*RESEARCH ARTICLE*

International Journal of Multidisciplinary and Scientific Emerging Research


Available at http://www.ijmser.com/ (ISSN 2349 – 6037)

# Study of the Different Approaches used to Estimate the Urban Heat Island Effect in India

**Ravina More[1], Neha Kale[1], Garima Kataria[1], Prof. R. A. Rane[1] and Shailesh Deshpande[2]**

[1]Department of Computer Engineering, Maharashtra Institute of Technology, Savitribai Phule Pune University, (India)
[2]Tata Research, Design and Development Center, Hadapsar (India)

Accepted **19** February 2015, Available online **15** May 2015, **Vol.4, No.2 (May 2015)**

***Abstract***

*Urban Heat Island is a growing concern for India, a developing country, with the 2nd highest population in the world. Sustainable growth has become a prime mover while planning cities and government policies. Environment concerns are being neglected due to a lack of scientific evidence supporting the environmental concerns. This paper aims to provide a summary of the research carried out in different cities to determine the formation of the urban heat island effect. The paper reviews the different aspects involved in estimating the urban heat island effect. The case studies have been grouped into the two main approaches used to obtain the data-Mobile Observations and Remote Sensing Observations..*

***Keywords:*** *Land Surface Temperature (LST), Urban Heat Island (UHI), Normalized Difference Vegetation Index (NDVI), Land Use Land Cover (LULC), Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), Thermal Infrared Remote Sensing (TIR).*

## 1. INTRODUCTION

An urban heat island (UHI) is a metropolitan area that is significantly warmer than its surrounding rural areas due to human activities [1]. Remote sensing is the practice of deriving information about the earth's land and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the earth's surface. Land surface temperature (LST) is the average temperature of an element of the exact surface of the Earth calculated from measured radiance [2].

The technique of sensing remotely has been extensively used to obtain infrared images in order to derive LST and emissivity [3]. Various satellite and airborne sensors have been developed to collect TIR from the earth, such as HCMM, Land sat TM/ETM+, AVHRR, MODIS, ASTER, and TIMS. LST is a primary factor for measuring the dynamics of the temperature model in different areas and thus assessing the UHI effect. The LST can be used as a good estimate for determining surface radiation and energy exchange, the internal climate of buildings, and human comfort in the cities [5].

This literature survey aims to highlight the literature published in the field of the UHI studies done in India. The review presents an analysis of the works of these authors and the transformation undergone in the process of using different tools to assess the formation of UHI in different parts of the country.

This review will not explore the research carried out in other countries. Lastly, the drawbacks of the existing methods and possible approaches of studying the UHI phenomenon more effectively will be evaluated.

While reviewing the papers, the authors realized a transition in the way UHI studies are being carried out. It was noticed that the approach shifted from a manual, mobile observatory one to a computerized, remote sensing one. Also, the work done in this field is spread over a variety of sources such as Science Direct, IEEE and individual publications over websites. As a result, the sources are difficult to accumulate.

## 2. LITERATURE REVIEW

The transformation of an area from a rural area to an urban conglomerate is best observed in developing countries. As a result, the study of the UHI effect in India during this time of the millennium is playing a pivotal role in analyzing the side-effects of urbanization.

In India, fair amount of research in the field of UHI

has been conducted in cities Madras (Chennai), Pune, Mumbai, Chennai, Bangalore, Delhi, Western Corridor, Ahmedabad, Kochi, Nagpur, Dindigul and Guwahati. This research has been taking place from 1991 is still ongoing. This section presents a review of the UHI studies carried out in India. Table 1 summarizes the nature of these studies. The studies can be broadly classified into two classes based on the methodology followed while collecting the data-Mobile Observations Approach and Remote Sensing Approach. This classification also shows a technological shift in the way data is handled since the research technique has now advanced into a less-effort, more value class. The two subsections will also discuss the advantages and trade-offs in adopting a different approach.

| **Author** | **Year** | **Area** | **Methodology** |
|---|---|---|---|
| S. Sundersingh et al [5] | 1991 | Madras(Chennai) | Mobile Observations |
| Deosthali et al [6] | 1999 | Pune | Mobile Observations |
| Kiran Chand et al [7] | 2005 | Hyderabad | LST |
| M. Lei et al [8] | 2008 | Mumbai | Simulated System(RAMS) |
| Devadas et al [9] | 2009 | Chennai | Mobile Observations |
| Rose et al [10] | 2010 | Chennai | Thermal Comfort Index |
| T. Ramachandran et al [11] | 2010 | Bangalore | LST |
| M. Mohan et al [12] | 2012 | Delhi | Stationary measurements and Remote Sensing(LST) |
| Bothrakur et al [13] | 2012 | Guwahati | LST |
| Arathyram et al [14] | 2012 | Western Corridor | LST |
| D. Bajaj et al [15] | 2012 | Ahmedabad | LST |
| G. Thomas et al [16] | 2014 | Kochi | Local climate zone (LCZ) classification based method |
| R. Agarwal et al [17] | 2014 | Nagpur | LST |
| Rajeshwari et al [18] | 2014 | Dindigul | LST |

**Table 1:** Summary of the UHI Case Studies Conducted In India.

### 2.1 Mobile Observations Approach

S. Sundersingh et al initiated the research in the field of UHI studies in India in 1991 by collecting mobile observations from 77 different points in the city of Madras (Chennai). This data consisted of physical factors such as humidity, surface temperature and wind data. This data was coupled with information obtained about the three-dimensional nature of the temperature profile from two separate observatories. The findings were mapped with the geographical co-ordinates on paper and a conclusive proof of the existence of the UHI effect was thus obtained. A similar approach was followed by Deosthali et al while collecting data for the Pune city in the year 1999. The researches carried out individually by these two groups present near accurate data and provide insight into actual weather conditions prevalent at the time of the research. However, both these studies have been carried out by manually placing the sensors at the location and mapping the mobile data onto the geographical coordinates. Although the data collected by this method provides accurate data, observations in the inaccessible geographic regions cannot be obtained and thus needs extrapolation of the existing data or assumptions. As a result, the holistic accuracy of the model gets affected. These models also had a drawback that they could not be compared to the temperature situations of the previous years and hence, doing a comparative study of the change in the temperature profile of a city over a period of years is not feasible.

Different approaches were tried in 2008 and 2009 by M. Lei et al and Rose et al when they studied the UHI method by experimenting with new approaches such as RAMS and thermal comfort index as a measure for assessing the phenomenon. Each of them came up with conclusive proof of the existence of the UHI phenomenon. The simulation approach followed by M. Lei et al

presented with a virtual model of the temperature gradient and gave a platform to analyze the temperature of the city holistically, nevertheless using a virtual model. A new method introduced by Rose et al also sparked interest considering that the team chose Thermal Comfort Index as a measure for demonstrating the UHI effect. Again, this was a good breakthrough, but it suffered from similar problems as those researches conducted in the 1900's.

### 2.2 Remote Sensing Approach

The obstacles in obtaining the data using the mobile observations approach were overcome in 2005 when Kiran Chand et al published a UHI case study on Hyderabad using LST as a measure for UHI. The data required for calculating the UHI was obtained from day and night infrared images captured from the ENVISAT-AATSR (Environmental Satellite-Advanced Along Track Scanning Radiometer). The methodology involved extracting the Normalized Difference Vegetation Index(NDVI) from the images.(NDVI def) NDVI has been taken as a parameter for estimating surface emissivity and algorithm based on nadir and forward scans of brightness temperature in 12 pm has been used for estimating surface temperature. This approach demonstrated a positive correlation of thermal inertia with variability in Land Use and Land Cover (LULC) characteristics. This was one of the first papers to demonstrate this correlation in India.

T. Ramachandran et al conducted a detailed analysis in 2010 by demonstrating an increase in the urban area by 632%. This was accompanied by a sharp decrease in the water bodies over a period of 30 years. The group conducted their studies using data collected from various satellites and government dataset. The data collected underwent geo-referencing to map it with the geographic co-ordinates. The classification of the images was done using the Bayesian Classifier.

Bothrakur et al demonstrated the UHI effect for Guwahati using LULC, NDVI and LST. However, this analysis was conducted only for short intervals of time. More insight could have been obtained from this study had a longer duration of time been investigated.

Mohan et al conducted an intensive study in the capital city of Delhi which was funded by ISRO and Japan. This survey consisted of data obtained from stationary sensors placed at different points in the city as well as data obtained from satellite. This was one of its kinds which highlighted a parallel between the two methods. While the data collected from stationary points was rich in content as well as accuracy, the data obtained from remote sensing was rich in terms of diversity and space.

Divya N Bajaj et al [15] demonstrated the UHI effect in Ahmedabad, Landsat 5 datasets were used for the study. NDVI was used for land cover classification which was further used to estimate the LST. Two images one of 1999 and other of 2012 were used to determine the correlation between the development of urban areas and temperature. The Digital Number (DN) value of the satellite images was used to determine the spectral radiance, which was further used to calculate the brightness temperature.

It proved that that as the built up area increased the corresponding temperature increased.

## 3. CONCLUSION

Based on these papers, it can be concluded that a majority of the literature available on the UHI is based on ascertaining the phenomenon by estimating the LST profile of the urban areas. Negligent research into obtaining the Ambient Air Temperature (AAT) has been done to analyze the UHI effect which is surprising since AAT is a more accurate and reliable way of estimating the UHI effect.

Contribution of important individual factors such as the radiation from atmospheric pollutants to the urban area, the production of waste heat from air conditioning and refrigeration systems, as well anthropogenic heat, and the obstruction of rural air flows by the windward face of the built-up surfaces, has not been researched into substantially. An analysis of these factors would play a pivotal role in determining the causative factors of the UHI effect and lead to a better understanding of not only the phenomenon but also the mitigation strategies to overcome it.

Also, it has been observed that the existing methods give only a static introspection into the calculation of the LST to ascertain the UHI effect. The near 2-weeks revisit period of the satellites does not give a facility to continuously keep on mapping the UHI effect and thus, does not give way for dynamic analysis of the effect on a micro level.

Thus, it can be concluded that a developing country like India needs to spend its resources on gathering statistics for analyzing the gravity of the UHI phenomenon. India's urban setting is rapidly increasing day by day and the studies done in this field are not increasing proportionately. A backing of scientific facts will lead to better town planning and organized city development.

## REFERENCES

[1] Urban Heat Island-Wikipedia, the free Encyclopedia. Available at:http://en.wikipedia.org/wiki/Urban_heat_island.

[2] Norman, J. M., and Becker, F., 1995. Terminology in thermal infrared remote sensing of natural surfaces. Remote Sensing Reviews, 12, 159–173.

[3] Qihao Weng, Dengsheng Lu, Qihao Weng,

Dengsheng Lu, Jacquelyn Schubring (2004) Estimation of land surface temperature–vegetation abundance relationship for urban heat island studies. Science Direct.

[4] J.A. Voogt, T.R. Oke (1998) Thermal remote sensing of urban climates. Science Direct.

[5] S.David Sundersingh (1991) Effect of heat islands over urban madras and measures for its mitigation Energy and Buildings: Volume 15, Issues 1–2, 1990–1991, Pages 245–252

[6] Vrishali Deosthali. (1999). Impact of rapid urban growth on heat and moisture islands in Pune City, India. Atmospheric Environment

[7] K. V. S. Badarinath, T. R. Kiran Chand, K. Madhavi Latha and V. Raghvaswamy(2008) Studies on Urban Heat Islands using ENVISAT AATSR Data. Photonirvachak: Journal of the Indian Society of Remote Sensing. Vol. 33, No. 4, 2005

[8] Lei, M., Niyogi, D., Kishtawal, C., Pielke Sr., R. A., Beltrán-Przekurat, A., Nobis, T. E., and Vaidya, S. S.(2008) Effect of explicit urban land surface representation on the simulation of the 26 July 2005 heavy rain event over Mumbai, India, Atmos. Chem. Phys., 8, 5975-5995, doi:10.5194/acp-8-5975-2008, 2008.

[9] Lilly Rose A. , Monsingh D.Devadas(2008) Assessing the Intensity of Urban Heat Island Effect in the Hot Humid city of Chennai: International Journal on Design and Manufacturing Technologies, Vol.2, No.1, July 2008.

[10] Monsingh D. Devadas, Lilly Rose A. (2009). Urban Factors and the Intensity of Heat Island in the city of Chennai. The seventh International Conference on Urban Climate, 29 June - 3 July 2009, Yokohama, Japan.

[11] Ramachandra T. V. and Uttam Kumar (2010) Greater Bangalore: Emerging Urban Heat Island. Geospatial Research Portal. Available on http://www.gisdevelopment.net/application/urban /spra wl/Greater-Bangalore-Emerging-Urban-Heat-Island.

[12] Manju Mohan, Yukihiro Kikegawa, B. R. Gurjar, Shweta Bhati, Anurag Kandya, Koichi Ogawa. (2012). Urban Heat Island Assessment for a Tropical Urban Airshed in India Atmospheric and Climate Sciences: Vol. 2 No. 2 (2012), Article ID: 18813, 12 pages. DOI:10.4236/acs.2012.22014.

[13] Monjit Borthakur, Bhrigu Kr. Nath (2012). A Study of Changing Urban Landscape and Heat Island Phenomenon in Guwahati Metropolitan Area. International Journal of Scientific and Research Publications, Volume 2, Issue 11, November 2012 1 ISSN 2250-3153.

[14] Arathyram. Rs, K. Venugopala Rao. (2012). Characterisation of Urban Heat Islands in one of the Most Urbanised Corridors of India from Space Based Multi-Sensor, Spatio-Temporal Data. Applied Geoinformatics for Society and Environment.

[15] Divya N. Bajaj, Arun B. Inamdar and Vineet Vaibhav (2012) Temporal Variation of Urban Heat Island using Landsat Data: A Case Study of Ahmedabad, India.

[16] George Thomas, A.P. Sherin, Shareekul Ansar, E.J. Zachariah()Analysis of Urban Heat Island in Kochi, India, Using a Modified Local Climate Zone Classification: Procedia Environmental Sciences: Volume 21, 2014, Pages 3–13, Urban Environmental Pollution 2013 – Creating Healthy, Livable Cities, doi:10.1016/j.proenv.2014.09.002.

[17] Robin Agarwal, Umesh Sharma and Arun Taxak (2014) Remote sensing Based Assessment of Urban Heat Island Phenomenon in Nagpur Metropolitan Area. International Journal of Information & Computation Technology. ISSN 0974-2239 Volume 4, Number 11 (2014), pp. 1069-1074.

[18] Rajeshwari A, Mani N D. (2014). Estimation of Land Surface Temperature of Dindigul District using Landsat 8 Data. IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308, Volume: 03 Issue: 05 | May-2014, Available @ http://www.ijret.org.