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A Study on the Spectral Annual Variability of Yealgiri hills

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Abstract: Forest is one the vital element for sustainment of life on earth. Forest as a terrestrial component of the earth ecosystem is inter–linked with bio-geo components of ecosystem. Forest combat climate change, reserving carbon and recycling in carbon di-oxide from the atmosphere and locking it in the biomass (UNEP & FAO, 2011). Yelagiri hills in Eastern Ghats are one among forest that is predominantly spread on the northern part of Vellore district in Tamil Nadu. A study was taken up to study spectral and spatial dynamics of Yelagiri hills using Advanced Wide Filed Sensor (AWIFS) satellite data. Systematic sampling technique was applied to the AWIFS (2009) image to derive nine grids (each gird size 1km*1km) were selected for spectral analysis within the study area. All the grids were subset by masking the other region of the study area. Remote sensing techniques such as image enhancement, geometric correction, feature extraction and statistical analysis were performed during the course of investigation. Vegetation Index namely Normalized Difference Vegetation Index (NDVI) model was run ERDAS IMAGINE software for the year 2009 and 2010 to identify spectral and spatial variability of vegetative cover of Yelagiri hills. NDVI was classified at four intervals *viz.*, Full Vegetation Coverage (FVC,1≥ NDVI≥0.9), High Vegetation Coverage (HVC,0.9> NDVI≥0.5), Medium Vegetation Coverage (MVC, 0.5>NDVI≥0.26), and Low Vegetation Coverage (LVC, 0.26>NDVI≥−1). Spectral Analysis of AWIFS data for temporal and spatial change in vegetation cover between the year 2009 (reference year) and year 2010, the spectral annual variability showed a significant change in Medium Vegetation Coverage (MVC) (i.e.) a decrease in 39.96 sq.km and increase in High Vegetation Coverage (HVC) (i.e.) 29.55 sq.km, an increase in Full Value Coverage (FVC) 10.79 sq.km for Yelagiri Hills.
Key words: NDVI, AWIFS data, Spectral annual variability, Yelagiri Hills.

Introduction

The Eastern Ghats constitute a discontinuously distributed hill ecosystem includes a rich assemblage of floral, faunal wealth including many endangered and endemic species in the states of Orissa, Andhra Pradesh, Karnataka and Tamil Nadu. The southern part of the 'Eastern Ghats are known to be major centers of plant and animal diversity [1].Eastern Ghats in Tamil Nadu comprise Yealgiri, Javadhu hills in North and South Arcot district, Salem (Yercaud hills, Kollimalai hills, Villupuram (Kalrayan Hills) and Coimbatore (Satyamangalam ranges).Yelagiri hills is situated in Jolarpet Panchayat Union of Tirupattur taluk, geographical area of 51 sq. km. of which 3297.68 ha. are under reserve forest.

Remotely sensed image has become a reliable and effective data source in vegetation dynamic studies especially for rapid monitoring at global or regional scale [3]. Topography is always recognized as a crucial natural factor restricting environmental changes such as land use change and vegetation coverage change,

especially in mountain areas with rough terrain, while it remains uncertain on how elevation gradient influences the change of vegetation coverage [4].

For global studies, the Normalized Difference Vegetation Index (NDVI) is the most widely used spectral vegetation index and is based on a ratio of red and near-infrared reflectance [5]. NDVI has been used as an indicator of vegetation productivity [6]. Along with the wide use in landscape dynamics and land use/cover [3], remotely sensed image has become a reliable and effective data source in vegetation dynamic studies, especially for rapid monitoring at global or regional scale.

The bio cover of the Yelagiri hills is dynamic due to spatial variability of the forest cover. Dry mixed deciduous and scrub forest occupy major portion of the study site and therefore spectral and spatial variability study seems too prominent in sequence to carbon sequestration potential of the study site. Since vegetation coverage shows significant spatial and temporal variation, it is difficult to estimate the vegetation coverage through traditional field sampling at a large scale with high accuracy. On the contrary, in view of these defects, the approach of remote sensing is competent for its good temporal and spatial continuity [7].

Objectives

- To derive Vegetation Index from AWIFS satellite data of Yelagiri hills.
- To assess the spectral and temporal bio cover of the region between the year 2009 and 2010.
- To understand the vegetation cover dynamics and its influence on the bio cover of the study site.

Study Area

Yelagiri hills is situated in the Jolarpet Panchayat Union of Thirupattur taluk, surrounded in the north, west and south by Vaniambadi taluk falls within the boundary of Vellore District with an area of 51 square km. This hill is situated 92 km. west of Vellore and 30 km. east of Tirupattur. Study area comprise Athanavoor revenue village, with thirteen hamlets. The study area is represented in figure 1. The Maximum temperature of Yelagiri hills during Summer (April) is of 27^{o}C and the minimum temperature goes down in Winter between December and January to 11^{o}C. It has comparative dry climate with low humidity of 45-50 %. The mean annual rainfall for Yelagiri hills is 1026.16mm. and a maximum of 131.8 mm received during South West monsoon and 333.7 mm during Northeast monsoon. About 50 percent of the land area is red loam clay and sandy soil that roughly constituting 13 and 12 percent of the total area respectively. Soil is derived from feldspar and hornblende. It has been observed that mineral resources such as Sulphides, Quartz, Hayte, Apatite and Vermiculite occur in areas adjoining Tirupattur hills.

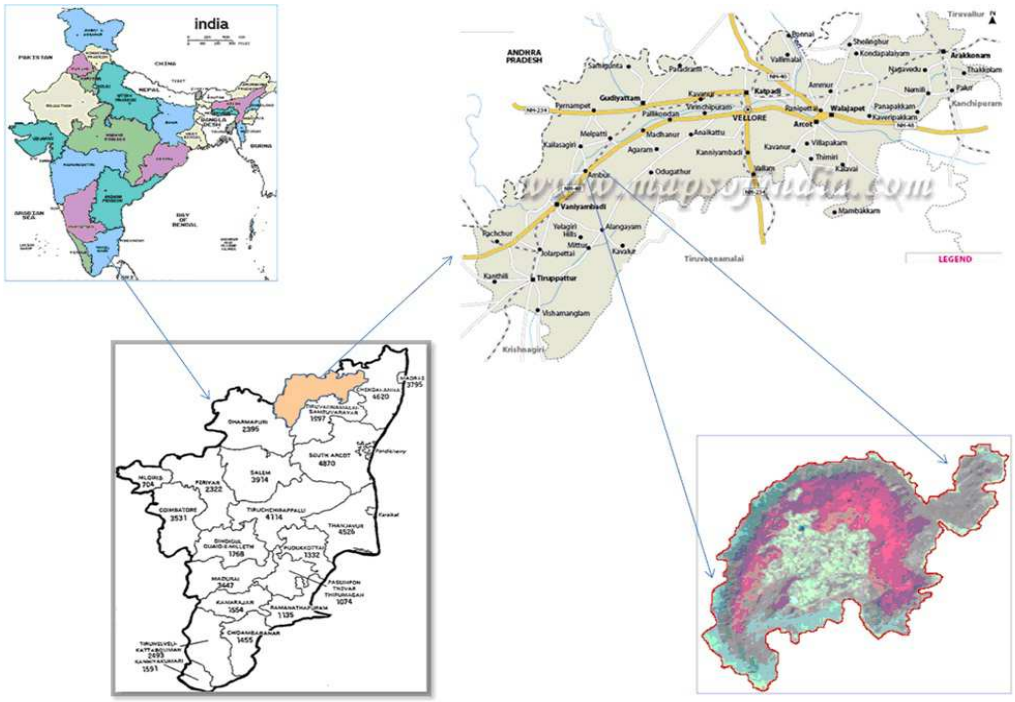

Figure 1. Index map of the Yelagiri Hills

Methodology

Satellite data Processing

AWiFS (Advanced Wide Filed Sensor data) data of path and row (144/52) corresponding the date of acquisition 16th February 2009 and 10th January, 2010 respectively were procured from National Data Centre (NDC), National Remote Sensing Centre (NRSC), Hyderabad. AWIFS data comprise four bands namely band 2, 3, 4 and 5 corresponding to Blue, Green, Red (R) and Near Infra Red (NIR) were subjected for geometric corrections due to extraneous factors. Individual bands were layer stacked and mosaicked in Lambart Conformal Conic (LCC) projection in Leica's Erdas Imagine 8.7 software. A vector dataset in shape file format of Yelagiri forest was created, derived and overlaid above the composite image, thus study area boundary was subset from the entire scene (figure 2). A pre field visit was made in the month of November 2012 to get basic information on physiographic conditions, terrain and tree species prevailing in the study area.

The hills are bounded by thick forest cover at the boundary of the Yelagiri hills, open forest and mixed semi dry deciduous forest were observed at the centre of Yelagiri Hills. Such spatial variation showed an insight of bio spatial variability of forest resources.

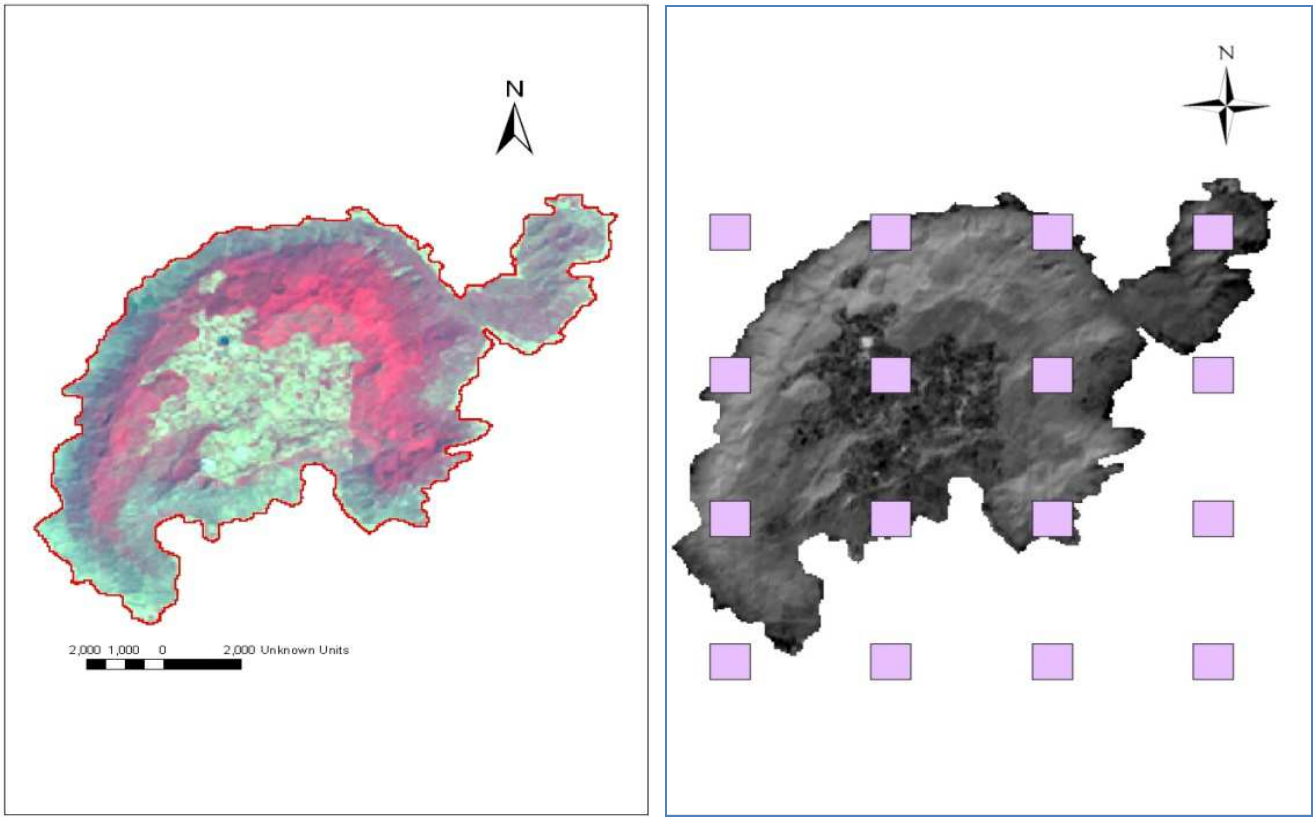

Figure 2 & 3. Satellite data of Yelagiri Hills of the year 2010 and sequential grids generated for analysis

Grid Generation

The study area possess complex vegetation coverage that can be construed as Very High, High vegetation, Moderate Vegetation and Poor Vegetation. After considering all the variables and the associated factors, AWIFS satellite image representing the study area was sequentially gridded in ERDAS IMAGINE software through grid generation tools. The grid size of 1km*1km with a spacing interval 3 km between two grids at both the X and Y axis was trained for the entire forest area resulted to a total of nine grids fall within the study area as represented in figure 3. Since vegetation coverage shows significant spatial and temporal variation, the girds are selected in such a way that vegetation coverage of all categories was selected through these strategy. A total of nine grids fall under this category of this 4 grids fall on the border of the study area. Among the four 2 grids occupy vegetation area of more than 90 per cent and other 2 grids cover an extent of more than 70 per cent. The geographic coordinates of the grid study site and its nature of vegetation were listed in Table 1.

Table 1. Study area grid details and its nature of vegetation

Plot No.	Latitude (N)	Longitude (E)	Site name	Land_mark	Distance	Nature of Vegetation
1	12.62242	78.6437	Mandalavadi	Near by small village	5.2km	Agriculture with forest
2	12.62240	78.6797	Alangayam	Near by forest	8.39 km	Agriculture with forest
3	12.62198	78.7175	Alangayam	forest	4.38 km	Forest
4	12.58576	78.6063	Ponneri	forest	3.08 km	Forest
5	12.58615	78.6434	Yelagiri lake	Near by Yelagiri lake	0.85 km	Agriculture
6	12.58573	78.6803	Mangalam road	Hilly area	2.36 km	Thick forest
7	12.54969	78.6067	Fakir dharga	Yelagiri village road	3.94 km	Forest
8	12.54968	78.6436	Perumapattu	Forest	3.66 km	Forest
9	12.54946	78.6799	Andiyappanoor	Forest	3.96 km	Forest

NDVI analysis

Normalized Difference Vegetation Index (NDVI) is the most widely adopted vegetation index proven to be highly sensitive with the vegetation coverage ratio of 25–80%, of Lijiang County [4] in China. NDVI is used to classify the spectral levels to understand vegetation dynamics in the study area. NDVI in (Eq. 1) is defined as the difference of the spectral reflectance between near-infrared band and visible red band normalized by the summation of these two bands, where NIR is near-infrared band, R is visible red band. In the case of AWIFS data, NIR is represented by band 4 with band 3 for R. NDVI ranges from −1 to 1. The negative value indicates land cover without chlorophyll, such as cloud, rock, water, storm, etc. The positive value represents vegetation coverage, with the higher value for the more dense coverage and healthy of green vegetation. RED and NIR stand for the spectral reflectance measurements acquired in the red and near-infrared regions, respectively.

NDVI = (NIR –Red) / (NIR+Red) ……. Eq. 1.

According to natural conditions of the study area, vegetation coverage is divided into four grades with NDVI value, i.e., full vegetation coverage (FVC, 1≥ NDVI≥0.9), high vegetation coverage (HVC, 0.9> NDVI≥0.5), medium vegetation coverage (MVC, 0.5>NDVI≥0.26), and low vegetation coverage (LVC, 0.26>NDVI≥−1).

Vegetation coverage change matrix analysis

Vegetation coverage of Yelagiri hill is dynamic due to climate change and anthropogenic activities. Analysis of AWIFS satellite data for the year 2009 and 2010 on vegetation indices such as NDVI was one of the important characteristics in deriving vegetation coverage change studies. Therefore, it is significant to assess the change of vegetation coverage, besides the change detection. At present, the method of grade change is widely used, which focuses on the distinct change of vegetation coverage and ignores the small change. AWIFS satellite data pertaining to 16th February 2009 and 23rd January 2010 was employed for NDVI analysis considering previous year as reference data for NDVI change matrix analysis corresponding for the year 2010, where change detection analysis between the two years resulted in change matrix image.

Results and Discussion

Satellite data for the year 2009 and 2010 were analyzed for spectral index assessment in order to study the temporal and spectral changes that have occurred during the two dates. AWIFS data for the study area were sub set from the entire scene. Both the data set were made to run NDVI module in ERDAS IMAGINE software to generate NDVI for the years 2009 and 2010.

NDVI Analysis

NDVI is the one of the prominent vegetation index universally adopted to understand the vegetative vigour of biome especially tree, crops etc. Analysis was carried for AWIFS data corresponding the year of 2009

and 2010 respectively. Spatial generated NDVI map for the entire study area has been represented in figure 4 and 5 where NDVI values ranged from -1 to 1. In Water bodies (e.g., oceans, seas, lakes and rivers) which have a higher absorption in spectral bands shown a very low positive NDVI values. Barren rock generally exhibit a low near-infrared spectral reflectance thus tend to exhibit a rather lower NDVI values in the range of 0.1 to 0.2. The central part of the study area possess a moderate values as represented more of open spaces intermixed with shrub and grassland with a NDVI values of 0.2 to 0.3. in figure 6. Dense vegetation was observed all along the boundary of Yealgiri hill that contain the NDVI values in the range of 0.4 to 0.8. Dynamics of NDVI between the images of 2009 and 2010 seem to be predominant exclusively at the lower and higher values.

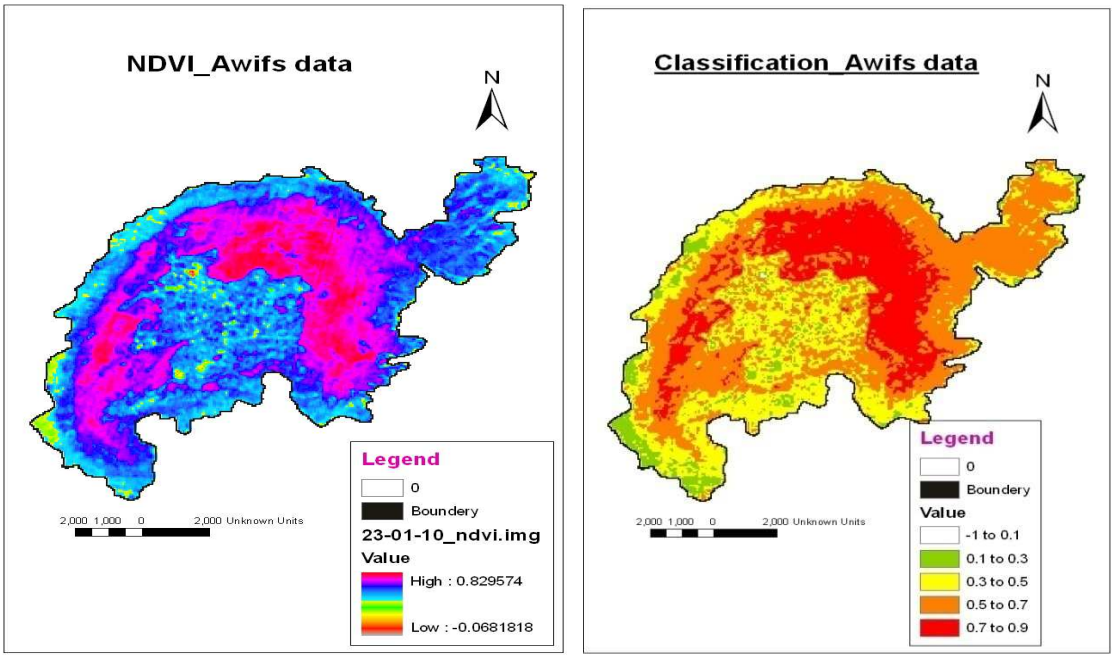

Figure 4 & 5. NDVI image of Yelagiri Hills for the year 16th Feb. 2009 & 23rd Jan.2010

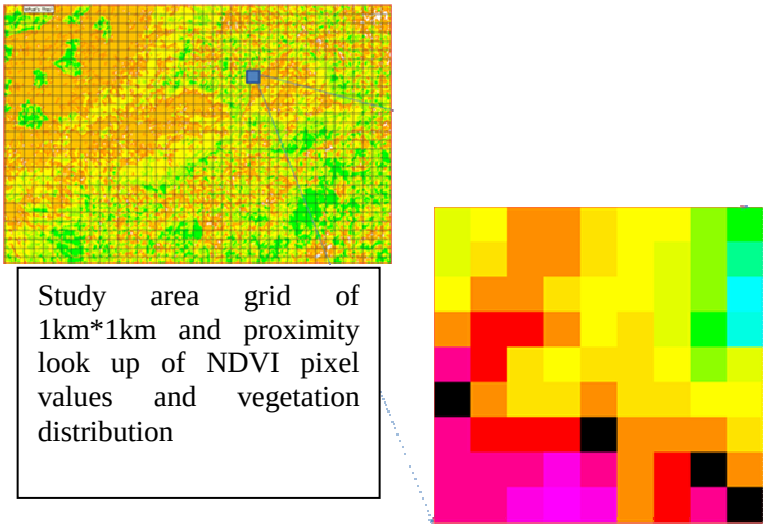

Figure 6. Characteristic NDVI Signatures of 2010 AWIFS image

In order to study temporal and spatial variability of NDVI values, the two NDVI images containing the attributes of both the NDVI values and the corresponding number of pixels in the attribute table of the images were exported to MS-Excel format. All the values were classified at four levels as LVC, MVC, HVC and FVC for the entire study scene for both the data sets. A total of 9 grids selected for the study were sub set by masking the remaining regions within the study area. All the NDVI values of both the years were plotted as a graph with NDVI values of 2009 and 2010 in X-axis and Number of pixels in Y-axis. A significant variation was observed for the values between 0.3 - 0.4 as well for the values 0.6 - 0.8 represented in figure 7.

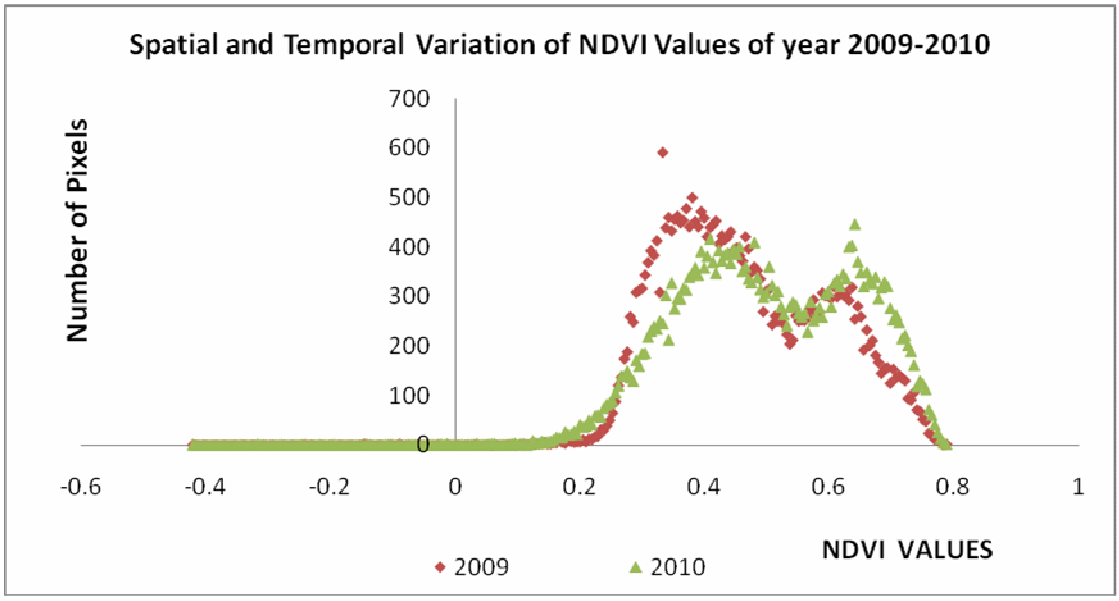

Figure 7. Pixel Quantity and corresponding NDVI of entire Yealgiri hills for the year 2009-2010

Such NDVI variation metrices between the two images especially at lower and medium NDVI values have provided insight to carryout in-depth NDVI metrics analysis of the study area. One such analysis was the gird generation and selection of the study site based on the spatial variability of NDVI matrices.

Grid Generation

A sequential grid sampling strategy, generated at as size of 1*1km and the spacing distance between the grids are kept at 3 km in ERDAS IMAGINE software through frame sampling tools through grid generation techniques in shape file format. A total of nine grids were generated under this process. Some grids lie on the border of the study area, 2 grids occupy an area of more than 90 per cent and other 2 grids cover an extent of more than 70 per cent of the study area. Grids in shape file format were overlaid above the satellite image and subset for the analysis purpose. NDVI images of all the girds were subset for further spatial variability analysis. Comparison of NDVI images of the entire study scene is quite difficult in contrast to the grid wise corresponding images. The grid images for the two dates were given in figure 8.

The results of the scatter plot showed and positive relationship of Y =0.8019x (r^2=0.62) for NDVI 2009 and 2010.

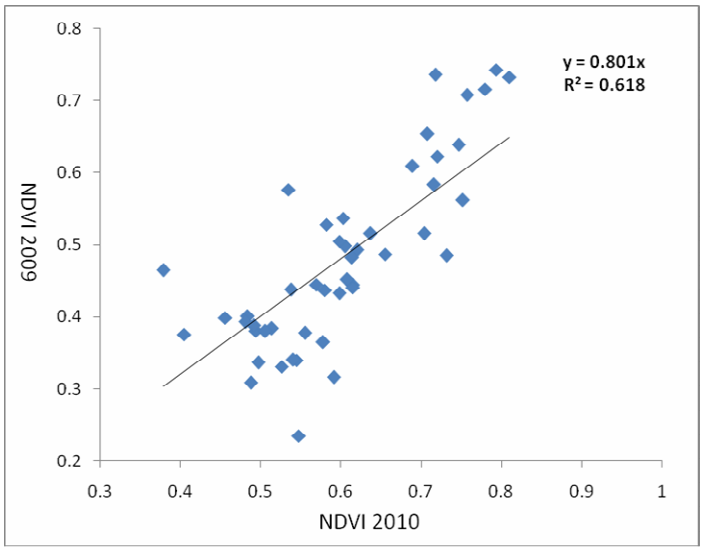

Figure 8. Scatter plot of NDVI values for six grids subset from Yelagiri hills

Grid wise NDVI Analysis

Grids were generated keeping in view of selecting such grids for filed survey of biomass assessment at Yelagiri hills Above Ground Biomass (AGB) value of the grids would be related to available NDVI values of the corresponding gird thereby to develop a model for the study area. Area under Medium Vegetative Cover has been decreased for the year 2010 and subsequently increased for High Vegetation Coverage (2010).

NDVI images of the grids were subset from the Yelagiri study area and preliminary analysis on NDVI classification was performed at eleven intervals at a threshold value of 0.1 for NDVI. Enormous data on pixels with respect to each thresholding lead to a complexity in investigating of NDVI variability metrics. A method [4] used to classify NDVI class four intervals were used in this study. Thresholding values of each class could not be matched with our derived values and therefore threshold values for each class were manipulated according to Yelagiri bio-climatic conditions. Such as full vegetation coverage (FVC, NDVI≥0.75), high vegetation coverage (HVC, 0.55> NDVI≥0.75), medium vegetation coverage (MVC, 0.22>NDVI≥0.55), and low vegetation coverage (LVC, -1>NDVI≥0.22). Analysis of grid wise NDVI values on the scatter-

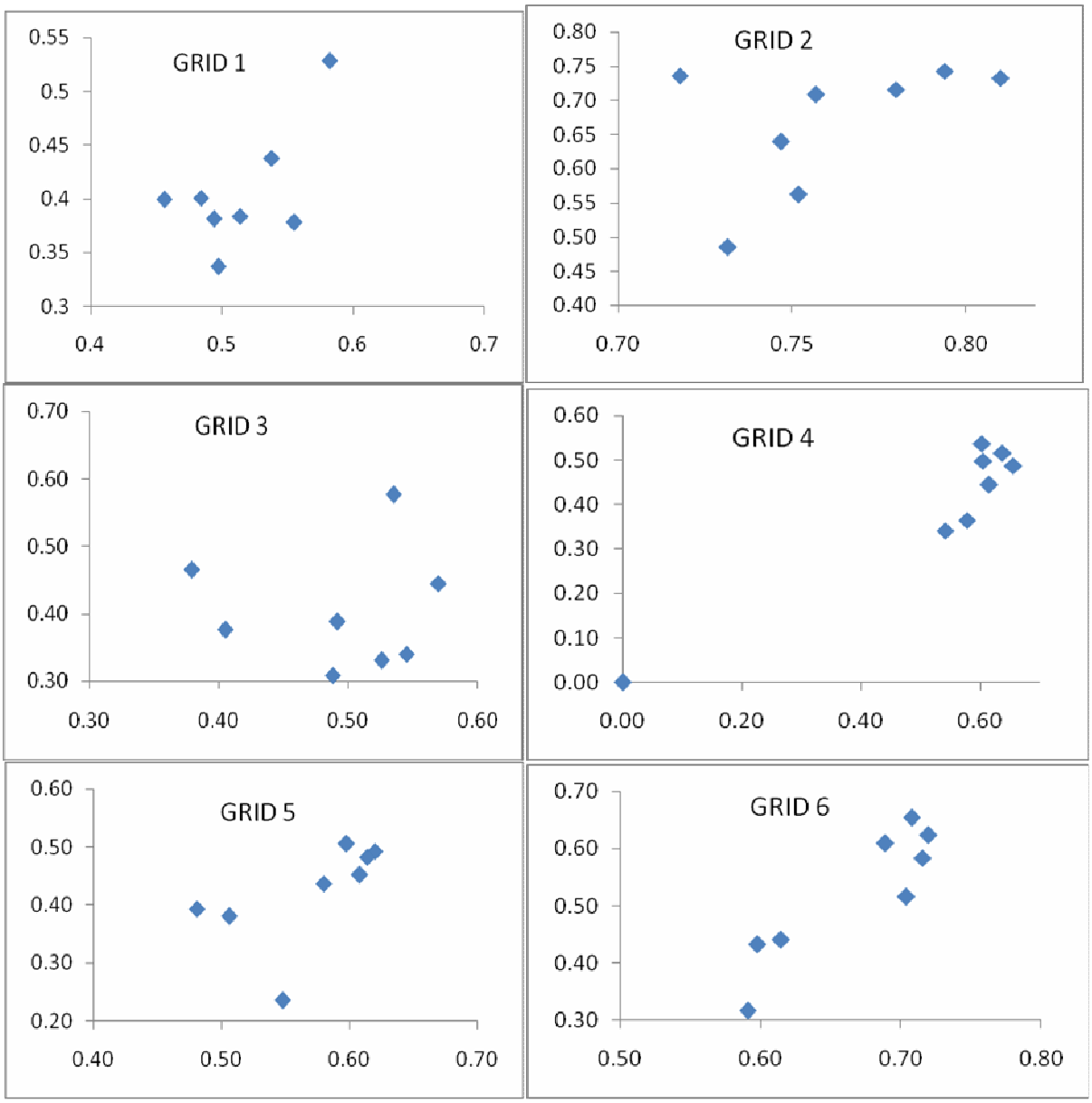

Figure 9 (a-f). NDVI values of each pixel within the grid for the year 2009-2010.

Plot has shown that spectral variation was higher invariably for all the six girds figure 9. Similarity in spectral values was nearer for the Grid 5 which might be due to homogeneity of the tress species prevailing in that grid.

Spectral Dynamics of Vegetation coverage

Vegetation coverage of Yelagiri hill is dynamic due to climate change and anthropogenic activities. Analysis of AWIFS satellite data for the year 2009 and 2010 on vegetation indices such as NDVI was one of the important characteristics in deriving vegetation coverage change studies. AWIFS satellite data pertaining to 16th February 2009 and 23rd January 2010 was employed for NDVI analysis considering previous year as reference data for NDVI change matrix analysis corresponding for the year 2010, where change detection analysis between the two years resulted in change matrix image.

Table 2. Vegetation Coverage in Yelagiri hills during 2009

Class	Pixels	Area in sq. km	Area in %
LVC	142	0.445312	44.77
MVC	22161	69.496896	69.86
HVC	9230	28.94528	29.10
FVC	187	0.586432	0.59
Total	31720	99.47392	100.00

Table 3. Vegetation Coverage in Yelagiri hills during 2010

Class	Pixels	Area in sq. km	Area in %
LVC	20	0.06272	0.06
MVC	9416	29.528576	29.68
HVC	18656	58.505216	58.81
FVC	3628	11.377408	11.44
Total	31720	99.47392	100.00

Analysis of attribute data derived from the classified image was represented in table 2, 3 and 4. Results exhibit the area of vegetation coverage under MVC has highest (69 sq.km) for the year 2009 and less than 1 km for FVC. It is construed that there was 40 % decline in MVC, 30 % increase in HVC and 10 % increase in FVC between 2009 and 2010 image. The resultant increase in vegetative cover from medium value cover to high and full value cover during 2009-2010 might be due substantial increase in rainfall lead to higher vegetative growth of MVC to HVC and FVC.

Table 4. Vegetation Coverage matrix in Yelagiri hill

Change vegetation		23-02-2010_CVC%				
Coverage ratio		LVC	MVC	HVC	FVC	Area ratio
16-01-2009_CVC%	LVC	7.75	88.73	3.52	0.00	0.45
	MVC	0.04	41.78	57.52	0.66	69.86
	HVC	0.00	0.34	63.69	35.97	29.10
	FVC	0.00	0.00	13.90	86.10	0.59
	Area ratio	0.06	29.68	58.81	11.44	100.00

Conclusion

The present study demonstrated the capability of IRS-AWIFS satellite data for deriving vegetation change of Yelagiri hill with reliable output on the assessment of forests and of forest cover dynamics between the year 2009 and 2010. Spatial and temporal variation for the entire scene was performed using NDVI metrics. Sequential gird approach was attempted for finding vegetation variability's to regional forest inventories. This study has demonstrated that grid wise approach was convenient in studying inter annual variations of vegetative coverage especially in the forest region. Results also established a dynamics in vegetative cover at Medium Vegetative coverage and High Vegetative Coverage.

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