Balancing Carbon, Costs, and Communities: A Novel Decision Support Framework for Urban Forest Management

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ABSTRACT

Urban forests (UF) play a key role in climate change mitigation, social well-being, and sustainable urban development. UF reduces urban heat islands, improves air quality, and enhances biodiversity. Moreover, green spaces improve mental and physical health, fostering community interaction and reducing stress. Integrating urban forests into sustainable urban planning is essential to enhance city resilience through innovative tools and strategies. This study introduces an innovative Decision Support Tool (DST) based on a multi-criteria approach, which integrates ecological (CO_2 sequestration), economic (costs and revenues), and social (accessibility and inclusivity) parameters to evaluate six UF management strategies over 27 years. (Business as Usual - BaU, Yielding Scenario - YS, High Management - HM, Forest Development - FD, Social Boost- SB, and Cover Maximizing- CM). Results show that all UF strategies offset CO_2 emissions within 6-7 years, with the BaU scenario increasing carbon removal capacity by 13.5%. The FD and SB scenarios achieved the best-balanced outcomes, with environmental indices of +0.45 and +0.59 and social indices of +0.49 and +0.12, respectively. However, both had negative economic indices (-0.26 for FD and -0.32 for SB), reflecting the need for substantial public investment. The CM scenario reached the highest environmental (+1) and social (+1) indices but incurred significant economic costs (economic index of -1). The YS scenario showed a positive economic index (+0.35) but negative environmental (-0.31) and social (-0.35) performances, illustrating trade-offs in passive management. This study emphasises the value of flexible decision-support frameworks to balance ecological, economic, and social goals in UF management. Future enhancements could incorporate advanced analytics and be adapted to diverse urban contexts, expanding the tool's applicability. Overall, the DST offers actionable insights to inform sustainable urban forest policies aimed at fostering resilient and inclusive cities worldwide.

Keywords: sustainable development, urban forests, management strategies, decision support tool, forest model, life cycle perspective

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