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Remote sensing & Geo-informatics technology in evaluation of forest tree diversity

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ABSTRACT

Plant diversity encompasses several community attributes. Preservation of plant diversity and understanding its status is therefore imperative. Evaluations of Indices such as Shannon-Weiner, Margalef and others are local measures. Scaling them at larger scale is subtle. However, as tools for sustainable management the inclusion of Remote sensing (RS) and Geographic Information System (GIS) technologies has provided a means to characterize such estimations on wider scale. An attempt not only to evaluate different indices but also to interpolate one of such index on larger area using RS-GIS tool has been made in this paper. Village wise spatial display of diversity indices generated can serve as a good input for forest planners. In addition, the species diversity map generated using kriging method proved useful in understanding the diversity status on a wider scale. Accuracy testing showed the outputs generated to be 65-75% accurate at 85% confidence level.

Key words: Diversity indices, Remote sensing, GIS, Kriging.

INTRODUCTION

Tropical forests constitute the most diverse plant communities on earth. This is due to species interaction and niche variation, which is a result of favorable climate (Ojo and Ola-Adams, 1996). During the past decade, the forests have endured high rates of deforestation. These forests are disappearing at alarming rates owing to deforestation for extraction of timber and other forests products. (Gentry, 1992). The resulting effects of this process are the loss of biological diversity and damage to wilderness habitats, increase in soil erosion, disturbance to the hydrological cycle and nutrient losses, among others. The pressure on India’s forests is very high because of high population. The rapid growth in the economy of the country in the last decade or so has put additional demands on trees for its resources and for infrastructure development, like building dams, roads, townships, etc. In such situation where there is demand for more land for such activities and with growing realization of the impacts of forests on climate change, the importance of forest cover and its diversity in the country is valued more. Conservation and preservation of species diversity is therefore a guiding principle for management and planning of forest tree diversity. Although diversity is often quantified with measurable indices common approaches used to measure diversity, for example the Shannon-wiener index, are not adequate for many forest studies, because they are affected by scale and sampling efforts. Assessing the distribution of diversity on a large scale and the efficiency of measures for conservation of this diversity is a major challenge for recent science (Nagendra and Gadgil 1999). Although some of the most important aspects of environmental change occur on a broad spatial scale (O’Neill et al. 1988: Ritters et al. 1995) where the traditional applications of diversity evaluation like Shannon-Weinner index (Shannon and Weaver 1949) and others, which focus at local level, becomes difficult. Moreover when performing diversity studies at higher scale it is often unclear how, or if, such local measures can be scaled-up to address larger regional conservation questions (Alatalo 1981; Walker et al. 2003). The use of the advance techniques of RS- GIS for sustainable management has tried to resolve this difficulty to some extent.

Remote Sensing technology provides an appropriate and cost effective method of monitoring wide spread natural resource like forests. While providing a synoptic view of large area, it also captures biophysical properties of land features through the reflected electro-magnetic radiations, often called signature in the remote sensing parlance.

Geographic information system (GIS) provides us new methods to enlarge the extent and increase the accuracy for study of tree diversity change by different inbuilt functions.

This work employed the Kriging interpolation technique.

Interpolation techniques:
Surface interpolation functions create a continuous (or prediction) surface from sampled point values. The continuous surface representation of a raster dataset represents height, concentration, or magnitude. Surface interpolation functions make predictions from sample measurements for all locations in a raster dataset whether or not a measurement has been taken at the location. The assumption that makes interpolation a viable option is that spatially distributed objects are spatially correlated; in other words, things that are close together tend to have similar characteristics.

Using the above analogy, it is easy to see that the values of points close to sampled points are more likely to be similar than those that are farther apart. This is the basis of interpolation.

Thus, combining ground surveys with the support from remote sensing image analysis has proven to be a very useful tool for solving the numerous practical problems involved in this type of undertaking (Innes and Koch 1998; Nagendra and Gadgil 1999; Muldavin et al. 2001; Kerr and Ostrovsky 2003). Analysis of these data with geographic information system (GIS) technology can make the process more efficient and effective. Utility of the interpolation function of GIS has been made on the spatial output generated using IRS LISS III data to check whether specie diversity data generated from the field can be extrapolated at a larger scale.

Study area
The study area is Dediyapada Taluka of Narmada district, of Gujarat state, India. It is spread out between 21° 38' 0" North, 73° 35' 0" East. This area contains both the Reserve forest i.e. Part of Shoolpaneshwar National Sanctuary and the Non Reserve forest area. Table-1 represents the details of the Sites selected for the study

Table-1 Details of the Sites selected for study

Sr. No	Name of village	Total Area ha	Forest Area ha
1.	FULSAR	709.6	621.8
2.	Chopdi	25491	1751.0
3.	Piplod	10908.8	423
4.	Sagai	924.6	924.6
5.	Dhumkal	1023.3	605
6.	Gangapur	1114.8	387.5
7.	Mota kabli	452.6	175.3
8.	Khapar	652	566.9
9.	Khatam	279.2	193.0
10.	Morjadi	2115.7	1546.6
11.	Kevdi	462.1	-
12.	Chuli	572.1	197.5
13.	Ralda	491.1	489.8
14.	Kokati	198.9	163.4

Methodology
Phyto-sociological data were collected from 14 different Points (Plate-1c) of the Dediapada region in both the reserve and non-reserve forest area. The Sample plot (quadrate) sizes of 20 x 20 m were laid down, and no. of

different plants was calculated. Different Diversity Indices (Shannon Index, Margalef Index, McIntosh Index and Brillouin Index),

With the help of IRPS_P3 LISS-III of April 2001 data, Normalized Differential Vegetation Index (NDVI) Map was generated. Different maps viz, NDVI, and Village. were converted into digital format . The indices data generated from the ground were then integrated with these maps. The Kriging interpolation technique generated Kriging map for the Shannon Index. Accuracy of the Kriging interpolation technique was then carried out to validate the result.

RESULTS AND DISCUSSION

The understanding of the diversity of Dediyapada Forest by evaluating and comparing different diversity indices (Table 2) has generated interesting results on the species distribution pattern of this forest community.

Table-2 Exhibiting diversity Indices in different Villages of Dediapada Region

Name of village	Shannon-Wiener Diversity Index	Margalef Diversity Index	McIntosh Diversity Index	Brillouin Diversity Index
FULSAR	1.41	1.94	0.58	1.02
FULSAR	1.15	1.16	0.53	0.88
Chopdi	0.56	0.48	0.32	0.41
Piplod	1.14	0.95	0.39	1.04
Mathasar	1.090	0.83	0.59	0.85
Sagai	0.97	0.93	0.32	0.88
Dhumkal	1.32	1.67	0.79	0.86
Gangapur	0.95	1.02	0.55	0.66
Mota kabli	1.31	1.22	0.56	1.11
Khatam	0	0	0	0
Morjadi	1.16	1.25	0.55	0.86
Kevdi	1.23	0.88	0.51	1.07
Chuli	0	0	0	0
Ralda	0.16	0.30693	0.04	0.12
Kokati	0.93	0.91	0.51	0.69

Four different types of diversity indices Shannon-Wiener (H) DI, Margalef (Ma) DI, McIntosh (MI) DI, and Brillouin (B) DI, (figure-2) calculated for different location in fourteen different villages indicates the H values to be on higher side. The results when subjected to statistical analysis exhibited that, all the species diversity indices showed a significant degree of negative Kurtosis and Skewness. Negative kurtosis exhibits peakedness, which means very frequent small changes and less frequent very large changes. H was highly negatively skewed when compared to all other indices with its Kurtosis values to be slightly lesser than MI and B. This indicated frequent and minor changes in this attribute when compared to other indices. The coefficient of variation (CV) for H was slightly lower than B. These CV for Ma and MI were still on higher side. In general, the better the variability of the index the poor is its conformity with the total population or its statistical performance with regard to normality, therefore a compromise seems to lay in the middle of two indices, H & B, with a variability around 54%. As H seems to be the most widely used diversity index, this seems to be good result.

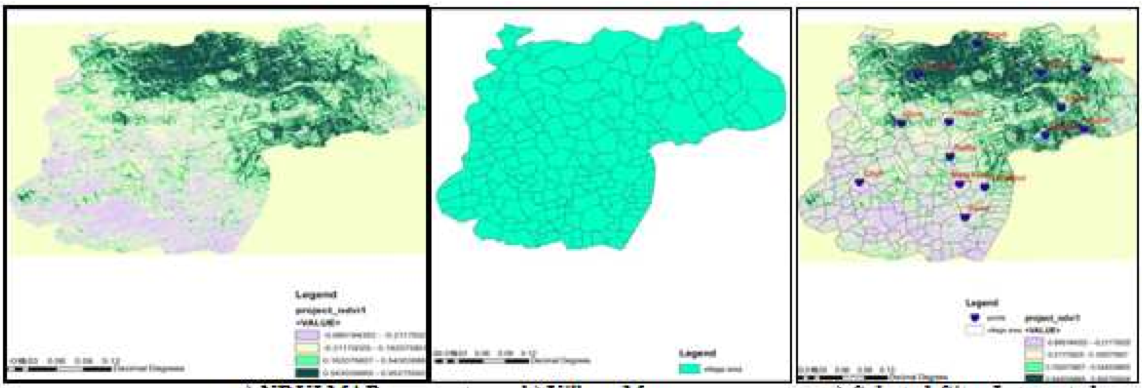
Table: 3 A comparative evaluation of different diversity indices

Diversity Indices	MEAN	STANDARD DEVIATION	COEFF OF VARIATION	SKEWNESS	KURTOSIS
Shannon-Wiener DI	0.89	0.48	53.79	-0.97	-0.51
Margalef DI	0.90	0.54	60.23	-0.047	-0.35
McIntosh DI	0.42	0.23	56.86	-0.69	-0.52
Brillouin DI	0.70	0.38	54.94	-0.87	-0.64

The assessment of forest biodiversity has recently become a priority area for forest research. Several measures of species diversity among communities have been recommended to assess biodiversity through environmental gradients (Whittaker 1972). Although tropical ecologists have put forward a number of hypotheses to explain this species diversity, testing these hypotheses has been hampered by the lack of field studies with sufficiently large long-term data sets. Evaluation of this is potentially an enormous task, and any methods that can be adopted to reduce the amount of time spent collecting data are therefore of interest. Remote sensing represents such method although it has been under-utilized in studies of forest biodiversity (Stom and Estes, 1993). In the present paper, utility of satellite data along with GIS tool has aided significantly in understanding and extrapolating the diversity information on a larger scale. The NDVI map generated from the IRS LISS III data (figure-1a) was overlaid on village map (figure-1b) gave a precise understanding of different species diversity indices in different villages (figure- 1c). The Shannon index is based on the proportional abundances of species. It takes both evenness and species richness into account. No assumptions are made about the shape of the underlying species abundance, so it is referred to as a non-parametric index. Values of this index when were incorporated to generate Species diversity map (figure-3) using the Kriging tool in GIS aided in extrapolating the understanding of this index in other areas other than the sampling points. This extrapolation was about 65- 75% accurate at 85% confidence level (Table 4). The accuracy and the statistical results together gave a precise idea regarding the distribution of the H index in the Dediyapada forest. Inclusion of more ground truth points in the areas where the values were more skewed can help in increasing the accuracy of the results.

Accuracy verification for Shannon Index-64.28 %

Sr no	Village name	Range of diversity	Accuracy Within Range (WR) / Out of Range (OR)
1.	Dabka	0.94-1.25	WR
2.	Singal Gaban	0.94-1.25	WR
3.	Khapar	0.94-1.25	OR
4.	Vaghumar	0.94-1.25	OR
5.	Gichad	0.31-0.62	OR
6.	Pansar	0.31-0.62	OR
7.	Bore	0.31-0.62	OR
8.	Dhanor	0.62-0.94	WR
9.	Tilipada	0.31-0.62	WR
10.	Khunbar	00000438-0.31	WR
11.	Kanjal	0.94-1.25	WR
12.	Pangam	0.62-0.94	WR
13.	Chikda	0.94-1.25	WR
14.	Namgir	0.94-1.25	WR



a) NDVI MAP + b) Village Map c) Selected Sites Integrated With NDVI and GIS

Figure-1 Showing the NDVI Map, Village And The Selected Site Map

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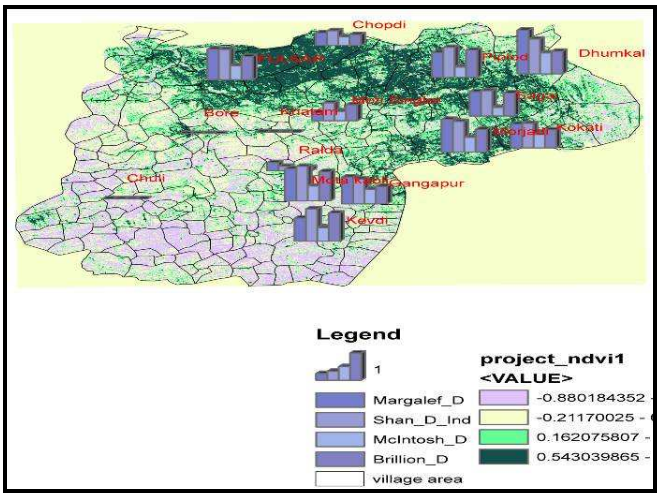
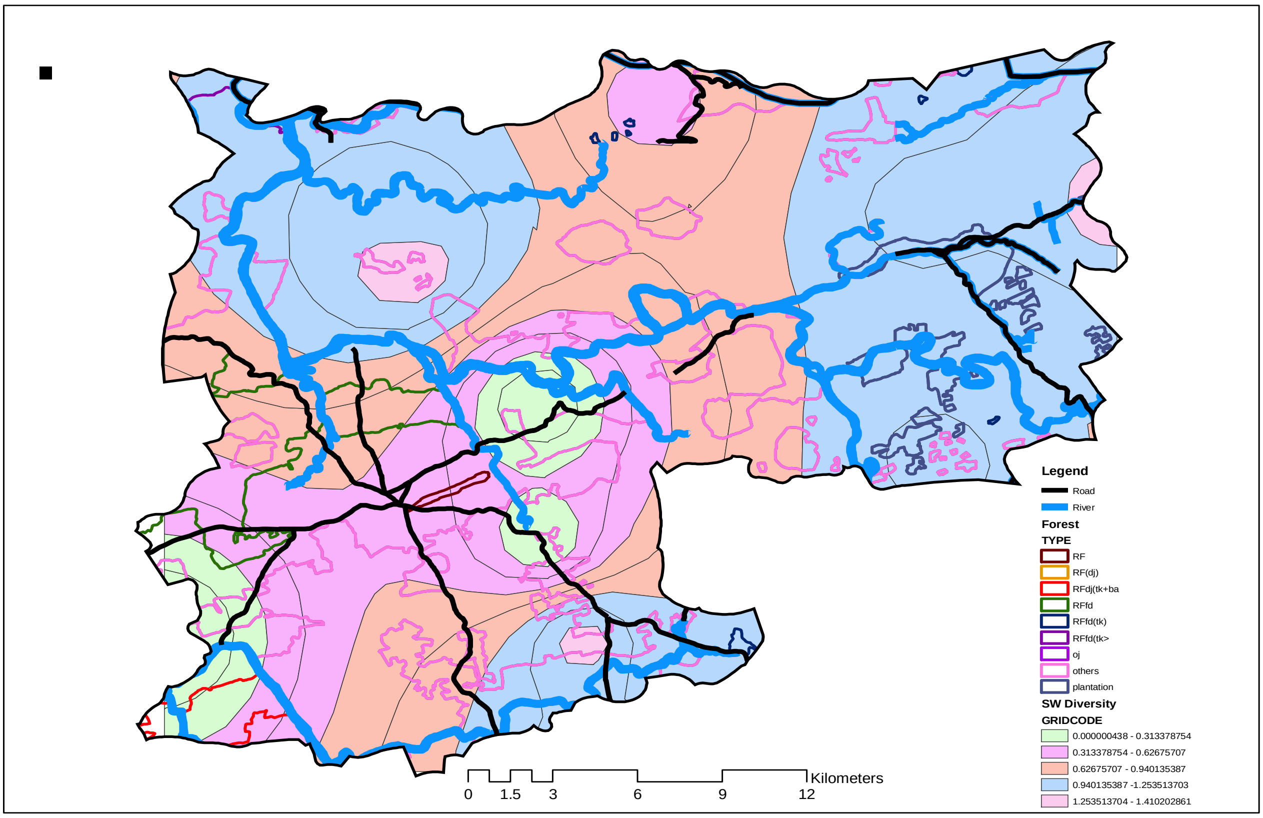


Figure-2 Map Exhibiting Different Diversity Indices

Figure-3: Showing the different Forest Type along with Shannon diversity Map



CONCLUSION

From the present investigation, it can be concluded that community diversity as such can be best measured by Shannon-Weiner information function H as compared to other indices. RS-GIS proved to be significant tool in extrapolating this information at higher scale. However, this should be restricted to specific region. Before extending these results to other forest areas or community, we need to be careful, as these results may be function of the taxa examined, of the environment or the total member of community.

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