Urban Climate xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Urban Climate

journal homepage: www.elsevier.com/locate/uclim

# Analyzing the role of biophysical compositions in minimizing urban land surface temperature and urban heating

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ARTICLE INFO

*Keywords:*
Land surface temperature
Surface urban heat island intensity
Biophysical composition
Spatial statistics
Urban growth

ABSTRACT

The alteration of the environment at local and regional scale is often attributed to the rapid urbanization in the developing economies like India, China, etc. The land use and land cover (LULC) modification due to urbanization affect the thermal character and Surface Urban Heat Island Intensity (SUHII) of an urban area. The Greater Hyderabad Municipal Corporation (GHMC) has witnessed the drastic urbanization in the last decade and, is the sixth largest agglomeration of India. In the present study, the temporal dataset from Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM + ) are used to trace the LULC, and land surface temperature (LST) changes during 2002–2015 and demarcate the fluctuation of different biophysical surfaces. Subsequently, four different indices viz. Normalized Difference Vegetation Index (NDVI), Land Surface Water Index (LSWI), Normalized Difference Built-up Index (NDBI), and Normalized Difference Bareness Index (NDBaI) are used to document the individual and collective response of the different LULC classes/biophysical surfaces. The simple linear and stepwise multiple linear regression models determined the complex and linear behaviour of the LST with the various biophysical compositions. The GHMC exhibits a rapid urban expansion resulting into increased the LST clusters that corroborate to the changing LULC pattern. The spatio-temporal changes of LULC, LST, and UHI of GHMC from 2002 to 2015 are quantified to evaluate the effects of biophysical indices on moderating or exaggerating LST. The study outlines the urbanization in the GHMC and interaction of changing LULC pattern with the local climate and urban biophysical compositions.

## 1. Introduction

The briskly increasing urbanization and changes in land use land cover (LULC) pattern in the past few decades have led to the problem of Urban Heat Island (UHI) in the main cities across the globe (Chudnovsky et al., 2004). The difference of air and earth surface temperature between cities and suburban area is known as UHI (Oke, 1976, 1982; Weng et al., 2004). The spatial

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http://dx.doi.org/10.1016/j.uclim.2017.10.002
Received 24 July 2017; Received in revised form 22 September 2017; Accepted 4 October 2017

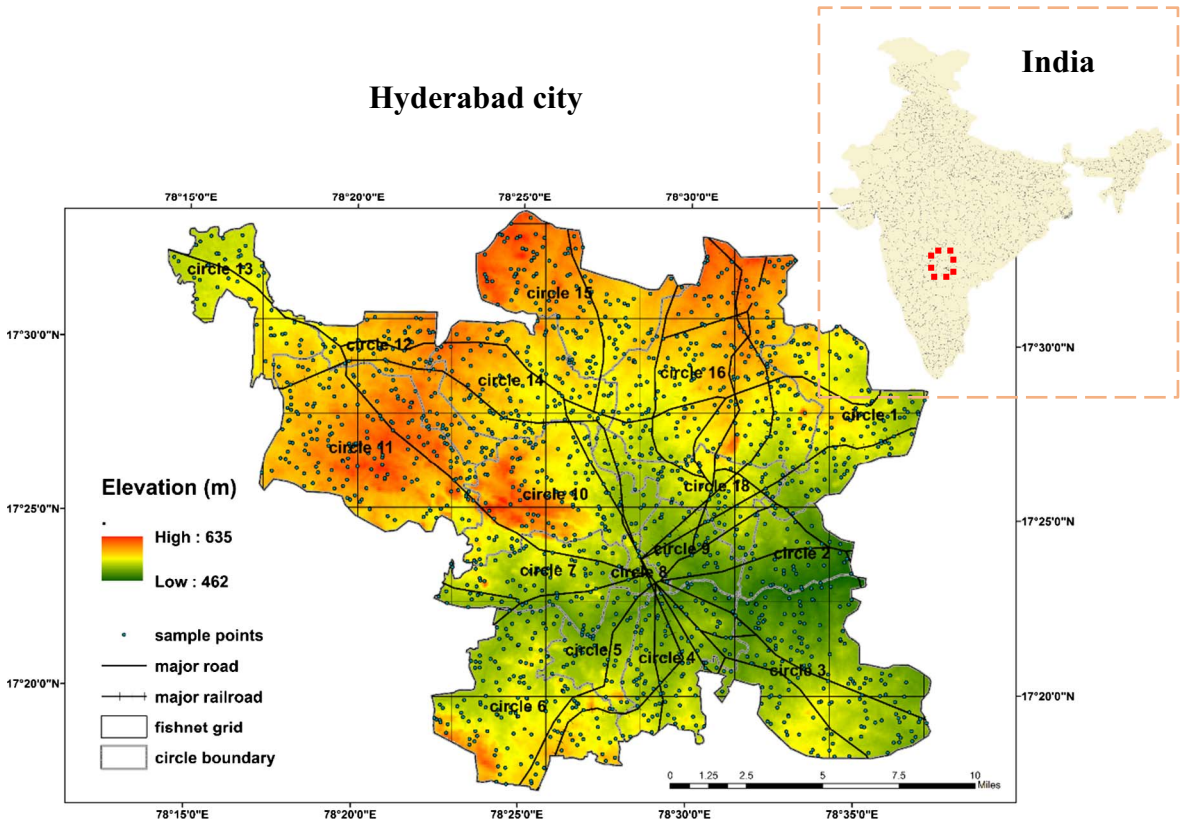


**Fig. 1.** Study area along with the elevation and major transportation network of the city.

discrepancies of the temperature difference between the core city and suburbs deteriorate the quality of urban life, i.e., hampers air quality, increase energy consumption, losses biological control, and affects people health's, etc. (Tran et al., 2017). Fluctuating LST is the major by-product of urbanization and in turn diversely affects the urban climate (Rinner and Hussain, 2011; Feng et al., 2014). The urban ecosystem comprises of the different biophysical surfaces and identification of these surfaces is crucial as each of them responds differently to the same climatic stimulus, i.e., heat waves, air quality and air pollution, etc. (Chudnovsky et al., 2004).

Remote sensing approaches are found to be fruitful in several studies in estimating Land Surface Temperature (LST) and UHI phenomenon over urban ecosystem (Asgarian et al., 2015; Guo et al., 2015; Mohan and Kandya, 2015; Rotem-Mindali et al., 2015; Xu et al., 2013; Deng and Wu, 2012; Ma et al., 2010). The moderate resolution multispectral Landsat satellite products; i.e., Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM +) and thermal data from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) have been used for estimating spatiotemporal LST (Amiri et al., 2009; Chun and Guldmann, 2014; Deng and Wu, 2013a; Deng and Wu, 2013b; Wu et al., 2011; Guo et al., 2015; Sannigrahi et al., 2017). In the present study, the discrepant impact of biophysical compositions on UHI intensity of Greater Hyderabad Municipal Corporation (GHMC) has been evaluated using thermal remote sensing data (Fig. 1). The changing LULC and LST pattern of GHMC for last 13 years (2002–2015) have been assessed using the temporal Landsat TM/ETM + data to evaluate the trend and degree of anthropogenic effect on the environment due to the urbanization. The cluster of LST hotspots was quantified through Anselin Local Moran's I and Getis-Ord-Gi statistics. Four different biophysical components; i.e., Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-up Index (NDBI), Normalized Difference Bareness Index (NDBaI) and Land Surface Water Index (LSWI) have been incorporated in conjunction with overall seasonal and annual LST characterization of the urban landscape to examine the complex agreement between LST and the biophysical compositions through simple linear and stepwise multiple regression analysis.

## 2. Materials and methods

### *2.1. Study area*

Hyderabad city occupies an area of 667 $km^2$ in the state of Telangana and comprises of the three districts: Ranga Reddy, Hyderabad, and Medak, making it the sixth largest metropolitan city in India (Census 2011, Govt. of India). Its periphery is defined by the Musli River to the east, the Deccan Plateau to the south, Osman Sagar and Himayat Sagar Lake to the west. The population of the city drastically increased from 3,637,483 in 2001 to 6,809,970 in 2011 with 8.2% growth rate (Census 2011, Govt. of India).