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A Remote Sensing and GIS based study on the tree canopy cover, distribution, pattern and its relationship with Normalized Difference Vegetative Index in the selected College and University campuses in Coimbatore district, Tamil Nadu, India.

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Abstract: *Urbanization in India is not only environmentally challenging but socially and economically alarming too. An attempt is made in the present study to quantify the degree of greenness in the college and university campuses of 21 selected sites in Coimbatore district. The study showed that linear canopy pattern is dominant in urban settings along road sides and surrounding built ups in many sites giving NDVI value ranging between 0.5 to 0.3. Most of the sites have open canopy cover mostly which are cultivated lands. The maximum NDVI recorded was 0.569 and minimum as 0.255. According to the coefficient of variance analysis closed canopy cover is best pattern fit to give maximum NDVI, but when it comes to urban settings street canopy has a significant role. Urban forest canopy is an emerging and challenging issue in Indian urban set ups but in this changing climate with heat waves, sun burns, skin cancers and behavioral agitations seen in the population it is important to analyze the urban forest network and its association with health aspects especially students.*

Keywords: *Urbanization, Green spaces, Normalized Difference Vegetative Index.*

I. Introduction

Wearing different sorts of clothing to shield against the direct sunlight is a very common sight now a days in India and other countries. Youngsters, middle aged working people all seem to be very aware of the fact that climate is changing and we need to cover ourselves up accordingly when we are out in the middle of the day. Trees in urban settings provide a broad spectrum of ecosystem services including biodiversity conservation, removal of atmospheric pollutants, oxygen generation, noise reduction, mitigation of urban heat island effect, microclimate regulation, stabilization of soil, groundwater recharge, prevention of soil erosion, carbon sequestration and many other direct and indirect benefits. A city with high-quality of generous green spaces epitomizes good planning and management, a healthy environment for humans, vegetation and wildlife populations (Brown, 2003). Compact urban areas are characterized by the close juxtaposition of buildings and roads with limited interstitial space to hold greenery. For day time temperatures, it is observed that large cities can be 3^{o}C hotter than the suburbs area. Research has showed the effectiveness of urban heat island in changing the urban micro-climate e.g. changes of intensity and frequency of rainfall (Godefroid, 2001; Kaplan, 1984).

Global warming boosts the probability of extreme weather events, like heat waves, far more than it boosts more moderate events. Heat waves are the most lethal type of weather phenomenon, overall. Between 1992 and 2001, deaths from excessive heat in the United States numbered 2,190, compared with 880 deaths from floods and 150 from hurricanes (Ulrich, 1986).Concern is now focusing on predicting the future likelihood of heat waves and their severity. More than 70,000 Europeans died as a result of the 2003 European heat wave (Kirby, 1989). Older adults, very young children, and those who are sick or overweight are at a higher risk for heat-related illness.

Most of the Indian population lives below the poverty line, and the majority are daily wage labors, according to the government figures. Many workers work outside in extreme heat despite the risk for their livelihood. Poverty and environmental risks are so interlinked and complicated. Some of the harmful radiations in sunlight can also lead to many skin related disorders, the most dreadful is the skin cancers. Greater than 90% of cases are caused by exposure to ultraviolet radiation from the Sun (Fuller *et al.,* 2007). The present study focuses the role of trees, their presence, and pattern of distribution in and around the campuses of colleges, universities or educational institutes of Coimbatore district, Tamil Nadu, India.

II. Study Area

Coimbatore district lies between 11° 00' of north latitude and 77° 00' of East longitude. After Chennai it is the second largest city and urban agglomeration in the state and sixteenth largest in India. It is surrounded by mountains on the west, with reserve forests and the Nilgiri biosphere reserve on the northern side. The

eastern side of the district, including the city is predominantly dry. The entire western and northern part of the district borders the Western Ghats with the Nilgiri biosphere as well as the Anaimalai and Munnar ranges. The mean maximum and minimum temperatures during summer and winter varies between 35°C to 18°C. Highest temperature ever recorded is 41 °C and lowest is 12 °C.

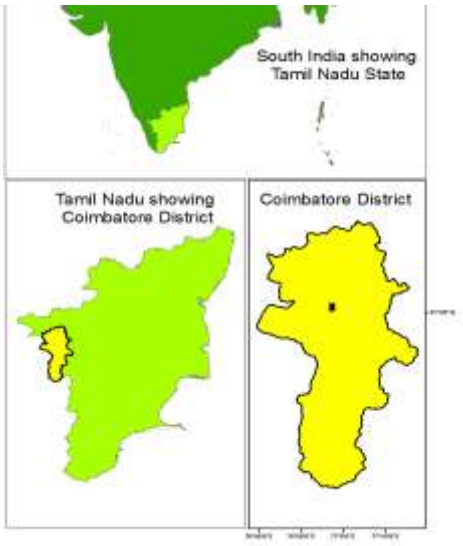

Fig. 1 Study area

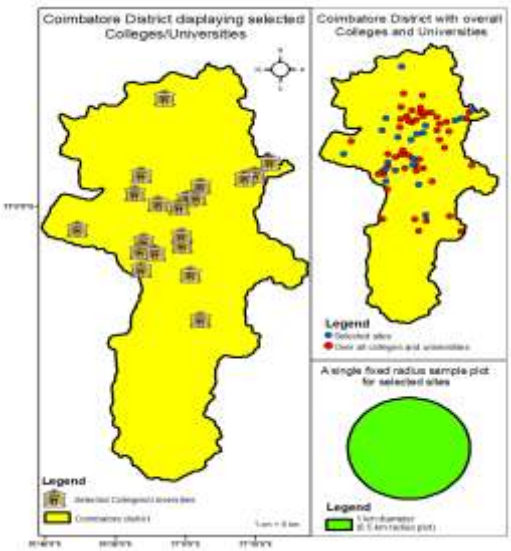

Fig. 2 Intensive Study Area

The major colleges and universities throughout Coimbatore district were selected in such a manner that their geographical locations were also taken into account so that climatic variations would be neutralized and differences would minimally bias the analysis. A total of 21 sites were taken for this study with fixed radius of 0.5km, each circular plot has 1km diameter. Total number of colleges and universities in Coimbatore are around 100 and the study has covered 20% of them.

III. Methods and Materials

The fixed radius circular plots were laid spatially on the study sites and the tree canopy cover was digitized and quantified by employing ArcGIS 10.1 and Google earth. NDVI was calculated and the values were further statistically correlated with the tree canopy cover. Tree canopy network pattern was also studied and mapped. The built-up land image was produced using the NDBI with the following equation: NDBI = (MIR-NIR)/(MIR+NIR) (Zha et al., 2003). NDVI is particularly used to assess the presence and condition of vegetation. A Normalized Difference Vegetation Index (NDVI) is an equation that takes into account the amount of infrared reflected by plants. Raster calculator was used for the TOA (Top of Atmospheric Correction) and NDVI calculations. Fourth and fifth bands of Landsat 8 imageries of 2014 September, February and June months were used. Formula for TOA reflectance is (0.00002*DN)+0.1/Solar angle. These data inputs can be acquired from the metadata that comes along with the satellite image we acquire.

The land use quantitative analysis was subjected to mapping and the data derived via NDVI calculations were used for statistical analysis, both the land use data and NDVI data were put into together to observe the relationship of the two. Digital Elevation Model and local NDVI were extracted from ASTER GDEM and BHUVAN local India coverage data respectively. The DEM data and local NDVI data were compared in reference with the distribution of educational institutes in and around Coimbatore district.

IV. Results and Discussion

This study mainly observed the presence and pattern of tree spread throughout the campuses of 1km diameter of selected sites. It was clear that the tree coverage found was not the outcome of any sort of urban tree planning, but it was the remaining left outs standing and in some cases tree line was seen lined around built ups which is a good sign as it cools the immediate surroundings. From the view point of students what the study wants to study was the street canopy which provides shade, comfort and relaxation in walking around the campus. Vegetation is a major parameter in urban environmental quality for many reasons, including aesthetic considerations, temperature control due to evapo-transpiration and shading, the filtering and recycling of pollutants and for as urban wildlife habitats and therefore biodiversity or city biodiversity (Dwyer *et al.,* 1992; Akbari *et al.,* 1992). In areas with no vegetation, evapo-transpiration may be zero, thus most incoming radiation is transferred to the urban atmosphere as heat.

The quantification and land use categorization with respect to the tree canopy coverage and pattern of distribution shows that linear canopy or street canopy is dominant in all sites. But the question was what tree types were present. Linear tree canopy along road sides must bare tree species having broader tree crown and leaf size. Open canopy was present in 76.19 % of 21 sites and closed canopy was 38.09 % only. Among the three types of canopy cover pattern (linear canopy cover, open canopy cover and closed canopy cover) linear was predominantly present as the urban network supports this kind of canopy cover in almost all the tightly packed urban centers having less open spaces and least closed canopy types. The site name (name of the college or university) and their respective sampling sequence number are as following:

Site 1 – PA College of Engineering And Technology, Site 2 - Karunya University, Site 3 - Bharathiar University , Site 4 - Tamil Nadu Agricultural University Site 5 - Nanjiah Lingammal Polytechnic College, Site 6 - Coimbatore Medical College, Site 7 – Avinashilingam University For Women, Site 8 - Tamil Nadu College of Engineering , Site 9 - Karpagam University, Site 10 - Akshaya College of Engineering, Site 11 - Amrita Vishwa University, Site 12 – CMS College of Engineering And Technology, Site 13 - Hindustan College of Engineering, Site 14 – Nehru Institute of Engineering And Technology, Site 15 - Dr.NGP Arts And Science College, Site 16 - Nirmala College For Women, Site 17 - Park College of Engineering And Technology, Site 18 - PSG College of Technology, Site 19 - Sree Narayana Guru College, Site 20 - KPR Institute of Engineering And Technology, Site 21 - Adithya Institute of Technology.

Table 1. The selected 21 sites quantification results

Site	Pattern 1%	Pattern 2%	Pattern 3%	Total canopy %	Built ups %	NDVI Max
1	1.5	25	7.5	30	35.25	**0.255**
2	30.62	2.33	5.5	38.55	23	0.539
3	8.08	24.2	6	38.36	14.87	0.469
4	**40.02**	1.58	0	**41.61**	15.62	**0.569**
5	2.95	4.02	9.25	16.22	15.37	0.484
6	13.41	0	1.3	14.78	28.12	0.392
7	3.46	11.3	0	14.8	5.8	0.452
8	5.6	0	5.25	10.85	6	0.373
9	5.8	0	0	5.88	21.87	0.373
10	0.65	15.5	0	16.21	11.75	0.443
11	32.4	6.21	0	38.61	15.25	0.503
12	2.5	37	0	39.5	3.125	0.469
13	1.28	5.62	0	6.91	7.625	0.47
14	1.33	**37.5**	0	38.83	8.125	0.482
15	11.32	0.18	0	11.51	13.5	0.407
16	20.25	0	0	20.25	73.2	0.42
17	6.12	2.7	4.2	13.08	8.25	0.408
18	12.5	0	0	12.5	**83.62**	0.491
19	6.56	11.81	0	18.37	14.62	0.526
20	7.8	6	0	13.8	15.87	0.429
21	1.7	5	**27.5**	34	16.2	0.41

Site 4 has shown the maximum linear /street canopy cover percentage, open canopy is maximum in site 14 and closed canopy is maximum in site 21. In the case of built ups site 1 has shown maximum of 35.25 %. Given under (fig 4) shows the maximum NDVI and maximum linear canopy (area in km^2) - Site 4 has recorded maximum NDVI as well as linear canopy cover among 21 sites.

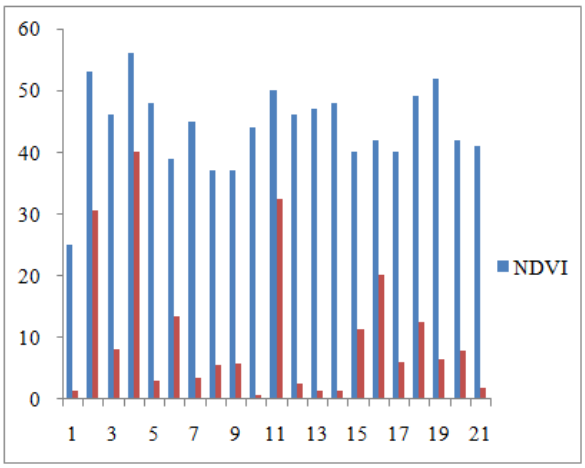

Fig. 3 NDVI and Linear Canopy Comparison

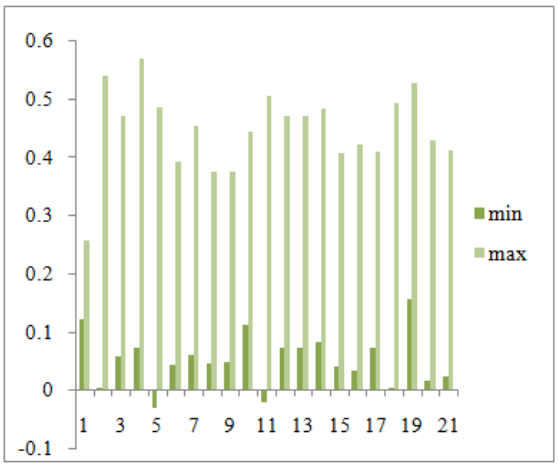

Fig. 4 Minimum and maximum NDVI

The (fig 3) showed the lists of NDVI values for 21 sites. NDVI scale is Negative one to zero to positive one. Negative value indicates poor vegetative conditions 1 indicates very healthy closed canopy. Site 4 has shown the maximum NDVI value 0.569 when we take into consideration the three temporal datasets. Site 2 comes second 0.569 and site 19 third in maximum NDVI value of 0.526. Whereas site 1 has least NDVI value of 0.255. Two sites give negative value of -0.031 and -0.022 (site 5 and 11 respectively).

Most of the maximum values range from 0.3 to 0.4 and some in 0.5, only one is in 0.2 range, whereas negative values are only two in minimum NDVI values. NDVI maps of maximum and minimum values with their corresponding land use maps are given. Site 4 – Tamil Nadu Agriculture University maximum NDVI and maximum linear canopy cover followed by site 2 and site 19.

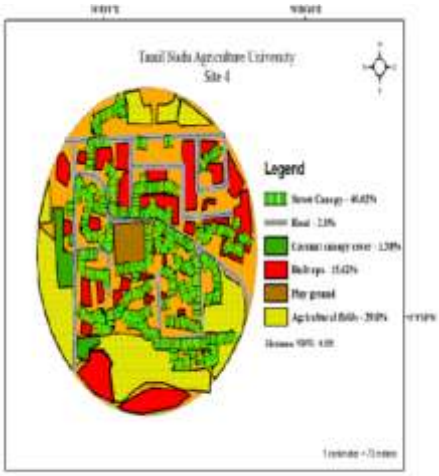

Fig. 5 Site 4 land use

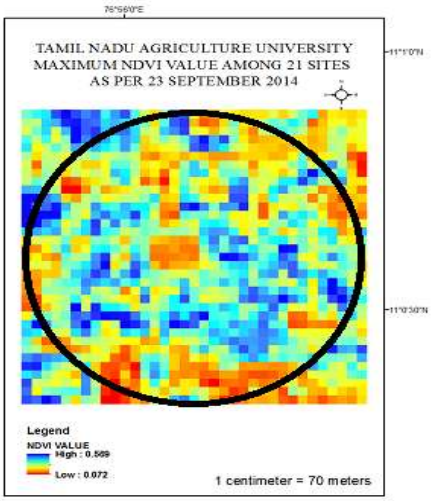

Fig. 6 NDVI of site 4

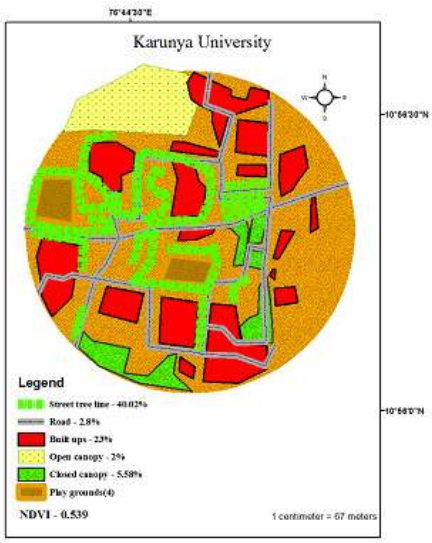

Fig. 7 Site 2 land use

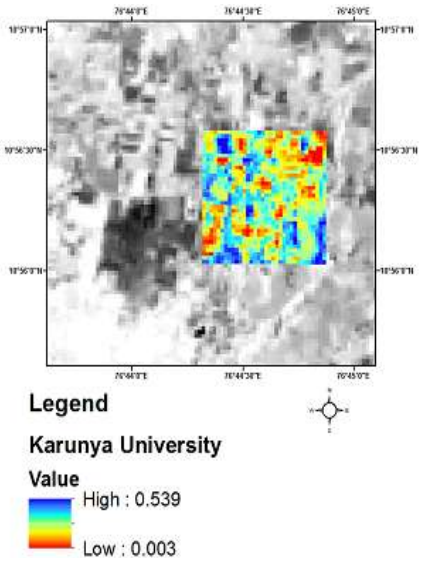

Fig. 8 NDVI of site 2

Tamil Nadu Agriculture University maximum NDVI and maximum linear canopy cover of 40.02 %. The linear canopy is dominant here which is the pattern 1 kind of canopy pattern considered in this study. The site is devoid of closed canopy cover and open canopy aside from the few single standing trees in the open agricultural fields.

The land use categorization for site 2 – Karunya University and its corresponding NDVI map highlighted from the rest of the satellite image giving the second maximum NDVI among the 21 sites in this study and also third maximum linear canopy cover of 30.62 %. The canopy cover pattern dominant here is pattern 1 running along the road sides and surrounding built ups giving a very clear and gridded network of tree lines. The third maximum NDVI is the site 19 – Sree Narayana Guru College holding NDVI value of 0.526, un like the first two sites – site 2 and site 4, this site shows the absence of thick linear canopy cover which is around 1.5 % only and yet giving a good moderate value of NDVI index which actually is backed by the

presence of open canopy and closed canopy cover of a total of 38.55 %. The Land use map and NDVI map of SITE 1 with the minimum NDVI value among 21 sites has been displayed in the following figures 10 and 11.

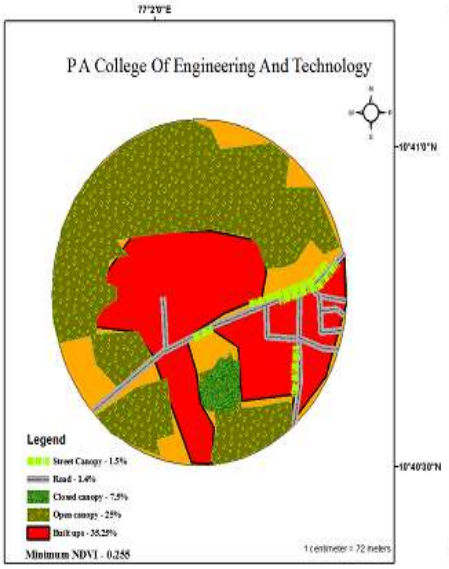

Fig. 9 Site 1 land use

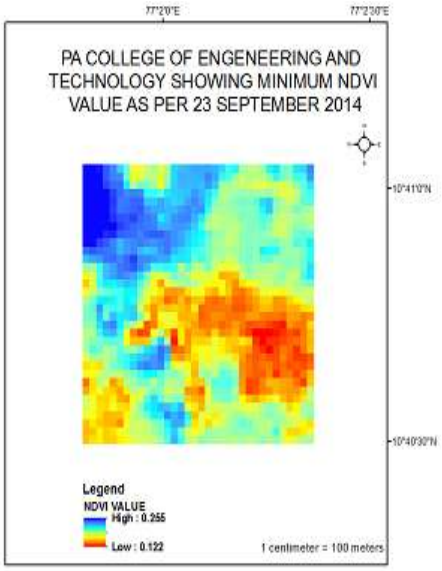

Fig .10 site 1 land use

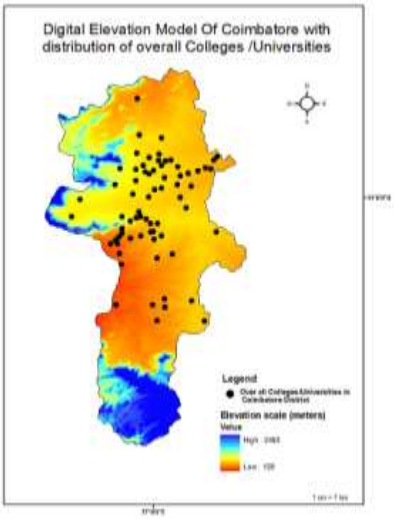

Fig. 11 Coimbatore DEM

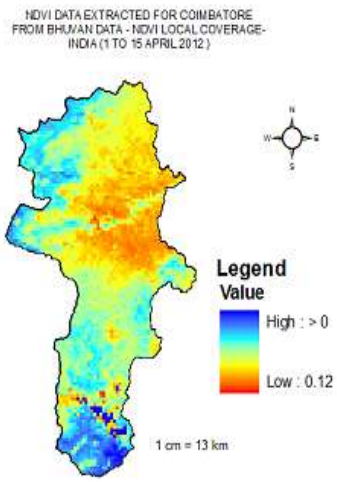

Fig. 12 Coimbatore NDVI

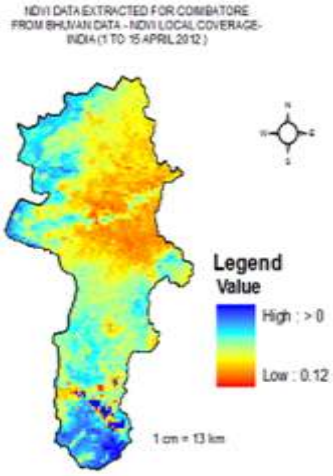

Fig. 13 Roads & water body

Site 1 holds 30 % of canopy cover in 0.8km^2 area mostly which is open canopy of coconut plantations whereas linear canopy holds just 1.5 % of area and gives NDVI value of 0.255 which is minimum record among 21 study sites. One can visually interpret the land use pattern and the corresponding NDVI. The areas holding a continuous open canopy cover shown in green, gives higher value of NDVI in the corresponding NDVI map of the same site. The red parts of both maps are the built up areas with decreasing NDVI value. In this study it was noticeable that most of the built ups had open to sky areas which contained considerable amount of canopy cover, this is economically and ecologically significant. Temperature differences of more than 9°F (5°C) have been observed between city centers without adequate canopy cover and more vegetated suburban areas (Kong *et al.,* 2012).

The digital elevation model of Coimbatore district showing the distribution of overall colleges and universities of Coimbatore and it reveals that most of the educational institutions are located in the center of the district which is having uniform elevation and the distribution is minimal as we move towards the edges having high elevation and heterogeneous landscape. Given next to it is the local coverage of NDVI extracted from bhuvan data for 2012 april 1st to 15th and it shows similarity with the DEM data. In this case also, the NDVI is maximum on the edges and minimum towards heart of the Coimbatore district, as elevation decreases NDVI remarkable and proportionally reciprocates elevation. The edges of the district shows medium NDVI values

which linearly decreases in the central part. Fig (14) gives the overall roads, water lines and water bodies in Coimbatore.

DEM and NDVI show visual similarities, the elevated parts are less urbanized as the lower elevated parts. if one will visualize the urban heat map of the same will observe same similarity, the core of the city will give higher temperature reading as compared to outer parts.

Statistical Analysis

The present study shows that there is a significant difference in the NDVI values among 21 selected educational sites in Coimbatore district and also a significant correlation of NDVI with the canopy pattern. The results of one way ANOVA which shows significant difference in NDVI values.

Table 2. ANOVA analysis

Type	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.290	20	.015	11285.278	.000
Within Groups	.000	42	.000		
Total	.290	62			

The pattern 1 is the linear canopy cover, pattern 2 is open canopy and pattern 3 is the closed canopy cover. According to the coefficient of variation analysis pattern 3 is the most suitable for NDVI values followed by the pattern 1 and least is the pattern 2. Open canopy makes the land more exposed and reduces the degree of greenness and hence the NDVI values. A practical method of mitigating the Urban Heat Island Effect is strategic planting of vegetation in urban areas and designing green technology approach (Siti *el al.*, 2013).

Table 3. Correlation

		LC	NDVI
LC	Pearson Correlation	1	.508*
	Sig. (2-tailed)		.019
	N	21	21
NDVI	Pearson Correlation	.508*	1
	Sig. (2-tailed)	.019	
	N	21	21

*. Correlation is significant at the 0.05 level (2 ailed).

Table 4. Coefficient of variation

S.N	n	mean	Standard deviation	Coefficient of variation
1	10	0.4531	0.0673	14.8532
2	8	0.4458	0.0809	18.1472
3	3	0.4223	0.0565	13.3791

Canopy cover is identified as an important measure of urban forest health in order to understand how canopy may be changing, and understanding canopy trends will allow managers to make important decisions regarding management strategies and determine how canopy is distributed among land use classes and citywide, and to determine how canopy is changing over time. Strong correlation (0.504 and 0.715) in 1991 and 2009 between surface temperature and NDVI values were found in a study (Mallick *et al.*, 2013) thus, the surface temperature can be estimated with reasonable accuracy using NDVI values. Precisely, replacing vegetation and greening landscaping in the new urban area can help to reduce the radiant temperature of the built-up area. Land surface temperature and vegetative indices are having strong correlation and thus one can get a clear picture of the environment and micro urban climate by estimating one of them. Delhi experiences an UHI effect due to urbanization and possibly Mumbai as well due to dense built up of infrastructure, industries and commercial centers. A research done on 33 urban areas in the western parts of India also shows significant increasing warming trend in annual and seasonal scale in most of the cities (Pingale *et al.*, 2014) and consequently, indicating an impact of LULC change.

Recommended Strategies for Educational Campuses postulated by the Present Study

- This study focuses on two important aspects in learning environment of students; one is the degree of greenness in their immediate environment and second is how this is related to reduce heat locally which indirectly affects their academic performances as well as their social, psychological behavior and physical ailments (heat strokes, sun burns and other major medical conditions).
- College campuses should focus on the road side canopy cover or otherwise called as street canopy cover which would considerably be helpful in reducing heat along road sides, the zone where most of the people tend to be present and active.

- The walking stripes should be constructed with possible partially covered roofs with climbing plants or other hanging plants which will not only be aesthetic but also add to the degree of greenery.
- Beautification of the campuses should be meaningful environmentally, maintenance should be economically viable.
- Participation of students in keeping the campus green should be encouraged to plant shade giving trees.
- Research works should be taken by students to estimate correct proportion of land under tree coverage with appropriate tree species.(average sized, broad leaves, pollution controlling and allergens free; pollens)
- Trees around built ups should be kept intact.
- Parking lots should have green roof tops and interstitial green spaces as the cars is just parked emit heat.

V. Conclusions

In this study the maximum and minimum degree of greenness was reported in site 4(0.569 NDVI) and site 1(0.255 NDVI) respectively. The maximum coverage of canopy was recorded in site 4 as 41.61% of the sampling site whereas the minimum canopy cover was recorded in site 9 as 5.8 % of sampling site. Maximum linear canopy was also recorded in site 4 which is 40.02 %. Almost all sites reported presence of cultivated areas with coconut canopy which can be considered as open canopy cover. Certain areas were devoid of open canopy and the fields were showing small agricultural crops with sparsely standing random single trees. Built ups were maximum and minimum recorded in site 18 as 83.62 % and 3.12% in site 12 respectively. Almost all the built ups were open to sky with large canopy tree species as visualized by satellite images via Bhuvan 2D. This study has focused on the canopy cover because it is very important for the changing climatic conditions and significant heat problems for which urban forestry is indespicable solution that we need to adopt.

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