URBAN HEAT ISLAND AND INDIAN METROPOLIAN CITIES –A CASE STUDY OF BANGALORE METROPOLITAN CITY

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Abstract

Urbanization is not a modern phenomenon but, an accelerated growth in urban areas and urban activities is relatively new low latitude in third world countries. Urbanization in third world is characterized by increasing population in cities as well as emergence of new metropolitan cities from cities such changes in the demographic configuration have triggered the economic displacements. It is recognized as the most evident characteristics of urban climate. It has resulted in the conversion of the natural land cover (LC) into impervious surface materials such concrete, asphalt, metal and decreasing areas of parks and play grounds, water bodies causing the development of urban heat island (UHI)phenomenon . Urban areas exhibits higher air and surface temperature than rural areas landing UHI phenomenon characterization and identification of UHI are based on Land Surface Temperature (LST), which is the skin temperature of the Earth's surface. LST has been as a primary factor for examining surface energy balance budget and accessing surface urban heat island (SUHI) effect. LST also helps in investigating risks associated with heat and susceptibility in Bangalore metropolitan cities. The rise in LST is many influenced by the energy interference between the atmosphere and Earth surface. Bangalore are particularly vulnerable to hazards such as urban heat island effect, urban floods and water scarcity because of rapid and unplanned urbanization most of which will be exacerbated by climate change. From the land use analysis show that spatial extent of tree vegetation In Bangalore is 100.02 sqkm(14.02). Bangalore has an average density of 0.15. Spatial extension of temperature shows that area unit of higher temperature increases.

This study high lights the city has crossed the threshold of urbanization evident from a range of psychological, social and health impact like enhanced asthma level, respiratory infection etc. Data analysis and preventive measures are enlightened in this paper.

Keywords: Demographic configurations, Natural Land Cover, Urban Heat Island, Land Surface Temperature

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1. INTRODUCTION

Cities around world have seen significant urbanization, marked by the increase in urban infrastructures and vehicular population. Permeable Land Surface which was covered by vegetation has been converted into impermeable and high emissivity surface and un-shaded. Such Urban surfaces tend to absorb the solar radiation and emit it later, which causes an increase in local temperature consequently the urban areas observing higher temperature become “Heat Island compared to their rural counterpart. [1]

Urban structure of a city which includes Land Use planning, building morphology, Surface characteristics along with anthropogenic heat which is generated from Vehicles and equipment’s such as air conditioners are the most crucial factors causing increase in air temperature or Urban Heat Island. These in then increase air pollution and also energy consumption of buildings in providing thermal comfort inside buildings by use of refrigeration. This eventually leads to increase of greenhouse gas emissions and negative impacts on heat of residents of metropolitan cities in India.[2]

Bangalore located in the heart of the South India, and third most populous city in India after Mumbai and Delhi with a total population of 12.3millian.It is among the world’s top 10 fastest growing cities with an average economic growth rate of 8.5%. Bangalore is the IT capital of India and is often branded as the Silicon Valley of India. Rapid urbanization has seen many negative environmental impacts on the city, which includes diminishing lakes traffic congestion along with air pollution levels, Urban flooding during heavy rains and increase in summer temperature. In the summer of 2018, highest air temperature recorded in Bangalore metropolitan city was 39.2°C (103°F).There were also unofficial records of 41°C(106°F). According the Karnataka state Natural Disaster Management Centre (KSNDMC) authority, Bengaluru, It has risen by 1 degree in the last decade itself. All the above Environmental impacts are resulted to Urban Heat Island effect, which is related to the manner urban development takes place. If the current scenario continues, Bangalore could lose it charm of enjoying the salurious temperature and modern weather condition.[3]

Thus in this Research work, It is planned to study the effect of urban characteristics on UHI by recording temperatures at strategically identified location along with the documentation of physical characteristics of Urban Planning and androgenic heat being emitted in the location. Based upon the monitored result relation between Urban Planning characteristics and UHI will be framed. This will provide with important guidelines for Urban Planner, and policy maker while carrying out Urban Planning for new location satellite city around Bangalore metropolitan city. [5]

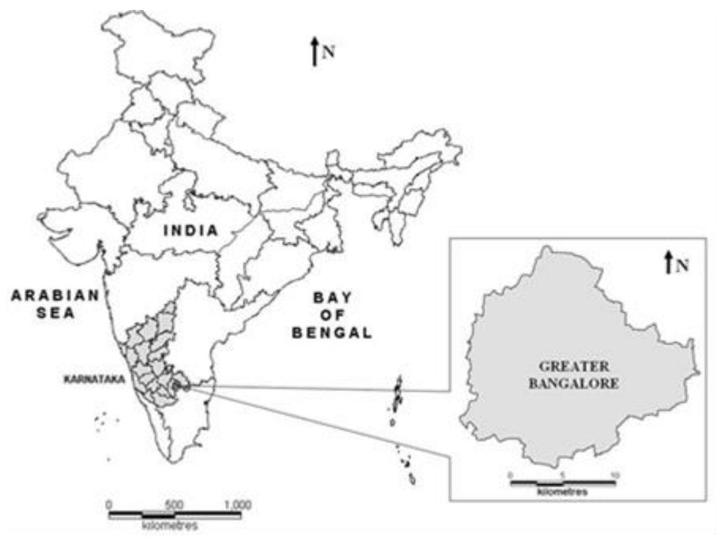

Figure 1: Study area – Greater Bangalore

2. LITERATURE REVIEW

The following studies were reviewed for their relevance to the study. They highlight the scope in thinking and progress in our understanding of urban heat islands to form the foundation for successful mitigation.

- **Wang et al, (2017**) opine that the mitigation measures against heat islands have been unsuccessful because of regional rather than local emphasis where application is more realistic. However, climate research is on a regional/global scale. Previous studies treated cities as uniform without considering the variability of locations within which might require different interventions. They proposed mitigation measures such as vegetation cover and high albedo materials at zonal or local area level.
- **Antonyova et al, (2017)** suggest that buildings benefit from energy savings from use of vegetation outside of houses which reduces their need for air conditioning. The authors achieved the temperature reduction with the use of vines as species.
- **Park et al, (2017)** found that small green spaces have a reduction potential of temperature on building blocks with mixed spaces fairing highly compared to monolithic spaces. Any green space has a reducing effect on the temperature of air with polygonal and mixed SGs reducing more than the linear and single types. Mixed type spaces had the best reduction performance

- **Feng et al,(2016)** in studying the impact of vegetation on temperature of central building objects found that

    - Vegetation has much more impact on low rise buildings than middle or high rise buildings

    - The closer the vegetation is to low rise buildings, the greater the reduction in its Land Surface Temperature.
    - The impact of vegetation on high rise buildings is not pronounced in the first 200m but is observable from 300 to 500m. High rise buildings have 'their own shade' and get little impact from vegetation.

    - With increase in areas, the impact of neighbouring land cover features on low rise buildings on Land Surface Temperature was low while the impact increased with mid-rise and high rise buildings.

MATERIALS AND METHODOLOGY:

It is proposed that the research work will be carried out under the following two stages

Stage No 1: Site selection and study of urban planning (land use planning). The study relies an real time monitoring result of different location in Bangalore metropolitan city hence the first work was to select ten form location in a such a way that each location presents a unique combination of urban characteristic's in terms of built up areas, greening and surface types.[4]

Site Selection: Bangalore has two predominant land use i.e. residential land use and commercial land use hence, location from each typology were selected.[6] The urban heat island can be governed by geometry, urban surface characteristics and anthropogenic heat. Out of these from factors, only two chiefly controlled by urban planners. i.e. green cover and urban geometry. Hence the locations identified for this study, are selected based upon different green covers and varied urban geometric that exist in the city

Stage 2; Field measurement and Analysis

Field measurement: Continuous hourly measurement of AT, RH, and GT were taken for multiple days simultaneously for each location. Multiple sessions of meritorious enabled us to overcome the limitation observed during earlier sessions. During one of the session, thermal images of streets were taken to better understand the surface temperature pattern of street

Analysis of monitored result: The measured parameter of AT, GT and RH were averaged out for each locations and represented on a 24 hour scale. Each location was first analyzed individually to determine the relationship between AT, RH, and GT. In the next step, the selected locations in each typology were compared against other location to observed the differences in similarities in their thermal behaviour

3 RESULTS AND DISCUSSION

Land use /land cover, and land surface temperature distribution and the study area the three main subsections in which the result of this study are presented

3.1 Characteristics of temperature changes and land use intern change

The fig 2 presents the result of the land use classification and intensity expression in 1973 and 2017 built up land increased gradually, whereas vegetation land decreased due to a transition to build- up land. The value of land use intensity in the Bangalore metropolitan city varied between 8.00% and 93.3%. A comparison of the land use classification and Intensity revealed that the land use intensity varied with the land use type, which was manifested as a continuous transition feature. The land use intensity gradually increased because rapid urbanization

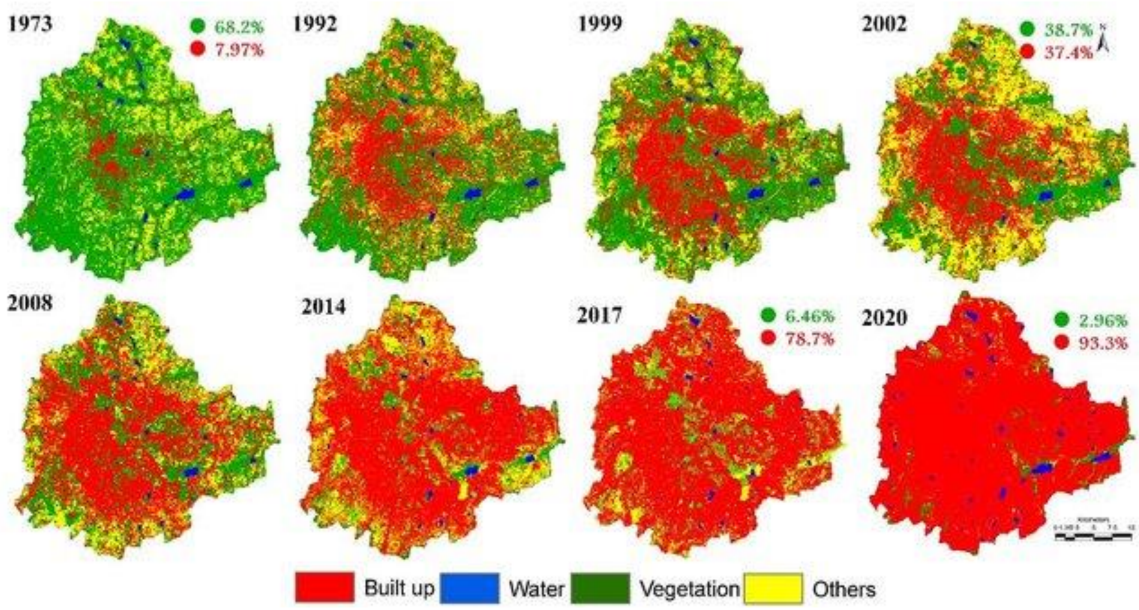

Figure 2: Land use Intensity

3.2 Analysis of influencing factors

The table 1 represents the dynamic changes in land use type and temperature from 1973 to 2018. The area of the buildup land increased by 85% and the area of vegetation, water bodies and other decreased by 68.3% to 20.49 , 3.4% to 0.9 and 20.4% to 1.0 respectively. The highest to lowest temperature increases from 2011 to 2017 was 37.5%. As per the Karnataka state Natural disaster management center the highest temperature in Bangalore is 39.6˚C in 2018 and it has raises by more than 1 degree in the last one decade itself. The results suggest that the temperature rise primarily resulted from the expansion of buildup land.

A land use dynamics in Bangalore

(Area I sqkm)

Table 1: Land Use Type in Bangalore Metropolitan City; source: BMRDA

YEAR	1973	1992	1999	2002	2008	2014	2017	2018	2020
Built up area	5448	31579	24163	25782	35301	37266	54807	57763.1	66463
Vegetation	46639	31279	31272	26453	20090	16031	5364	4413	2108
Water	2324	1790	1542	1263	613	617	696	696	696
Other	13903	16303	11346	14825	15256	14565	10394	5441	2002
Built up area	8.00	27.3	35.4	37.7	49.5	49.5	76.9	63736	93.3
Vegetation	68.3	46.2	45.8	38.7	28.2	23.4	7.5	2049	3.0
Water	3.4	2.6	2.3	1.8	0.9	0.9	1	683	1
Other	20.4	23.9	16.6	21.7	21.4	21.3	14.6	1912	2.8

The characteristics of the thermal systems of each land covers class must be studied first. The average values of radiant surface temperature by land cover type in 1973to 2018 are summarized in the table 2 and 3. In this study buildup area with paved surface exhibits the highest surface radiant temperature 39.5°C in 2018 followed vegetation 34°C and water bodies 30°C these temperature shown in the table

Table 2: Average surface temperature °C by land use/cover type

Land cover	2017	Standard deviation	2018	Standard deviation
Build up area	38.5˚C	1.2	39.5˚C	1.5
Vegetation	32.9˚C	3.7	34.1˚C	1.4
Water bodies	30˚C	1.9	31˚C	2.8
Other	31˚C	3.5	32˚C	3.6

Table 3: Consolidated Spatial Variation of Land Surface Temperature

Consolidated Spatial Variation of Land Surface Temperature				
Study area	**Associated land use/land cover**	**Min Temp (°C)**	**Max Temp (°C)**	**Mean Temp (°C)**
Bangalore 2014	Built up	29.5	38.9	34.20
	Water body	13.0	18.9	15.95
	Vegetation	14.2	18.2	16.20
	Other	25.0	30.0	27.50
Bangalore 2017	Built up	28.1	38.9	33.50
	Water body	24.1	26.9	25.50
	Vegetation	19.2	37.0	28.10
	Other	35.2	36.0	35.60
Bangalore 2018	Built up	36.1	37.9	37.00
	Water body	27.9	26.1	27.00
	Vegetation	19.2	37.0	28.10
	Other	37.6	37.1	35.31

4. **CONCLUSION**:

The present study has concentrated on three aspects to find out the temporal changes temperature, compare the spatial extension of temperature and compare temperature between different land uses. The result of the first aspects of temporal changes through that the minimum and maximum temperature of Bangalore metropolitan city has increases. The second aspect of the spatial extension of temperature shows that, the areal unit of higher temperature has increased while the lower temperature decreased in Bangalore metropolitan city. The third aspect which was conducted to find out the temperature variation between different land uses shows that Build up areas have higher temperature than other land uses while vegetation and water bodies have the lowest temperature, which clearly shows that increase in vegetation & protection of water bodies in city area can be reduce the surface temperature.

These changes resulted in an increase in the land use intensity; Built-up &cultivated lands were major factors that accounted for the temperature increase. Therefore, the influence of human activities can be quantitatively expressed based on the land use intensity.

An increase in the land use intensity generally corresponds to a temperature increase, such as the heat island effect. However, the result of this study suggests that the temperature increase was primarily caused by a change in the land use intensity. This finding may be interpreted as land cover change owing to hierarchical transition & characteristics of temperature changes in the lake area. Therefore, in addition to the effect of greenhouse gases and radioactive forcing, the regional land cover or land use conversion must have enhanced the temperature change and infiltration increases and thus significant rise in ground water table by use of grid pavers.

5. **POLICY RECOMMENDATIONS**

It is well established that cities experience urban heat island effects and therefore imperative that action is done to mitigate their negative effects or at the minimum adapt to overcome the effects. Though temperatures have been rising in Bengaluru Metropolitan city, since the 2017 by 0.90C on average and the projected increase of 1.50C is expected in the next three years unless drastic action is taken to mitigate climate change the status quo does not address the current challenge. The most urgent situation needs the creation and adoption of guidelines for green development specific to the city of Bengaluru addressing urban heat islands

1. Increase shade around home

Planting trees and other vegetation lowers surface and air temperatures by providing shade and cooling through evapotranspiration. Trees and vegetation that directly shade home can decrease the need for air conditioning, making your home more comfortable and reducing energy bill. Trees also protect your family's health by improving air quality, by providing cooling shade for outdoor activities, and reducing exposure to harmful UV radiation.

2. Install green roofs

A green roof, or rooftop garden, is a vegetative layer grown on a rooftop. Green roofs provide shade and remove heat from the air through evapotranspiration, reducing temperatures of the roof surface and the surrounding air. Green roofs absorb heat and act as insulators for home, reducing energy needed to provide cooling and heating (which decreases your energy bill), improving indoor comfort, and lowering heat stress associated with heat waves.

3 Install cool roofs

Cool (or reflective) roofs help to reflect sunlight and heat away from your home, reducing roof temperatures. This allows for your home to stay cooler, reducing the amount of air conditioning needed during hot days. Cool roofs can provide annual energy savings of almost 50 cents per square foot. Such energy savings can also result in better air quality in community and fewer greenhouse gases emitted to the atmosphere.

6. RECOMMENDATIONS FOR FUTURE RESEARCH

The research related to urban heat islands and the urban microclimate has been expanding rapidly and a lot has been researched already. This study resulted in an early UHI warning regarding the change of cityscape lay-outs. However, the complexity of the influence that cities have on their environment offers plenty of opportunities for further studies. This paragraph discusses the recommendations for future research.

In this study, the relationship between urban configuration and urban heat island intensity was examined. The first step in relating urban heat to the space matrix density variables was made by the study of seven neighborhoods. Based on the results, the relationship between the space matrix indicators and UHI intensity appears to be significant. Besides, the statistical significance of the results of this study will change because of the higher number of analyzed cases. An alternative option would be to research the sensitivity of the space matrix indicators to different scale levels.

Another suggestion for further research would be to investigate the possible impact of the found results of this study on the urban planning practice. A significant contribution to the planning process would be to investigate in what manner mitigation and adaption of urban heat are currently institutionalized within municipalities and how urban planners and decision-makers could benefit from urban climate research. The question arises, is neighborhood level the most useful scale? While conducting this research, it became apparent that the gap between research and the application of adaption and mitigation strategies is large at some points. By getting a better understanding of how the planning process works, the gap between science and practice can be bridged.

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