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Topic of Research: Assessment of Spatio-temporal Change in Land Use/ Land Cover and Urban Heat Islands using Geospatial Technology: A Case Study of Varanasi City, Uttar Pradesh

Keywords: Land Surface Temperature (LST), Urban Heat Islands (UHI), Environmental Impact, Urbanization Pattern, Temperature Trends, Land Surface Temperature Intensity, Urban Thermal Field Variation Index (UTFVI), Geospatial Technology, Varanasi City

Findings

Significant trends were observed in the land cover and environmental variables in Varanasi from 1992 to 2019. Urban areas experienced a substantial expansion, with built-up areas increasing from 5.514% in 1992 to 38.118% in 2019, reflecting a global trend of urbanization driven by migration and better prospects. Vegetation initially decreased but showed a slight recovery from 2010 to 2019, while agricultural lands increased overall but declined in 2019. Waterbodies remained relatively stable, with a minor increase over the years.

In terms of land cover transitions during the pre-monsoon period, notable changes included a shift from vegetation to sandbars over 1992-2019. Specific periods showed distinct changes, such as reductions in shrubs and open space vegetation from 1992 to 2001, increased conversion of open spaces to built-up areas from 2001 to 2010, and a rise in built-up to agricultural land from 2010 to 2019.

Spectral indices analysis revealed a decline in the Normalized Difference Vegetation Index (NDVI) from 0.2155 in 1992 to 0.1340 in 2019, indicating reduced vegetation density. The Enhanced Vegetation Index (EVI) fluctuated but ultimately decreased from 0.2315 to 0.2128. Water indices showed slight increases in the Normalized Difference Water Index (NDWI), while the Modified NDWI (MNDWI) exhibited decreased variability in water content.

Zone-specific trends highlighted fluctuations in NDVI and EVI in Varunapur, with a slight rise in 2019, and a small increase in EVI in Adampur from 2001 to 2019. Kotwali exhibited fluctuations in NDVI and EVI, indicating an initial increase followed by a slight decline, while Bhelupur showed higher mean NDVI and EVI in 2010 and 2019, suggesting increased vegetation.

Land surface temperature (LST) trends showed pre-monsoon temperatures rising from 24.12°C in 1992 to 35.77°C in 2010 before slightly tapering to 35.77°C in 2019. Post-monsoon temperatures ranged from 17.89°C in 1992 to 28.81°C in 2019. The urban heat island (UHI) effect displayed an upward trend over time, notably in 2019. Implementing buffers around the city significantly reduced UHI effects, indicating effective mitigation measures.

Correlation analysis between spectral indices and LST for 1992 and 2019 revealed strong negative correlations between LST and NDVI/MNDWI, signifying lower temperatures in areas with higher vegetation and water content. Positive correlations between LST and urbanization indices (NDBI and NDBaI) indicated higher temperatures in built-up regions.

Ecological and thermal comfort assessments using the Urban Thermal Field Variance Index (UTFVI) consistently showed "Excellent" ecological evaluations for lower UTFVI values (<0). Higher UTFVI values correlated with reduced ecological quality. Thermal comfort declined over the years due to urban expansion, indicating an increase in the UHI phenomenon due to land conversions. The expansion of green spaces in the city's northeastern part positively influenced thermal conditions in 2019.

Temperature trends and UHI effects during the pre-monsoon period showed mean values hovering close to zero, indicating marginal temperature variations between urban and non-urban areas. Post-monsoon UHI patterns displayed more varied trends with an evident warming trend in LST values from 1992 to 2019. The study underscores the critical need for sustainable land use management and green space augmentation to ameliorate urban thermal comfort and ecological quality. The findings emphasize the importance of strategic urban planning to mitigate rising temperatures and UHI effects, promoting greenery, and preserving water bodies to maintain ecological balance and thermal comfort in Varanasi.