A Web Based Geographic Information Platform to Support Urban Adaptation to Climate Change

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1. Introduction

The urban climate is changing rapidly. Therefore, climate change and its projected impacts on environmental conditions must be considered in assessing and comparing urban planning alternatives. In this paper, we present an integrated framework for urban climate adaptation tool (Urban-CAT) that will help cities to plan for, rather than react to, possible risks. Urban-CAT will be developed as a scenario planning tool that is locally relevant to existing urban decision-making processes.

Cities have an opportunity to become more resilient to climate change through changes made to urban infrastructure today. Comprehensive characterization of the complex urban landscape and its critical infrastructure is newly possible as a result of recent advances in computing, simultaneous with the collection and integration of large disparate datasets. Higher resolution earth system models are now advancing to the point of being able to directly characterize future climate conditions at scales vitally needed by urban decision makers. Providing cities with climate projection information now, in the form that they need most to identify key vulnerabilities and effectively allocate funding, will help reduce the vulnerability of our cities to extreme weather events over the next 30+ years.

The question of urban system resilience to climate change is particularly urgent for several reasons. By 2030, over 60% of the world's population will live in cities (WHO, 2014). Although cities have proven to be extraordinarily resilient, the recent frequency of extreme weather events worldwide has raised concerns about their future vulnerability due to increasing number and intensity of extreme weather events (IPCC, 2014). Climate change impacts are expected to vary by location (IPCC, 2014; EPA, 2014), and provision of scientifically-based tools for understanding and evaluating climate impacts in conjunction with growing urban populations will be critical to the development of adaptation strategies designed to avoid the increasing socioeconomic costs of severe weather-related damages to urban landscapes (Preston, 2013). This will be especially beneficial to mid-sized cities that currently house nearly half of all urban dwellers worldwide (WHO, 2014).

As a first step toward achieving scalable, comprehensive urban climate change resilience planning, we are developing a web-based geographic information platform called Urban-CAT (Urban Climate Adaptation Tool) that will help cities to plan for, rather than react to, possible risks. Urban-CAT will be developed as a scenario planning tool that is locally relevant to existing urban decision-making processes. While cities may already have sophisticated tools to evaluate current site-specific scenarios, they lack: (i) tools that scale site-specific conditions to neighborhood and citywide scales; and (ii) credible climate data projections and population growth data to project future changes to urban landscape. According to a recent global survey of 468 cities, changing storm water runoff and storm water management requirements are the most widely anticipated urban climate change impacts (Carmin, Nadkarni & Rhie, 2012). The 2014 Intergovernmental Panel on Climate Change (IPCC) has identified changes to urban drainage systems as a key adaption issue for North America. Consequently, the proposed Urban-CAT framework will use storm water management as an application area. Since this is an adaptation tool, we are also using green infrastructure (GI) as an adaptation strategy for storm water management.

2. The Urban-CAT Framework

The Urban-CAT tool is designed to support the development of resilient urban solutions. The capabilities of the tool will include an advanced visualization platform to support decision making, access to future climate scenarios and environmental modeling results tailored for urban planning, connectivity to multitude of data sources that promote assessment and comparison of local project scenarios under different climate conditions, and better insights into local effect of climate change through scenarios management capability for testing and comparing planning alternatives.

2.1 Framework

The visualization platform is designed and developed as a multi-layered system. The system will be accessible via a simple-to-use, yet feature-rich web-based collaboration and visualization client, which will give authorized users access to system features. Among these features being to allow on-demand multi-criteria analysis and visualization of surface data in order to identify climate change risks and adaptive opportunities. The interface will allow planners to iterate over several scenarios by adjusting criteria thresholds to visually discover new opportunities or to track the impact of previously implemented adaptive strategies. Additionally, local stakeholders, including scientists, analysts, climatologists, and engineers, will be able to upload variable-resolution, small scale raster information for analysis with other surface datasets already defined as risk indicators. The platform will be supported by several middle-tier components including services for data access and interchange, a geoprocessing engine for performing map algebra and serving results, and web mapping services (WMS) and other map data services for visualizing infrastructure, ancillary, and reference data. The system will also expose these services via an authenticated application programming interface (API) that allow local stakeholders to integrate standards-based services and data into their own systems. On the backend, the system will utilize a number of different datastores for handling the technical requirements necessary to support the application, including application persistence, data retrieval and ingestion, and geo-processing tasks.

2.2 Methods

Using a common spatial grid, we meshed downscaled and bias-corrected climate data for both historical (1960-2005) and future (2010-2050) periods with land use/land cover information, topography demographics, sewer pipe layouts, social media accounts of local flooding events, among other sources, to effectively characterize the complex Knoxville urban landscape and its water infrastructure. This integration helps to identify areas vulnerable to flooding and discriminate system exposure, sensitivity, and stress, among other risk factors. In order to integrate approximations of both adaptive capacity and the adaptive process into the tool, a set of indicators were developed and used to quantify each spatial grid. We defined urban resilience as a measure of eight components (Ross, 2013) – climate, social, community, capital, economic, institutional, infrastructure, and ecological – using multiple indicators from different sources including land cover/land use, imperviousness, slope, demographics, projected extreme precipitation, projected extreme temperature, and floodplain areas. These indicators are then aggregated to create a score for each grid cell. The scores are in turn used to rank the spatial cells and the overlapping urban areas. The ranking was subsequently used to develop resilience profiles for each spatial cell. The developed indicators and resilience profiles are jointly used to develop risk-based approaches for stormwater and floodplain management respectively.

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