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A Green Roof with Agricultural Cultivation and "agrovoltaics" System in a Desert Area and Its Environmental, Economic, Agricultural, and Energy Contributions.

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Abstract

Rapid global population growth is intensifying the demand for essential resources, including food, energy, water, housing, and infrastructure. Concurrently, accelerated urbanization processes are leading to significant environmental challenges, such as the loss of agricultural land, depletion of natural water resources, intensification of the urban heat island (UHI) effect, increased energy consumption, and the expansion of urban infrastructure. These pressures are further exacerbated by climate change and the rapid rise in global temperatures, particularly in semi-arid and desert regions, where environmental conditions are already extreme. In response to these challenges, there is a critical need to develop innovative and sustainable strategies for food production and renewable energy generation that can be effectively integrated within urban environments. Such approaches should aim not only to enhance local food security through urban and modern agricultural practices but also to contribute to mitigating the UHI effect and improving overall urban environmental quality. The integration of green infrastructure with renewable energy systems represents a promising pathway toward achieving these goals. This study investigates the implementation of rooftop agrivoltaic systems within an urban setting characterized by a semi-arid desert climate. Specifically, it examines the environmental, economic, energetic, and agricultural performance of strawberry cultivation on a green roof integrated with a photovoltaic (PV) system designed for on-site renewable electricity generation. An experimental framework was established to assess multiple performance indicators associated with the green roof and agrivoltaic system. These include stormwater runoff reduction and retention dynamics, soil temperature regulation, water consumption, roof and surface temperature variations, shading effects, evaporation rates, crop yield, relative humidity, and evapotranspiration processes. Data were collected through a comprehensive network of sensors deployed across the experimental site to ensure high-resolution monitoring of both microclimatic and agronomic parameters. The empirical data obtained from the experimental system were subsequently integrated into advanced analytical frameworks, including techno-economic modeling, building energy performance simulations using DesignBuilder software, and life cycle assessment (LCA) methodologies. These analyses enable a holistic evaluation of the system’s performance, considering both environmental impacts and economic feasibility. Overall, this research aims to provide a comprehensive assessment of rooftop agrivoltaic systems as a multifunctional solution for sustainable urban development, particularly in regions facing water scarcity, high temperatures, and limited land availability.

Keywords: Green roof, agrivoltaics, renewable energy, urban agriculture, energy efficiency

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