Predicting Urban Expansion and Green Space Loss in Gauteng Province Using Sentinel-2 MSI Satellite Imagery and Machine Learning

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Urban growth and the associated loss of vegetation and green spaces in Gauteng Province, South Africa, were analysed for the period 2016-2040. The study examined land cover change, particularly the conversion of vegetated areas into built-up land, and assessed the environmental implications of continued urban expansion. Sentinel-2 satellite imagery was classified using a Random Forest supervised classification algorithm in Google Earth Engine to map five land cover classes for 2016, 2018, 2020, 2022, and 2024. Change detection and area calculations were conducted in QGIS. Future land cover for 2032 and 2040 was projected using the MOLUSCE plugin with an Artificial Neural Network. Classification accuracy was validated using a confusion matrix. Urban land cover increased from 13.39% in 2016 to a projected 27% by 2040, representing a 101.64% increase. Vegetation cover declined from 58.4% to 41.03%, resulting in a loss of approximately 3,324.86 km². The most significant urban expansion and vegetation loss occurred after 2020, particularly in Johannesburg. These results demonstrate rapid urban expansion and substantial vegetation decline in Gauteng. Continued trends may intensify environmental challenges, including urban heat islands, biodiversity loss, and increased flood risk. The integration of Earth observation data and machine learning proved effective for monitoring and forecasting land cover change and provides evidence supporting strengthened green space management policies.

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