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| **Estimating Green and Teal carbon stocks across the Gauteng Province of South Africa using a multi-source remote sensing approach** |
| **Introduction/Aim:**  Cities across the globe are known to emit more carbon than they sequester and store. To reduce the impact of climate change, cities, governed by their climate action plans and international climate programs, have sought to reach carbon neutrality. To reach this goal, a detailed inventory of carbon sinks and sources is required at the highest possible measuring unit. Remote sensing technologies, coupled with representative calibration and validation datasets and machine learning upscaling approaches, have been considered vital tools for carbon accounting. This study sought to quantify green (i.e. tree and grass carbon) and teal (i.e. from wetland vegetation) carbon stocks across the built-up province of Gauteng South Africa, using multi-source (field data, airborne LiDAR, L-band ALOS-2 PALSAR-2, C-band Sentinel-1 and Sentinel-2) remote sensing datasets within a Random Forest machine learning environment.  **Methods:**  Land Use Land Cover and national wetland inventory datasets were used to mask out the urban footprint, rivers and open water bodies. Green carbon estimates were predicted based on an approach, which estimated vegetative above-ground biomass (AGB) by upscaling ground-measured AGB (via allometric measurements and equations) to regional airborne LiDAR data, and then upscaling to the satellite scale using integrated ALOS-2 PALSAR-2 L-band SAR and Sentinel-2 derived RENDVI vegetation index datasets. Teal carbon estimates were predicted based on an approach, which estimated herbaceous AGB by upscaling localised ground-harvested (and dried) wetland AGB (together with in-field measured leaf area index measurements) directly to spaceborne Sentinel-1 backscatter and Sentinel-2 reflectance bands. For the modelling approaches, Random Forest (RF) machine learning models were trained to predict green and teal AGB and subsequently carbon at the resampled spatial resolution of 25m. Model accuracies were documented using validation statistics such as R2 and RMSE. AGB was converted to carbon using a conversion factor of 0.5.  **Results:**  Using a 35/65% calibration and validation dataset split, the RF yielded a validation accuracy of R² = 0.74 and RMSE = 12.17t/ha (AGB) for the green carbon model. A higher quantity of green carbon was found in the peripheral areas outside the main cities than within the city limits. The northern half of the Gauteng province contained more stored green carbon than the southern half. Greater densities of green carbon were also found within protected areas of the province (50 MgT/ha). The overall green carbon stock in Gauteng was estimated to be 488.8 MgT/ha. Preliminary results of the teal carbon RF model (using a 65/35% calibration and validation dataset split) yielded R² = 0.65 and RMSE = 41.3 g/m2 (AGB). The spatial analysis of this model and subsequent map is still pending.  **Conclusions:**  Understanding the largest share of terrestrial carbon (i.e. green carbon) and the most elusive (i.e. teal carbon) carbon sinks, coupled with updated emissions data, can help cities understand how far off they are from a carbon-neutral status. |