhattacharrya distance and trasformed divergence critera and confusion matrices, these types merged and the classification was iterated with 5 types. The best overall accuracy and kappa coefficient inferred from MD classifier were 47.13% and 22.83% respectively. In this case, separability criteria, user and producer accuracies for amygdalus scoparia were better than those of the others.
4- Finally by merging all of the types except for *Amygdalus scoparia*, because of its better results, the classification was performed with 2 types consisting *Am. Scoparia* and the others as a mixed type. The best overall accuracy and kappa coefficient obtained by MD classifier were 92.16% and 67.58% respectivley.

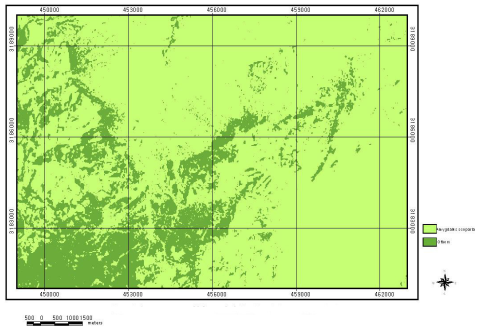

Figure 3. Forest type map with 2 types including *Amygdalus scoparia* and others

6. Conclusions

In this research inspite of utilizing precise digital processing techniques and using an accurate ground truth map, the results achieved were modest. A conclustion to be made from this investigations is that low canopy area (up to 45%) strengthens the role of bare soil and background cover in the reflection achieved.

Similar researches confirm this too (Hurcom & Harrison, 1998; Todd & Hoffer, 1998; Schmidt & Karneili, 2001). On the other hand there are many forest types in the study area which they change gradually. Therefore there is not any distinct boundary between the types and mixed pixels will increase.

All of the aforesaid instances make spectral similarity between density classes and forest types and this causes misclassification. About *Amygdalus scoparia* type which was separated from the other types more favourably, it can be mentioned that in this forest species, lack of leaves or few numbers of them and needle phylla, make the light to influence into the crown. Furthermore, all of the phylla are green, thus in this type in comparison with the other types, by the same canopy area percent, more chlorophylls will be at the sensor field of view. On the other hand this type was distributed completely far from the other ones and the background reflection is mostly related to the bare soil because the background vegetation is very poor. So that it can be said that it is possible that the satisfactory results of this type indeed indicated desirable separability of the soil and not the forest type.

On the basis of the results, it must be noticed that in such a region, ETM+ data do not show a heigh potential for forest type mapping, although this conclusion needs further validation. The other satellites data with higher spatial resolution like SPOT, IRS-LISS and ASTER and also improved analysis methods are consequently recommended.

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