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Monitoring Vegetation and Land Surface Temperature Dynamics in Similipal Biosphere Reserve, Odisha

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Abstract

The Moderate Resolution Imaging Spectroradiometer (MODIS) has provided an improved capability for moderate resolution land surface monitoring and for studying surface temperature variations. Surface temperature is a key variable in the surface energy balance. The knowledge of surface temperature is important to a range of issues and themes in earth sciences central to urban climatology, global environmental change, and human-environment interactions. In the study, an attempt has been made to estimate surface temperature over Simlipal Biosphere Reserve. The particular significance of this study is due to the large scale effect of Similipal in the local microclimate of this region. From the study, we found that the north-western part of SBR, there is a greening up tend particularly in the dense forest where NDVI value is supposed to be higher than 0.4. in some part, near to transition and buffer boundary, the open forest (<0.2 NDVI) is increasing over the period. LST mean and LST max curves have more or less same value throughout the year except for the duration DOY161 to DOY257. Except the few occasional deeps which may be data error, the maximum NDVI curves are more or less similar in all the observed periods. The temporal trend of minimal NDVI does not follow any definite pattern and very much irregular in its annual course compared to maximal and mean NDVI. There exists a negative correlation between NDVI and LST with correlation coefficient is below 0.4 in all the observed years.

Keywords

GIS, NDVI, LST

1. Introduction

Land cover composition and change are important factors that affect ecosystem

condition and function. These data are frequently used to generate landscape-based metrics and to assess landscape condition and monitor status and trends over a specified time interval. These have been a common perception and understanding that the forest resources of the world have progressively been decreasing over the last few decades in terms of both area and quality. Such understanding exists among most of the professional and scientific communities Land surface temperature can provide important information about the surface physical properties and climate which plays a role in many environmental processes [1] [2]. In explaining forest dynamics, remote sensing techniques using satellite imagery are effective methods to document the rates and patterns of change in forest ecosystems and can provide information to help resolve controversies about future management directions. Remote sensing data are the availability of high resolution, consistent and repetitive coverage and capability of measurements of earth surface conditions [3]. By using this technique, we collect data for large areas that have increased the application capacity of monitoring the national conditions and landscape dynamics of both protected areas and the immediately adjacent areas for a more comprehensive and comparative studies. Continued efforts in data processing techniques and modeling approaches heat can bridge integration of remote sensing and *in-situ* observation has the great potentials. The complexity of the landscape of the study sites and image processing methodologies in information extraction impose challenges to obtain the necessary information for science-based decision making in management of protected lands. Land cover change analysis and monitor the dynamics of indicator data such as the NDVI can be a powerful tool for assessing natural and anthropogenic impacts at landscape-scale to protected lands, provided that we identify independent variables o processes that can be related to the changes observed with the remote sensing data. The Similipal Biosphere is situated in the middle part of the Mayurbhanj district of Odisha state, in the end of the Eastern Ghats. It locates in the Mahanandian Biogeographical region and within the Biotic region, Chhota Nagpur Plateau, it spreads over an area of 2750 sq. km. Similipal is unique in many respects, notable among which are its flora, fauna forests, landscapes, tribes and waterfalls. The present study was carried out with the following objectives: to study spatial and temporal dynamics of land surface temperature (LST) and NDVI in the biosphere reserve and to study the correlation among them.

2. Study Area

The famous Oriya poet Radhanath Ray has described this hill block as "Salmali Saila" meaning moss-covered hills. The name Similipal may also have been derived from the magnificent and enchanting "Simul" trees with red flower, which are so abundant in the district. Similipal is located between latitude 20˚17'N - 22˚34'N and longitude: 85˚40'E - 87˚10'E. The core area of Similipal Tiger Reserve is 845 km according to the Sanctuary from 1979 and the amount of buffer area is 2129 km (Reserved Forest) and the Transition Area spreads up to 2595 km. The

length of Periphery of Similipal Sanctuary is about 600 km. The highest mountain peak Khairiburu which is 1168mts above mean seas level. In comparison to National status, the composition of Flora and Fauna of Similipal constitute 7% flowering plants, 8% Orchids, 7% Reptiles, 20% birds and 11% mammals. The average elevation is 559.31 mt however the entire Similipal area is undulating, rising from 600 mt to 1500 mt. The climate of reserve is influenced by monsoon pattern of Rainfall. Maximum Rainfall occurs from mid-June to October accounting for 75% - 80% of annual rainfall the amount of average annual Rain fall is not co related with elevation and generally ranges from 28.11- 344.96 cm. The temperature rarely goes above 40˚C. Minimum temperature in winter is 14˚C. The soil of Similipal broadly classified into Red soil, lateritic soil. The Red soil later classified into three Sub group namely Typical Soil, Red loamy soil, and clay-long soil. Two types of lateritic namely lateritic Morrum and laterite rocks have so far been identified in this area (Figure 1).

3. Methodology

Data Source and Data Used (Figure 2):

- http://glcf.umd.edu/data/landsat/;
- Google Earth;
- Web: https://lpdaac.usgs.gov/;

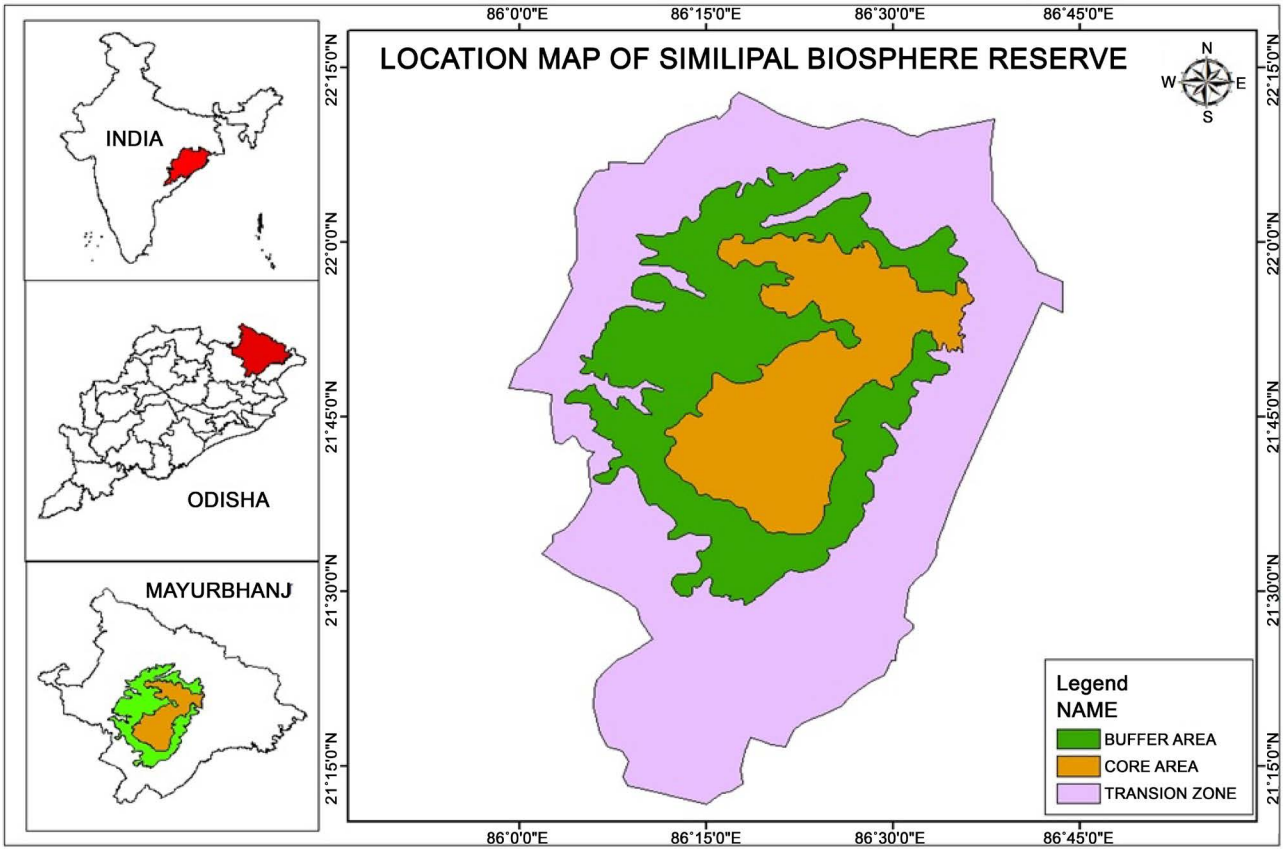

Figure 1. Location map of the study area.

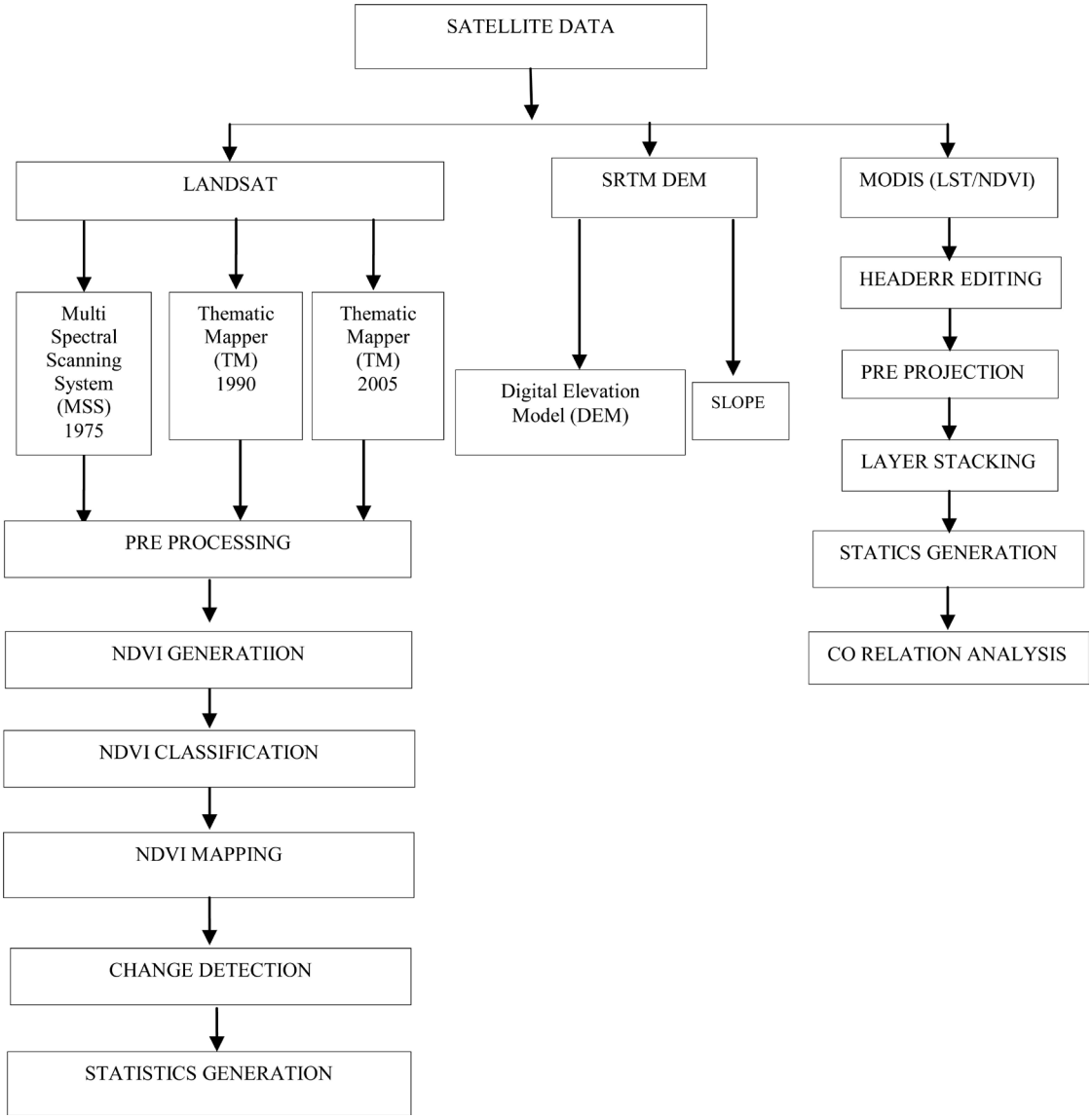

Figure 2. Data flow diagram of all research methodology.

- http://reverb.echo.nasa.gov/reverb;
- Survey of India Topo sheet of 1:50,000 scale for vector layer digitization;
- Landsat 7, MSS, TM and PAN data for study area delineation and to show the change detection;
- Google Earth for vector layer digitization;
- SRTM(DEM) for Slope and aspect;
- Moderate Resolution Imaging Spectroradiometer (MODIS) value added product of NDVI and night time LST for 16 and 8 day composite respectively during 2012 and 2014.

3.1. MODIS Sensor

NASA is the maker of observation system of earth. Both Terra and Aqua satellites are carried by (MODIS) Moderate Resolution Imaging Spectroradiometer,

the data using in generate oceanic, atmospheric, and terrestrial data products [4] [5] are collected by Terra (February 2000) and Aqua (June 2002). The MODIS sensor passes the same point on a place approximately twice per day as both terra aqua satellites orbit the earth in opposite directions, in morning the terra crossing the equator from North to south and in afternoon the aqua crossing the equator from South to North. The data of active fire location and their timing of earth surface area are provided by MODIS, instantaneous radioactive power, and smoldering ratio, presented at a selection of spatial and temporal scales [6] [7]. The all global Biogeochemical and Hydrologic Modeling, Agricultural Monitoring and forecasting, Land use planning, Land cover characterization and Land cover change detection are included in general application of MODIS.

3.2. Data Description

In December 1999 and May 2002 launched earth observing system (EOS) instruments on board terra and aqua platforms. The sensors scan ±55˚ from Nadir at an altitude of 705 km in 36 spectral bands with instantaneous field of view (IFOV) of 250 m to 1 km respectively at Nadir with bands 1 to 19 and 26 invisible and NIR range and rests are in TIR regions 3 - 15 μm. The model of earth at the same time track detectors per spectral band 10 along through each scan. From its polar orbit MODIS provide day time and night time global coverage every 1 - 2 days. MODIS records data in 12 bit radiometric resolution. MODIS data can be obtained four times a day *i.e.* 1:30 hr, 10:30 hr, 13:30 hr and 22:30 hr. NDVI values range from −1.0 to 1.0, the clouds and water indicated negative values, positive values near zero indicating bare soil, and higher positive values of NDVI ranging from sparse vegetation(0.1 - 0.5) to dense green vegetation (0.6 and above). The thermal Infrared signature received by satellite sensor is determine by surface temperature, surface emissivity, reflectivity and scattering action open thermal radiation from the surface and the solar radiation in day time.

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

3.3. MODIS Land Surface Temperature (LST) Product

MODIS standard LSD product is created using a generalized split-window set of computer instructions which is taken from a (usually) 1st order Tayler series (act of something getting bigger, wider, etc.) of the radiative move (from one place to another) equation. The coefficient for the set of computer instructions are detyermine4d through moving backward analysis of radiative move (from one place to another) stimulation for a wide range of surface and (related to the air outside) conditions. The split window method uses two (related to ghosts or the colors of the rainbow) close bands in the NIR wavelengths and assumes that the differential brilliances between these band is a linear function of the (related to the air outside)

(mental concentration/picking up of a liquid) at those wavelengths (due mostly to water vapor). However, to guess (a number) the (movement-related) (skin) temperature, surface emissivity values are usually needed/demanded for one or more terms in a split window creation. MODIS (related to ghosts or the colors of the rainbow) band 31 and 32 are used for LST set of computer instructions. The emissivity in MODIS bands 31 and 32 are guessed (based on what was known) from the land cover types based on TIR BRDF models that test out (in a way that's close to the real thing) this way scene emissivity from the proportions, surface structures and (related to ghosts or the colors of the rainbow) emissivity's of the parts/pieces in the scene.

The day/night LST method retrieves land surface temperature and band emissivity's (at the same time) from pairs of day time and night time MODIS data in seven TIR bands.

The MODIS L2 LST product contain 9 scientific data sets (SDSs); LST, QC, errorT, Emis_31, Emis_32, view angle, view time, (how north or south you are/freedom to make decisions) and (how Far East or west you are). The first seven DSDs are for 1 km pixels. The last two DSTs are rough resolution (5 km) (how north or south you are/freedom to make decisions) and (how Far East or west you are) data. Each set of them goes along with/matches up to a center pixel of a 5 km by 5 km block of pixels in the LST SDS. A mapping relationship of geolocation data to the first seven DSDs is a specified in the worldwide attributes structure Meta data 0. The first element (0, 0) in the geo location SDSs goes along with/matches up to element (2, 2) in LST SDS, then (increases a tiny bit) by 5 in the cross-track or along track direction to map geolocation data to the LSD SDS element.

LST is retrieved from TIR data only clear sky conditions. It is not mixed with cloud top temperature in the atmospheric products (TIR signals from surface cannot penetrate clouds to reach satellites).

LST is defined by the radiation emitted by the land surface observed by MODIS at the instantaneous viewing angle.

Proper resolving of the land atmosphere coupling is the key in retrieving surface and atmospheric properties. Multi-bands in the atmospheric window is used for LST retrieval. The values of atmospheric temperature and water vapor are useful to improve the LST retrieval. However there may be large errors in these values.

3.4. Normalized Difference Vegetation Index (NDVI)

The (usual/commonly and regular/healthy) normalized difference green plants index (NDVI) is measure of the amount and energy of green plants at the surface. The importance of NDVI is related to the level of photosynthetic activity in the watched/followed green plants. When sunlight strikes objects, certain wavelengths of this spectrum are soaked up (like a towel) and other wavelengths are reflected. The color in plant leaves, that is, chlorophyll, strongly soaked up (like

a towel) visible light (from 0.4 - 0.7 Âμm) for use in (making food from light). The cell structure of the leaves on the other hand strongly reflected NIR (from 0.7 - 1.1 Âμm). this is a contrast to almost all other surface on the earth like water are bare soil where there is no obvious difference between reflectance in the visible and in the NIR are mathematically NDVI is define as the difference between the visible (RED) and NIR bands, over there sum and is given as;

$$\mathrm{NDVI} = (\mathrm{NIR} - \mathrm{RED})/(\mathrm{NIR} + \mathrm{RED})$$

3.5. Tools and Technique

(Combined different things together so they worked as one unit) Land and water information system open source geospatial software was used for image processing and (related to space or existing in space) carefully studying. Terra MODIS images are not georeferenced and given in a rectangular grid. All Terra MODIS images downloaded in raw format were geo-referenced using the software MODIS re-projection tools (MRT). Terra MODIS images files are presented as an img. format. All images are geo-referenced to UTM WGS-84 coordinate system. A geo-referenced image of NDVI of 1 km (ability to display or measure very small things) after carrying out processing with MODIS MRT software.

Geo-referenced images, afterward, were hid/hidden for the study area for carrying out further analysis for each event for strong desire/formal decision about something of NDVI, LST and temperature values using the ENVI 4.2 software. A hid/hidden MODIS NDVI image on 01st January 2012 is the MODIS NDVI values in the images are multiplied by a factor of 0.1 as per MODIS data format (detailed description of exactly what is required).

3.6. Vegetation Index

A number-based value used to (describe a possible future event) or test/evaluate (like a vegetable) (features/qualities/traits) such as plant leaf area, total (energy from) wood and plant material, and general health and energy of the surface green plants. Green plants points to/shows are usually came/coming from multispectral remote sensing (instance of watching, noticing, or making a statement). Since growing plants strongly reflect the wavelengths of light in the near-infrared, combinations of measurements in the near-infrared and visible-red parts of/amounts of the spectra are used to create a variety of different indices.

Green plants indices such as NDVI and Tasseled Cap are used to detect green plants from information collected by satellite sensors. In order to fully understand the remote sensing processes in green plants mapping, one has to identify the (related to ghosts or the colors of the rainbow) (features/qualities/traits) of green plants. Plants have a high rate of (related to electricity producing magnetic fields) radiation due to the high difference in reflection rate between the water rich cell contents and the intercellular air spaces. The NIR spectrum, in the wavelength range of 700 nm to 1300 nm, is the most important part of/amount of the (related to electricity producing magnetic fields) spectrum for carefully stud-

ying green plants because plants appear very bright (high reflectance) in the range. Plant appear dark from 400 nm to 700 nm and also from 1300 nm to 2500 nm (expect for a small increase in reflectance at 550 nm).

Therefore, (more than two, but not a lot of) green plants indices have been developed to measure green plants attributes using NIRE radiation. Green plants causes for remote sensing have been being worked on now for 35 years. Jensen (2000, 2005) outlines the developments of the earliest green plants index from the simple ratio in 1968, NDVI in 1974, the tasseled cap change in 1976 and 1979, SAVI (Soil (change to make better/change to fit new conditions) Green plants Index) in 1988, to the latest developments such as VARI (Visible (related to the air outside) ally Resistant Index), in 2002 and NDVI in 2003. The green plants index will be used for this research: NDVI, the most commonly used green plants index.

3.7. Vegetation Mapping Using NDVI

The differences in green plants index green plants values between pairs of images was done using the ENVI's band math function. The percentage change in the green plants reflectance value per unit area in km^2 and by green plants classes (desert, forest and highland shrub) was used to test/evaluate the rate and (related to space or existing in space) pattern of green plants change using the NDVI and TC greenness. The images processed using ENVI were moved (from one place to another) to ArcGIS 9.0 for three purposes although ENVI has the ability to hide images, GIS does it less in a tired way, and so was used for this purpose. ArcGIS was used to calculate the areas used for map making. The comparison of the green plants indices was done at two scales, Large and Small. The large scale test/evaluation was done by testing/evaluating the decrease in percentage brought across by the three different indices for the whole area of each of the eight study area. Green plants in the eight study areas were classified as desert, highland shrub, or forest.

The worldwide farm-related watching/supervising (GLAM) project collects and processes NDVI data for display in crop explorer and for used by USDA's office of worldwide analysis (OGA) of the foreign farming-based services (FAS) crop analysts. NDVI data in crop explorer is taken from the raw (computer-based pictures, Photoshop, etc.) for the red and NIR channels collected from (more than two, but not a lot of) different satellites, namely the Advanced High Resolution Radiometer (AVHRR) sensor placed on-board the national ocean-related and (related to the air outside) management (NOAA) satellite series with worldwide area coverage (GAC) or 4.0-km (related to space or existing in space) (ability to display or measure very small things) reprojected to 8-km pixels.

4. Result and Discussion

4.1. Spatio-Temporal Dynamics of LST and NDVI

MODIS terra received/made from NDVI and LST images for the year 2012-2014

were processed in order to study the (related to space or existing in space) and time-related patterns (of relationships, movement, or sound) in the SBR area. Zonal statistics were (pulled out or taken from something else) and mathematical relationship-related analysis followed.

4.2. Spatio-Temporal Dynamics of LST and in the SBR

The terra MODIS received/made from eight-day (made up of different things) LST images were processed for the year 2012, 2013, and 2014. Zonal statics were (pulled out or taken from something else) for the change (from one thing to another) area of SBR and presented in figure that shows that for the years 2012 and 2014, the time-related (popular thing/general way things are going) in mean LST is almost the same whereas the 2014 LST values follows a lower value from DOY of 129 to 257. But all the curves again merge at around 273 DOY. Time-related profile of LST max for 2012-2014 is presented in figure that shows that maximum LST for 2014 has lower value from DOY of 161 to 225.

4.3. Spatio-Temporal Dynamics of NDVI in the SBR

The terra MODIS received/made from sixteen-day (made up of different things) NDVI images were processed for the year 2012, 2013, and 2014. Zonal statistics were (pulled out or taken from something else) for the change (from one thing to another) area of SBR and presented in **Tables 1-6**. Time-related profile of mean NDVI for 2012-2014 is presented in **Figures 3-6** and (related to space or existing in space) profile in below figures that shows that for the year 2013, the time-related (popular thing/general way things are going) in NDVI follows higher values from DOY 33 to DOY 225 and the year 2012 has lowest value of NDVI for the same periods. Time-related profile of NDVI min and max are presented in figures below. Except for few occasional deeps which may be data error, the maximum NDVI curves are more or less almost the same in all the watched/followed periods. The time-related (popular thing/general way things are going) of min NDVI does not follow any definite pattern and very much irregular in its once-a-year course compared to max and min NDVI.

4.4. Co-Relation of Mean NDVI and LST

The NDVI-LST correlation depends on the season and tie of the year. Scatters plots showing correlation between NDVI and mean LST are presented in figure below. In all the observed years there exist a negative correlation between NDVI and LST. As NDVI increases the temperature decreases due to high evaporative cooling, hence a decrease in LST results. Due to some outliers the correlation coefficient remains below 0.4 in all the cases (**Figures 7-9**).

5. Conclusions

The salient findings of the study are except the north-western part of SBR, there is a greening up tend particularly in the dense forest where NDVI value sup-

Table 1. LST mean characterization.

DOY	2012 LST mean	2013 LST mean	2014 LST mean
1	23.89627	22.32233	21.57889
17	26.1817	32.54988	23.72632
33	28.83673	26.17111	28.04183
49	31.95485	29.60872	28.31121
65	35.16813	34.91585	34.77604
81	38.96193	42.29135	39.70102
97	45.22914	45.46935	40.57257
113	46.8801	46.13319	42.53795
129	46.50114	55.54242	46.18954
145	36.08147	44.19342	46.27102
161	45.50342	26.52341	41.32456
177	30.14567	28.22341	33.24563
193	31.2879	23.31267	32.19567
209	32.04511	24.45433	29.36723
225	33.2189	26.54378	32.56432
241	24.4321	24.53452	33.2315
257	32.56889	24.53712	28.23908
273	31.29366	31.88669	31.77873
289	32.69097	31.39893	32.86265
305	32.11124	31.22702	31.07196
321	26.59589	28.55088	30.17276
337	26.35886	25.97429	28.2977
353	24.17906	24.23724	23.6515

Table 2. NDVI mean characterization.

DOY	2012 NDVI mean	2013 NDVI mean	2014 NDVI mean
1	0.654919	0.72806	0.719149
17	0.63793	0.73872	0.702056
33	0.645461	0.723828	0.632944
49	0.580044	0.684962	0.660902
65	0.520608	0.591373	0.660902
81	0.39672	0.457351	0.504867
97	0.347744	0.342738	0.385689
113	0.35076	0.327941	0.425047
129	0.345915	0.355578	0.492114
145	0.42616	0.486924	0.55696
161	0.561382	0.487169	0.601772

Continued

177	0.493582	0.506536	0.690068
193	0.290944	0.440764	0.579363
209	0.413433	0.534447	0.679909
225	0.565047	0.774523	0.75397
241	0.701206	0.76222	0.789822
257	0.870423	0.636454	0.796852
273	0.830245	0.787477	0.829755
289	0.832725	0.788665	0.826647
305	0.777477	0.817793	0.80699
321	0.705646	0.794968	0.71577
337	0.711714	0.743532	0.676575
353	0.712735	0.718015	0.627859

Table 3. LST min characterization.

DOY	2012 LST min	2013 LST min	2014 LST min
1	13.03	13.56	13
17	16.07	14.06	14.02
33	18.96	15.32	18.18
49	21.32	18.28	14.32
65	25.18	23.78	23.08
81	26.78	31.56	27.36
97	30.09	34.74	27.07
113	34.96	31.04	26.56
129	25.54	30.66	29.48
145	25.62	29.98	28.98
161	23.98	27.44	22.42
177	21.34	26.98	21.98
193	22.98	25.98	23.98
209	23.98	26.98	22.98
225	24.05	24.98	21.98
241	25.98	22.98	26.42
257	22.06	21.98	25.36
273	26.98	23.04	24.66
289	23.84	18.54	23.78
305	21.82	18.72	22.38
321	16.44	18.62	2082
337	18.34	17.98	16.64
353	14.46	16.24	15.18

Table 4. NDVI min characterization.

DOY	2012 NDVI min	2013 NDVI min	2014 NDVI min
1	0.0597	0.0478	0.1469
17	0.0372	0.001	0.1799
33	0.0356	0.1587	0.1482
49	0.0216	0.1324	0.1814
65	0.0417	0.0984	0.1814
81	0.033	0.0814	0.1762
97	0.0412	0.0551	0.1223
113	0.0042	0.0854	0.0503
129	0.0421	0.081	0.0209
145	0.0087	0.066	0.0591
161	0.1122	0.129	0.0533
177	0.0756	0.1278	0.0533
193	0.1176	0.0565	0.0879
209	0.0485	0.0652	0.033
225	0.0145	0.0516	0.0845
241	0.2282	0.2015	0.1086
257	0.1239	0.0448	0.0705
273	0.1441	0.0321	0.0053
289	0.1075	0.219	0.0011
305	0.0378	0.1976	0.0492
321	0.0348	0.2234	0.0368
337	0.0251	0.0775	0.0164
353	0.1026	0.0899	0.011

Table 5. LST max characterization.

DOY	2012 LST max	2013 LST max	2014 LST max
1	25.1	23.26	34.52
17	27.06	39.52	24.64
33	29.78	27.12	29.04
49	32.96	30.5	30.04
65	36.1	35.98	35.86
81	40.28	43.58	41.22
97	46.6	46.5	42.32
113	48.02	48.36	44.84
129	49.42	47.78	48.54
145	38.08	48.1	58.96
161	58.64	59.64	59.28

Continued

177	54.85	53.92	47.48
193	50.54	52.66	46.06
209	49.36	45.18	38.16
225	44.68	48.82	38.06
241	43.54	37.52	43.72
257	34.22	42.86	39.72
273	45.6	35.1	32.46
289	33.8	34.84	33.72
305	33.4	32.46	31.98
321	27.84	29.58	31.14
337	27.24	27.8	29.26
353	25.3	25.8	24.58

Table 6. NDVI max characterization.

DOY	2012 NDVI max	2013 NDVI max	2014 NDVI max
1	0.9412	0.9858	0.9615
17	0.9358	0.9949	0.9743
33	0.9395	0.9883	0.9585
49	0.971	0.9844	0.9904
65	0.8928	0.9132	0.9904
81	0.9259	0.8413	0.8674
97	0.8628	0.7482	0.8117
113	0.8983	0.8233	0.9404
129	0.9318	0.8633	0.8839
145	0.8931	0.8937	0.8589
161	0.8741	0.9073	0.9293
177	0.8327	0.9175	0.9275
193	0.7044	0.9455	0.9626
209	0.9308	0.9984	0.9199
225	0.9853	0.9591	0.9746
241	0.9989	0.9956	0.957
257	0.9994	0.9989	0.95
273	0.999	0.976	0.9992
289	0.9975	0.9981	0.9988
305	0.9742	0.9969	0.999
321	0.9777	0.9973	0.9587
337	0.9606	0.9667	0.914
353	0.9736	0.9611	0.9232

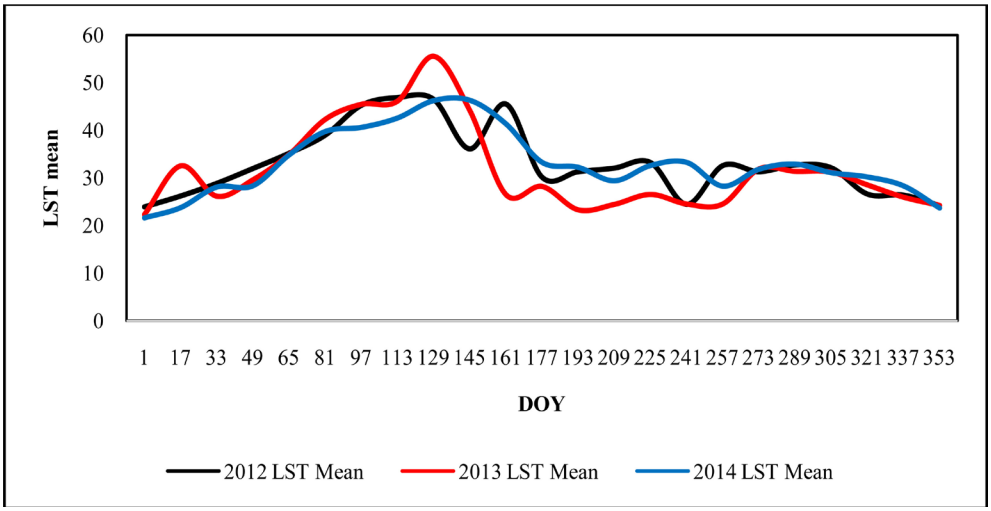

Figure 3. Temporal profile of LST mean (2012-2014) in SBR.

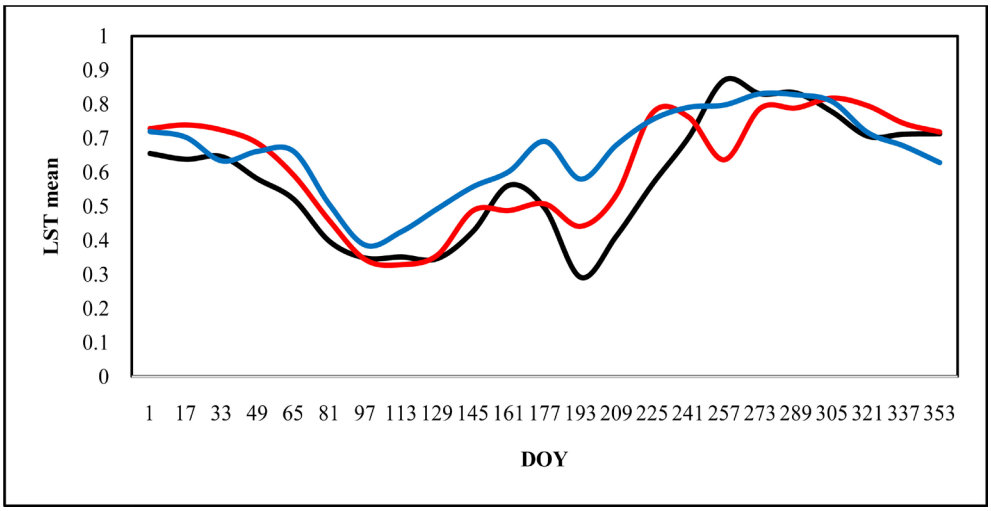

Figure 4. Temporal profile of NDVI mean (2012-2014) in SBR.

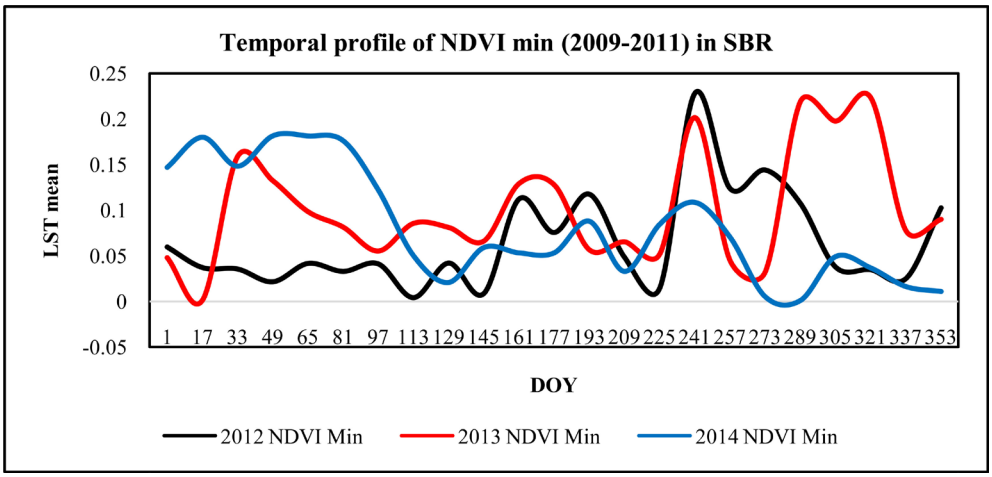

Figure 5. Temporal profile of NDVI min (2012-2014) in SBR.

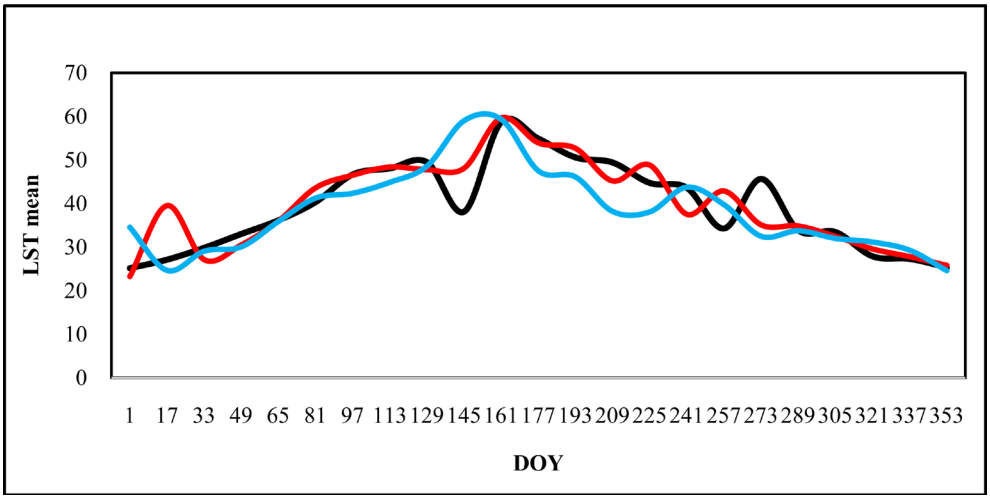

Figure 6. Temporal profile of LST max (2012-2014) in SBR.

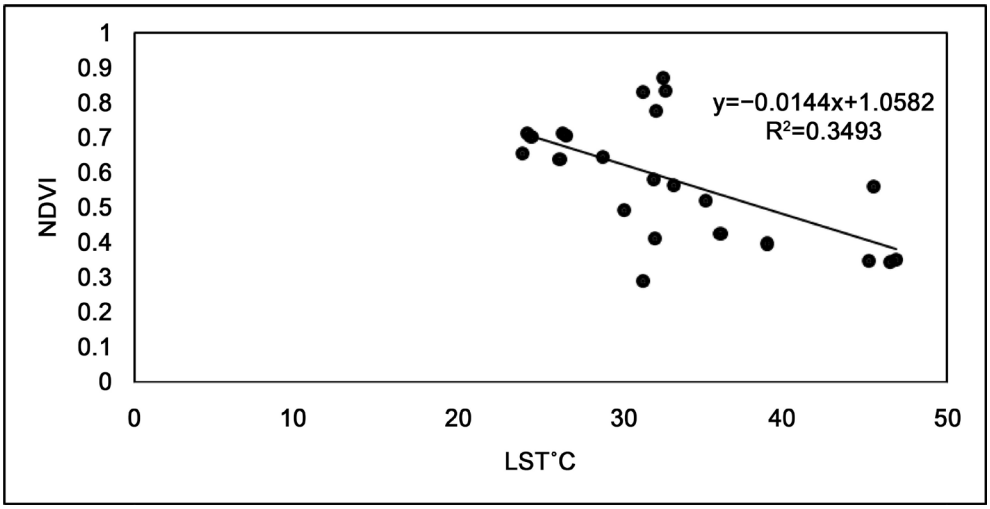

Figure 7. Scatterplot showing the correlation of NDVI-LST for 2012.

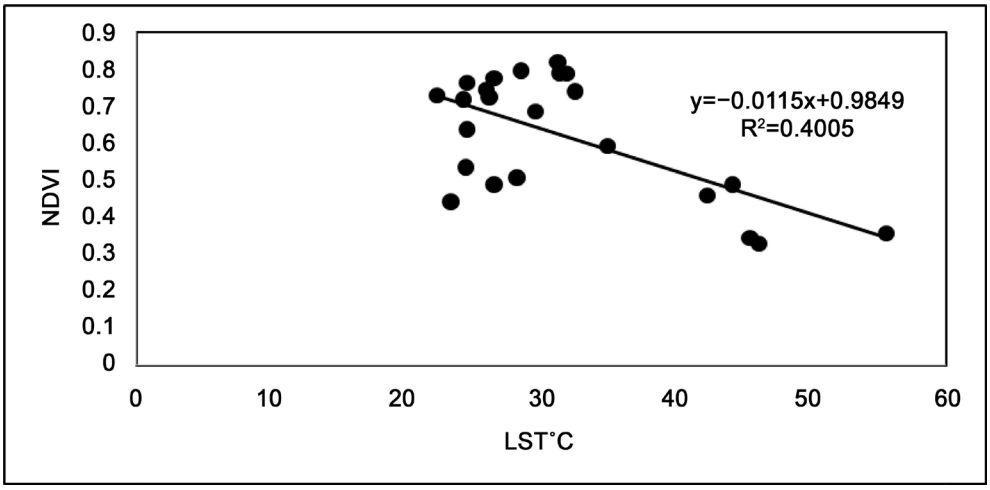

Figure 8. Scatterplot showing the correlation of NDVI-LST for 2013.

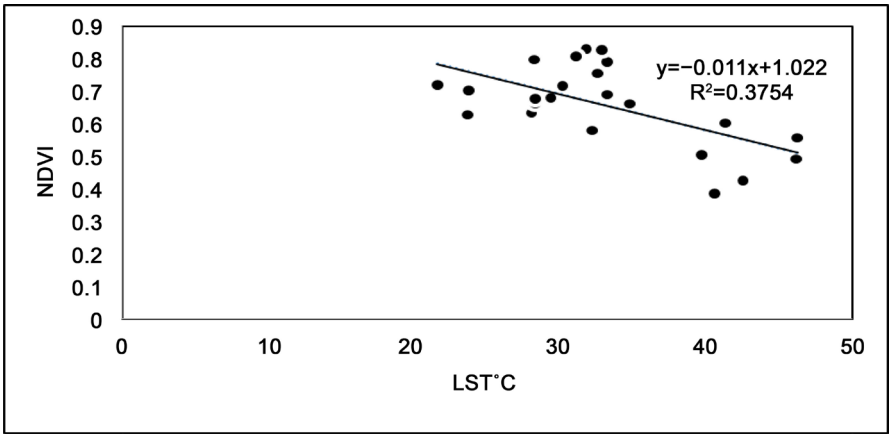

Figure 9. Scatterplot showing the correlation of NDVI-LST for 2014.

posed to be higher than 0.4. in some part, near to transition and buffer boundary, the open forest (<0.2 NDVI) is increasing over the period.

- Hence, the dense forest is not disturbed and the open forest is subjected more deforestation.
- Hence the human-induced pressure in the transition area also did not result in much disturbance in the vegetation density.
- The forest density moves towards higher side in the eastern part of the Similipal Biosphere, where the elevation is also higher.
- LST mean and LST max curves have more or less same value throughout the year except for the duration DOY161 to DOY257. Except the few occasional deeps which may be data error, the maximum NDVI curves are more or less similar in all the observed periods.
- The temporal trend of min NDVI does not follow any definite pattern and very much irregular in its annual course compared to max and mean NDVI.
- There exists a negative correlation between NDVI and LST with correlation coefficient is below 0.4 in all the observed years.

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