Trend analysis of different vegetation cover types using FPAR and Surface Reflectance: A case study of Western Ghats, India

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Abstract

Use of remote sensing data is an obligatory alternative to study biodiversity loss in this fast changing world. The Moderate Resolution Imaging Spectroradiometer (MODIS) instrument (Terra) time series data (2000 to 2015) for surface reflectance and fraction of photosynthetically active radiation (FPAR) were acquired in this study, considering the diverse landscape of Western Ghats, India as the study site. The spatial pattern of surface reflectance and FPAR was observed to be varying inversely. The Mann-Kendall trend analysis (2000-2015) was performed separately for surface reflectance and FPAR on 24 different vegetation types. Based on Sen's slope the trend was evaluated as positive and negative. In case of FPAR the positive trends observed for artificial managed vegetation while natural vegetation types were depleting along the period 2000-2015, except for *Acacia sp.*, and the remaining vegetation types shown negative trends for surface reflectance. Overall, the threat to naturally occurring vegetation types marked significantly with negative trend compared to manage vegetation types having some economic values. Although, managed systems were also found sensitive to changing climate and are under significant risk. The study suggested exploring this concept with more intense data and field observations to reduce the risk to plant diversity.

Keywords: FPAR, remote sensing, spatial pattern, time series, Western Ghats

1. Introduction

The spatial variability on our planet highlights the fundamental changes in the biosphere and exclusive study may help to discontinue the beginning for major biome conversion (Running *et al*., 1999). However, remote sensing derived products were observed to be a strong alternative to provide continuous information on spatial variability.

Integration of multi sensor imagery plays an important role in measuring and monitoring the surface variables, and in the validation of global ecosystem models (Cohen and Justice, 1999). A study based on three-tier methodology that combines field measurements, remote sensing products and modeling suggests that the remote sensing estimates are relatively closer to filed data than of modelled observations (Senna *et al*., 2005). Readily available high frequency spatio-temporal vegetation indices data from Moderate Resolution Imaging Spectroradiometer (MODIS) is grabbing reasearcher attraction for many vegetation analysis.

2. Study area

The Western Ghats of India is the world's most densely populated biodiversity hotspot. With a geographical area of 1,25,035 Km^2 bounded between 8°04′45′′ to 20°01′40′′ N latitude and 72°38′34′′ to 78°28′18′′ longitude is home of many threatened and endemic species. The temperature gradient ranges between 25° at the sea level to 10° to the top elevation gradient (300-2700m). There are 24 major vegetation reported in the region ranging from tropical moist deciduous to abandoned jhum cultivation. Human invading to the hotspot that raising agricultural land, plantation, grazing and built-up brought the alteration in the composition of vegetation types i.e. natural versus managed (Chitale and Behera, 2014).

3. Methodology

The field data was collected from Biodiversity Characterization at Landscape Level (BCLL) project database, available for free access (http://bis.iirs.gov.in/). The geo-tagged plant database holds sampling sufficiency at vegetation type's level using stratified random sampling (Roy *et al*., 2012). As ground truthing the sample information on vegetation type's was extracted and arranged for Western Ghats. The data summarized a list of 24 major vegetation types (Table 1). We acquired the best available temporal and spatial resolution data from MODIS Terra sensor. The MOD09Q1 for surface reflectance data of 8-Day L3 Global 250m and MOD15A2H for FPAR 8-Day L4 Global 500m (https://modis.gsfc.nasa.gov/, https://reverb.echo.nasa.gov/). The MRT and geospatial software ArcGIS (Version 2013) used to generated the annual average data of surface reflectance (620-670 nm) and FPAR (Figure 1).

The spatial data on surface reflectance and FPAR were extracted and attached to the field data points for all the 24 vegetation types. The Mann Kendall trend analysis was performed using XLSTAT-2017 to address the variability in the patterns of FPAR and Surface reflectance with respect to each vegetation types (Figure 2; Table 1). The interpretation is based on the trend line and Sens's slope values.

4. Results and Discussion

Our analysis is based on single time period plant data collected from BCLL. On the other hand, the MODIS time series data carry forward the information in spatial domain that intact and efficiently retrieve the data. Considering the advantage of MODIS data 16 years average spatial image for FPAR and surface reflectance was derive (Figure1).

The surface reflectance and FPAR values observed to be inversely related. Towards the coastal area of Western Ghats the range of FPAR is very high while surface reflectance value declines significantly. However, moving towards north-east region of Western Ghats the range of surface reflectance increases but inverse to FPAR (Figure 1).

However, the inverse relationship does not impact the trend in due period of 2000-2015. The analysis of Mann Kendall trend analysis performed using MODIS inputs of FPAR and Surface reflectance from 2000-2015 as per vegetation types. In case of FPAR, for 16 vegetation types the trend observed to be positive and negative for remaining 8. Hence, it can range of adaptation to climatic variability. be inferred that; 1) some vegetation may have long 2) The increasing trends are may be economical and managed artificially. Among the vegetation types, tropical thorn forests have the highest slope (0.017) in positive while Kans holds the lowest slope range (0.0001). But, the worry lies for negative trends of vegetation types in the hotspot area. The vegetation types such as Sacred grooves (-0.008) followed by Tropical evergreen (-0.005), Orchards (-0.003) and Tropical Semi-evergreen (-0.003) were observed to be under high risk. Besides being managed some are still sensitive to climatic variability like orchards, which holds economic but still have negative trend. This infers more management practices to be strong to cope up with the climate variability.

However, the trend analysis of surface reflectance with respect to all the 24 vegetation types holds negative trend in majority except Acacia (Table 1). We observed the impact of inverse relationship between FPAR and surface reflectance also in the

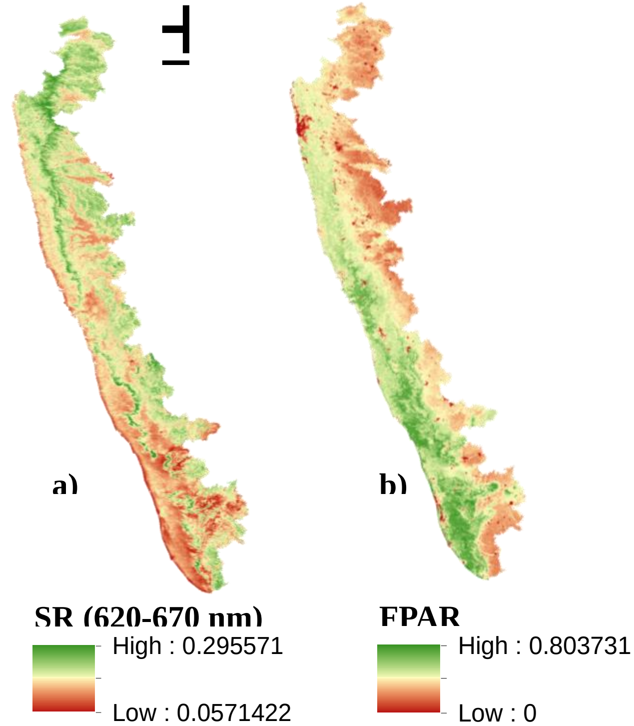

Figure 1. Showing inverse reflection properties in the annual average map of 16 years (2000-2015) for a) SR (Surface reflectance) and b) FPAR (Fraction of photosynthetically active radiation)

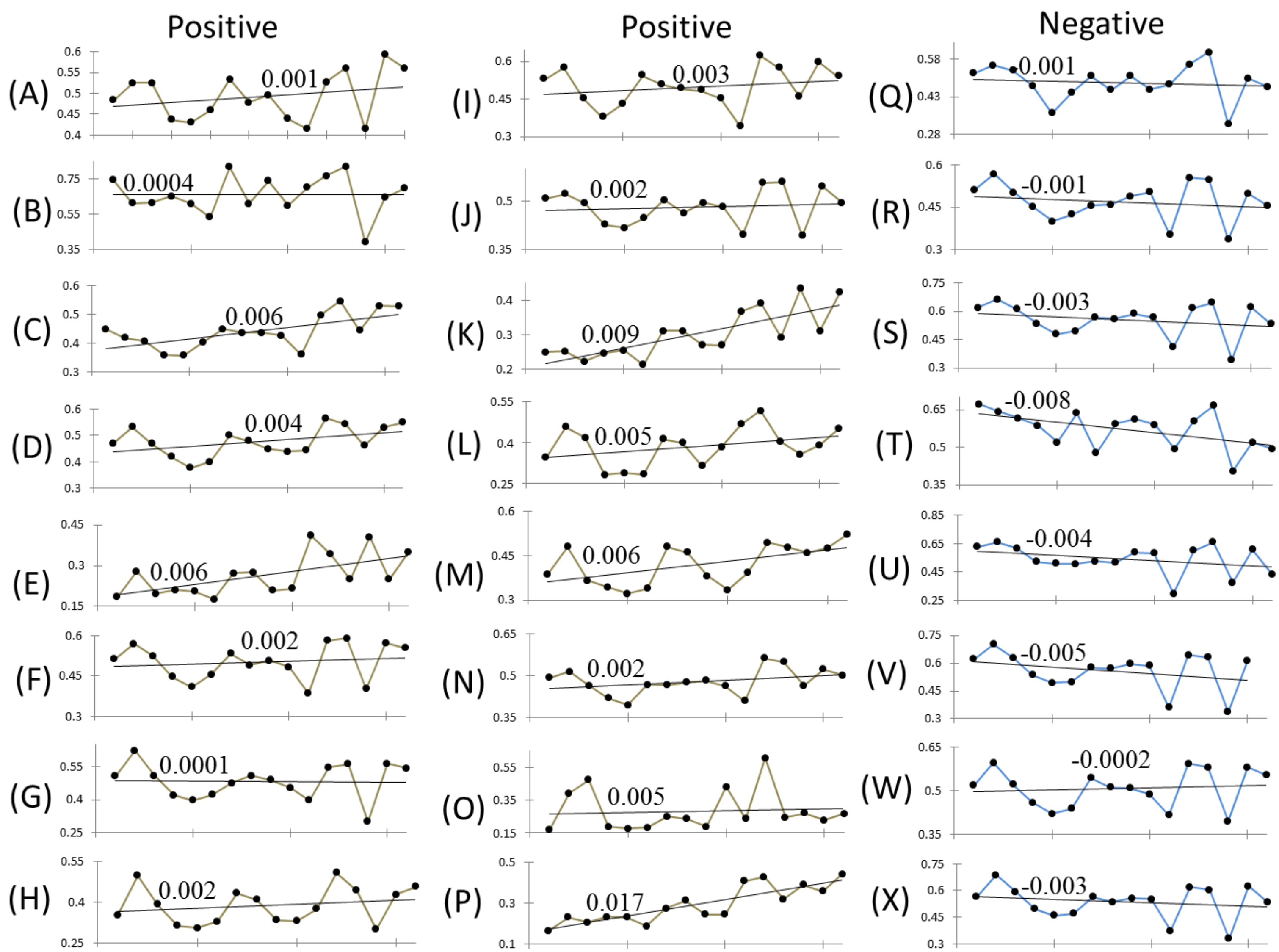

Figure 2. Showing the slope derived for 24 vegetation types (16 positive, 8 negative) using Mann Kendall analysis for the period 2000-2015 based on FPAR variables. Where, A) Acacia, B) Arecanut, C) Bamboo, D) Degraded Forest, E) Dry Deciduous Scrub, F) Forest Plantations, G) Kans, , H) Mixed Plantation, I) Riverine, J) Scrub, K) Shrub Savannah, L) Teak Mixed Moist Deciduous, M) Thorn Scrub, N) Tropical Dry Deciduous, O) Tropical Teak Mixed Dry Deciduous, P) Tropical Thorn Forest, Q) Abandoned Jhum, R) Grassland, S) Orchard, T) Sacred Groves, U) Sholas, V) Tropical Evergreen, W) Tropical Moist Deciduous, X) Tropical Semi Evergreen.

Table.1 Showing the slope (positive and negative) for surface reflectance result of 24 vegetation types from Mann Kendall trend analysis.

Sl No.	Veg type	Slope
1)	Acacia	0.0030
2)	Arecanut	-0.0005
3)	Bamboo	-0.0020
4)	Degraded Forest	-0.0016
5)	Dry Deciduous Scrub	-0.0010
6)	Forest Plantations	-0.0020
7)	Kans	-0.0020
8)	Mixed Plantation	-0.0010
9)	Riverine	-0.0020
10)	Scrub	-0.0010
11)	Shrub Savannah	-0.0008
12)	Teak Mixed Moist Deciduous	-0.0009
13)	Thorn Scrub	-0.0010
14)	Tropical Dry Deciduous	-0.0010
15)	Tropical Teak mixed Dry Deciduous	-0.0030
16)	Tropical Thorn Forest	-0.0030
17)	Abandoned Jhum	-0.0001
18)	Grassland	-0.0010
19)	Orchard	-0.0004
20)	Sacred Groves	-0.0008
21)	Sholas	-0.0004
22)	Tropical Moist Deciduous	-0.0020
23)	Tropical Evergreen	-0.0030
24)	Tropical Semievergreen	-0.0010

trend analysis. As FPAR derived the positive trends for 18 vegetation types whereas surface reflectance resulted for only one vegetation type (0.003).The satellite derived variables acts as surrogate to explain the spatial variability. But, the study on their relationship and variation is able to highlight the alteration from space. Hence, the satellite derived variables were observed acting as strength to explain the status of diversity and threat to them.

5. Conclusions

A simple and classic trend analysis of two spatial variables infers the variability in spatial expansion or reduction of vegetation in Western Ghats. The relationship between the variables and the vegetation type's response to them at different time domain are analyzed. The study suggests and left open questions for more intense work to unfold the science behind the alternate response of naturally occurring vegetation and managed vegetation. Also the sensitivity of different vegetation towards climate resulting spatio-temporal change need furthers study with appropriate conservation measures.

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