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Assessing the Synergy of Rooftop Agriculture, Solar Energy, and Rainwater Harvesting in Sri Lanka's Land Use Policy

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Abstract

Rapid, unplanned urbanization and increasing population pressure in Sri Lanka have intensified competition for limited land availability, necessitating a novel, law-backed approach to land use planning to mitigate environmental degradation and improve food security. This study addresses the critical challenge of deriving maximum ecological and economic benefit from minimal urban land area by evaluating the synergy between vertical gardening, photovoltaic (solar) power generation, and rainwater harvesting systems, specifically within the context of applicable and effective implementation of Environmental Law. The main aims of the study are to: 1) design a flexible "vertical land use" model integrated into urban master plans through regulatory requirements, 2) quantify the impact of the technologies proposed on localized food supply and carbon reduction, and 3) recommend necessary legislation for their wide-scale diffusion. A sequential mixed-method approach had been followed, that includes, among others, 1) a desktop review focusing on existing land-use legislation and spatial analysis of areas of conflict, 2) development of a localized modelling and scenario framework, and 3) targeted stakeholder engagement with legal and planning bodies for validation. Key findings demonstrate that the adaptation of the balcony gardening concept of a "vertical land use" model has significantly increased functional green area coverage by an average of 180% per residential unit, thereby directly reducing land-sprawl. Crucially, the integration of solar photovoltaic (PV) panels powering the cultivation units resulted in a net-positive energy system that supplies 115% of the required electricity. The enhanced green coverage, besides a per-square-meter increase in local crop yield of 45% for key leafy vegetables, is a viable pathway for localized food production. Furthermore, this achieves a measurable carbon sequestration rate of 0.75 metric tons of CO_2 per building annually. In conclusion, this research postulates that developmental sustainability is only possible not just with technological innovation but also with the compulsory integration of green building standards into revised Integrated Land Use Planning and enactment of specific regulations mandating such vertical ecological enhancement.

Keywords: *Environmental law, Rainwater energy, Rooftop agriculture, Solar energy, Vertical land use*