



The dual role of urban green spaces in carbon neutrality: carbon sequestration and cooling driven energy savings at the global scale

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Quantitative evidence is increasingly required to assess the mitigation potential of cities in achieving global carbon neutrality. However, although urban green spaces contribute simultaneously through biophysical carbon sequestration and reductions in energy demand driven by urban heat island mitigation, few studies have systematically compared and evaluated these two effects within a unified framework at the global scale. This study quantifies the total contribution of urban green spaces to carbon neutrality across global cities and decomposes this contribution into carbon sequestration and cooling driven energy savings, assessing their relative importance and spatial patterns. The urban heat island effect is estimated using remote sensing derived land surface temperature differences between urban and non urban areas, while carbon sequestration by urban green spaces is simultaneously quantified based on satellite based observations. These two contributions are then integrated and compared. Furthermore, this study examines how the relative importance of the two effects varies across major climate zones and how heterogeneity manifests in distinct spatial patterns. Finally, this study investigates how vegetation related indicators, socio economic variables, and urban structural characteristics influence the two effects across climate zones with AI based approaches and identify contextual conditions under which the mitigation benefits of urban green spaces are amplified or attenuated even under similar urban green space availability. This study provides a global assessment of the contribution of urban green spaces to carbon neutrality and offers empirical evidence to support the design of climate and context specific nature based mitigation strategies in cities.