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Optimization of Low Impact Development Practices on Water Quantity and Quality using Multi-Objective Genetic Algorithm for Overdeveloped City

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Climate change and population growth are important issues for urban developments. In terms of the water resource shortage and flooding problems, how to establish the efficient storm water management should be one of the means to mitigate the problems. The concept of storm water management has gradually shifted from the centralized processing system to the low-impact-development (LID) using on-site processing system. The main idea of LID is to increase the infiltration or storage space of the catchment area and directly reduce surface runoff. LID can also increase the surface green cover to reduce the urban heat island effect, effectively reduce the vulnerability of floods, heat waves and other disasters, and enhance urban resilience. The peak discharge control is currently the key evaluation for rainstorm management in related research. Peak discharge only presenting the amount of hydrology at a certain point in watershed is insufficient to represent the runoff process during the storm event. Water quality is seldom considered when LID conducted for mitigating discharge. In terms of it, the index of mass first flush (MFF) representing the initial pollutant for a rainfall event is usually applying; however, the evidence shows that MFF cannot be used in complicated or large watersheds. In this study we modified MFF to mass emission first flush (MEFF) to avoid the above issue. With considering the overall downstream peak flood flow factor and the pollutant mitigation, this study adopts the hydrological footprint residence (HFR) and MEFF which can indicate the runoff and pollutant process as the impact factors.

The study regions will focus on New Taipei City which are the high-density developed zones. The SWMM model is conducted to simulate the LID facilities and detention ponds with considering the land use characteristics of the area. Rainfalls with different return periods and different delays were applied as different scenarios. In scenarios where LIDs are set up in different regions, the priority of spatial configuration must be explored when the budget is limited. A multi-objective genetic algorithm (MOGA) was used in this study to obtain the relationship among the cost, peak flow mitigation, HFR and MEFF in the optimal spatial configuration. To accomplish the aforementioned purpose this study develops a simulation-optimization methodology couples SWMM with the non-dominating sorting genetic algorithm (NSGAII) to evaluate the optimal spatial configuration of LID facilities under different budget conditions in order to minimize the construction cost, peak flow, HFR and MEFF. The maximum effectiveness for LID configuration was set to 80% of the designed area, which is the same as 100% configurations for the hydrological effect. For the purpose of the peak flow mitigation, the LID should be set on the branch line that flows into the middle of the drainage trunk. Finally, the Monte Carlo test was conducted to figure out the relationship between the optimal space configuration of LID and the water impermeability for the study region. The contribution for this study is to identify the optimal trade-off between budgets and the effects of urban development on downstream ecosystems.