Brief Report

Title: The Impacts of Suburban Development on Surface Runoff in Cypress, Texas

PI: Hyun Woo Kim, Ph.D. Candidate, Landscape Architecture and Urban Planning, Texas A&M University

Co-PIs: Ming-Han Li, Professor, Landscape Architecture and Urban Planning, Texas A&M University

Jun Hyun Kim, Assistant Professor, Landscape Architecture and Urban Planning, Texas A&M University

Fouad Jaber, Associate Professor, Biological and Agricultural Engineering, Texas A&M University

The entire manuscript is currently under review in the *Landscape and Urban Planning* with the title entitled as "Examining the Impact of Suburbanization on Surface Runoff using the SWAT" (Manuscript #: LAND-D-15-00663). The manuscript (including six figures and six tables) will be submitted to the TWRI after the acceptance.

Abstract

Urbanization has been known to alter the hydrologic characteristics of a watershed. This study empirically assesses this notion by investigating the relationship of developed land use/land cover (LULC) changes and surface runoff generation. We examine the Cypress Creek watershed, where its recent development pressure is significantly high due to the rapid growth of Houston, Texas. The watershed is located within Harris County, with the distance of 37 km from Houston. A hydrological model, the Soil and Water Assessment Tool (SWAT), is employed to estimate the generated runoff for two land use scenarios from 2002 to 2010. The findings show that the mean annual runoff change was high for most sub-basins that experienced significant suburbanization. The correlation coefficients between runoff changes and three developed LULC classes (low, medium, and high developed lands) ranged from 0.5 to 0.8, while its correlation with green spaces was about -0.6. The importance of development densities in managing stormwater runoff is highlighted throughout the research and the results suggest local plan-makers and engineers on where and how to regulate the future residential developments and install low impact development practices in suburbanizing communities.

Keywords: SWAT, stormwater management, land cover, simulation, urbanization

Problems and Research Objectives

Land cover changes are the main cause of hydro-modification, a process that changes the features of water. Several previous literature addressed that the increased percentage of impervious surfaces caused by urbanization have negative hydrologic consequences, including excessive runoff, lack of infiltration, and insufficient aquifer recharge (Booth and Jackson, 1997; Brabec, 2009; Gearheart, 2007; Paul and Meyer, 2001; Schueler, 1994). Starting from the 1960s, populations increasingly moved to suburbs of metropolitan areas in the United States, and this development trend is still occurring in most communities nearby large cities (Levy, 2009). However, suitable drainage systems cannot be designed by traditional development patterns. Conventional pipe-drainage systems that are designed to promptly remove waters within the surface failed to control the excessive overflow and it eventually triggered downstream flooding and water degradation (Booth and Jackson, 1997; Ferguson, 1998; Yang and Li, 2011). The increment of impervious surfaces also accelerated the number and occurrence of flash flooding event. This study explore the gap in the previous research by answering two critical questions: (1) To what extent have developed land covers correlated to surface runoff? (2) Which type of residential development should be preferred for the rapidly urbanizing watersheds?

Methodology

The research was conducted by three phases. First, the LULC percent change between 2001 and 2011 was identified for sub-basins (N=37) within the Cypress Creek watershed by using ArcGIS software (version 10.2). Eight major LULC classes were examined for two specific years. Second, generated runoff was estimated for two land use scenarios from 2002 to 2010 by using SWAT (version 2012). Calibration and validation analyses were conducted to improve the model efficiency by comparing the streamflow data at the gauging station # 08068800 (Hernandez et al., 2000). Finally, the degree of correlation between the change of runoff and developed lands was examined through the Pearson's Product-Moment Correlation Coefficients technique.

Findings and Discussion

The findings show that Cypress Creek watershed has been suburbanized significantly from 2001 to 2011. Overall developed lands increased by 42.1%, while green spaces have been decreased by 12.9%. Total runoff increased by 4.3% when comparing two land use scenarios. Through the

SWAT simulation, we reveal that the mean annual runoff has increased significantly for the sub-basins that are seated at the southeastern part of the watershed. Interestingly, a sub-basin (#22) that is located at the outlet of the Cypress Creek watershed and have a high development pressure did not experience significant change on runoff volume. The results from the correlation test show that the change of 'medium density' developed lands has the highest correlation with the runoff change (r=0.79). 'High density' developed lands and 'low density' developed lands had the coefficients of 0.72 and 0.56, respectively. The change of green spaces had a negative relationship with the mean annual runoff change (r=-0.62), which was consistent with the past studies' results.

The percentage of open spaces within the Cypress Creek watershed is still up to 75%. Considering this fact, planners need to focus more on implementing environmental land use planning tools and strategies, such as conservation easement, purchase/transfer of development rights, cluster zoning, and urban growth boundaries. In addition, BMPs and LID practices should be placed where the velocity and volume of stormwater runoff is high to maximize the capacity of on-site storage.

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