Future water availability in Texas cities under urbanization and climate change: A case study in Dallas

2015-16 TWRI Mills Scholarship Application

Contact Information

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Research Proposal

With the rapid population growth and economic development in the State of Texas, urbanization has been occurring at an unprecedented rate over the past several decades. One direct consequence of urbanization is the land cover conversion from vegetated surfaces to artificial impervious areas. With reduced infiltration and elevated peak flow, the surface hydrological processes have been changed remarkably (Zhao et al., 2014; Zhao et al., in review). Meanwhile, as more people aggregate into Texan cities, drinking water demand continues to grow dramatically. For example, with a population growth of 440,000 from the 1960s to the 2000s, the annual municipal water use in Metropolitan Dallas has increased from 131,600 acre-feet to 319,500 acre-feet. Despite the many efforts made to meet the growing needs−such as groundwater withdraw, water conservation, and flow regulations−sustainable availability of freshwater resources remains a grand challenge for the future of Texas. Unfortunately, this water shortage is further exacerbated by the changing climate, which leads to more frequent and more severe extreme events (e.g., droughts and floods). To best support decision making, it is essential to quantify the amount and uncertainty of future Texas water resources within the context of urbanization, climate change, and water management.

The overarching objective of this proposed study is to use the Dallas metropolitan area as a pilot domain of interest to evaluate the joint impacts of urbanization, climate change, and water management on future water availability in Texas. Dallas has seen extremely rapid growth over the past decades (its population tripled from 1950s to 2000s) and is now the ninth most populated city in the US. To meet the increasing municipal water needs, several reservoirs were constructed in the Trinity River Basin during the past 60 years. These include Grapevine Lake, Lavon Lake, Lewisville Lake, Lake Ray Hubbard, and Ray Roberts Lake. Even though the designed storage capacity of these reservoirs is sufficient to meet the current water demand, the actual storage varies considerably. With frequent droughts and growing water withdraw, reservoir storage in this area has been close to the historical low during the past several years. In addition to this, there is a need for adjusting the flow regulation rules to compromise the altered streamflow from ever increasing impervious area. Therefore, future water management and water security issues must be addressed to nourish the growth of Dallas metropolitan area.

In this study, a hydrologic model, the Distributed Hydrology Soil Vegetation Model (DHSVM), will be employed to examine the long-term effects of urbanization and climate change on water availability for Dallas. DHSVM is selected since it has the capability of simulating urban hydrological processes for partially urban (or urbanizing) conditions at high spatial resolution (e.g., 100 m or less). In addition, with a recently added reservoir module by the applicant (Zhao et al., in preparation), DHSVM is able to simulate reservoir storage and outflow accurately. The proposed research will involve several steps. First, the DHSVM model will be calibrated and validated during the historical period. Next, it will be driven by forcings from the Coupled Model Intercomparison Project Phase 5 (CMIP5) (to represent future climate scenarios) and projected onto land cover maps (to represent future urbanization/migration scenarios). Specifically, the Representative Concentration

Pathway (RCP) 8.5 scenario from multiple downscaled CMIP5 models will be employed to run the simulations from 2020 to 2099. Land cover maps will be generated using Geographical Information System (GIS) tools based on historical urban area coverage and future migration scenarios. Finally, the overall water deficit/surplus will be calculated based on the projected water demand (associated with urbanization/migration scenarios) and the simulated water availability. Results will be analyzed on seasonal, annual, and decadal scales. Furthermore, feasible solutions to promote water availability will be tested, while taking into account the uncertainties from the CMIP5 models and the projected migration rate. It is expected that this study of water availability under various climate change and urbanization scenarios will contribute to solutions for sustaining water resources in Texas metropolitan areas.

References:

Zhao, Gang, Huilin Gao, Lan Cuo (2014). Effects of Urbanization and Climate Change on Hydrological Processes over the San Antonio River Basin, Texas. Abstract H31H-0714 presented at 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec.

Zhao, Gang, Huilin Gao, and Lan Cuo. Effects of Urbanization and Climate Change on Hydrological Processes over the San Antonio River Basin, Texas. Journal of Hydrology. (in review).

Zhao, Gang, Huilin Gao, Bibi S. Naz, Shih-Chieh Kao. Integrating reservoir flow regulation scheme into a spatially distributed hydrological model. Hydrological Processes. (in preparation).

Proposed Use of Funds

The scholarship will be used to pay tuition. Matching funds will be provided by the academic advisor to support the applicant as a Graduate Research Assistant.

Intended Career Path

During my Ph.D. period, I plan to extend our knowledge about how urbanization, climate change, and flow regulation will impact the water quality in Texas river basins (e.g., Trinity River Basin and San Jacinto River Basin). After graduation, I want to work for an environmental NGO and continue using my knowledge to address issues associated with sustainability of our precious water resources.