Evaluation of Urban Drainage Infrastructure: New York City Case Study

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Flood response in an urban area is the product of interactions of spatially and temporally varying rainfall and infrastructures, such that the presence of impervious surfaces and constructed drainage system increase the runoff variability. In urban areas, however, the complex subsurface networks of tunnels, waste and storm water drainage systems are often inaccessible, pose challenges for modeling and prediction of the drainage infrastructure performance. The increased availability of open data in cities is an emerging information asset for better understanding of the dynamics of urban water drainage infrastructure. This includes crowd sourced data and community reporting. A well-known source of this type of data is the non-emergency hotline "311" which is available in many U.S. cities. "311" is the US Federal Communications Commission code assigned for non-emergency telephone communication that allows residents to ask for government services. This may contain information pertaining to the performance of physical facilities, condition of the environment, or residents' experience, comfort and wellbeing.

In this study, seven years of New York City 311 (NYC311) call during 2010-2016 is employed, as an alternative approach for identifying the areas of the city most prone to sewer back up flooding. These zones are compared with the hydrologic analysis of runoff flooding zones to provide a predictive model for the City. The proposed methodology is an example of urban system phenomenology using crowd sourced, open data. We present a novel algorithm for calculating the spatial distribution of flooding complaints across NYC's five boroughs, and present an approach for separating the features that represent reporting bias from those that relate to actual infrastructure system performance. Kernel Density Estimator (KDE) is employed to create a smooth distribution of 311 calls. We then propose an approach to account for the effect of propensity using comparison of the spatial variation in the reporting statistics pertaining to other complaint types. The estimated propensity density is then used as a normalizer to infer the actual sewer back up condition. The result is identification of areas in NYC most prone to sewer back up flooding, or other reported phenomena, following the same approach. The sewer backup results are assessed with the spatial distribution of runoff in NYC during 2010-2016. With advances in radar technologies, a high spatial-temporal resolution dataset for precipitation is available for most of the United States that can be implemented in hydrologic analysis of dense urban environments. High resolution gridded Stage IV radar rainfall data with the resolution of 4km×4km along with the high resolution spatially distributed land cover data are employed to investigate the urban pluvial flooding. The rainfall data are used to calculate the excess runoff with respect to the Natural Resources Conservation Service approach, suggested by USDA for modeling the runoff in small watersheds of urban areas. The model consider antecedent moisture condition, soil type, and land use. The monthly results of excess runoff are compared with the sewer backup in NYC using Mutual Information (MI). It determines how similar the joint distribution is to the products of factored marginal distribution, meaning it captures nonlinear dependence. Having this relation, we are able to build a predictive model of flood zones according to the 311 phone calls for NYC.

Urban flooding is a material consideration in planning legislation, and it is hoped that the location of future development will ensure a reduced exposure to the hazard. The implementation of sustainable urban drainage systems and sustainable flood retention basins to control flooding and diffuse pollution for small and large scale developments is a very good practice in sustainable flood risk management of urban areas which is the main goal of this study.