A 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 of Coimbatore District, Tamil Nadu

Kaler. Sonam Sree  
Biodiversity and Aquatic Ecology Lab,  
Department of Environmental Sciences,  
Bharathiar University, Coimbatore– 641046,

Arunachalam Manimekalai  
Biodiversity and Aquatic Ecology Lab,  
Department of Environmental Sciences,  
Bharathiar University, Coimbatore– 641046,

Abstract— Urbanization in India is not only environmentally challenging but socially and economically alarming too. Compact urban areas are characterized by the close juxtaposition of buildings and roads with limited interstitial space to insert greenery; mixed land use. A city with high-quality and generous green spaces epitomizes good planning and management, a healthy environment for humans, vegetation and wildlife populations. The urban surfaces absorb heat and increase the temperature comparatively to the surrounding area. Green spaces in close proximity to homes encourage exercise, which can improve mental health. Green spaces, such as community gardens or even the shade of a large tree, encourage students to perform better academically and reduce mental stress. Educational theory suggests that contact with nature facilitates children’s development of cognitive, emotional, and spiritual connections to social and biophysical environments around them. 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.

Key words: Urbanization, green spaces, Normalized Difference Vegetative Index.

I. INTRODUCTION

Trees in urban system provide a variety 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 and carbon sequestration. Urban heat island (UHI) is one of the urban climatology problems arising in the urban development. Trees and vegetation play vital role to mitigate UHI effects. Urbanization in India is not only environmentally challenging but socially and economically alarming too. Currently 300 million Indians live in urban areas, within another 20-25 years 300 million people more will get added up and the urban expansion will happen at a speed quite unlike anything that India has seen before(The Planning Commission, approach to the 12th plan). Compact urban areas are characterized by the close juxtaposition of buildings and roads with limited interstitial space to insert greenery; mixed land use; and a union of form and function [1]. The urban surfaces absorb heat and increase the temperature comparatively to the surrounding area. The heat bubble, known as urban heat island (UHI) not only reduced human comfortability but it also could increase energy consumption in buildings [2]. For daytime temperatures, it is observed that large cities can be 3°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 [3] and [4].

A city with high-quality of generous green spaces epitomizes good planning and management, a healthy environment for humans, vegetation and wildlife populations and bestows pride on its citizenship and government [5]. It is human nature to harbor psychological attachment to beautiful natural objects such as meritorious amenity vegetation[6],[7]. Different socio-economic strata develop similar appreciations and preferences for urban nature [8]. The multiple functions and benefits of urban vegetation are widely known [9] and expressed in tangible monetary terms. The advantages and disadvantages of compactness have been well expounded. Many cities contain areas with exceptionally high development density in the innercity or the old urban core, formed by organic accretions. Some cities develop new compact areas or infill existing areas to a higher density[10]. Whether old, modified or new, such compactness needs more attention to greenspace provision.
and environmental well-being, which could be overlooked or sacrificed. The destruction of existing vegetation and inadequate plantable spaces degrade the environmental quality, quality of life and human health [11].

The community forestry programmes implemented by various cities can actively involve local people and interest groups, largely as volunteers, in a synergistic partnership [12,13]. With increasing environmental awareness and literacy, some residents have taken the initiative to organize themselves to take up more proactive roles in urban greening in their own neighborhoods [14].

Urbanization impacts on physical and psychological health aspects by certain weather conditions. Most common is the heat strokes, classified into two as: classic non-exertional heat stroke (NEHS) and exertional heat stroke (EHS). Classic heat stroke occurs most commonly in very young or older individuals, who have health risks. Exertional heat stroke occurs more often in younger, healthy individuals who participate in strenuous physical activity. Working or exercising in hot conditions or weather without drinking enough fluids is the main cause of heat stroke. People with alcoholism, chronic illnesses like heart disease, obesity, older age, Parkinson's disease, uncontrolled diabetes, use of certain medications such as diuretics and antihistamines and use of some psychoactive drugs such as alcohol and cocaine are prone to heat strokes. Heavy clothing and some skin conditions can also contribute to the occurrence of heat stroke.

Heat waves is another weather condition. It is a prolonged period of excessively hot weather, which may be accompanied by high humidity, especially in oceanic climate countries [15]. 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 [16]. 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 [17]. Older adults, very young children, and those who are sick or overweight are at a higher risk for heat-related illness.

"Either we have to work in fields for food or we stay at home — both ways, we may suffer death," said Ram Ranjan, 42. The poor farmer lives in the southern state of Andhra Pradesh, one of the hardest hit areas along with Telangana state. Together, the two regions account for more than 1,000 of the deaths. More than 29% of the Indian population lives below the poverty line, and the majority are daily wage laborers, according to the government figures. Because of that many are working outside in the extreme heat despite the risks. States in northern India — Punjab, Haryana, Uttar Pradesh and Madhya Pradesh — are also dealing with extreme temperatures. In New Delhi, temperatures of 111 degrees are melting asphalt that's

distorting painted pedestrian crosswalks. The heat wave is now the fifth-deadliest in recorded world history and the second-deadliest in India’s history, according to EM-DAT, the International Disaster Database. Authorities said the majority of the dead are laborers working outside on farms and construction sites, or are elderly.

Heat rash, also known as prickly heat, is a maculopapular rash accompanied by acute inflammation and blocked sweat ducts. The sweat ducts may become dilated and may eventually rupture, producing small purplish vesicles on an erythematous base. Heat rash affects areas of the body covered by tight clothing. If this continues for duration of time it can lead to the development of chronic dermatitis or a secondary bacterial infection. Heat cramps are painful, often severe, involuntary spasms of the large muscle groups used in strenuous exercise. Heat cramps tend to occur after intense exertion. They usually develop in people performing heavy exercise while sweating profusely and replenishing fluid loss with non-electrolyte containing water. This is believed to lead to hyponatremia that induces cramping in stressed muscles. Rehydration with salt-containing fluids provides rapid relief. Patients with mild cramps can be given oral 0.2% salt solutions, while those with severe cramps require IV isotonic fluids.

Areas of the Persian Gulf coast could be essentially uninhabitable to humans by the end of the century for those without air-conditioning, due to rising temperatures from global warming.

In addition to physical stress, excessive heat causes psychological stress, to a degree which affects performance, and is also associated with an increase in violent crime [18]. Furthermore, in politically unstable countries, high temperatures are an aggravating factor that leads toward civil wars. If a heat wave occurs during a drought, which dries out vegetation, it can contribute to bushfires and wildfires. Heat waves can also damage rail roads, such as buckling and kinking rail's, which can lead to slower traffic, delays, and even cancellations of service when rails are too dangerous to traverse by trains.

Heat Wave Warning Symptoms includes urinary pain and burning sensation with reduced urine output, headache, disorientation, forgetfulness, giddiness, dryness of mouth, muscle cramps, high fever, and high pulse, symptoms of diseases like diarrhea, dysentery, and chicken pox. General precautions are as follows: avoid direct exposure to sun, wear clothes completely covering the body and loose fitting with light colours, and drink plenty of water, butter milk, coconut water, lemon water with salt and sugar. Avoid sudden temperature fluctuations. 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 [19]. There are three main types of skin cancers, they are: basal-cell cancer (BCC), squamous-cell cancer (SCC) and melanoma. Decreasing exposure to ultraviolet radiation and the use of sunscreen appears to be effective methods of preventing melanoma and squamous-
cell cancer.[20] Skin cancer is the most common form of cancer, globally accounting for at least 40% of cases especially common in people with light skin.

The experience of nature helps to restore the mind from the mental fatigue of work or studies, contributing to improved work performance. Parks and walkways incorporated into building design, provides calming and inspiring environments and encourages learning and alertness [21], [22]. Contact with nature helps children to develop cognitive, emotional, and behavioral connections to their nearby social and biophysical environments. Social relationships, intellectual development, creativity and cognitive development are influenced by natural set ups [23], [24] and [25]. Symptoms of ADD in children can be reduced through activity in green settings, thus “green time” can act as an effective supplement to traditional medicinal and behavioral treatments [26], [27] and [28]. Even brief glimpses of natural elements improve brain performance by providing a cognitive break from the complex demands of urban life. [29] Not having nature views or indoor plants are associated with higher levels of tension and anxiety in office workers. [30] Having plants within view of workstations decreases both illness incidence, and the amount of self-reported sick leave. When plants were added to a college computer lab, the study participants were more productive and showed less stress—but there was no difference in number of errors made on the test. Additionally, participants reported feeling more attentive and better able to concentrate in the presence of plants. [31] In other studies, participants performed better on creative tasks in rooms having foliage plants, versus those without, and the authors conclude that nature may provide inspiration and a source of stimulation for creativity. [32] College students with more natural views from their dorm windows scored higher on tests of capacity to direct attention (CDA) and rated themselves as able to function more effectively. [33] In another study of college students, those who participated in a nature walk performed higher on a subsequent CDA test than those who went on an urban walk or relaxed in a comfortable room with magazines and light music prior to the test.

Educational theory suggests that contact with nature facilitates children’s development of cognitive, emotional, and spiritual connections to social and biophysical environments around them. Ecological theory also suggests that contact with nature is important for children’s mental, emotional, and social health because imagination and creativity, cognitive and intellectual development, and social relationships are encouraged in outdoor activity, all of which improve the child’s mental health and function.

Nature can provide both background and objects for play and learning. Among older children, exposure to nature encourages exploration and building activities, which can improve problem-solving abilities, ability to respond to changing contexts, as well as participation in group decision-making. Younger children often use outdoor settings having plants, stones, and sticks as props for imaginative play, which is key to social and cognitive development. One study of children’s play found that a cluster of shrubs was the most popular place to play on an elementary schoolyard because it could be transformed into many imaginary places: a house, spaceship, etc.[34] In another study, children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) performed better on an objective concentration test after exposure to a relatively natural urban setting as compared to a less natural urban setting.

Better sleep patterns, improved hormone balance, and decreased agitation and aggressive behavior have all been observed in dementia patients in association with contact with nature and the outdoors.[35] More than 100 studies have shown that relaxation and stress reduction are significant benefits associated with spending time in green areas. [36], [37] Depression also occurs at any age and can be helped through improved social connections (to decrease the feeling of isolation) and exercise, both of which are promoted by having nearby green outdoor spaces. Green spaces in close proximity to homes encourage exercise, which can improve mental health. Green spaces, such as community gardens or even the shade of a large tree, encourage social contact by serving as informal meeting places and sites for group and shared activities [38].

Landsat, with high spatial resolution and standardized normalized difference vegetation index (NDVI) data, has been widely used in biophysical feature extraction (biomass, green cover, Net Primary Productivity), climate change (phenology), ecological and hydrological modeling and more for over 40 years. Landsat has the potential to offer long-term NDVI products at both a regional and global scale which is superior to that of low spatial resolution NDVI products of AVHRR NDVI (1989-present with 1km spatial resolution; 1992-present with 8 km spatial resolution), MODIS NDVI (2000-present with 250 m, 500 m or 1 km spatial resolution), and VEGETATION NDVI (1999-present with 1.15 km spatial resolution). The rough urban landscapes inhibit wind movement and hence lowers convective heat loss while the reduced thermal inertia and vegetation index constrain heat loss from latenth heat flux [39]. Furthermore, air pollutants influenced by urban waste heat lead to abuild-up/natural landscape temperature contrast [40]. Microclimatic conditions within the urban landscapes affect the comfort and health of urban residents, energy consumption and air quality.

**II OBJECTIVES OF THE STUDY**

1. To quantify the tree canopy cover and pattern of its distribution in the selected university and college campuses and compare within sites.
2. To estimate the NDVI of selected sites and corresponding mapping followed by analysis of correlation between NDVI and estimated tree cover if any.
3. To highlight the social significance of tree canopy cover in educational institutions in reference to its importance.
on the physical, mental and psychological health of students via literature survey.

III. STUDY AREA

Coimbatore district lies between 11° 00' of north latitude and 77° 00' of East longitude. It is also known as Kovai and is a major city in Tamil Nadu. After Chennai it is the second largest city and urban agglomeration in the state and sixteenth largest in India. It was ranked as the best emerging city in India by the India Today in the 2014 annual Indian city survey. It has a total area of 254 square km lying at an elevation of 398 meters. 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. 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. This district is known as the Manchester of South India and is known for its textile factories, engineering firms, automobile parts manufacturers, health care facilities, educational institutions and hospital industries. Under given is a glance at the south Indian states highlighted Coimbatore district.

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 undertaken for this study with fixed radius of 0.5km ie; 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.

IV. 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 and google earth. NDVI was calculated using erdas imagine and the values were further statistically correlated with the tree canopy cover. Comparison was made between all sites for the highest and lowest NDVI and the tree canopy cover. Tree canopy network pattern was also studied and mapped. NDVI (Normalized Difference Vegetation Index) was employed to determine vegetation cover which is basically used for medium spatial resolution remote sensing imagery such as landsat images. NDVI uses spectral bands in the red and near infrared portion of the electromagnetic spectrum. Raster calculator was used for the TOA calculations and NDVI.

The normalized difference vegetation index (NDVI) is one of the most widely applied vegetationindices. Formulas used were (REF_NIR-REF_RED) / (REF_NIR+REF_RED) for NDVI with fourth and fifth bands of landsat 8 imageries of 2014 September, February and June months. Formula for TOA reflectance is (0.00002*DN)+0.1/Solar angle, whereas solar angle is sin (sun elevation). These data inputs can be acquired from the metadata that comes along with the satellite image we acquire. Remote sensing and some other geoinformatics techniques such as GIS modeling and spatial analysis plays a major role to produce vegetation cover maps [41].
The quantified data derived manually was used for landuse quantitative analysis and was further subjected to mapping and the data derived via NDV I calculations were used for statistical analysis, both the land use data and NDVI data were put 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.

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 giving 100% presence. Open canopy is present in 76.19% of 21 sites and closed canopy is 38.09% only. Among the three types of canopy cover pattern (linear canopy cover, open canopy cover and closed canopy cover) linear is 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 maximum values have been highlighted. 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 - Karpa gam 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.

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 km²) - Site 4 has recorded maximum NDVI as well as linear canopy cover among 21 sites.

The (fig 5) given below has listed the NDVI values for 21 sites. NDVI SCALE is Negative one to zero to positive one. Negative value indicates poor vegetative conditions 1 indicates very well. 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 below. Site 4 – Tamil Nadu Agriculture University maximum NDVI and maximum linear canopy cover followed by site 2 and site 19.
Table no: 1; 21 sites Quantification Results

<table>
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<th>Site</th>
<th>Pattern 1%</th>
<th>Pattern 2%</th>
<th>Pattern 3%</th>
<th>Total canopy %</th>
<th>Built ups %</th>
<th>NDVI Max</th>
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Fig (5): minimum and maximum NDVI

Fig (6): site 4 land use and below left

Fig (7): NDVI of site 4
The above given map represents 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, unlike 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 below.

NDVI maps of maximum and minimum values with their corresponding land use maps are given below. Site 4 – 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.
Site 1 holds 30% of canopy cover in 0.8 km² 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 above 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. Many studies showed that built ups with good amount of canopy cover in their surroundings as compared to the built ups with no tree covers around had significant difference in the electricity usage. Shade from trees reduces the amount of radiant energy absorbed and stored by hardscape and other impervious surfaces, thereby reducing the heat island effect. Temperature differences of more than 9°F (5°C) have been observed between city centers without adequate canopy cover and more vegetated suburban areas [44].
Above given is 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 bhuwan data for 2012 April 1st to 15th and it shows similarity with the DEM data. In this case too 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. The urban tree canopy cover can be achieved by definite planning management and maintenance. The urban network works with urban canopy when there is a definite clear cut idea regarding every aspect of the region. In thick urban centers urban forestry can be well established along the roads and built ups, the point to be considered here is the network underlyng the ground which should not collapse the water system and other important networks.

STATISTICAL ANALYSIS – RESULTS AND DISCUSSION

The 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. Given below is the result of one way ANOVA which shows significant difference in NDVI values. The sites located in the core of the urban agglomeration has shown linear canopy cover pattern on and off road sides and around built ups. Linear pattern is predominantly present in all huge urban settings globally. The quantity and pattern of urban green spaces is very important in urban micro climate and many ecological psychologists consider it as an important factor affecting mind set of people and their social life. Colleges and other educational institutions must be green, lively and motivating students. The impact of the heat island suffered so many people in many ways. Based on many previous researches, the UHI mitigations are discovered and havebeen applied in sub-tropic countries (e.g.: China and Hong Kong). The mitigation strategies call for the use of lighter-color, reflective surfaces on new developments, as well as the replacement of existing dark-color surfaces with lighter ones. A more practical method of mitigating the UHI is strategic planting of vegetation in urban areas and designing green technology approach [45].

<table>
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<td>.015</td>
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</table>

Table (2) ANOVA

There is a significant difference between the NDVI values among 21 sites. According to the study site 4 shows the maximum NDVI value followed by site 2 and site 19. The minimum NDVI value was recorded in site 1. Site 2 and site 4 have a very good coverage of linear canopy network spread across the campus and lined by the roads.

<table>
<thead>
<tr>
<th>LC</th>
<th>NDVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>.508</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.019</td>
</tr>
<tr>
<td>N</td>
<td>21</td>
</tr>
<tr>
<td>NDVI</td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.508</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.019</td>
</tr>
<tr>
<td>N</td>
<td>21</td>
</tr>
</tbody>
</table>

Table (3) Correlations

There is a positive correlation between the area under linear canopy cover and the corresponding NDVI values of 21 sites. Most of the sites had this pattern of distribution of trees and in urban landscapes mostly this network of linear canopy is dominant and fits the urban network of built ups and roads.
Table(4)Coefficient of variation

<table>
<thead>
<tr>
<th>pattern</th>
<th>n</th>
<th>mean</th>
<th>Standard deviation</th>
<th>Coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>0.4531</td>
<td>0.0673</td>
<td>14.8532</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>0.4458</td>
<td>0.0809</td>
<td>18.1472</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0.4223</td>
<td>0.0565</td>
<td>13.3791</td>
</tr>
</tbody>
</table>

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. In this study among 21 sites pattern 1 is dominant but globally pattern 3 is the one which shows significant relationship between NDVI as it covers the area better than linear canopy, whereas open canopy makes the land more exposed and reduces the degree of greenness and hence the NDVI values.

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 [46] 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 [47] 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).
- In countries where climate is harsh and hot people tend to use umbrellas to protect themselves from heat. Now days it is a common sight of students covering arms and head with rags and driving or using umbrellas while walking.
- 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 hanger plants which will not only be aesthetic but also add to the degree of greener.
- Beautification of the campuses should be meaningful environmentally, maintenance should be economically viable.
- Participation of students in keeping the campus green tree should be encouraged to plant shade giving trees.
- Research works should be taken by students to estimate the 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.
- Bus stop and other landmarks should be assigned for tree spots.
- Gardens with small plants and ornamental plants which need plenty of water should be reduced.
- Small ponds and drinking water facilities in the campuses.

**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 when we start getting into a situation where we are in a city where we don’t tend to have air conditioning, or in a situation where being able to afford keeping the air conditioning running is a real problem, that’s where we are going to see significant heat problems. Students tend to experience the heat more often and bear the effects as they tend to spend time outdoors being in college campuses. Along with global warming local micro climates also need to be focused and meant to be kept at reasonable bearable levels with minimal detrimental effects. Due to the often high demand for space in urban areas, creation and preservation of urban greener as heat sinks is commonly perceived as “a waste of space”. Consequently, there is an increasing need for creation and preservation of such spaces. Pollution is not the only one we need to fight with when we step outside, in fact every day...
we come across new environmental challenges and unknowingly become its victims, to an extent all these alarming situations are underestimated or ignored as it doesn’t produce instant alerts in our systems, as in the case of adverse effects of heat and micro climate on the common people of India. Studies are many on the learning characteristics and urban environments but there are very few studies in reference with this crisis. We have clean and plastic free campuses now a days, we are aware of green campuses but a quantitative study on the degree of greenness is rare and importantly the color green is not the one which is important in today’s harmful UV radiation filled atmosphere or using bulk of harmful chemicals like sunscreens and other lotions, what we need to focus is the number of trees standing around us providing us significant shade and protection.

FUTURE SCOPE OF STUDY

1. Micro climate can be modified to an extend by physical structural modifications of the immediate environment.
2. Environment and changing climate has drastic effect on people and their both physical and mental health, micro climate monitoring and assessment is significant in residential areas of cities.
3. Students and environment is less studied, future studies should focus on this kind of issues when it comes to the urban studies or urban forestry and its psychological impacts.

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REFERENCES


