JOURNAL BRIEF: Advances and Challenges in Urban Green Infrastructure

Sustainable Healthy Cities Journal Brief - 2019, No. 15 - Green Infrastructure Advances and Challenges

This brief is adapted from the following peer-reviewed journal article: Culligan, P.J. (2019). Green infrastructure and urban sustainability: A discussion of recent advances and future challenges based on multiyear observations in New York City. *Science and Technology for the Built Environment*, 0(2019), 1-8. DOI: 10.1080/23744731.2019.1629243

Study Intent and Research Question

This article considers multiple years of green infrastructure (GI) work in New York City (NYC) as a basis to review the role that GI systems can play in climate adaptation strategies for urban areas where temperature and precipitation are projected to rise over the coming decades. The review provides a discussion of the advantages that a distributed, or neighborhood-level, GI system might bring to an urban climate adaptation strategy.

Key Background Information

GI describes networks of green space, including natural areas such as waterways and woodlands, and built areas such as parks and community gardens. Both types are widely considered to provide services to humans and the environment (Benedict and McMahon 2002).

The majority of urban GI programs are currently driven by stormwater management challenges.

The development and installation of engineered green infrastructure designed to reduce urban stormwater runoff and pollution has proliferated in recent years (e.g. green roofs, porous pavement, rain gardens, and rain cisterns).

GI is believed to provide additional benefits including: heat and air pollution mitigation (Oberndorfer et al. 2007; Yang et al. 2008), carbon sequestration and biodiversity enhancement (Toronto and Region Conservation Authority 2006), public health and well-being benefits (Van Renterghem and Botteldooren 2011), and "green collar" job creation (Center for American Progress 2009).

Key Review Findings

The NYC Green Infrastructure Plan was introduced in 2010 as a multi-decade, multi-billion dollar plan to improve water quality in the city. (NYC DEP 2010).

The NYC plan invests in engineered GI such as green roofs, right-of-way bioswales, green streets, and street trees.

By increasing vegetation in the city, the goal is to increase the amount of precipitation that can be soaked up locally, reducing stormwater contamination of local water bodies and incidents of flooding during heavy rain.

The plan calls for the construction of thousands of GI interventions on both public and private property, resulting in a distributed, or neighborhood-scale, infrastructure approach to realize citywide stormwater management goals.

Green roofs are a common type of engineered GI intervention. Extensive green roofs are relatively shallow (<15 cm thick, allows for short rooting only) and less expensive to install/maintain, while intensive green roof are deeper and are generally more expensive. Even for large storms, rainfall retention of green roofs is 30% or more of incident rainfall, reaching more than 50% for thicker intensive roofs.

Demonstration projects testing green, white and black roof treatments have shown that the temperature reduction of green and white roof treatments are similar, except during wet summers months when green roof treatments significantly lower temperatures beyond white roof treatments.

Progress has been made documenting the performance of individual GI interventions, but we still do not have a clear understanding of the overall impact of a system of many GI interventions.

Distributed GI systems composed of many parts are likely to interface with social systems and communities, adding complexity around public acceptance and stewardship.

Public acceptance of right-of-way GI in NYC has been mixed. Some residents note concerns about loss of parking, accumulation of trash in GI, dislike of plantings, and/or dissatisfaction about perceived lack of public consultation. In some instances, right-of-way GI has been vandalized.

Survey work has found the public places more value on the cultural, social, and aesthetic services provided by GI than the environmental services.

A key question is how to define "acceptable" performance for a distributed GI system. For example, what is an acceptable level of safety for a distributed system? Should safety be evaluated for an individual component of a GI systems or across the cumulative system as a whole? Similar questions arise for resilience.

Policy and Practice Implications

Leveraging GI potential requires a shift in thinking that considers a GI system as whole, rather than just individual GI installations.

Appropriate sensor networks and data management/support systems—essentially a "smart cities" approach to urban GI programs—could help advance systems-level real-time monitoring of GI system performance, reducing the need for systems-level predictive modeling, which can be complex and uncertain.

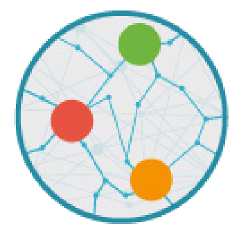
GI designs and implementation should account for public values, preferences, and perceptions. Doing so could result in better long-term performance and stewardship outcomes.

Decision makers should consider design and operation of GI interventions that maximize sustainability co-benefits that go beyond stormwater management.

Green Infrastructure

Water & Wastewater

Technology & Design Innovation



Spatial Reconfiguration

Further Reading and References

--Benedict, M.A., and E.T. McMahon. 2002. Green infrastructure: Smart conservation for the 21st century. Renewable Resources Journal 20:12–19. [OPEN ACCESS]
--Center for American Progress. 2009. New York City green collar jobs roadmap.
--New York City Department of Environmental Protection. 2010. NYC Green Insfrastructure Plan: A Sustainable Strategy for Clean Waterways. New York: Office of the Mayor.
Oberndorfer, E., J. Lundholm, B. Bass, R.E. Coffman, H. Doshi, N. Dunnett, S. Gaffin, M. Kohler, K.K.Y. Liu, and
--B. Rowe. 2007. Green roofs as urban ecosystems: Ecological structures, functions, and services. BioScience 57(10):823–33. [OPEN ACCESS]
--Toronto and Region Conservation Authority. 2006. Evaluation of an Extensive Greenroof. Toronto: The Toronto and Region Conservation Authority. [OPEN ACCESS]
--Van Renterghem, T., and D. Botteldooren. 2011. In-situ measurements of sound propagating over extensive green roofs. Building and Environment 46:729–38. [OPEN ACCESS]
--Yang, J., Q. Yu, and P. Gong. 2008. Quantifying air pollution removal by green roofs in Chicago. Atmospheric Environment 42:7266–73. [OPEN ACCESS]

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About the Sustainable Healthy Cities Network

The Sustainable Healthy Cities Network is a U.S. National Science Foundation supported sustainability research network focused on the scientific advancement of integrated urban infrastructure solutions for environmentally sustainable, healthy, and livable cities. We are a network of scientists, industry leaders, and policy partners, committed to building better cities through innovations in infrastructure design, technology and policy. Our network connects across nine research universities, major metropolitan cities in the U.S. and India, as well as infrastructure firms and policy groups to bridge research and education with concrete action in cities.