Estimating the Rangeland Vegetation Cover of Tang-e-Sayyad Region (Chaharmahal-o-Bakhtiary Province) Using IRS LISS-III Data

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Received: Jan, 2011 Accepted: Oct., 2011

Introduction
Rangelands encompass about 55% of Iran's total area. These lands are the habitat of Iranian nomads and their animals. The extension, variations in climate, soil and vegetation cover require specific management. Having knowledge about the vegetation parameters, especially the coverage, is highly significant for efficient utilization and erosion control of the rangelands. Vegetation cover is defined as the percentage of ground covered by live vegetation within a given reference area such as a plot. Normally vegetation cover is measured using a reference frame, a ring, a square or a circle. The reference frame allows the researcher to focus on a small area (depending on the size of the frame) and estimate vegetation cover versus bare rangeland areas. Point-intercept and line-intercept methods were suggested by some researchers. Vegetation cover is an indicator for some environmental indices. For instance, Amaral, et al. (2007) applied normalized difference vegetation index (NDVI) along with climatic and topographical factors for the probability distribution of five plant species. They reported that the application of NDVI had increased the efficiency of models.
Firmino, et al. (2009) studied the relationship between NDVI and precipitation. They concluded that NDVI is a spatial function of precipitation. Using remote sensing techniques for the monitoring of vegetation cover in rangelands of Iran is inevitable due to the extensive and dynamic behavior of these land covers. Normally, using remote sensing for vegetation monitoring corresponds to the application of vegetation indices, which are suggested to minimize the external impacts on spectral data and determining vegetation cover and leaf area index. Taylor et al. (1985) reported the existence of significant correlation coefficients between biomass and grass-prosopis cover, and NDVI and ratio vegetation index (RVI), calculated from NOAA-7 data.
Rondeaux, et al. (1996) compared the correlation coefficients of six vegetation indices of SAVI, OSAVI, TSAVI, GEMI, NDVI and MSAVI with vegetation cover and reported that MSAVI is the most sensitive index to vegetation cover. Zhaa, et al. (2003) studied the vegetation cover of grasslands in Western China using 68 plots, and reported that NDVI had the highest correlation coefficient with vegetation cover percentage. Madoganda et al. (2008) assessed biomass and leaf area index of deciduous forests of Westchats in India, by using IRS-P6 LISS-IV. They reported existence of positive correlation coefficients between satellite data and leaf area index and biomass.
Tang e Sayyad National Park is the habitat of precious wild life in the semi arid zone of Charmahal-o-Bakhtiari Province. Assessing the vegetation cover of this national park contributes to management, indirect estimation of animal capacity, and soil conservation of the park. This study was carried out at the early season of drought of 2008.

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The objectives of the research were: 1) to study the relationship of the conventional vegetation indices and vegetation cover in Tang-e Sayyad National Park, 2) to evaluate the capability of IRS-P6 LISS-III for detecting the vegetation cover of different vegetation types in early season of a drought, 3) to examine the possibility of estimating vegetation yield via vegetation cover.

Materials and Methods

Study site
The mountainous National Park of Tang-e Sayyad is located between the geographical coordinates of 32° 03' to 32° 17' N and 50° 59' to 51° 09' E. It covers an area of over 27000 ha and is located in the east side of Shahrekord City, the centre of Charmahal-o-Bakhtiari Province. The soils are mostly shallow and classified as Lithic xerorthent and Typic xerorthent. According to Bobek's Ecological Classification (1951), the ecological zone of the National Park of Tang-e Sayyad is Zagross Makran with a large variation of vegetation species cover. Mean annual precipitation and temperature are 424 mm and 11.5 °C, respectively. Altitude varies between 2100 and 3100 masl. Twenty vegetation types and 250 vegetation species from 52 families have been recognized in the Park. Among these, families of high frequencies are Chenopodiaceae, Compositeae, Umbellifereae, Papilionaceae, Caryophylaceae and Laniateae. The Park also is the habitat of goat, leopard, shocal, wolf, Persian squirrel, Indian crested porcupine, chukar partridge, hedge hog, kuil's pipistrelle, Caspian snow cock, kestrel, saker, sand boa, versicolored wood snake, Caspian pond turtle and large-scaled rock agama.

Sources of Information
The resources of spatial data and attributes are:
1. Topographic maps (1:25000) which were used for geometric correction of images.
2. On time IRS-P6 LISS-III data in 4 bands acquired on 28th of April 2008 corresponding to the field work.

Other information resources were field data. The location of 30 sampling units were determined randomly in different vegetation types. Throughout every unit which covers 3×3 imagery pixels, 12 sampling plots were determined randomly. The vegetation cover of grasses, forbs and bushes were measured in each plot and the average coverage areas of 10 plots were used for training the models. The average coverage areas of 2 plots were applied for the validation of statistical models.

Image processing
Imagery data consists of 4 raw bands which were corrected for radiometric distortions by being converted into radiation and reflection. The images also were corrected geometrically using 16 ground control points.

Vegetation indices
Twenty four conventional vegetation indices were considered. The coordinate of each plot was determined and the reflection of the corresponding pixels in each appropriate band was applied for the calculation of vegetation index.

Statistical analysis
The correlation coefficient between vegetation indices and the coverage of grasses, forbs, bushes, grasses plus forbs and total vegetation were calculated. The vegetation indices of high and significant correlation coefficients with vegetation cover types were used in a regression model for the estimation of coverage area. The validities of models were estimated using reduced variance (RV) and mean estimation error (MEE) (eq. 3 and 4).

Results and Discussions
Among 24 vegetation indices, 15 were significantly correlated with grass coverage. The highest and lowest significant coefficients belonged to PVI and MSI, respectively. The best regression models for estimating vegetation cover were selected based on the coefficient of determination and standard error of
estimation. Gong, et al. (2003) and Haboudane, et al. (2004) also used coefficient of determination for selecting efficient models. The results showed that DVI, in a growth model with the lowest standard error of estimation and the highest coefficient of determination, is the best index for the estimation of grass coverage. The same 15 vegetation indices were statistically suitable for the estimation of the summation of grasses and forbs' coverage. The DVI was also the most suitable index for the estimation of the coverage of grasses plus forbs (eq. 6). Equation 6 is a growth model. The standard error of estimation, RV and MEE of the model were 0.379, 0.68 and 0.23, respectively. Due to the image acquisition carried out in early season, we had few samples with high vegetation cover, and the models underestimated the vegetation coverage in some cases as high as 12%. Ten vegetation indices showed significant correlation coefficients with the total vegetation cover. The highest and lowest correlation coefficients belonged to MSAVI2 and SAVI, respectively. However, NDVI and a second ordered regression model seemed to be the best method for the estimation of the total vegetation coverage. Steven, et al. (2006) expressed that the nonlinear relationship of NDVI and vegetation factors could be due to dark soil background and vegetation shadows in the canopies. In this case study, shadows of bushes and vegetation residuals at the surface might lead to a second order model. The correlation coefficients between vegetation coverage components and their yield were calculated. The results showed strong and significant (P<0.01) correlation coefficients between the coverage areas and the yields of grasses, forbs, bushes and the summation of grasses and forbs. The correlation coefficient between the total vegetation cover and total yield was not significant. Overlaying of different vegetation types might lead to such results. As the National Park is the habitat of precious herbivores such as goats, using vegetation cover for the estimation of the yield of the Park in critical conditions like early seasons is valuable.

Key words
Vegetation cover, IRS-P6 LISS-III, Tang e Sayyad, Vegetation Indices, Rangeland