Urban biophysical composition and its impact on thermal changes and ecosystem production

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Human driving forces, especially, urbanization, population pressure, and socioeconomic development are significantly changing the efficiency of ecosystem service provision in an urban ecosystem. Greater Hyderabad Municipal Corporation (GHMC) is the sixth largest urban metropolitan region in India had faced an alarming pace of urban expansion from 1973 to 2015. MODerate Resolution Imaging Spectroradiometer (MODIS) thermal products MOD11A2 and surface reflectance products MOD09A1 were employed in this work to simulate areal and temporal dynamics of Urban Heat Island (UHI) and Diurnal Temperature Range (DTR) of the GHMC region from 2002 to 2015. A Light Use Efficiency (LUE) based Vegetation Photosynthesis Model (VPM) was adopted in this work to quantify Net Primary Production (NPP) and to assess the spatiotemporal changes of NPP during 2002 to 2015. MODIS yearly NPP products MOD17A3 were applied here for the purpose of model validation. Linear Spectral Mixture Analysis (LSMA) technique was employed in this research to generate impervious surface fraction image of GHMC. Spatially explicit gas regulation service included as a regulatory ecosystem service to assess the trade-off between economic viability and ecosystem conservation. Acute urban expansion (over 200%) is mainly accounted to changes the Land Surface Temperature (LST) over 3ºC to 4ºC in the inner city region during 1991 to 2015. Surface vegetation and moisture dynamics have been evaluated by incorporating Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-up Index (NDBI), Normalized Difference Bareness Index (NDBaI) and Land Surface Water Index (LSWI) for the year of 2002, 2011 and 2015, respectively. The four distinct UHI cluster, i.e. H-H, H-L, L-H & L-L were retrieved from the segmentation of estimated LST using Local Indicators Spatial Autocorrelation (LISA) technique. Further, the Getis-Ord-Gi hotspot analysis method has been employed to identify the local proximity of spatial hot and cold UHI clusters. The areal coverage of built-up urban class was changed from 208.11sq.km in 1973 to 419.55 sq.km in 2015 with 5.03 sq.km/year expansion rate. The selected biophysical indices are found highly sensitive to the changes in land use and land cover (LULC). LST hotspot (H-H) in 2002 was observed in the central and the southeast portion of the region due to the presence of higher thermal anomalies and high concentration of LST (ºC). The Island (H-L) part of the city was mostly covered by the built-up urban area in 2002 exhibiting the highest concentration of LST, whereas the mean LST (ºC) of the neighboring region is below than the average. GiZScore with low standard deviation value proven the existence of active hotspot of LST and UHI over the central urbanized area in GHMC.A strong negative correlation has found between the selected human driving forces: UHI, LST, population density, settlement density and impervious fraction with NPP ensembles the facts of human control in an urban ecosystem. This study demonstrated the necessity of proper quantification and valuation of urban ecosystem services to achieve effective and efficient decision for urban ecosystem management.