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Using Artificial Neural Network Models to Address the Efficiency and Benefits at City-scaled Water-Food-Energy Nexus

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With increasing population, built environment and climate change impacts, various pressures on sufficient provision of freshwater, food and energy have emerged to be interweaving issues challengingly in water-food-energy nexus (WFE Nexus) for city development. To aim high on sustainability but engage from the ground substantially, we probe to develop a practicable approach to address the efficiency and benefits in the urban WFE Nexus: when driven from water perspective to grow food extensively on appropriate lands and subsequently decrease energy consumption, how the context of "partial self-sufficiency locally" to enhance resource management can be achieved at city scale? The green infrastructure (GI) approach with (semi-) natural services for water resources management is considered opportunities to improve the built environment through various ecological-oriented measures. As the largest and most populated city in Taiwan, there are still many vacant lands in Taipei with potential for GI installation to scale-down the resource exacerbation in WFE Nexus. In this paper, we select some spacious rooftops of large commercial and institutional buildings (e.g. schools, hospitals) and riparian lands with vegetables growing to simulate the effect of applying “urban farming” concept. To reduce irrigation demand from direct municipal supply, the security of water provision from the nature locally is a very practical alternative. By taking advantages of high precipitation in Taiwan, we acquire the “water resource” from collecting, treating and recycling rainwater in cities to feed forward the flow to produce vegetables for local residents at “city-block” scale. As vegetation land cover, it further decreases building temperature and energy consumption for indoor-cooling in urban setting. The harvest not only provides fresh vegetables for neighborhoods with reduced water footprints on food production, carbon footprints on food processing and transporting, but also saves energy consumption, decrease urban heat island effect and CO_2 emission. We propose to use two powerful artificial neural network models: the feature clustering tool of Self-Organizing Mapping (SOM), and the Backpropagation Neural Network (BPNN) tools. They are adopted to simulate the environmental prerequisites, and efficiency of recycled rainwater use, food yields value and energy demand alleviation in the WFE Nexus. First, we use the SOM tool to obtain the clustering of selected vegetables with their favorable growth requirements and optimum spatial distribution, then we apply the mapping results to the selected lands by using BPNN tool to simulate and forecast the efficiency and benefits of such dynamic interlinks on water usage, food production and energy consumption respectively within Taipei precinct. The eventual results will provide decision-makers for further urban planning on resource allocation by stringing together the recycled water management, local food production, energy efficiency and CO_2 reduction in city, in order to achieve the green environment and better sustainability in Taipei, while also serve as potential adaptation measures against the climate change impacts in Taiwan.