Modeling and Optimization of Low Impact Development Layout Designs for Urban Flood Management

*Chien-Lin Huang[1], Yao-Hsien Huang[1], Nien-Sheng Hsu[1], Hung-Jen Liu[1]

1. National Taiwan University, Taiwan

This study develops a novel systematic optimization model for urban flood management by combining multiple Low Impact Development (LID) devices, taking into consideration a Benefit-Cost (B/C) Analysis. The contributions provided by this study include: (1) analysis of flooding consequences on the development of a megacity; (2) development of an innovative technical approach enabling an automatic and effective optimization process, linking with newly considered interdisciplinary embedded simulation model; and (3) proposal of adaptive solutions using a combined layout design scheme, by considering the economic hydrology-statistic aspect. Our investigation sets the Benefit/Cost ratio as the objective function in order to deal with flooding in all return periods (RPs). The decision variables correspond to the allocated areas and quantity of LID devices, including porous pavements, bioretention cells, infiltration trenches, rain barrels, vegetable swales, green roofs, and tree boxes. Under such layout, the flooding loss was simulated with a Storm Water Management Model (SWMM), and the optimal solution was solved by employing a Simulated Annealing (SA) algorithm. Min-Sheng Community in Taiwan is chosen as study area for demonstrating the applicability of the developed model. Results show that the B/C ratio of identified optimal design can reach 1.448, with green roofs and bioretention cells as main devices, and rain barrels and porous pavements as secondary supplies. Regarding rainfalls in all return periods, the peak flows and delay of peak times downstream of Fu-Yuan Pumping Station can decrease significantly in the range of 5.75-29.80% and 12.50-20%, respectively; and 9.52%-23.49% and 12.50%-37.5% at the subcatchments. The efficiency of flood detention is higher for low RPs than high RPs, while the time-delay ability is smaller.

Keywords: Flood mitigation and adaption, Low Impact Development, optimal layout design, Storm Water Management Model, Simulated Annealing, sustainable water management

