

Evaluations of different indices for canopy/ land cover estimation in Khalkhal County (North West of Iran) using IRS imagery

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ABSTRACT: This study was conducted to use IRS P6LISSIII imagery to examine different indices for estimating land / canopy cover in Khalkhal County in south of Ardabil province. An image by considering seasonality patterns and phenological stages was selected. Pre image processing stages such as atmospheric and geometric correction and topographic normalization were conducted before image utilization. Most of the used and currently using indices in Iran by different purposes were considered; indices such as DVI, RVI, NDVI, PVI, and SAVI were selected for final analysis. Initially land / canopy cover of 114 sites using point intercept method (1000 points) were estimated and sample sites using GPS were recorded. Collected points transferred on image and using zonal-based attributes / statistics average of 16 pixels around the GPS points transferred to excel file and correlated with field collected data. Results show that except NDVI, SAVI and PVI all of the other examined indices have no significant relationships with total canopy and intensive canopy covers (gardens, trees, meadows and forest), herbs, shrubs, stones and bare soils. Although NDVI, SAVI and PVI had significant ($p>0.05$) relationships with total canopy and intensive canopy covers, however these indices did not show significant relationships with herbs, shrubs, stones and bare soils. According to these results more consideration for a particular land / canopy cover and more investigation on the same ecological zones are required to conclude the suitability of a specific index in the south of Ardabil province. The next step of this study is to examine the derived indices from whole image and accuracy assessment process.

1. INTRODUCTION

Canopy cover can be considered as an ecological and a management indicator. It is considered the best indicator of protection of the landscape from degradation (Bastin et al. 1993). It is one of the commonly measured attributes in vascular and non-vascular plant sampling for rangeland assessment (Bonham. 1989) as well as being used in estimation in traditional ground-based methods (Bonham. 1989). Canopy cover of vascular and non-vascular plants is a characteristic expression of ecological dominance.

Spectral indices are simple mathematical combinations of two or more spectral values to produce a single value that describes a photosynthetic organism's quality or condition and quantity (Tucker, 1379; Allan et al, 2003). The basic idea of a spectral index is to collapse the multispectral or hyperspectral remote sensing values to a particular measure, which is related to some characteristics (i.e. vegetation cover and greenness) of an object (Rundquist , 2002). The Simple Ratio (SR), Normalized Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI) are examples of the most common vegetation indices to analyze the green cover of photosynthetic vegetation and / or soil noise effects in image processing.

Extensive literature are exist in developing, calibration and application of different indices in throughout the world (Tucker, 1379; Allan et al, 2003). Most of the literature in Iran, have been conducted with the application of different indices without field versus image data calibration (Farzadmehr et al, 2005; Arzani et al, 2009). This study was conducted to evaluate the capability of the most commonly used indices for land/ canopy cover estimation in south of Ardabil province in North West of Iran.

2. STUDY AREA

Khalkhal County with 292867 ha is located in North West of Iran (south of Ardabil province / Figure 1a). Altitude varies from 521 to 3230 m (Figure 1b). Mean annual precipitation is about 360 mm (15.7% of that in March and 1.7% in August as the highest and lowest during a year), mean annual temperature is 9.7° C (Max 35 and Min -35.5° C), and generally with cold semi-arid climate. As can be seen from Figure 2, more than 95% of this county is mountainous area, the major land uses are rangeland (more than 80%) and rest of the land uses are dry

farming, irrigated farming, gardens, residential and forest lands respectively. Major physiognomic vegetation types on natural lands are: Juniperous semi-steppe woodlands, hyrcanian forest, steppic shrublands and meadows.

Initially, digital 1:25000 topographic maps of the study area were used for image georegistration and producing of the DEM map of the study area (Figure 1b).

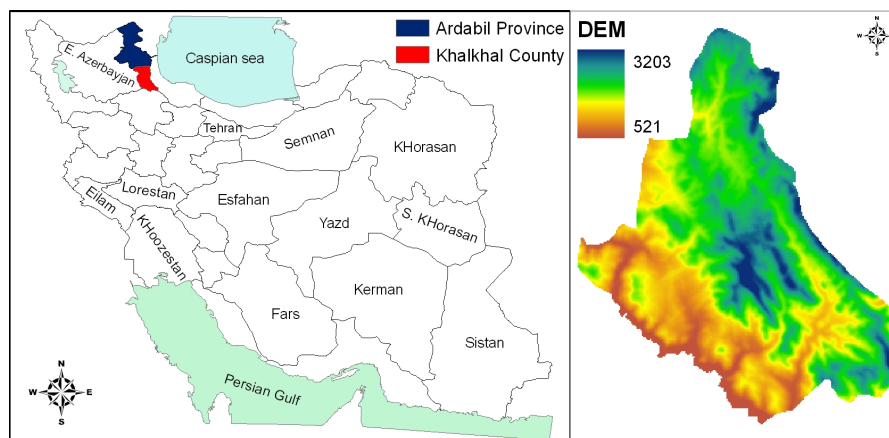


Figure 1. a) Study location in Iran and Ardabil province, b) DEM of the Khalkhal County

By considering seasonality and phenological patterns of the Khalkhal County, according to the 2682 m altitude differences, there is no considerable seasonality variation, but phenological stages are different (there are 4 discernable seasons, but with different temperature and type of precipitation in different elevation, thus phenological stages are different). However, by considering these issues the best time of the image selection to cover both low and high altitude areas was to select an image in late April or early May of each year. Because of the moisture affects on the image acquired data (Bastin et al. 1993). Fifteen days before image selection were considered however there was no considerable rainfall in this period. Therefore an image by considering seasonality and phenological patterns and moisture content was selected.

The © IRS P6LISSIII copyright 2008 (166-34/ the available image/ 2008/5/26) was selected based on average of the full growth of annuals and perennials for this study. Obtained image has been registered to the UTM map projection with a datum of the WGS84. However, according to the collected Ground Control Points (GCP) and other GIS layers such as registered topographic maps, acquired images were still required to be rectified by affine transformation model to the WGS84 to align accurately with the GIS layers and collected GPS points. The study area is located in one zone 39. In image rectification Root Mean Square (RMS) errors of 25 points selected from 50 GCP were less than 2 pixels and total RMS was 1.45 pixels.

Image preprocessing stages, including atmospheric, geometric and radiometric corrections, topographic normalization and image enhancements, were conducted before image utilization (Chavez & Jr, 1996; Chander, & Markham, 2003). Most of the used and currently using indices in Iran by different purposes were considered in this study; indices such as DVI, RVI, NDVI, TNDVI, PVI, SAVI, MSAVI, TSAVI initially using pixel values, which were derived from the selected image on the around of GPS records were considered. Finally DVI, RVI, NDVI, PVI, and SAVI were selected for this study. Land / canopy cover of 114 sites using point intercept method (1000 points) were estimated and sample sites using GPS were recorded. Major land covers such as bare soil, litter, stone (> 3cm), non woody plants, shrubs, trees on different land uses were recorded. Collected points transferred on image and using zonal-based attributes / statistics, average of 16 pixels around the GPS points transferred to excel file and correlated with field collected data using SPSS ver. 12 for correlation analysis.

An accuracy assessment of the NDVI index was undertaken using confusion matrices and Kappa statistics (Congalton & Green, 1999). The accuracy of the classified image was assessed using field data collected in the study area. Producer and user accuracies for each class were calculated along with the overall accuracies and Kappa statistics.

3. RESULTS AND DISCUSSION

The collected sample points and derived NDVI (as a sample of derived indices from the selected image) are presented in Figure 2. As shown in this Figure, according to the accessibility limitation, the sample locations were selected regarding to the existing roads. As Figure 3 shows, the NDVI value fluctuated from -0.75 to 0.27, which by considering the theory of NDVI that varies from -1 to +1, there are no 0 and 100 percent canopy cover at the study area. However, by considering the field visit and collected data and existing forest area with 100% canopy cover the validity of the NDVI in applying to such area is questionable and needs more investigation.

Results of correlation for different indices and land covers are presented in Table 1. Results show that except NDVI, SAVI and PVI all of the other examined indices have no significant relationships with total canopy and

intensive canopy covers (gardens, trees, meadows and forest), herbs, shrubs, stones and bare soils. Although NDVI, SAVI and PVI had significant ($p > 0.05$) relationships with total canopy and intensive canopy covers, however these indices did not show significant relationships with herbs, shrubs, stones and bare soils. According to these results more consideration for a particular land covers and more investigation on the same ecological zones is required to conclude the suitability of a particular index in Ardabil province. The next step of this study is to examine the derived indices from whole image and accuracy assessment process.

In literature, there is also evidence that NDVI cannot be accurately transformed between field and satellite scales in a linear fashion (Quattrochi et al, 1997; Goodin & Henebry, 2002). Indeed, there is little knowledge of interactions between spatial heterogeneity in a photosynthetic canopy and spatial scale of measurement, although researchers are beginning to address such issues (Quattrochi et al, 1997; Goodin & Henebry, 1998). Another problem with NDVI is that often it is not a product of the process with which it is correlated [5]. These include dissimilarities in canopy background (i.e. substrate) reflectance characteristics: the presence of leaf litter, senescent (i.e. standing dead) vegetation, and woody materials; differences in green vegetation coverage, density, geometry and phenology; short and long-term climate variation; canopy bi-directional reflectance properties; and contrasting management practices (Huete, 1988).

The accuracy of derived NDVI, depended on many issues, including the familiarity of the analyst with the pattern and distribution of different land cover components (e.g. woodland, shrubland, etc), as well as familiarity with their spectral and spatial patterns on the remote sensing imagery. Overall by considering the summary of confusion matrices (Table 2) results were unacceptable, which means using IRS images for different indices on the areas such Khalkhal county more consideration are required.

To sum up, by considering the results so far, the next step of this study will: 1) Increasing the sample sites; 2) Testing different images and sensors; 3) Testing other indices; 4) Deriving possible new indices; 5) Testing segmentation / physiognomic type based indices; and 6) Testing altitude based / phenological based indices.

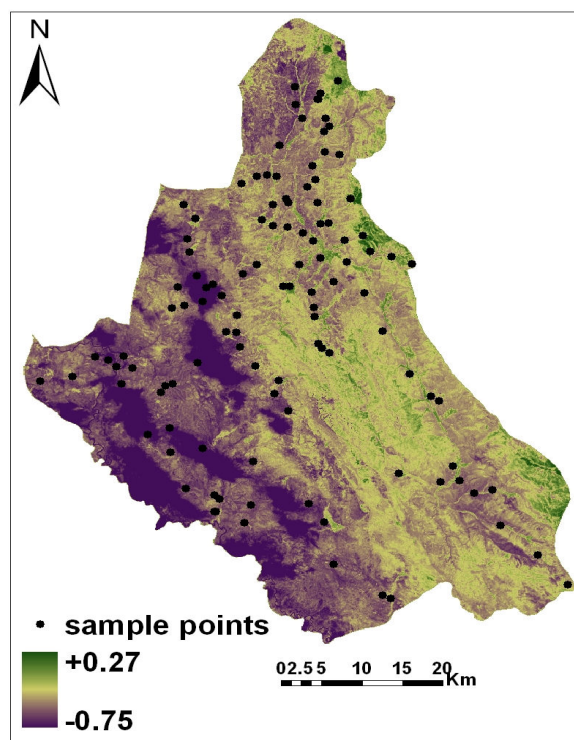


Figure 2. Derived NDVI indices for the study area

Table 1. Summary of confusion matrices for the accuracy assessment

Pre-defined class name	Producer (%)	User (%)	Kappa
Bare ground (Stone / Rock / Outcrop+ Litter + Bare ground)	14	11	0.07
Meadows / forbs / herbs	25	22	0.17
Shrublands	12	14	0.11
Woodlands	21	18	0.18
Forest / intensive tree + horticultural lands	47	32	0.22
Total vegetation cover	41	32	0.31
Overall accuracy =24%			
Overall Kappa =0.18			

Table 2. Formulas and abbreviations for the spectral vegetation indices used in this study. Correlation significance among the field collected land covers and derived spectra from IRS P6LISSIII image (2008/05/26)

Indices	Formula	Correlation Significance Number	Land covers					Intensive tree canopy/ Total canopy
			H erbs	Bar e soil	S tone	L itter	Sh rubs	
DVI	Nir-Red	R ²	0.03	0.04	0.01	0.02	0.07	-0.17
		Sig.(2-tailed)	0.77	0.68	0.94	0.87	0.44	0.08
		N	111.0	113.0	113.0	112.0	111.0	113.0
RVI	Red/Nir	R ²	0.00	0.03	0.00	0.00	0.06	-0.13
		Sig.(2-tailed)	0.96	0.77	0.96	0.97	0.51	0.18
		N	111.0	113.0	113.0	112.0	111.0	113.0
NDVI	$[(R_{895} - R_{675}) / (R_{895} + R_{675})]$	R ²	0.04	0.03	0.01	0.02	0.05	-0.19*
		Sig.(2-tailed)	0.69	0.79	0.91	0.85	0.57	0.04
		N	111.0	113.0	113.0	112.0	111.0	113.0
SAVI	$[(R_{nir} - R_r) / (R_{nir} + R_r + L)](1 + L)$	R ²	0.04	0.02	0.01	0.02	0.05	-0.19*
		Sig.(2-tailed)	0.66	0.82	0.91	0.84	0.51	0.04
		N	111.0	113.0	113.0	112.0	111.0	113.0
PVI	$[(R_{S_r} - R_r)^2 + (R_{S_{nir}} - R_{nir})^2]^{0.5}$ or sin(a) NIR-cos (a) red	R ²	0.08	0.17	0.17	0.08	0.11	0.20*
		Sig.(2-tailed)	0.38	0.08	0.07	0.43	0.51	0.03
		N	111.0	113.0	113.0	112.0	111.0	113.0

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