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Spatio-temporal analysis of built-up impervious surface area and interplay with land surface temperature in Pretoria, South Africa

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Abstract

Evaluating changes in built-up impervious surface area (ISA) to understand the urban heat island (UHI) extent is valuable for governments in major cities in developing countries experiencing rapid urbanization and industrialization. This work aims at assessing built-up ISA spatio-temporal and influence on land surface temperature (LST) variability in the context of urban sprawl. Landsat-5 Thematic Mapper (TM) and Landsat-8 OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) were used to quantify ISA using built-up Index (BUI) and spatio-temporal dynamics from 1993–2013. Thereafter using a suitable analytical sampling scale that represents the estimated ISA-LST, we examined its distribution in relation to elevation using the Shuttle Radar Topography Mission (SRTM) and also create Getis-Ord Gi* statistics hotspot maps to display the UHI extent. The BUI ISA extraction results show a high predictive accuracy with area under the receiver operating characteristic curve, AUROC = 0.8487 for 1993, AUROC = 0.8302 for 2003, AUROC = 0.8790 for 2013. The ISA spatio-temporal changes within ten years interval time frame results revealed a 14% total growth rate during the study year. Based on a suitable analytical scale (90 × 90) for the hexagon polygon grid, the majority of ISA distribution across the years was at an elevation range of between >1200 m–1600 m. Also, Getis-Ord Gi* statistics hotspot maps revealed that hotspot regions expanded through time with a total growth rate of 19% and coldspot regions decreased by 3%. Our findings can represent useful information for policymakers by providing a scientific basis for sustainable urban planning and management.