

Mapping Urban Forest Structure and Carbon Storage Using Airborne Laser Scanning to Support Climate-Resilient Cities

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ABSTRACT

Tóm tắt:

Urban trees are critical nature-based assets that enhance climate resilience by regulating microclimates, mitigating urban heat islands, and sequestering atmospheric carbon. Yet, comprehensive assessments of urban forest structure and carbon storage remain constrained by labour-intensive field inventories, limiting their application in rapidly growing cities. This study presents an airborne laser scanning (ALS)-based framework for efficient, high-resolution assessment of individual-tree structure and carbon storage without relying on extensive field measurements of diameter at breast height (DBH).

The proposed framework integrates high-density LiDAR point clouds with allometric modelling to estimate key tree attributes, including height, crown dimensions, DBH, aboveground biomass (AGB), and aboveground carbon (AGC). The approach was demonstrated in Thu Le Park, Hanoi, Vietnam, where 1,141 individual trees were automatically delineated from the ALS dataset. Estimated total AGB and AGC reached 261.11 Mg and 122.72 Mg C, respectively. ALS-derived structural metrics exhibited robust power-law relationships with biomass and carbon estimates that were consistent with established allometric models. Validation against field observations showed only minor underestimation of DBH, tree height, and AGB while successfully preserving the structural variability and size distribution of the urban forest.

These results demonstrate that airborne laser scanning can provide reliable, scalable, and cost-effective estimates of urban forest structure and carbon storage, substantially reducing dependence on conventional field inventories. By enabling detailed urban carbon accounting and spatially explicit assessment of green infrastructure, the proposed framework supports evidence-based urban planning, nature-based climate solutions, and urban heat island mitigation. The approach offers a practical pathway for integrating high-resolution Earth observation into climate-resilient urban management, particularly in rapidly urbanising tropical cities where timely and comprehensive urban forest inventories are urgently needed.

Keywords: Airborne Laser Scanning (ALS); LiDAR; Urban forest; Individual-tree biomass; Carbon stock; Allometric modelling