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Analysis of Urban Green Spaces & Its Impact using Geospatial Approach in Lucknow City

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ABSTRACT: Urbanization, development and population increase are all interconnected. When we talk about urbanization in simple words it means becoming more like a city. Actually, urbanization is a boon for any area only when it is managed and planned properly. With the help of urbanization one can reduce the inequality, unemployment and increase the living standard, health and education of that place but at the same time unplanned urbanization causes severe threat not only to the people living there but also to the environment, climate which leads to the creation of urban heat islands

Urban heat island (UHI) is a phenomenon where temperature distribution in the urban area is significantly warmer than its surrounding suburban areas. One of the main causes of UHI is the replacement of natural surfaces by built surfaces through urbanization. Urban Heat Island leads to increase energy consumption induce pollution and threatened the health of Citizens.

Most noticeable and direct impact of urbanization on the environment is the changes in daily and seasonal thermal variable and increase the hydraulic stress. Both are cumulatively formed the urban heat island (UHI) effects. From the sustainability point of view, it is very crucial for research to focus on how to mitigate UHI. Therefore, the main objective of the present study is to evaluate the cooling effects of different types of urban green spaces at local and park level to make people aware as to how these green spaces in terms of percentage of land cover or average size of the green patch is very important to reduce the UHI as these urban green spaces not only reduce urban heat island effects but at the same time provides livable environment and to the nearby occupants. The average temperature of whole study area is found to be 30.89 while average temperature of the green space is 30.63 a difference of 0.26 degree which indicate that there must be some cool island existence. When buffer of 500 m is calculated it was found that average temperature is increasing as 30.66 where as it is further increasing as 30.79 when buffer of 1000m is created.

KEYWORDS: Urbanization, Urban Heat Islands, Green Spaces.

I.INTRODUCTION

Urbanization is a new trend throughout the world. Worldwide, the urban heat island (UHI) effect has been detected in megacities and also in small town in recent years. Over the span of nine decades since 1900, the world population trebled from 2 billion to 7.8 billion, but the urban population increased more rapidly from 2.4 million to 2.9 billion in 2000 and is expected to rise to 5 billion by 2030. India is one of the developing countries in the world with a population of 1.37 billion approximately. It ranks second most populous country in the world. Population residing in urban areas in India, according to 2001 census, was 28.53% this count increased to 30% according to 2011 census, and currently standing at 35%. According to a survey by UN State of the World Population report in 2007, by 2030, 40.76% of country's population is expected to reside in urban areas (Bandnakhe et al., 2017; et al., 2017).

Rapid Urbanization is great threat to urban green spaces. The conversion of green spaces to uses associated with growth of populations and economy is a main type of land use and land cover change in human history. It has a great impact on climate. By covering with buildings, roads, and other impervious surfaces, urban areas generally have higher solar radiation absorption, and a greater thermal capacity and conductivity, so that heat is stored during the day and released by night. Therefore, urban areas tend to experience a relatively higher temperature compared with the surrounding rural areas. This thermal divergence, in conjunction with waste heat released from urban houses, transportation and industry, contribute to the development of urban heat island (UHI) (Balogum A. Ifeoluwa and Daramola, 2018).

Urban Green spaces, such as open parks, forests, grasslands and water bodies have been increasingly recognized as key components of urban planning. Urban green spaces have been shown to form cool islands which stress UHI mitigation by effective landscape plan in development and improve outdoor thermal comfort throughout seasons, as well as significantly reduce environmental stress produced by heat island (Du Hongyu and Cai Wenbo, 2017; et al., 2017). They can also provide critical ecosystem services that could improve residents' health and wellbeing (Oliveira and Andrade, 2011). Urban green spaces, mainly resulting from direct shading and cooling through evapotranspiration, can reduce air and surface temperature and may generate localized cooling. The reduced temperature at green areas compared to surrounding urbanized area creates which is known as urban cool islands (UCI) (Buyadi and Naim, 2018; et al., 2018). This phenomenon is observed majorly around the urban parks due to the composition of urban park surface which is mainly vegetation and water bodies. It results in less solar radiation absorption through shading of the land surface. The changing land use patterns abandon the old structures and cause the demolition of these structures. The land resources reduce the number and area of the open playing spaces as well as parks and green spaces of recreational nature. Per capita green spaces are rapidly reducing in the cities especially in the core areas. Increasing population density and vehicle density in the core areas also results in rise of demand for more number of parking spaces. The need for adequate information of urban green spaces and the influence on the urban microclimate is crucial for the development of effective adaptation schemes and mitigation approaches (Connors and Galletti, 2012; et al., 2012).

The integration of remote sensing and Geographic Information Systems (GIS) has been widely applied and been recognized as a powerful and elective tool in quantifying cool island effect for urban green spaces (Djedjing and Bozonnet, 2012; et al., 2012). With the availability of high resolution remote sensing images and multi- source geospatial data, there is a great need to transform Earth observation data into useful information necessary for urban planning and decision making. To prepare thematic map of public UGS with detailed classes which are relevant for planners and policy maker (Q. Weng, 2001). It is an integrated dataset with added information and status of different typologies of green spaces and surface temperature.

II. AIM OF RESEARCH

Quantification and estimation of land surface temperature is no more based on imperial techniques. Quantification of urban green spaces need advance technologies to regulate the urban microclimate of the city. Temperature is a notable parameter that changes within the urban environment. Green spaces within an urban area are representative of natural or semi natural conditions, thus, serve as protection for the urban ecological environment. Urban green spaces have been observed to bring about reduction of temperature within the area through shading and evaporative cooling. This study aims to the quantification of urban green space indicator which can affect the temperature of the urban cool island.

III. RESEARCH OBJECTIVE

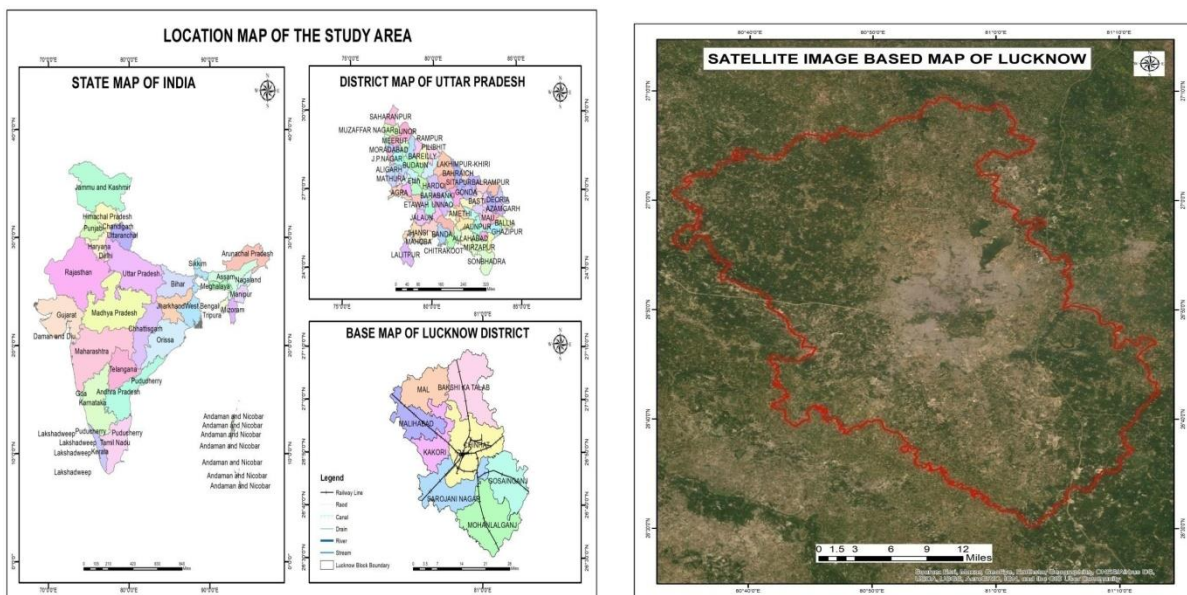
- It is very necessary to quantify how far cool island effect of urban green spaces extends in which direction so that urban green spaces can be planned in such a way that they can effectively regulate urban microclimate.
- To quantify cool island effect for urban green spaces to mitigate the urban heat islands
- Distribution of urban green spaces is very important for regulating urban microclimates.
- It is necessary to know relation between the impact factors of UCI and UCI indicators for mitigating the effect of increasing land surface temperature.

IV. STUDY AREA AND DATASET LUCKNOW CITY

Lucknow is situated on the Northern Gangetic Plains of India. The total area covered by Lucknow is around 3204 square kilometers. The geographical location of Lucknow is between 26.500 North and 80.500 East. It is located at an elevation of 123 meters above sea level. This city was known by the name of Awadh in ancient times. The Gomti river, is the chief geographical feature, meanders through the city, dividing it into the Trans-Gomti and Cis-Gomti regions. City is located in the seismic zone III.

Lucknow's location is responsible for the diverse weather patterns and climatic changes. It does not have a uniform weather throughout the year and experiences extreme summers and extreme winters. It has a warm humid subtropical climate with cool, dry winters from December to February and dry, hot summers from April to June. The rainy season is from mid-June to mid-September, when Lucknow gets an average rainfall of 1010 mm mostly from the south-west monsoon winds. In winters the maximum temperature is around 25°C and the minimum temperature is in the 6 to 8°C range. Summers are very hot with temperatures rising to the 40 to 45°C range.

Lucknow is the largest and capital city of the Indian state of Uttar Pradesh and is also the administrative headquarter of the district and division. It is the fourteenth-most populous city and the twelfth-most populous urban agglomeration of India.



Approaches used for the urban cool island effect:

Temperature is one of the most varying phenomenon on the earth; it varies different for different region some of the identified approaches are as;

1. Devising a method to detect and compare the local cool island intensities of various parks. (Jou and Changchi-Ru, 2007; et al., 2007)
2. Simulation with a widely evaluated conceptual atmospheric boundary layer model coupled to a land surface model reveal that UCI can form due to difference between the early morning mixed layer depth over the city and over the country side.
3. To explore and quantifying the characteristics of the green- space cool island (UCI). It is also largely unknown whether or how the patterns of green space and land use, as well as the adjacent urban thermal environment, affect UCIs. Multiple linear regression models were then used to explore and quantify the combined effects of factors related to the UCI intensity. (Fanhua Kong, and Haiwei, 2014; et al 2014).

Approaches used for the urban cool island effect:

Urban Green Infrastructure (UGI) is an inevitable part of urban planning, and their significance is understood exceptionally for keeping up the natural quality and sustainability of the city environment. Bio-parks, parks, gardens, places of recreation, informal green spaces such as aquatic fronts, green spaces surrounding historical sites, railway and road corridors and native vegetation types constitute the Urban Green Spaces (UGS) of a city. Some are the major factor responsible for the urban cool island given below:

Size of green space:

The amount of cooling provided by a green space and the distance over which that cooling extends depend on factors such as green space size and characteristics. Size plays major role for regulation of temperature. The cooling effect of an urban park can be extended in the surrounding area with a distance similar to the length of the park.

Vegetation density:

If the vegetation density will be more there is the chance the temperature will be low. If vegetation will be sparsely than it will develop more temperature.

Water body:

Water spaces such as stream and lakes in particular play an important role in creating urban cool islands because water spaces have higher evapotranspiration rates than green spaces. To achieve this, the UCI effects of urban water spaces were analyzed by applying UCI indices such as UCI scale, temperature difference, and UCI intensity. Next, considerations for composing and managing water spaces to mitigate urban heat islands were identified through analysis of the relationship between UCI indices and characteristics of water spaces such as area, perimeter, shape, and width. The results show that larger water spaces are more useful in reducing urban heat. In addition, more complex water spaces were found to be more efficient than simple ones (D.lee, K.Oh, 2016, et al., 2016).

Type of plants:

Larger plants such as trees attenuate radiant energy flows through absorption and reflection. Less radiant energy contacting the ground surface reduces surface and near-surface temperatures. This microclimate ecosystem service is known as shading. The second mechanism is related to plant Consumption of energy during transpiration. As water is evaporated from a liquid to a gas at the surface of cellular structures inside leaves, temperature reductions occur in the immediate Environment surrounding a leaf. We refer to this microclimate ecosystem service as transpiration cooling.

Urban morphology:

The urban morphology is regarded as one of the main reasons for urban heat island (UHI). In this paper, we presented a rule-based regression model for investigating the nonlinear relationship between land surface temperature (LST) and urban morphology represented by building height, building density and sky view factor (SVF) across different dates in 2005. Results found that an urban morphology of medium building height and lower density significantly yielded higher LST variation levels, whereas the lowest LST variation levels occurred in high-rise and high-dense building arrays. Urban morphology of medium building height and a lower building height and a lower building density significantly cause higher LST. (Guanhua Guoa, Xiaoqing Zhoua, 2016., et al 2016) Anthropogenic heat:

The anthropogenic heat released from vehicles, power plants, air conditioners and other heat sources, dramatic removal the vegetation cover and increasing of hard surfaces is major contributor for the formation of UHI (Memon et al., 2008 and Senanayake et al., 2013).

Government initiative in this direction:

- Gomti River Front Development
- Eco Conservation Of Ponds Of Lucknow
- Green Eco Park Development
- Development Of Green Belt Along Major Network Corridors
- Provision of Plantation on the Road Dividers

(Source: City Development Plan Lucknow, 2006)

List of Data used:

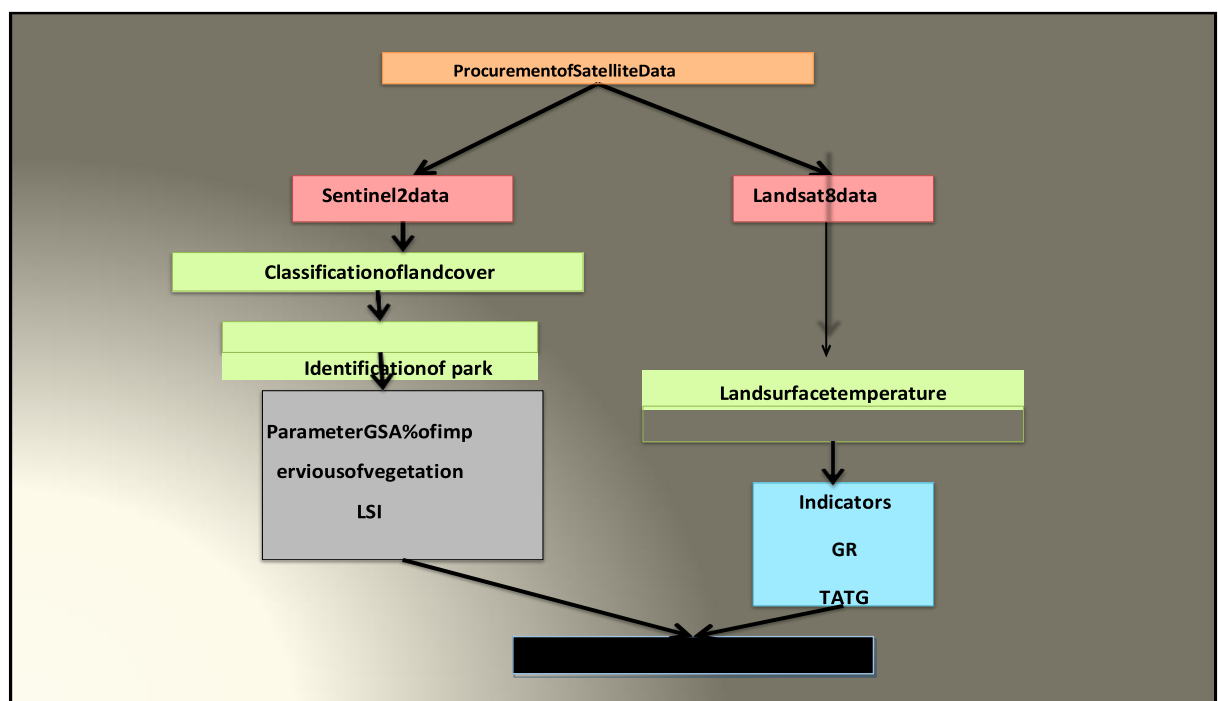
S.No.	Data	Year	Use in study
1.	Sentinal2	2018 March 8	Classification of green space
2.	Landsat8	2018 March 10	Calculation of land surface temperature
3.	City development plan, Lucknow	2006 August 14	Delineation of parks

4.	Revised city development plan, Lucknow	2040	For government initiatives and municipal cooperation
5	Google earth image	2020	For exact location of parks

V.METHODOLOGY

The approach of satellite-based image analysis to quantify cool island effect for green space is based on the geospatial technique of satellite image for procurement of land surface temperature and GIS based study for the development of parameters. Remote sensing data provides percentage of impervious surface, percentage of vegetation, landscape shape index as well as land surface temperature. On the other hand it also provides area, number and spatial location of green spaces which are very help for quantification of urban cool island effect. The great observation based on the remote sensing data is the green cool islands (GCI) indicator; indicators include green cool island range (GR), Temperature Drop Amplitude (TA), and Temperature Gradient (TG) with respect to the parameters. This is helpful for the mitigating the land surface temperature. Directional based study is helpful for knowing that how far cool island effect exists in urban green spaces.

Methodology Flow Diagram:



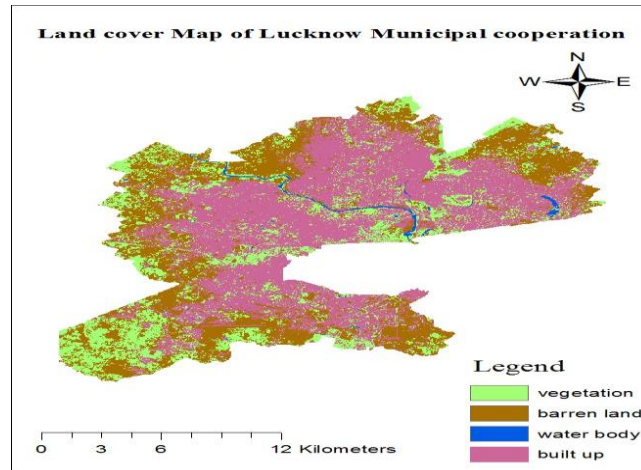
Generation of Land Cover Map

Sentinel 2 having 10m spatial resolution image is used to generate the land cover map of the Lucknow Municipal Cooperation. The process of generating land cover map is carried out in the ERDAS Imagine digital image processing software. The supervised classification method is used to generate land cover maps. For a more detailed study, land cover profile and characteristics of the study areas are identified.

The following 4 classes are identified which are as follows:

1. Built up
2. Water body
3. Vegetation
4. Barren land

In this classification built up and barren land contribute to the impervious surfaces.



Hierarchy of park:

For identification of park in the study Area City Development Plan of Lucknow is used. Total identified park is 71 but for study area with the help of stratified random sampling we had chosen 25 parks with different categories. Followed hierarchy for different types of park is given below:

S.No.	Area(square meters)	Types of parks
1	500-3000	Housing area park
2	3000-5500	Neighborhood park
3	5500-8000	Community park
4	8000-10500	Multipurpose community park
5	10500-13000	District park
6	13000-15500	Multipurpose district park
7	15500-18000	Zonal park
8	18000-20500	Multipurpose zonal park
9	20500-23000	Amusement park

Calculation of land surface temperature

The landsat8 is used which is having 11 spectral bands for this study of temperature generation we will use band 10 TIRS (10.6-11.19 μ m) 100m. The single channel algorithm is used to generate the LST map. The single channel algorithm requires three parameters; NDVI, proportional vegetation, emissivity, transmittance and effective mean atmospheric temperature-

Calculation of NDVI

$$NDVI = (NIR - R) / (NIR + R)$$

$$(Pv) = \{ [NDVI - NDVIMIN] / [NDVIMAX - NDVIMIN] \}^2$$

Calculation of Proportional Vegetation

Pv= vegetation proportion

Calculation of emissivity

The emissivity can be estimated by utilizing NDVI. The final expression of land surface emissivity is given by

$$e = 0.004 P_v + 0.986$$

e=emissivity

p_v= proportional vegetation

Conversion of DN to Radiance

The information on the thermal infrared band is stored in a digital number (DN) with a range between 0 and 255. The

$$L_\lambda = MLQ_{cal} + AL$$

linear equation model is used to convert the DN into radiance temperatures as shown

L_λ =TOA spectral radiance (Watts/(m²* srad * μm))

ML =Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number) AL =Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the band number) Q_{cal} =Quantized and calibrated standard product pixel values (DN)

Computation of Land Surface Temperature including brightness temperature and emissivity

The thermal band radiance values were converted to a brightness temperature value using the Planck's function Equation as

K₁ and k₂ are the calibration constant

$$T = \frac{K_2}{\ln \left(\frac{K_1}{L_\lambda} + 1 \right)}$$

Values used for the LST calculation

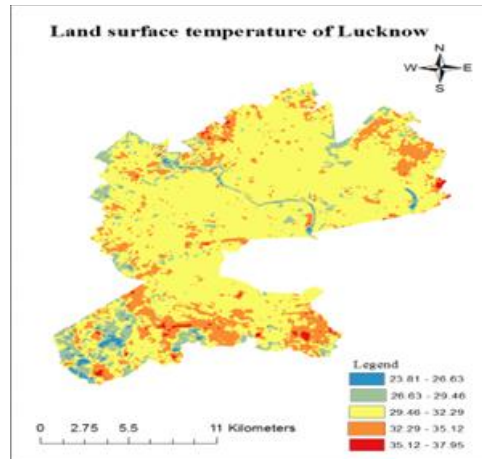
Band 10	
Radiance multiplier	0.0003342
Radiance add	0.1
K1	774.89
K2	1321.08

$$T = T_b / [1 + (\lambda * T_b / c2) * \ln(e)]$$

Conversion from AT satellite temperature to land surface temperature

Where,

- λ = wavelength of emitted radiance
- $C2 = h * c / s = 1.4388 * 10^{-2} \text{m K} = 14388 \mu\text{m K}$
- h = plank's constant = 6.626^{-34} J/K
- s =Boltzmann constant = $1.38 * 10^{-23} \text{ J/K}$
- c = velocity of light = $2.998 * 10^8 \text{m/s}$



SELECTION AND DEFINITION OF PARAMETER

● **Calculation of landscape shape index of green space:** Shape indices are based on perimeter and area of a patch and represent the complexity of landscape patch shape. If the shape of patch is complex its landscape structure is equally complex. Landscape patch shape index which represents the degree of agglomeration in relation to shape complexity.

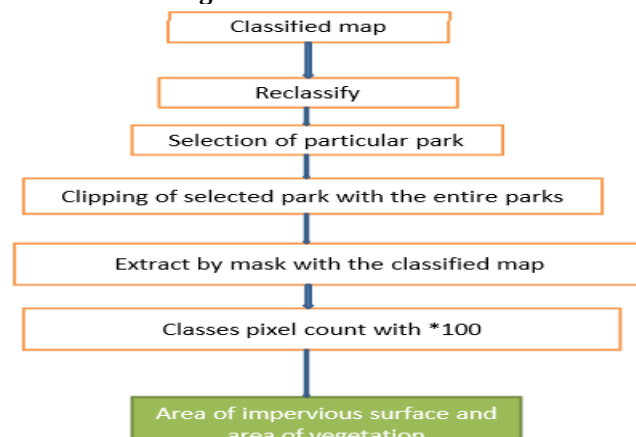
$$LSI = (\pi \times GSA)^{-0.5} \times D/2$$

Where, π is 3.14 and GSA is the area of park where D is the perimeter of parks.

● **Percentage of impervious surface and vegetation cover:**

Any material covering the ground that prevents infiltration of water into the soil can be classified as an impervious surface (Arnold & Gibbons 1996). While it is not a single homogeneous quantity, when impervious surface is used as a landscape indicator it is typically presented as a percentage of the land that is covered with impervious materials. The word imperviousness is also regularly used to refer to the extent of this percentage. Impervious surfaces come in different types such as paved surfaces (roads, parking lots, sidewalks, etc.) and building rooftops that fall unambiguously under the definition of impervious surface. Yet there are also traditionally pervious surfaces, man-made and natural, that are so heavily compacted that they become functionally impervious. Examples of these are compacted soil in construction areas, dirt roads, bedrock outcrops and, even to ascertain extent, grass turf in our residential. Vegetation coverage has a significant influence on the land surface temperature distribution. In addition to it, planting of in vegetation is one of the main strategies to mitigate the urban heat island effect (Wong et al. 2007). Rose and Levinson (2013) analyzed the effects of urban trees on the residential Aledo, which corresponds with urban heat island.

Flow diagrams of % of impervious and % of vegetation cover



Green space Area

Green space is land that is partly or completely covered with grass, trees, shrubs, or other vegetation. Green space includes parks, community gardens, and cemeteries. Green Space area is calculated with the help of Arc GIS 3.4.2. Software with inbuilt tool present in Software as Raster calculation. For calculating GSA we need classified image as vegetation cover. It has given the area of the selected polygon with metric unit of square meters.

- **GREEN COOL ISLAND INDICATORS:**

- **GCI Range (GR):**

The distance between the first turning point of temperature curve and the edge of green space. The unit is meter.

Temperature Drop Amplitude (TA):

The LST drop between turning point and green space interior. The unit is °C. TA or PCI intensity is measured from air temperature in a park and the surrounding urban area. The definition of PCI intensity in this work is temperature difference of the average temperature value between mobile observation outside the park and stationary observation inside the park:

Where, T_O be the average temperature of urban surroundings within

500 m from the park, which is wide enough to include thermal information on roads, business buildings and other

$$TA = T_O - T_I$$

spaces.

T_I is the average temperature inside the park, which includes open lawn, lawn shaded from trees, open cement ground and cement ground shaded from trees.

Temperature Gradient (TG):

The gradient (temperature drop with unit distance) of surrounding LST. The unit is °C/km.

$$TG = TA / GR^2 * 1000$$

VI.RESULTS AND DISCUSSION**Green space characteristics and GCI effects**

The average temperature of whole study area is found to be 30.89 while average temperature of the green space is 30.63 a difference of 0.26 degree which indicate that there must be some cool island existence.

When buffer of 500m is calculated it was found that average temperature is increasing as 30.66 where as it is further increasing as 30.79 when buffer of 1000m is created.

Mean temperature of parks with buffer:

temperature of park		with 500m buffer			with 100m buffer		
TYPE_OF_PA	AREA	MIN	MAX	MEAN	MIN	MAX	MEAN
community park	63900	29.07785	31.35022	30.49317	29.07785	31.35022	30.49317
housing area park	67500	28.52219	32.59515	30.73489	28.52219	32.59515	30.73489
neighbourhood park	61200	29.67682	31.87534	30.88933	29.67682	31.87534	30.88933
multipurpose community	32400	30.34573	31.20789	30.60999	30.34573	31.20789	30.60999
multipurpose district park	12600	29.80951	30.21359	30.05829	29.80951	30.21359	30.05829
amusement park	23400	30.11099	30.59592	30.32569	30.11099	30.59592	30.32569
district park	9900	29.72714	30.43219	30.01933	29.72714	30.43219	30.01933
zonal park	16200	30.95667	31.96301	31.23659	30.95667	31.96301	31.23659

Here in the study when we consider the all park we found that multipurpose community park (13) observed that the

LST around park rises as the distance from green space increase in all the four direction. As the distance further increases, the temperature increase slows down or even decrease. This indicates that GR is reached at some extend. One of the best observations can be made for all the 8 type park is that it showing temperature increase in north direction and west direction almost for all the parks.

Statistics of green space characteristics and its effect:

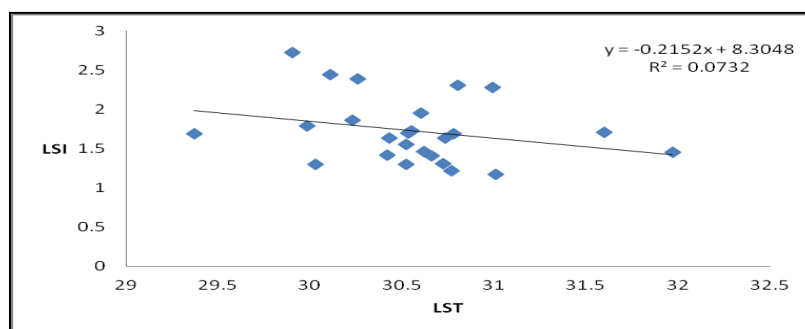
			GR(m)				TA(°C)				TG(°C/km)			
	GSA	LST	North	Sourh	east	West	North	South	East	west	North	South	East	west
MEAN	5853.2	30.56	53.96	42.36	55.16	41.5	-0.15	-0.08	0.1	0.18	-0.57	0.18	0.52	0.68
MIN	532.8	29.37	28.44	28.37	28.58	27.62	-3.18	-4.42	-0.95	-1.37	-15.15	-12.82	-6.68	-9.76
MAX	22198	31.97	179.27	100.28	117.62	268.8	3.67	1.45	2.05	1.8	8.77	9.68	6.41	8.6

As per the given table, GR (N) is between 28.44 m-179 m with an average value of 53.96 m, the TA(N) lie between (-3.18 °C)-3.67 °C with an average value of (-0.12°C) and the TG(N) lie between (-15.15 °C/km-8.7 °C/km) with an average value of (-0.57 °C/km). GR (S) is between 28.37 m-100.28 m with an average value of 42.36 m, the TA(S) lie between (-4.42 °C)-1.45 °C with an average value of (-0.080°C) and the TG (S) lie between (-12.82 °C/km-9.6 °C/km) with an average value of 0.184 °C/km. GR (W) is between 27.62 m-117.62 m with an average value of 41.50 m, the TA (W) lie between (-1.37 °C)-1.8 °C with an average value of 0.181°C) and the TG (W) lie between (-9.76 °C/km-8.60 °C/km) with an average value of 0.68 °C/km. GR (E) is between 28.58 m-268.8m with an average value of 55.16 m, the TA (E) lie between (-0.95°C)-2.05 °C with an average value of (0.106°C) and the TG (E) lie between (-6.68 °C/km-6.41 °C/km) with an average value of (0.52 °C/km).

Green space LST and Impact factor:

● Landscape shape index

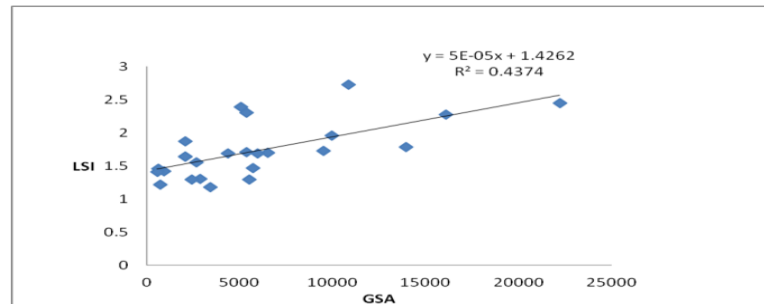
The highly fragmented urban green parks dominated the landscape. Though this kind of park can provide more shade than larger patches with the same total area, they are too small to generate significant cool island effect (Cao et al., 2010; Zhang et al., 2009). The increase of patch area may play a more important role than the increase of edge density in decreasing LST, which lead to a positive relationship between LST and edge density which concluded that higher edge density could decrease temperature by providing more shade. we observed that district park is having maximum value as 2.73 whereas neighborhood park is having the smallest value as 1.18. The larger LSI indicates a more complex shape of green space. So here it is observed that district park having more complex shape getting temperature of 29.9 which is 1.11 less than neighborhood park where as neighborhood having less complex shape having temperature of 31.01.



Graph between LST and LSI

The LST of green space is significantly negatively correlated with LSI. For green spaces with LSI greater than 2, the average LST is 30.41 °C which is lower than 30.60 °C For LSI smaller than 2. So the green space with more complicated shape leads to

lower inside LST.

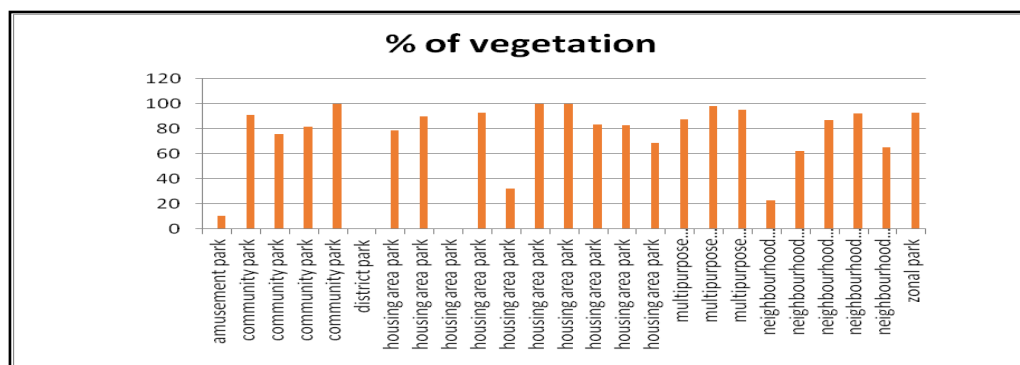


Graph between GSA and LSI

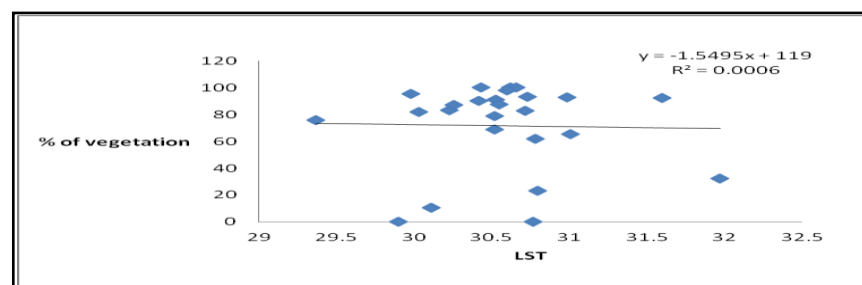
When the Landscape shape index is compared with the green space area it is observed that it is positively correlated with the LSI with value of 0.66 which indicates that when size of park is more than LSI will also be more and result into the decreasing of temperature.

● Vegetation

Green space relations with % of vegetation



Community area park and housing area park showing completely 100% vegetation which indicates that they are helping for the urban cool island in highly density urban area.

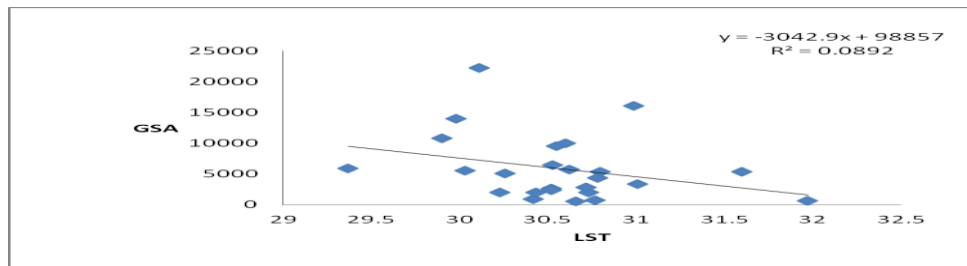


Graph between LST and % of vegetation

LST and vegetation is negatively correlated in this study this implies that when vegetation will be increased leads to lower LST. It is observed that housing area park have good % of vegetation cover.

● Green space area:

For the selected 71 green parks the average land surface temperature is **30.89**, from best fitting curve we can GSA is significantly negatively correlated with its LST. This means the GSA is one of the major impact factors of LST.

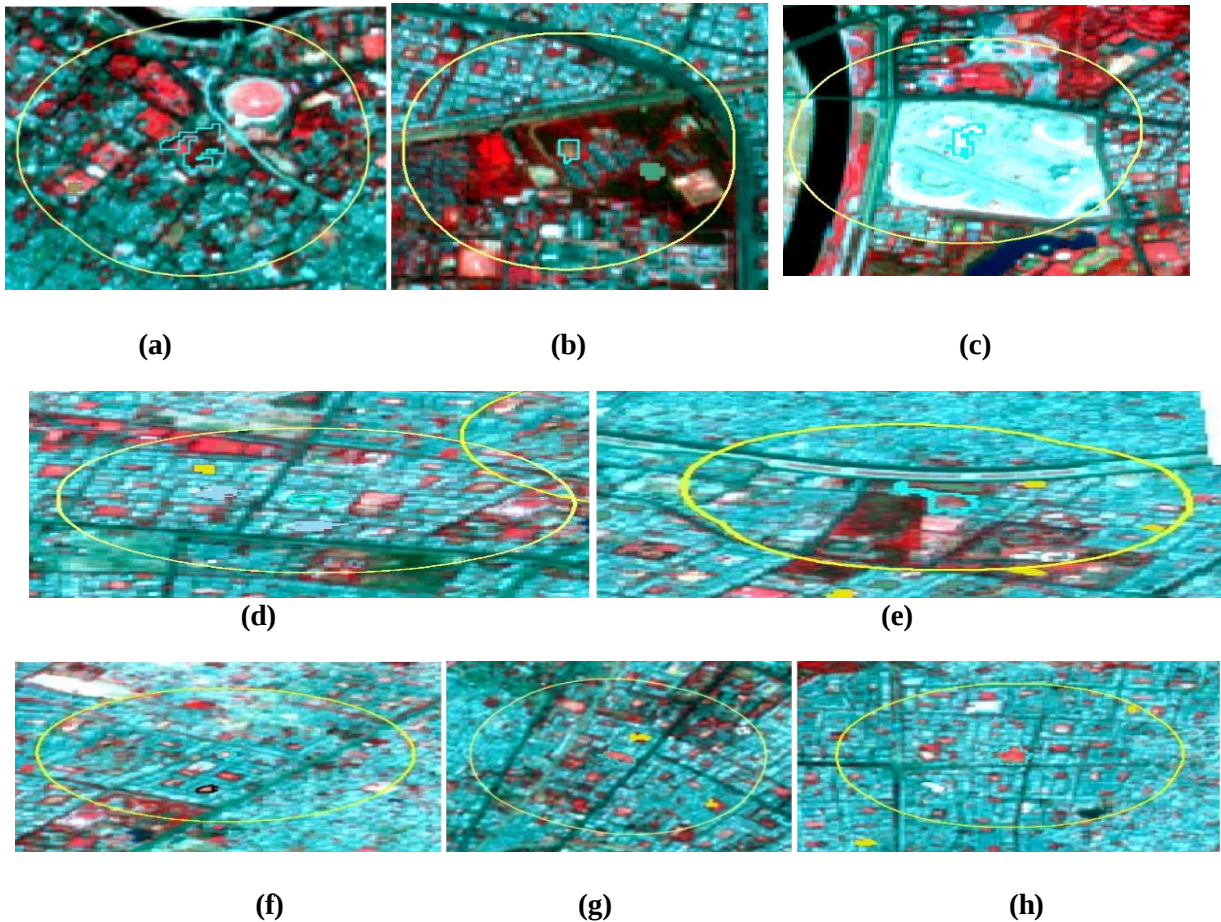


Graph between LST and GSA

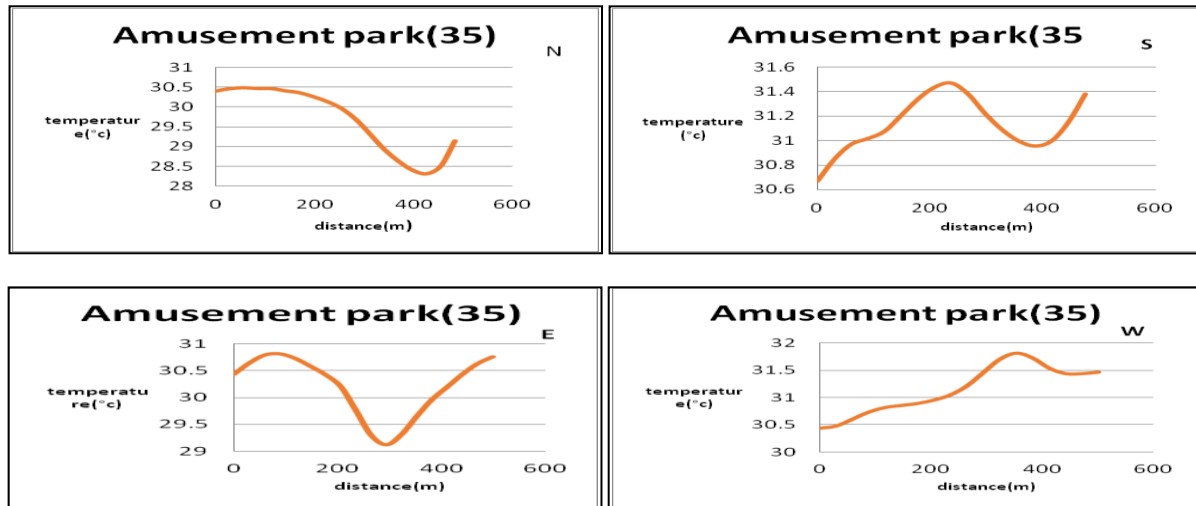
The reason is that larger GSA contains more vegetation, then the photosynthesis and transpiration consumes more energy, thus leads to a lower LST. It can be concluded from above observation that District Park contains 100% impervious surfaces but due to its complex shape it is showing minimum temperature of all the selected parks. This indicates that landscape shape index of green spaces is the major factor for regulating land surface temperature which result into the urban cool Island effects.

GREEN COOL ISLAND INDICATOR AND IMPACT FACTORS:

● GCI indicators for different parks:



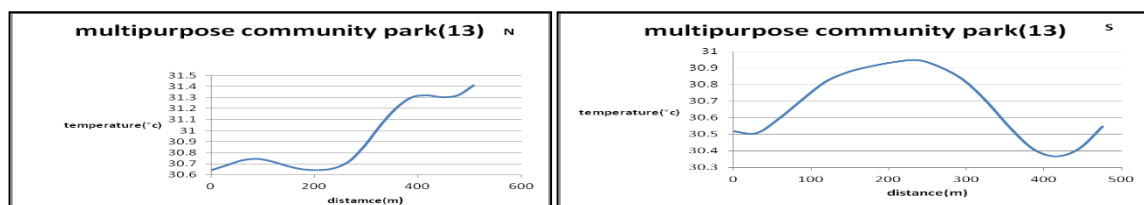
Snapshot different parks in study area



Distance vs. temperature graph of Amusement park in different directions

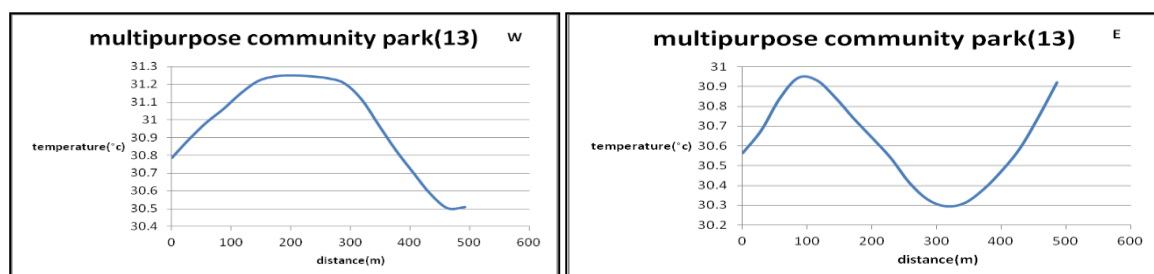
In north direction, from above figure we can see that temperature is stagnant till 100m, the reason behind this boundary is covered with vegetation as moving away from the park temperature start decreasing it is coming across to the high density vegetation.

In south, west and east direction temperature is increasing as we are moving away from park this indicates that it coming across to built up and impervious surface in after reaching a threshold value its start decreasing.



Distance vs temperature graph of Multipurpose Community Park in different directions

From above figure we can say that in North direction the temperature is fluctuating due presence vegetation inside the built up area while for south east and west firstly it increase and after reaching certain distance start decreasing.



Relation between GCI and Impact indicator:**Pearson correlation between GCI and impact Indicator:**

GCI	green space cool island range(GR)				temperature drop amplitude(TA)				temperature gradient(TG)			
	N	S	W	E	N	S	W	E	N	S	W	E
GSA	0.145	0.016	0.152	-0.144	-0.1766	0.0698	0.3254	0.233	-0.0154	0.0344	0.325	0.2403
LSI	-0.04	-0.2526	0.247	-0.127	-0.171	-0.245	0.564	0.019	0.5648	-0.322	-0.045	0.517
% of impervious	-0.085	0.073	-0.0765	0.466	-0.166	0.015	-0.08	-0.059	0.0452	0.0776	-0.035	-0.185
% of vegetation	0.082	-0.078	0.08175	-0.458	0.17	-0.0194	0.0757	0.049	0.045	-0.079	0.176	0.028

GR (N) is positively correlated with the GSA and % of vegetation and negatively correlated with the LSI and % of impervious. GR can be improved by enlarging the GSA and vegetation and decreasing the LSI and % of impervious surface. TA (N) is only positively correlated with the % of impervious this indicate that TA is only impacted by %_im. TG (N) reflects the efficiency of GCI effects, it is significantly positively correlated with the LSI, %_im and %_veg. This Indicates higher %_veg and LSI will increase the GCI efficiency. GR(S) is positively correlated with GSA and %_im and negatively correlated with LSI and %_veg GR can be improved by enlarging the GSA and %_im and decreasing LSI and %_veg. TA(S) is positively correlated with GSA and %_im it will be great affected by the GSA and %_im. TG(S) tells about the efficiency, it is positively correlated with GSA, and %_im. This Indicates higher GSA and LSI will increase GCI efficiency. GR (E) is only positively correlated with the %_im so here GR can be improved by enlarging the GSA, LSI and %_veg. TA (E) is only significantly negative correlated with the %_im here it is only affected by the all three indictor except the %_im. TG(E) tells about the efficiency, it is positively correlated with GSA and %_veg which shows efficiency can be improve by higher GSA and %_veg. GR (W) is only negatively correlated with %_im this indicate that GR attain good value as compared with all other the direction. A (W) is also only negatively correlated with %_im. TG (W) as well negatively correlated with _im. All three GCI indicators are positively correlated with the LSI, %_veg and GSA.

List of Abbreviation:

GR- Green Cool Island Range
LST- Land Surface Temperature
LSI- Landscape Shape Index
TA-Temperature Amplitude
TG- Temperature Gradient
UGI- Urban Green Infrastructure
UGS- Urban Green Spaces
UHI- Urban Heat Islands
UCI- Urban Cool Islands
%_im- Percentage of Impervious Surface
%_veg- Percentage of Vegetation Surface

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