VOL. 7, NO. 4, APRIL 2012 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

PROBABILITY MEASUREMENT TO ESTIMATE FOREST TREE DIVERSITY USING IRS-P6 SATELLITE IMAGES IN CASPIAN BROAD LEAVED FORESTS

Mir Mozaffar Fallah Chai, Shohreh Bayat and Seyed Armin Hashemi
Department of Forestry, Lahijan Branch, Islamic Azad University, Lahijan, Iran
E-Mail: mir_mozaffar@yahoo.com

ABSTRACT

In present study, the ability of LISS III sensor data of IRS-P6 satellite to estimate species diversity of woody plant species of forest was studied in Gombol forests in Lahijan. Ground information was collected through selective sampling with sample plots of 900m^2 area. Geometric conformity was performed using 20 ground control points and mean root error of 0.32 in x axis and 0.37 in y axis. Chavez model was used for atmospheric correction of data. Shannon - veiner species diversity was used to study the species diversity. Amount of this index was calculated for each plot. Then amounts of spectral values for each sample plot were extracted in different bands. Best subset regression was used to analyze the relationship between species diversity and mentioned bands. Results of regression indicated that studied polynomial equations as independent variables could estimate species diversity of trees and shrubs better than other bands or compositions (R^2 = 0.449). Results indicate relatively low ability of IRS-P6 satellite data to estimate tree and shrub species diversity in study area.

Keywords: species diversity, shannon - veiner, Gombol forests, IRS-P6 satellite, Lahijan.

INTRODUCTION

Given increasing population of the world and development of science and technology, burden of anthropologic destruction on the nature has increased and the nature is losing its initial natural status (Javanshir, 1372). Excess exploitation of natural resources during past years specifically during the 20th century has led to gradual decline of many susceptible ecosystems world wide including forests (Pile var, *et al*., 2002). Forests are among most important genetic reservoir of the world where biodiversity is a fundamental factor for them to play their roles (Akhany, 2001).

Term "Biodiversity" is abbreviation of statement “Biological Diversity”. According to United Nations Conference on Environment and Development (UNCED), any variation between organisms in all resources including terrestrial, marine and other aquatic ecosystems and its ecological processes is called biodiversity (Mahmoudy, 2009).

Understanding the fundamental concepts of biodiversity is very important for foresters, policy makers and other managers of natural resources since conservation of biodiversity is valuable and is considered as a major goal in management of landscape and natural resources. Conservation of biodiversity in forest ecosystems manages the forest sustainability (Pour Babaiy, 2009).

Nowadays, diversity and composition of woody species are estimated in the forests world wide to understand the changes created in ecosystems (Poor Babayie, 2009). So far, many proposals have been prepared and performed for management of Northern Iran forest watersheds. Continuous administration of these plans has created changes in plant and animal species and their frequency. But no step was taken to estimate and record these changes. Therefore, estimation of forest ecosystems diversity is very important. So that, if such estimates are performed in parcel, forest types or series level, they may be very efficient and suitable to use in forest management projects (Aminy, 2002).

Biodiversity discussion is often focused in species diversity of ecosystem diversity and most common of these is species diversity (Lust and Nachtergale, 1996; Dahiels *et al*., 1995). The aim of present study is to estimate species diversity which is including species number (richness) and relative number of each species individuals (frequency or evenness) in a given area or group of organisms. Usually 3 levels of species diversity are considered: their α diversity means diversity within ecosystem, β diversity means diversity between two growing place or 2 neighboring ecosystems along the environmental gradient and γ diversity means the diversity in a landscape (Poor Babayie, 1384). In present study diversity has been estimated using different indexes.

Since using conventional methods to estimate forest biodiversity is very expensive and time-consuming, using satellite images may be considered as a effective means to continuous management of natural resources due to their unique properties such as rapid and conform covering, continuous imaging and being multi-spectral. Increasing abilities of data both in spectral and special viewpoint encouraged many managers and policy makers to replace this kind of data to previous techniques due to decreased cost and time and obtaining updates.

To evaluate these changes and recognizing woody species status, it is required to obtain information on tree and shrub species types and their populations. And according to the fact that this is necessary in forest management, it is required to be performed with low cost and time and with acceptable precision. For this purpose, satellite data may be a useful means to meat this goal.

ARPN Journal of Agricultural and Biological Science

Naueimy (1378) used TM data of lands at satellite to evaluate and prepare the map of diversity and richness of species in Golestan national park. He studied the relationship between values of plant indexes to richness and diversity based on ground data. Results indicated that there is a strong relationship between vegetation indexes and floristic diversity.

Parma vishtayie (1388) in a study analyzed the ability of ETM+ measuring data prepare the maps of diversity and density of forest trees canopy covering in Ghalajeh forests of Kerman shah province. Results of this study indicates relatively low ability of ETM+ data to prepare the canopy covering density map and to estimate tree and shrub species diversity in study area. Walker *et al*. (1992) in a study in California confirmed a relationship between richness of plant species and NDVI plant index.

Stomes watts (1993) published an article titled "a research instruction for remote sensing for mapping and displaying biodiversity". The aim of this article was to suggest a study technique for using remote sensing data and to develop our knowledge on special distribution of species richness and its echologic determinants and to predict its response to overall changes which in present study its biodiversity, its determining ecological parameters and abilities of remote sensing have been discussed.

Bawa *et al*. (2002) using IRS 1C satellite images, determined the diversity richness of forest species with plant indexes, correlations between NDVI plant index and richness values obtained from Shannon index based on ground data. Results indicated that there is positive relationship between NDVI and tree species diversity.

Gille spine (2005) using ETM+ obtained corrected determination coefficient of 0.50 for NDVI to study woody species diversity in tropical dry forests of southern Florida.

Gillespine *et al*. (2009) used ETM+ measuring NDVI index to determine tree species richness in panama tropical forests and obtained 0.58 corrected determination coefficient.

Nagendra *et al*. (2010) compared the ability of Landsat images to Ikonos images to estimate plant diversity in central India tropical dry forests. Results of this study indicate high precision of Ikonos data to estimate biodiversity.

MATERIAL AND METHODS

Study area

Series 2 of Gombol forest with 4099.2 h^2 area covers middle and northern part of Koured Rood watershed. This series is considered as part of Lahijan Natural Resources administration conservation domain and covers part of eastern forests of managerial domain of Natural Resources administration of Guilan. This series is located between $49° \ 59' \ 0''$ to $70° \ 7' \ 30''$ eastern longitude longitude and $37° \ 5' \ 0''$ to $37° \ 12' \ 30''$ northern altitude. Its minimum altitude from open sea surface is 50 m and its maximum altitude from sea surface is 830 m. Its common direction is towards North (Forests and Rangelands Organization of Iran). Study area in present study is parcels 1, 3, 6, 18, 19 and 20 of Gombol series 2.

Satellite data

In present study IRS-P6 satellite's LISS III sensor data related to Ahust 2008 was used.

Table-1. Characteristics of LISS III remote sensor data of IRS-P6 satellite.

Image width	Harvesting period	Radiometric resolution power	Spectral range	Resolution power	Number of bands
140 KM	24 days	7 Bit	520 - 590 nm	23.5	Green B2
			620 - 680 nm		Red B3
			770 - 860 nm		Near infra - red B4
			1550-1700 nm		B5 infrared with short waves

Providing ground data

In present study, selective sampling with 900 m^2 sample plots was used. 30 square shaped sample plots with 30×30 m area were performed. Center of each sample plot was determined using GPS and information such as species type, height and diameter at breast height (larger than 7.5 cm) was collected.

Pre processing and post processing of satellite data

To assure the image conformity rate, forest road layering with GPS was used to study the accuracy of geometric data. Then geometric correction was performed using PCI GEOMATICA software. Most common nonparametric technique to perform geometric conformity is using ground control points (Jahedy and Farrokhy, 1375). To perform land referencing, 20 control points were defined in intersection of roads - waterways and were marked on corresponding images. Then by re sampling

ARPN Journal of Agricultural and Biological Science

and nearest neighbor technique images were drawn and mean root error of 0.32 in x-axis and 0.37 mean root error in y-axis were achieved.

Chaves method (decreased numerical value of dark pixels) was used for atmospheric correction of image.

In this method it is assumed that pixels may be found in each image band whose values are zero or near unity, such as water. Therefore, atmospheric effect of deviating radiation is added to pixels of each band as a constant value. So, to remove radiometric error, each band's pixels values must be subtracted from related minimum DN. This process is performed to decrease atmospheric distribution effects on the image.

Thus, decreased darkness of phenomenon is a simple method which is used widely in many cases (Chavez, 1996). In this study, ENVI software is used for removing radiometric error. Then, satellite image vegetation indexes RVI, TTVI, TVI, AVI, IPVI and NDVI were extracted.

Table-2. Vegetation indexes of satellite image used in present study.

Order	Index relation type	Abbreviation	Index Latin name	Index name
1	$NRVI = \frac{(NIR - RED)}{(NIR + RED)}$	NDVI	Normalized deference vegetation index	Normalized vegetation difference index
2	$IPVI = NIR/(NIR + red)$	IPVI	Infrared percentage vegetation index	Infrared percentage vegetation index
3	$AVI = MIR - red$	AVI	Ashburn vegetation index	Ashburn vegetation index
4	$TVI = \sqrt{\frac{NIR - RED}{NIR - RED} + 0.5}$	TVI	Transformed vegetation index	Transformed vegetation index
5	$TTVI = \sqrt{\lvert NDVI + 0.5 \rvert}$	TTVI	Thiam's transformed vegetation index	Thiam transformed vegetation index
6	$RVI = \frac{RED}{NIR}$	RVI	Ratio vegetation index	Ratio vegetation index

Tree and shrub diversity

In this step, extracted bands from satellite image are transferred to GIS. Mean DN of corresponding pixels in each sample plot are extracted in different bands. Additionally, ground data are studied suing Ecological methodology software and Shannon - veiner richness index is extracted for each sample plot.

Shannon - veiner function

$$H' = -\sum_{i=1}^{s} P_i \log_2 P_i \quad (1)$$

H' = Shannon - veiner species diversity index.
P_i = i th species number to total number of species ration.

Statistical analysis

Relationship between Shannon - veiner diversity index and spectral values were studied through best subset regression and best regression model was recognized. In the best subset regression, all the possible regression models related to independent variables are studied and based on parameters of determination coefficient and RMSE, the best regression model was selected (Mesdaghy, 1383).

RESULTS

After geometric correction of images, geometric correctness of images was affirmed by placing road layering on those images. After extracting the numerical values of images in sample plots location (according to Table-3), relationship between Shannon - veiner index as dependent variable and spectral values as independent variable were recognized using the best subset regression. Results of regression indicated that polynomial equations used as dependent variables can estimate trees and shrubs species diversity better than other utilized bands and compositions. The rate of R^2 extracted from polynomial equation for different bands are given in Table-4.

Before using satellite images for analysis, it is required to ascertain their geometric and radiometric quality. Presence of geometric errors in LISS III image in present study supports this issue. In this study, geometric correctness of study area satellite images was affirmed by adjusting the road and points extracted by GPS with corresponding roads and points on the image.

Results of previous studies in other countries and in our country indicate the importance of these studies in different conditions of forest ecosystems.

In this study also the ability of IRS - P6 satellite data to estimate tree species diversity in Gombol Forests of Lahijan was evaluated. To achieve optimum results, 6 different artificial bands were used and regression taking was studied with all possible regression models and best regression model was selected.

Synchronous usage of multi - spectral and pancrometric data in image combination process improved

ARPN Journal of Agricultural and Biological Science

the ability to interpret the visual data. As mentioned in Shetabi *et al*. (1388), image combinations don't has any priority on using original data in respect of numerical interpretation of image.

In this study indexes AVI, IPVI, TTVI, RVI, TVI and NDVI are used and it is recommended to use original and artificial bands in further studies.

Achieving 0.45 total correctness in this study is near the results of Gillespie (2005) which was performed in Florida and achieved total correctness of 0.50. Additionally in another study by Gillespie *et al*. (2009) which was performed in Panama tropical forests, 0.58 total correctness was achieve which is near to results of this study.

Table-3. Shannon - veiner index and numerical value extracted from different indexes of satellite images vegetation index.

IPVI	TTVI	TVI	AVI	NDVI	RVI	Shannon-veiner
76	51	1.01	64	0.51	0.31	0.388734
76	52	1.01	66	0.52	0.31	0379192
76	51	1.01	65	0.51	0.32	0.632715
77	53	1.02	64	0.53	0.3	0.494879
75	50	1	52	0.5	0.33	0.881532
75	50	1	59	0.5	0.32	0.641323
72	46	0.97	50	0.46	0.36	0
73	46	0.98	48	0.46	0.37	0.463655
74	49	0.99	53	0.49	0.34	0.37677
72	44	0.97	42	0.44	0.38	0.93877
76	52	1.01	59	0.52	0.31	1.070639
71	43	0.96	41	0.43	0.39	0.995793
74	49	0.99	52	0.49	0.34	0.585164
75	50	1	55	0.5	0.33	0.723254
75	50	1	58	0.5	0.33	0.623654
75	50	1	63	0.5	0.32	1.092271
75	50	1	57	0.5	0.32	0.781837
75	50	1	54	0.5	0.33	0.68773
73	47	0.98	53	0.47	0.35	0.927277
76	53	1.01	63	0.53	0.31	0.657157
74	48	0.99	52	0.48	0.35	0.84792
76	51	1.01	59	0.51	0.32	1.110971
75	51	1	62	0.51	0.32	0
76	52	1	62	0.52	0.31	0.633039
74	48	0.99	47	0.48	0.34	1.074092
76	51	1.01	57	0.51	0.32	1.617096
73	46	0.98	47	0.46	0.36	1.615897
76	52	1.01	64	0.52	0.31	1.693409
76	53	1.01	61	0.53	0.29	1.105539
75	50	1	54	0.5	0.33	1.548063

After performing the regression, determination coefficient for different indexes are extracted according to Table-4.

Table-4. R^2 amount (determination coefficient) obtained for different bands.

NDVI	=	0.429
RI	=	0.40
TTVI	=	0.429
TVI	=	0.359
IPVI	=	0.377
AVI	=	0.449

Results of this study have higher correctness compared to study by Shetaby *et al*. (1388) with 0.327 total correctness. It may be due to higher precision of LISS III sensor compared to ETM+ sensor.

Results of this study significantly differ from Negendra *et al*. (2010) who studied the biodiversity by using Ikonos satellite since they obtained very suitable results on diversity estimation. This difference is attributable to the difference of satellites and very much precisian of Ikonos satellite compared to IRS. Diversity is an important characteristic of vegetation which evaluation requires field harvestation operation with its specific limitations. Thus for its evaluation, complement tools and techniques such as satellite numerical data must be used. Satellite images used must have great radiometric quality and geometric correctness. Since regression models validity depends on reality of data (independent, predicted variables) in first step. Additionally, there must be an exact special adjustment between samples extracted from ground and its corresponding spectral values. Based on results of regression analysis in present study, polynomial equation of NDVI and AVI bands which has been used as independent variable was able to indicate trees and shrubs species diversity better than other bands and compositions. According to the studies of Gillespie (2009), Gillespie (2005) and Perma *et al*. (1388) used NDVI index to study the diversity, presence of this index in best correlation combination indicates good ability of this vegetation index in vegetation studies. This may be due to high spectral radiation along infrared wave length is very important to evaluate tree and shrub species diversity (Bawa *et al*., 2002). The reason for lower corrected determination coefficient of this study compared to Gillespie (2005) and Gillespie (2009), with R^2 = 0.50 and R^2 = 0.58, respectively may be attributable to lower density of this forest due to its destruction following excess exploitation and grazing. But it is necessary to perform similar research to ascertain the validity of this result.

SUGGESTIONS

- Further studies must use satellite images with higher special resolution power to evaluate quantitative characteristics of forest;
- This study must be performed in different forest ecosystem conditions;
- In subsequent studies, systematic randomized data collection must be used; and
- Original and artificial bands must be used.

ACKNOWLEDGEMENTS

By this way, we are thankful to the geographic organization of army powers of the country due to offering satellite images.

REFERENCES

Poor Babayie Hassan and Koda Yardad W. 2010. Woody plant species diversity in series 1 forests of Kalardasht, Mazandaran. Journal of biology of Iran. Winter Edition. 18(4): 84.

Javanshir Karim. 2011. Plant sociology (pamphlet). Faculty of Natural Resources, University of Tehran.

Organization of forests and Rangelands of Iran. 2009. Forestry project of revision of series 2 of Gombol, Natural Resources administration of Lahijan, Iran.

Shataey Jooibary Shaban, Roholla Parma. 2009. Study on possibility to prepare maps of diversity and density of canopy covering of Zagross forests, using EM+ sensor images, (case study: Galajeh forests of Kermanshah province). Journal of Forest of Iran. 2(3): 231-242.

Mohamady Jahangir, Shaban Shetabyl Hashem Habashy and Farhad Yaghmaey. 2009. Comparing remote sensing and ground statistic in evaluation of the number of trees per hectare (Case study: Laveh oak forests of Gorgan). Journal of agriculture and natural resource science of Gorgan, Iran. 15(1): 10-21.

Mahmoudy Jala., Zahedy Ghavameddin Adely., Ebrahim and Ramin Rahmany. 2009. Recognition of plant ecologic groups and their relationship to soil characteristics in plain forests of Kalar Abad. Journal of natural resources of Iran. 58(2): 351-363.

Medsaghy Mansoor. 2008. Regression techniques in agriculture and natural resources studies. p. 290.

Naeimy Babak. 2008. Evaluation and preparing the map of diversity and richness of Golestan national park using satellite data. Thesis of TM MSC, Tarbiat Modaress University. p. 95.

Akhani H. 2009. Plant diversity of Goletan national park. Complex articles of biodiversity and paleology. pp. 217-237.

Amini M. 2007. Methods of comparison and consider the uneven - aged forest stands structure (on the basis of tree number distribution in diameter classes). Journal of Pajouhesh and Sazandegi. 50: 4-13 (In Persian).

Bawa K., J. Rose N. K. Ganeshaiah, N. Barve, M. C. Kiran and R. Umashaanker. 2003. Assessing Biodiversity from space: an Example from the Western Ghats, India. J. Conservation Ecology. 6: 2-7.

Gillespie T. W. 2005. Predicting woody - plant species richness in tropical dry forests: A case study from south Florida, USA. Ecological Application. 15(1): 27-37.

Gillespie T. W., G. M. Moddy, D. Rocchini, A. P. Giorgi and S. Saatchi. 2008. Progress in Physical Geography. 32(2): 203 -221.

Gillespie T. W., S. Saatchi, U. Pau, S. Bohlman, A. P. Giorgi and S. Lewis. 2009. Towards quantifying tropical tree species richness in tropical forests. International Journal of Remote Sensing. 30(6): 1629-1634.

Krebs J. C. 1988. Ecological methodological, Edition Wesley Longman. p. 650.

Nagendra *et al*. 2010. Assessing plant diversity in Dry tropical forest: comparing the utility of landsat and IKONOS satellite images. Remote Sensing. 2: 487-496.

Pilehvar B., Makhdoom M. F., Namiranina M. and Jalili A. 2002. Measuring woody plant diversity "Vaz" forest by using whittker multiscale plots modified for Northern forests of Iran. Journal of Pajouhesh and Sazandegi. 53: 41-45 (In Persian).

Walker R. E., D. M. Stoms, J. E. Estes and K. D. Cayocca. 1992. Relationships between biological diversity and multi - temporal vegetation index data in California. ASPRS ACSM held in Albuquerque, New Mexico. American Society for Photogrammetric and Remote Sensing. 15: 562-571.