Scholarly Research Journal for Interdisciplinary Studies,
Online ISSN 2278-8808, SJIF 2021 = 7.380, www.srjis.com
PEER REVIEWED & REFEREED JOURNAL, MAR-APR, 2022, VOL- 9/70
doi.org/10.21922/srjis.v9i70.10091

VEGETATION CHANGES ANALYSIS USING NORMALIZED DIFFERENCE VEGETATION INDEX AND LAND SURFACE TEMPERATURE MEVASI FOREST

Vasave Mohan Arjun, Ph. D.
Assistant Professor, Department of Geography
Arts, Commerce & Science College Taloda District Nandurbar, Maharashtra
Email : mohanvasavegeo@gmail.com

Paper Received On: 25 APR 2022
Peer Reviewed On: 30 APR 2022
Published On: 1 MAY 2022

Abstract

The present study monitors the interrelationship of Normalized difference vegetation index (NDVI) with land surface temperature (LST) in Mevasi forest in Nandurbar district, Maharashtra, India, using Landsat satellite sensor for the season of 2013 and 2021. Climate change is caused by global warming due to human activities that contribute to greenhouse gas (GHG) emissions. Land-based human activities result in changes in dense vegetation, especially forest stands to land cover with low vegetation density. Remotely sensed multispectral data from Landsat-8 is highly useful in vegetation change analysis based on remote sensing indices and temperature parameters. NDVI (Normalized Difference Vegetation Index)-LST (Land Surface Temperature) relation is essential to understanding the climatological effects on vegetation on regional scales. Threshold-based classification has been used to realize vegetation change in multi-temporal studies.Similarly, in this study NDVI based classification has been applied to understand the change in the area covered by vegetation and waterbodies. Overall, a weak negative correlation (r = 0.647) iiwas iifound between NDVI-LST and observed that our results based on correlation analysis reaffirmed previous findings for LST-NDVI relations in semiarid regions.

Introduction

Forests are significant in climate change mitigation measures because they absorb Carbon dioxide and transform it into a new dimension for trees. Loss of forest cover, reduction in forest area, or forest degradation result in greenhouse gas emissions, reducing the forest's quality as a renewable resource. (Achmad et al.,2020). Even on regional scales, NDVI (Normalized Difference Vegetation Index) has been used to study vegetation phenology change. Identifying climatological and environmental influences on inter-annual and intra-annual variations in vegetation cover is critical. Because vegetation health and soil humidity are directly related, NDVI and LST (Land Surface Temperature) analyse vegetation conditions in semiarid and arid regions (e.g., drought conditions). The relationship between NDVI and LST, on either hand, is seasonal, with a large yet negative relationship observed during in the summer months.

(Fenshot et al., 2009). n contrast, a positive correlation was found in the winter months (Sun et al., 2007). Multi-temporal analysis based on NDVI and LST is preferred to understand the adverse affects of desertification on vegetation cover because the combined use of both would allow a better understanding of changes in vegetation, iioccurring iiin iivarious iiregions. iiFor iieg, iiNDVI iivalues iiwill iibe iisteadier iiand iialmost unvarying in arid regions, b) Semiarid regions will see higher NDVI when the temperature is lower, and c) In tropical regions, NDVI values will change associate to temperature (Julien et al., 2011). Furthermore, direct albedo present value of the future can be used to highlight differences between various cover types.

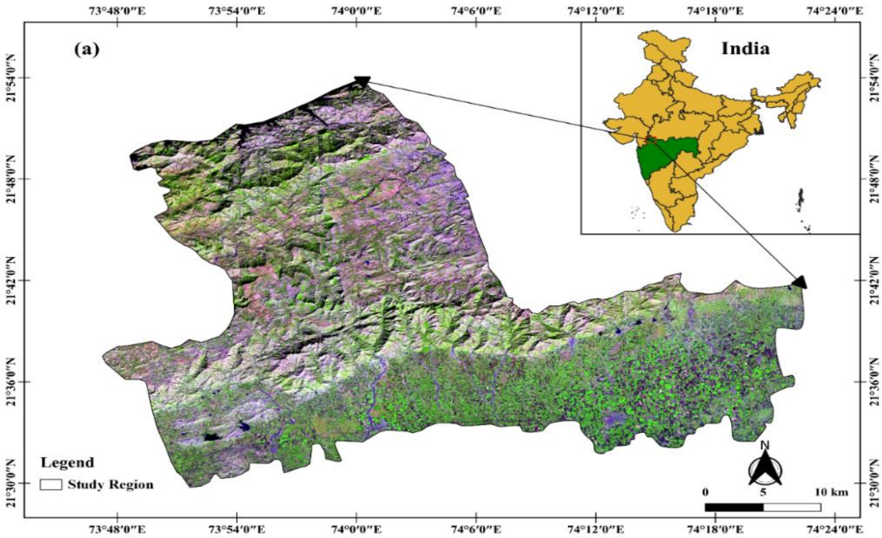
NDVI has also been used to prepare land cover classifications at the continental and global levels since multitemporal NDVI data based on seasonal and inter - annual variations can produce valid and reliable results.(Defries et al.,1994).This is because these variations can be observed due to climatic variability or actual change in land covers In addition, changes in vegetation cover can be directly observed by NDVI as the correlation between vegetation cover and NDVI is very high. Even moderate resolution satellite imagery effectively understands and monitors vegetation cover dynamics. Given that rainfall distribution and other climatic parameters are constant and uniformly distributed geographically, a multitemporal research based on NDVI can potentially identify vegetation cover degradation due to tropic forces over time (Jacquin et al., 2010).

Land surface temperature (LST) is considered an essential parameter in analyzing the exchange of composed material, energy balance, and biophysical and chemical processes of the land surface (Tomlinson et al., 2011).In semiarid regions, the NDVI and LST varies both spatial and temporally. NDVI is minimum in the advent of the significantly lower-than-average precipitation annually, seasonally drops to lowest in the dry summer and spatially the NDVI has variations, e.g., NDVI tends to be higher in the rural area. Whereas LST-NDVI relations vary seasonally, overall, it has a weak and negative relationship; however, NDVI rises with LST in winters. Also, in all three semiarid climatic seasons, i.e., summer, winter, and autumn, daytime LSTs are lower in densely built-up areas. (Rasul et al.,2016) In semiarid climates, the relationship between precipitation and average yearly NDVI is positively correlated, especially in the growing season. So it is inferred that precipitation can be the main driving factor in decreasing NDVI as recurring droughts and climate variability have caused an annual reduction in NDVI, especially in shrublands and croplands. Although precipitation is significant, temperature changes can have a direct effect on vegetation, as strong negative correlations between temperature and NDVI have been found in these regions during the growing season (Measho et al., 2019). Moreover, changes in land use - land cover can have an influence on LSTs; for example, if irrigated agriculture and forest covers are substituted by built-up areas over time, air and land average temperatures will increase. In contrast, if bare soil cover changes to an urban area, the average LST of that region can decrease; thus, vegetation and urban sprawl can both reduce LSTs on a local scale even though vegetation has a cooling effect through transpiration, shadows, and rainwater accumulation, whereas urban region can play this role because of the erath surface and category of material that makes convection more effective than bare soil or rocky areas. (Rasul et al.,2017).

This analysis performs a bi- temporal NDVI and LST vegetation cover change and regression comparison using QGIS 3.22 Open Source Environment in Mesavi Forest. Also, this timeframe was chosen to observe the post scenario of the Asiatic Lion census 2015, which occurred in the post-monsoon period between 2013 and 2021 in the mesavi forest . We believe that higher LSTs have a major impact on vegetation cover. This research will look at the most recent changes and how they affect various vegetation cover types, taking into account diverse conservation areas, urban settlements, water bodies, and other land surface features.

Study Area

The study region includes two tehsils, Akkalkuva and Taloda, in the Nandurbar district of Maharashtra, India, with geographic coordinates of 21° 30' and 21° 54' N latitude and 73° 48' and 74° 24'E longitude. It covers an area of 1358.21 km2. According to the Köppen Geiger climate classification map, this region has a Hot Semiarid climate (Bsh) with hot, dry summers and moderate winters (Peel et al., 2007). Additionally, this region is part of the Agro-ecological region no.6.1, which encompasses the Deccan Plateau, Maharashtra Plains, and Satpura mountain and hilly region. A hot-semi arid region categorizes by moderately deep black soils and shallow dep soil (Mandal et al.,2016).



(a) Fig.1 Study area map of Mevasi Forest in Nandurbar District.

Moreover, this study region lies within three major agro-climatic zones of the Western Ghat Zone, all of which are characterised by a dry sub-humid climate. The region's vegetation is classified into Tropical thorn forest and patches of dry deciduous forest. The region's vegetation is classified into Tropical thorn forests and patches of Dry deciduous forest (Champion et all., 1968). The Average Annual Precipitation is 712 mm for Akkalkuwa and 599.8 mm for Taloda tehsil of Mesavi forest in Nandurbar District. Average Daily Max. Air temp. Akkalkuva is 32 **°C** and for Taloda is 35 °C, whereas the Average Daily Min. air temperature. For Akkalkuwa is 21 °C and for Taloda is 26 °C. Also, the relative humidity of Akkalkuwa is 51% and of Taloda is 59% (Indian Metrological Department, 2020).

Metholoogy and Database

Datasets

The datasets used in this study were from the USGS Landsat satellite Level-1 Data Product, which consists of raster images of multispectral image data in the form Digital Numbers (D.N.) i.e. For a bi-temporal comparison, pixel values for the December months of 2013 and 2021 were used. Band 4 (Red), Band 5 (Near-Infrared), and Band

10 (Thermal Infrared 1) were utilised to create NDVI and LST maps in this study. Bands 4 and 5 had a spatial resolution of 30 m, whereas Band 10 had a resolution of 100 m. Using the vector boundary of the two tehsils of the Nandurbar District indicated earlier, required geo rectification, mosaicking, and subsetting were performed on all raster images used in this analysis.

NDVI Computation

Band 4 and Band 5 are used for calculating NDVI since the ratio of these bands is applied. The NDVI is a dimensionless quantity with values ranging from +1 to -1. It ranges from 0 to 1, signifying sparse to dense vegetation, although values less than 0 indicate a complete lack of flora, representing water or ice. It's computed using Eq.

$$\mathbf{NDVI} = \frac{\mathbf{Band\ 5 - B\ and\ 4}}{\mathbf{Band\ 5 + Band\ 4}} \qquad (1)$$

Band RS-GIS Plugin of QGIS 3.16 was used to compute instant NDVI raster images as it converts the D.N. values to Reflectance for Band 4 and Band 5 to obtain NDVI.

LST Computation

A few processing steps on the TIRS Level-1 data, i.e. Band 10, are required to compute LST. In QGIS 3.16, however, all of these procedures are completed automatically using RS-GIS plugins.

a) D.N. and TOA (Top of Atmosphere) radiance (L_λ). The first step is to convert raw D.N. into TOA radiance, as shown in Eq. 2.

$$\mathbf{L_\lambda = ML_\lambda \times Q_{cal} + AL_\lambda} \qquad (2)$$

Where MLλ is the radiance multiplicative scaling factor for the respective spectral band, ALλ is the radiance additive scaling factor for the respective spectral band, and Qcal is the pixel value i.e., D.N.

b) Temperature (T) of TOA Radiance to At-Satellite Brightness Eq.3 shows what the following stage would appear as.

$$\mathbf{T_\lambda = \frac{K_2}{\ln \frac{K_1}{(L_\lambda + 1)}} - 273.15} \qquad (3)$$

Where Lλ is the radiance, K1 and K2 are prelaunch calibration constants (U.S. Geological Survey, 2016).

a) Emissivity calculation before final LST computation Author: To compute LST, it is required to calculate emissivity (e) as shown in Eq. 4.

$$\mathbf{e = 0.004Pv + 0.986} \quad \mathbf{(4)}$$

Where Pv is the vegetation proportion and is calculated with the help of scaled NDVI (by using the NDVI obtained earlier) as shown in Eq. 5.

$$\mathbf{Pv = \left[\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right]^2} \quad \mathbf{(5)}$$

Where the NDVI is computed earlier per pixel. While, $NDVI_{min}$ and $NDVI_{max}$ are the minimum and maximum NDVI, respectively. The equation portion in the squared brackets is also called 'scaled NDVI' (Carlson & Ripley, 1997).

c) LST Calculation

$$\mathbf{LST = \frac{T_{\lambda}}{1 + \left(\frac{\lambda \times T\lambda}{\rho}\right) Lne}} \quad \mathbf{(6)}$$

Where, Tλ is the at-satellite brightness temperature, λ is the wavelength of the emitted radiance, ρ = h×c/j (h is Planck's constant i.e. 6.62607015×10-34 Js , c is velocity of light i.e. 2.99 x 108 m/s and j is the Boltzmann constant i.e. 1.380649×10-23 J K-1) and as mentioned earlier the emissivity (e) computed using Eq. 4 will be further used to calculate the final LST (Artis & Carnahan, 1982).

NDVI Derived Vegetation Cover

Thresholding NDVI values prepare the vegetation cover maps. The threshold values of the cover types are approximately based on the reference studies as mentioned in Table 1. The bare Land threshold was based on two studies, one directly and the other indirectly based on the minimum threshold value of the crop. Similarly, the sparse vegetation threshold was indirectly based on the minimum threshold values of crops.

Table 1. NDVI threshold values of different cover types.

Sr iiNo	Class iiType	NDVI ii iiValue iiThreshold ii	Reference
0	Water iibodies	-0.046	(Bisrat ii& iiBerhanu, ii2018), (Dalezios iiet iial., ii2001)
1	Bare iiLand	0.25	(Ding iiet iial., ii2016) ii(Thorat et iial., ii2015)
2	Low iiVegetation	0.35	(Thorat iiet iial., ii2015)
3	Moderate iiVegetation	0.5	(Bisrat ii& iiBerhanu, ii2018), (Dalezios iiet iial., ii2001)
4	Dense ii iiVegetation	1	(Dalezios iiet iial., ii2001)

Result and Discussion

As shown in Fig.1 and fig.2, it is confirmed clearly that the 2013 NDVI values are significantly lower than 2021 NDVI values, as the mean NDVI value for 2013 was found to be 0.39 (±0.12 S.D.) in contrast to the 2021 mean NDVI value which was 0.43 (±0.12 S.D.). For 2013, the minimum and maximum NDVI values were - 0.75 and 0.81, respectively. For 2021, the minimum and maximum NDVI values were – 0.53 and 0.80, respectively. In the central part of the study area where the Khardi and Varkhedi River Basin lies, there was a clear difference in NDVI, suggesting the significantly varying vegetation cover while comparing the two years.

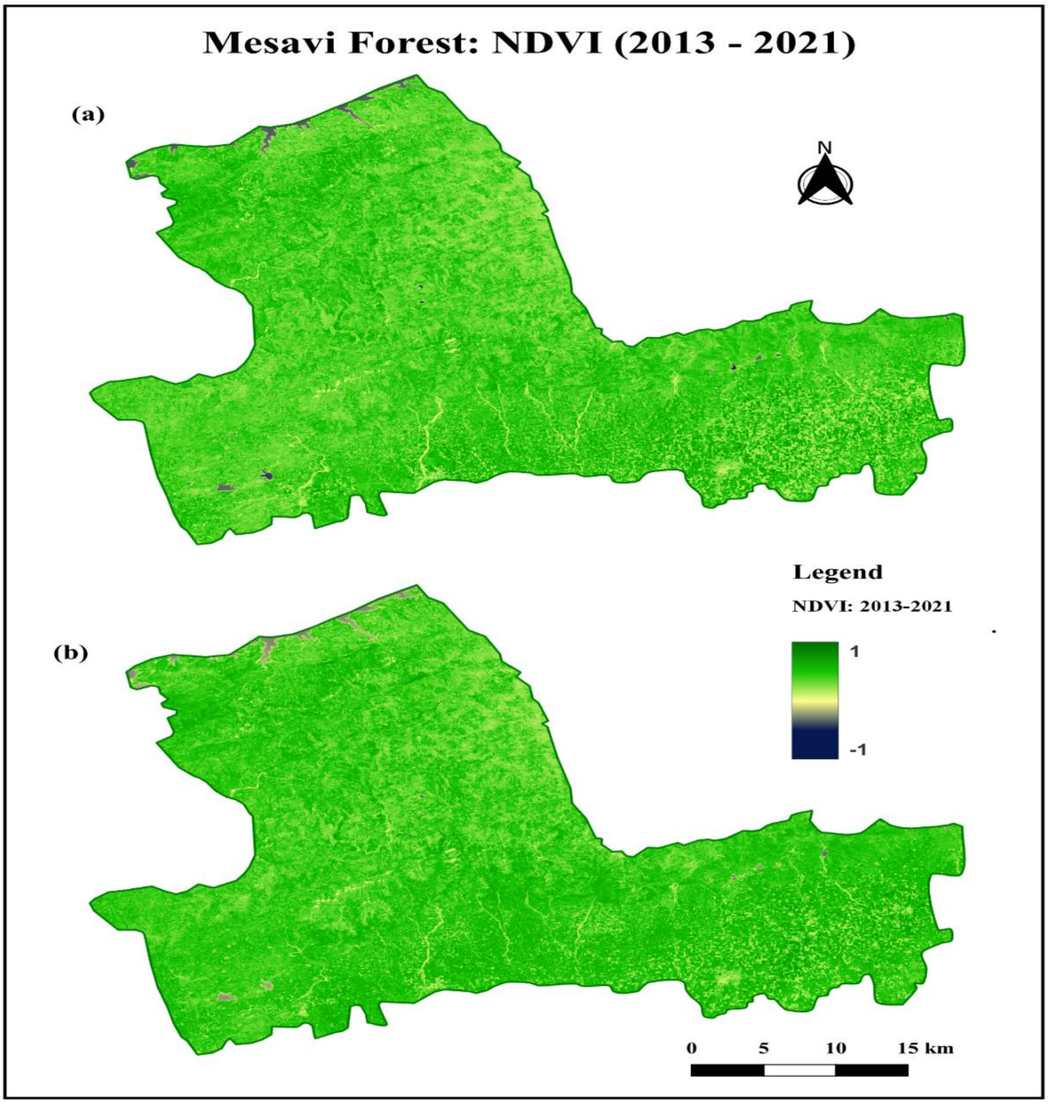


Fig.2 (a) NDVI Map of 2013 & (b) 2021 for Mevasi Forest in Nandurbar District.

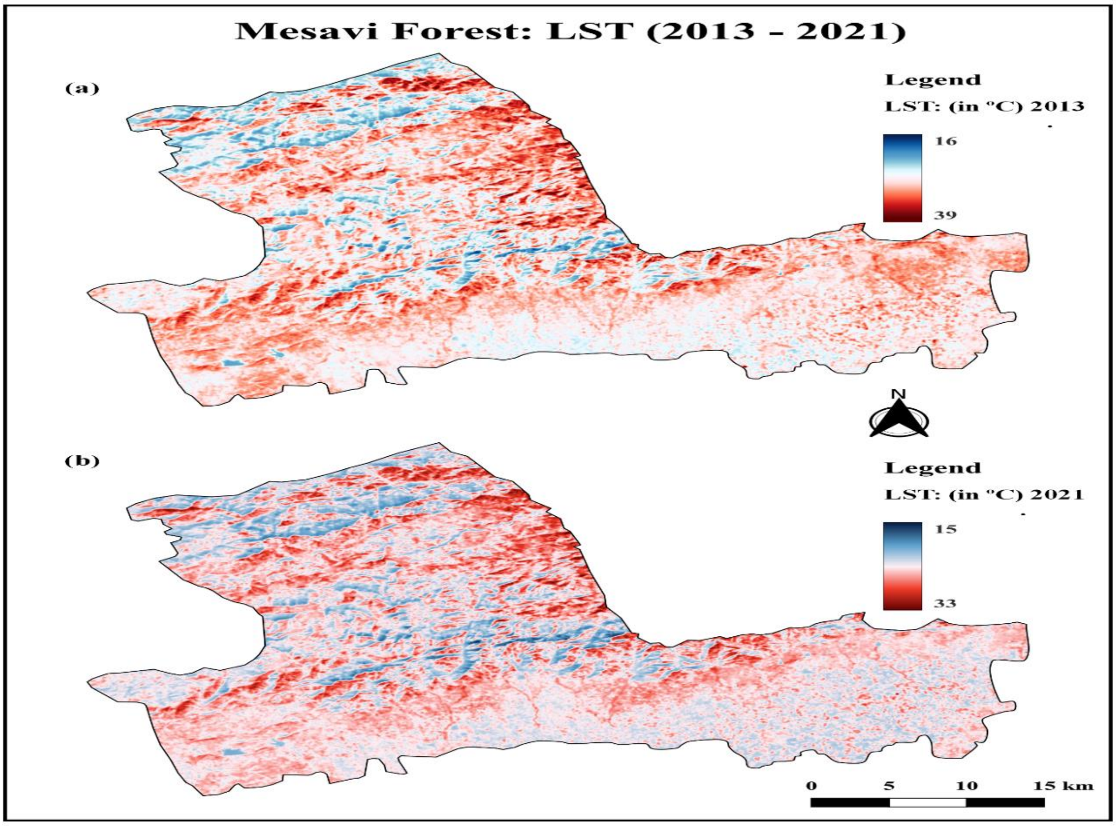
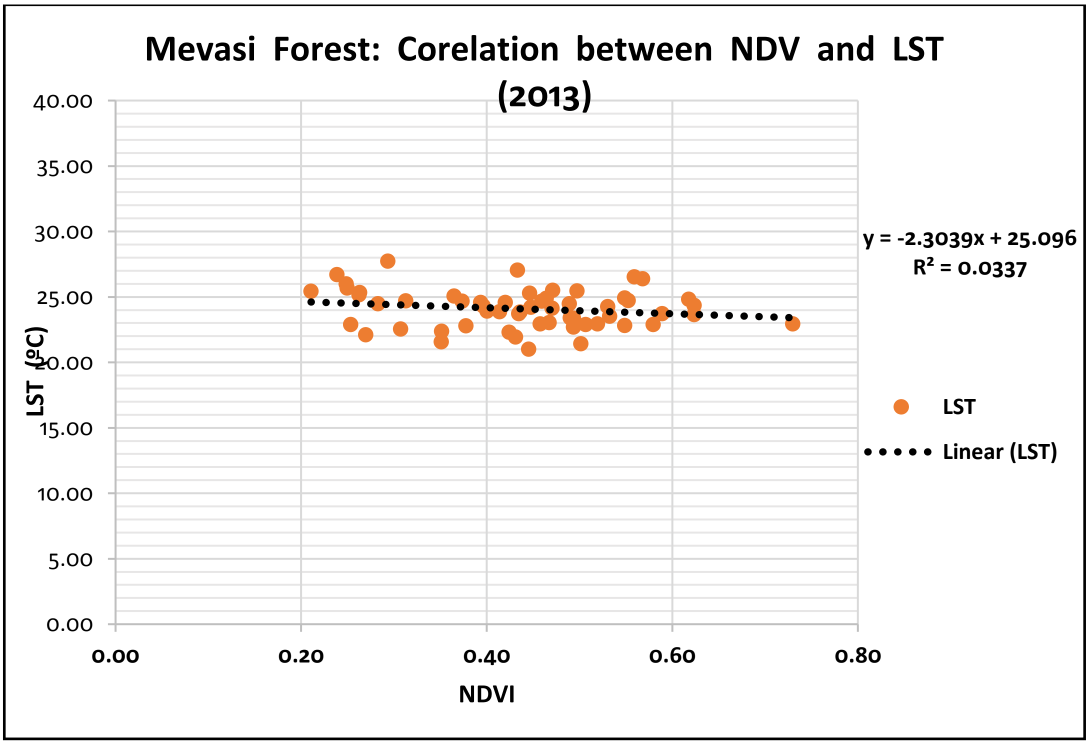


Fig.3 (a). iiLST iiMap iiof ii2013 & 2021 iiiifor Mevasi iiMesavi iiForest iiin iiNandurbar



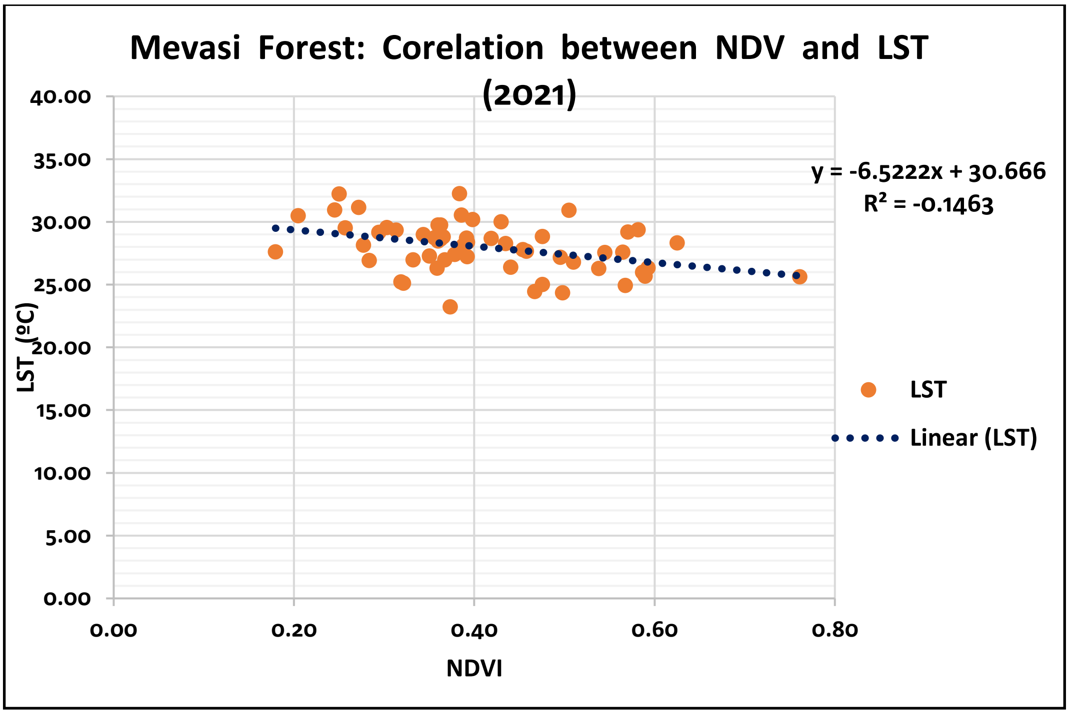


Fig. 4 LST- NDVI Scatterplot for compering 2013 and 2021 Values.

Also, the LST maps, as shown in fig.3 and fig.4 reveal a significant difference in LSTs while comparing the two years. In 2013, the mean LST of the entire area was 24.39 °C (±1.9 S.D.), whereas in 2021, the mean LST was 28.3 °C (±2.5 S.D.). This clearly suggests that 2013 year must have higher temperatures even in December as it is almost the onset of winter in this region.

In Comparison, 2013 witnessed a stark difference in LSTs between different land cover types e.g. water bodies and barren areas in the north, in contrast to 20121, where the southern central part had higher temperatures than the north, and temperature differences were not significant as 2013 LSTs. Our results agree with a study that implies strong positive correlations between LST and NDVI are only witnessed in the warm months, including summer. When approaching the onset of winter (i.e., December in our study area), the change from negative to positive correlation starts (Sun et all., 2007). As shown in fig.5. An overall weak positive correlation (r = 0.647) was found for both years. In addition, there was an even weaker positive correlation (0.146) found in 2021 between LST- NDVI values compared to 2013, where although it was a weak negative (0.033), it was still stronger than in 2021. Moreover, as shown in fig. 5. scatter plot, the NDVI values in 2013 are almost normally distributed compared to 2021, which is slightly positively skewed and shows it has relatively lower positive NDVI values than 2013. This also confirms the result of 2021 LSTs which shows cooler temperatures than in 2013. When comparing Figures 6 and 7, the variation in vegetation cover types, particularly in the dense vegetation class, is significant. Sparse and Moderate vegetation-covered more area in 2013 than in 2021. Dense vegetation patches are few in the 2013 vegetation cover map. Most importantly, dense vegetation cover patches were almost absent in 2015 in the Khardi River Basin area.

Table No .3 Mevasi Forest: Area in Vegetation changes

Sr. iiNo	Class	Area iiin iisq iikm (2013)	Area iiin iisq iikm (2021)	% (2013)	% (2021)
1	Water iibodies	10.79	9.79	0.79	0.72
2	Bare iiLand	22.66	40.59	1.67	2.99
3	Low iiVegetation	435.73	634.13	32.08	46.69
4	Moderate iiVegetation	793.86	607.85	58.45	44.75
5	Dense ii iiVegetation	95.17	65.84	7.01	4.85
Total		**1358.21**	**1358.21**	**100**	**100**

Table, 3 presents comparison statistics for the area.As per Table 2, the Dense vegetation cover in 2021 was almost 2.16 % higher than in 2013, which can be because the LSTs in 2013 were higher than in 2021, and higher LSTs can be due to dryness or drought-like conditions in that year. Therefore 2013 has less dense vegetation cover than 2021. Water cover was lower by almost 20.58 sq. km (0.07%) in 2013 than in 2021. Additionally, Bare soil area had been reduced from 2013 to 2021 by more than 1.32 %. This shows clearly significant variations in vegetation cover between the two years.

Conclusion

Our results reveal that strong positive relationships between LST and NDVI can only be seen in decamped months, i.e., in the winter. Positive relationships are found in our climatic zone, as well as other zones throughout the world. Another noteworthy finding is that the percentage of water bodies was much lower in 2013 than in 2021, implying that decreasing precipitation has an impact on NDVI values, as well as irrigation in semiarid areas like our study area.

To overcome the limitations of the LST-NDVI relationship for vegetation change study, a precipitation and irrigation scenario can be included to better understand the NDVI relationship. For similar threshold-based vegetation cover classification, we recommend using several indices like the Enhanced Vegetation Index (EVI) or Perpendicular Vegetation Index (PVI), Vegetation Health Index (VHI), and Normalized Differences Water Index (NDWI).

Refrences

Artis, iiD. iiA., ii& iiCarnahan, iiW. iiH. ii(1982). iiSurvey iiof iiemissivity iivariability iiin iithermography iiof iiurban iiareas. iiRemote iiSensing iiof iiEnvironment, ii12(4), ii313–329. iihttps://doi.org/10.1016/0034- ii4257(82)90043-8.

Bisrat, iiE., ii& iiBerhanu, iiB. ii(2018). iiJOURNAL iiOF iiNATURAL iiRESOURCES iiAND iiDEVELOPMENT iiIdentification iiof iiSurface iiWater iiStoring iiSites iiUsing iiTopographic iiWetness iiIndex ii(TWI) iiand iiNormalized iiDifference iiVegetation iiIndex ii(NDVI) iiArticle iihistory. iiJournal iiof iiNatural iiResources iiand iiDevelopment, ii08, ii91–100. iihttps://doi.org/10.5027/jnrd.v8i0.09. ii ii ***ii***

Carlson, iiT. iiN., ii& iiRipley, iiD. iiA. ii(1997). iiThe iirelation iibetween iiNDVI, iifractional iivegetation iicover, iiand iileaf iiarea iiindex. iiRemote iiSensing iiof iiEnvironment, ii62(3), ii241–252. iihttps://doi.org/10.1016/S0034-4257(97)00104-1 iiChampion, iiH. iiG., ii& iiSeth, iiS. iiK. ii(1968). iiA iiRevised iiSurvey iiof iithe iiForest iiTypes iiof iiIndia. iiGovernment iiof iiIndia.

Dalezios, iiN. iiR., iiDomenikiotis, iiC., iiLoukas, iiA., iiTzortzios, iiS. iiT., ii& iiKalaitzidis, iiC. ii(2001). iiCotton iiyield iiestimation iibased iion iiNOAA/AVHRR iiproduced iiNDVI. iiPhysics iiand iiChemistry iiof iithe iiEarth, iiPart iiB: iiHydrology, iiOceans, iiand iiAtmosphere, ii26(3), ii247–251. iihttps://doi.org/10.1016/S1464-1909 ii(00) ii00247-1.

Defries, R. S., & Townshend, J. R. (1994). Ndvi-Derived Land Cover Classifications At a Global Scale. International Journal of Remote Sensing, 15(17), 3567–3586. https://doi.org/10.1080/01431169408954345..

Ding, iiY., iiZheng, iiX., iiZhao, iiK., iiXin, iiX., ii& iiLiu, iiH. ii(2016). iiQuantifying iithe iiimpact iiof iiNDVIsoil iidetermination iimethods iiand iiNDVIsoil iivariability iion iithe iiestimation iiof iifractional iivegetation iicover iiin iiNortheast iiChina. iiRemote iiSensing,8 ii(1), ii1– ii15. iihttps://doi.org/10.3390/rs8010029.

Fensholt, R., Rasmussen, K., Nielsen, T. T., & Mbow, C. (2009). Evaluation of earth observation based long term vegetation trends - Intercomparing NDVI time series trend analysis consistency of Sahel from AVHRR GIMMS, Terra MODIS and SPOT VGT data. Remote Sensing of Environment, 113 (9),1886-1998.

Indian iiMeteorological iiDepartment. ii(2010). iiClimatological iiTables iiof iiObservations iiin iiIndia, ii1981-2010. ii893. iihttp://www.imdpune.gov.in/library/public/1981-2010 iiCLIM iiNORMALS ii(STATWISE).pdf.

Jacquin, A., Sheeren, D., & Lacombe, J. P. (2010). Vegetation cover degradation assessment in Madagascar savanna based on trend analysis of MODIS NDVI time series. International Journal of Applied Earth Observation and Geoinformation,12(SUPPL..

Peel, iiM. iiC., iiFinlayson, iiB. iiL., ii& iiMcMahon, iiT. iiA. ii(2007). iiUpdated iiworld iimap iiof iithe iiKöppen-Geiger iiclimate iiclassification. iiHydrology iiand iiEarth iiSystem iiSciences, ii11(5), ii1633–1644. iihttps://doi.org/10.5194/hess-11-1633-2007.

Mandal, D. K., Mandal, C., & Singh, S. K. (2016). Delineating Agro-Ecological Regions. National Bureau of Soil Survey and Land Use Planning, 1–8.

Rasul, A., Balzter, H., & Smith, C. (2016). Diurnal and seasonal variation of surface Urban Cool and Heat Islands in the semiarid city of Erbil, Iraq. Climate, 4(3). https://doi.org/10.3390/cli4030042.

Rasul, A., Balzter, H., & Smith, C. (2017). Applying a normalized ratio scale technique to assess influences of urban expansion on land surface temperature of the semi-arid city of Erbil. International Journal of Remote Sensing, 38(13), 3960–3980. https://doi.org/10.1080/01431161.2017.1312030.

Sun, D., & Kafatos, M. (2007). Note on the NDVI-LST relationship and the use of temperature-related drought indices over North America. Geophysical Research Letters, 34(24), 1–4. https://doi.org/10.1029/2007GL031485.

Thorat, iiS. iiS., iiRajendra, iiY. iiD., iiKale, iiK. iiV., ii& iiMehrotra, iiS. iiC. ii(2015). iiEstimation iiof iiCrop iiand iiForest iiAreas iiusing iiExpert iiSystem iibased iiKnowledge iiClassifier iiApproach iifor iiAurangabad iiDistrict. iiInternational iiJournal iiof iiComputer iiApplications, ii121(23), ii43–46. iihttps://doi.org/10.5120/21845-515.3.

U.S. iiGeological iiSurvey. ii(2016). iiLandsat ii8 iiData iiUsers iiHandbook. iiNasa, ii8(June), ii97. iihttps://landsat.usgs.gov/documents/Landsat8DataUsersHand iibook.pdf.