Evaluation of LID practices for sustainable stormwater management under different climate change scenarios

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Abstract

Intensity and frequency of extreme storms have been increasing over time due to climate change making sustainable stormwater management a challenging task. Increase in extreme storm is susceptible to cause significant damage and losses to live, property, and infrastructure if not managed adequately and appropriately. Low Impact Development (LID) is a recently developed and widely accepted alternative stormwater management technique often proposed for managing excess stormwater due to increase in extreme storms. However, limited research have focused on the optimization of LID controlled stormwater management in terms of number and types of LIDs required, percent reduction in total and peak runoff, and implementation cost. This study evaluate the performance of LIDs for meeting the challenges of increased rainfall for the current and future periods under different climate change scenarios; and identify the best performing LID implementation scenario employing an optimization algorithm. The methodology was applied in Seattle metropolitan area, at Renton City. In order to achieve our objective. First, a statistical rainfall-runoff model was developed to estimate the runoff for the current and future periods to understand the effects of increased rainfall on stormwater management. Results indicate significant increase in runoff due to increase in rainfall over the period 2020 to 2040 compare to the historical period 1995 to 2014. Later, Storm Water Management Model (SWMM) was employed to calibrate the rainfall-runoff model with the exiting conditions and the performance of different LIDs (e.g., bio-retention, rain barrels, rain gardens, Infiltration trenches, and permeable pavement) are evaluated for flood mitigation (reduction of runoff volume). Results show that the performance of LIDs in reducing total runoff volume vary with types and combinations of LIDs. Depending on different combinations of LIDs, reduction of total runoff ranges from 30% to 75% for the historical and climate changed induced future rainfall with design storms of 50-year and 100-year return periods. Finally, 30 different scenarios are considered composed of combinations of different types of LIDs, LID implementation strategies, and design storms for the historical and future periods to optimize the LID controlled stormwater management system. For optimization, a Genetic Algorithm (GA) based optimization approach is used where cost minimization was considered as the objective function which is eventually function of type, size, and number of selected LIDs in a typical sub-catchment. Additionally, reduction in total and peak runoff are also considered as the objective functions separately in the optimization exercise. This study provides a comprehensive framework to evaluate the performance of LID controls for the present and future climate change scenarios and identify the cost-effective strategies for LID controlled stormwater management. The framework introduced in this study will help local authorities and practitioners to implement appropriate climate change adaptation strategies by maximizing the benefit form LIDs and ensure sustainable stormwater management for the current and future climates