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"Competing pathways for equitable food systems transformation: Trade-offs and synergies"

Satellite remote sensing for above-ground biomass mapping of agroforestry plots: Enhancing income streams through carbon credits

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Abstract

Smallholder agriculture is an essential contributor to food security and income generation in many parts of the tropics. Agroforestry systems offer a unique opportunity for farmers to diversify their income streams by participating in carbon credit programs. However, monitoring above-ground biomass (AGB) and carbon stocks in these plots can be challenging and costly. Thus a narrative review was conducted of satellite remote sensing methods for assessing AGB on a plot level with the aim to reduce monitoring costs and enhance the feasibility of carbon projects. The review focused on sources from 2003 onwards to incorporate the latest technological advancements while excluding outdated satellite-based platforms. Various satellite remote sensing methods, including optical multispectral, hyperspectral, radar, and LiDAR techniques, were examined for their scope of application of plot-level AGB measurements.

Optical multispectral sensors, such as Landsat and Sentinel-2, provide valuable data for estimating AGB in these plots. However, precision and saturation issues need to be addressed. Higher-resolution optical data from commercial constellations such as RapidEye and Dove can offer more detailed information but may imply higher costs. The incorporation of Synthetic Aperture Radar (SAR) sensors, such as ALOS PALSAR and Sentinel-1, permits AGB estimation even in areas with persistent cloud cover, providing valuable insights into the agricultural landscape. LiDAR sensors, including ICESat-2 and GEDI, offer detailed information on the vertical distribution of AGB and can enhance precision in biomass mapping. Future missions, such as NASA's NISAR and ESA's BIOMASS, hold promise for improved SAR and LiDAR data.

Combined sensor optical data and LiDAR provide the most accurate results for AGB data at the plot level. Using only Landsat 8, the RMSE for AGB was 66 %, 50 % for LiDAR, and 49 % for a combination of Landsat 8 and LiDAR. This approach facilitates the establishment of cost-effective monitoring, reporting, and verification (MRV) systems, enabling effective participation in carbon offset programmes and enhancing the viability of plot-based carbon projects. By leveraging satellite remote sensing, farmers and local communities can engage in sustainable land management practices, diversify income streams through carbon credit programs, and contribute to climate change mitigation.

Keywords: Agro-forestry, remote sensing

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