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Evaluation and Optimization of Low Impact Development Designs for Sustainable Stormwater Management in a Changing Climate

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The Intensity and frequency of extreme storms have been increasing due to possible climate change, making it challenging to manage stormwaters in highly urbanized areas. Without an adequate and appropriate stormwater system, these storms may cause significant damage and losses to live and properties. Low Impact Development (LID) is a recent but widely accepted alternative for managing the increased stormwater. However, limited research is available to understand their effectiveness and optimize the mix of LIDs and conventional stormwater systems. This study evaluates the performance of several LIDs under current and future storm conditions, identify the best performing mixes of LIDs and convention stormwater system and provide a decision-making tool for urban stormwater management. The methodologies will be tested for Renton City, which is part of the Seattle Metropolitan Area.

In order to achieve our objective, first, a statistical rainfall-runoff model will be developed to assess the current stormwater system and estimate runoff for the current and future periods. The final results indicate a significant increase in runoff due to the increased rainfall in the future (2020-2040) compared to the past (1995-2014). The Stormwater Management Model (SWMM) will then be used to simulate the rainfall-runoff under conventional and LIDs (e.g., bio-retention, rain barrels, rain gardens, infiltration trenches, and permeable pavement) stormwater system. The final results show that the performance of LIDs in reducing total runoff volume varies with the types and combinations of LIDs. A 30% to 75% reduction in runoff was achieved for the past and future 50-year and 100-year storms. A Genetic Algorithm (GA) is used to optimize the LID and conventional stormwater system considering the reduction in runoff, installation and maintenance costs. The type, size, location, and number of different LIDs will be considered as decision variables for the GA. Finally, the study aims at developing a comprehensive framework to evaluate the performance of LIDs under present and future storms and identify cost and performance effective LIDs in a given urban area. The framework introduced in this study will help local authorities and practitioners to implement appropriate climate change adaptation strategies by maximizing the benefit from LIDs and ensure sustainable stormwater management for the current and future climates.