What is green infrastructure?

Green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier urban environments. Green infrastructure can range in scale from site design approaches such as raingardens and green roofs to regional planning approaches such as conservation of large tracts of open land. In conjunction with gray infrastructure, interconnected networks of green infrastructure can enhance community resiliency by increasing water supplies, reducing flooding, combatting urban heat island effect, and improving water quality.

Climate Change Effects on Cities

City managers are feeling the effects of climate change now. Fortunately, green infrastructure can help improve community resiliency. Depending on where a community is located, climate change poses different threats to critical infrastructure, water quality, and human health:
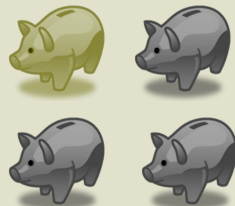
Flooding: Heavy downpours have increased in frequency and intensity in the last 50 years, and are expected to become *more* frequent and intense as global temperatures continue to rise. Consequently, flood risk is likely to increase dramatically across the United States. The average 100-year floodplain is projected to increase by 45% by the year 2100, while annual damages from flooding are predicted to increase by $750 million. *

Drought: In some areas of the country, decreased precipitation associated with climate change will further stress already fragile local water supplies, especially in the southwest.

Urban Heat: Climate change will likely lead to more frequent, more severe, and longer heat waves during summer months. The City of Chicago, for example, expects to see the number of days over 100°F increase by roughly 30 days per year under "high" greenhouse gas emissions scenarios. Under lower emissions scenarios, Chicago's new average summer heat index is expected to increase to around 93°F by the end of the century – similar to current summer conditions in Atlanta, GA. **

Coastal damage and erosion: As global temperatures continue to climb, sea levels will likely continue to rise, storm surges will likely be amplified, and heavy storms will occur with greater frequency and intensity. All of these changes are expected to exacerbate shoreline erosion and damage to coastal infrastructure.

*FEMA. (2013). The Impact of Climate Change and Population Growth on the National Flood Insurance Program Through 2100. Prepared by AECOM.

**From: *Reducing Damage from Localized Flooding: A Guide for Communities*, Federal Emergency Management Agency, (2005). Report #511.

*** *Chicago Climate Change Action Plan – Climate Change and Chicago: Projections and Potential Impacts, Executive Summary (May 18, 2008).*

Did you know?

25% of the **$1 billion** in annual flood damages in the U.S. can be linked to stormwater.**

Community Resiliency Solutions

Manage Localized Flooding

How does it work? By reducing stormwater runoff and protecting floodplains, green infrastructure can help manage both localized and riverine floods.

Plan it. Communities may want to conduct hydrologic and hydraulic (H&H) modeling to identify a set of green and gray infrastructure practices that will meet desired flood reduction and water quality goals. When preserving open space throughout a watershed, communities may want to target areas with well drained, water-absorbing soils.

Build it. Several cities have launched programs to conserve land in or around the floodplain to manage riverine flooding. Geographic-information-based models can help estimate the flood damage benefits of green infrastructure, compare these benefits to the cost of land acquisition, and target investments in conservation towards the most cost-effective areas. Urban site-scale practices can also be sited to effectively mitigate localized flooding.

Milwaukee Metropolitan Sewerage District (MMSD) *partnered with The Conservation Fund to protect key properties around Milwaukee where major suburban growth is expected. As of 2013, the program, known as Greenseams, had protected over 2,700 acres of land capable of storing an estimated 1.3 billion gallons of water. By protecting this land, MMSD reduced future flows into receiving rivers and mitigated future flooding.*

Build Resilience to Drought

How does it work? By allowing rainwater to soak into the ground, rain gardens and green streets can help replenish local groundwater reserves. On individual properties, rainwater harvesting techniques such as rain barrels and cisterns can reduce demand for potable water.

Plan it. Becoming a drought resilient community means making the most of water when it is available, as well as storing it for later within deep groundwater reserves. Start by prioritizing areas in your community where it makes sense to locate infiltration-based features. Proper siting of green infrastructure should be considered to protect ground water supplies. For example, avoid infiltrating large quantities of water in contamination hot spots or on steep slopes.

Build it. Communities may want to consider incentives or local requirements to encourage on-site rainwater harvesting and use. By using rainwater stored in cisterns to irrigate landscaping in public parks, schools or municipal buildings, cities can reduce or eliminate the need to purchase potable water from out of town. Captured rainwater can also be used in the home for flushing.

Tucson, Arizona *passed a commercial rainwater harvesting ordinance requiring facilities to meet 50% of landscape irrigation demands using harvested rainwater. Covered facilities are required to prepare a rainwater harvesting plan and water budget, meter outdoor water use, and use irrigation controls that respond to current soil moisture conditions. Green streets also infiltrate rainwater to augment local water supplies and filter runoff to reduce water pollution. Photo credit: Watershed Management Group.*

Protect the coast

How does it work? Coastal plants and reefs use natural processes to slow down sediment and encourage vegetative growth. Increased vegetation can protect eroding marsh edges and mitigate sea level rise. In contrast to hard structures such as bulkheads and sea walls, vegetative shorelines provide multiple ecosystem benefits such as improved water quality and aquatic habitat.

Plan it. Before moving forward with your coastal improvement project, conduct a site assessment. This process includes determining the type of shoreline you possess (slope of bank), the rate at which the shoreline is eroding, the forces that are eroding the shoreline, type of substrate, and salinity levels.

Build it. Living shorelines can be a mixture of structural and organic materials, such as native wetland plants, stone and rock structures, oyster reefs, submerged aquatic vegetation, coir fiber logs, and sand fill.
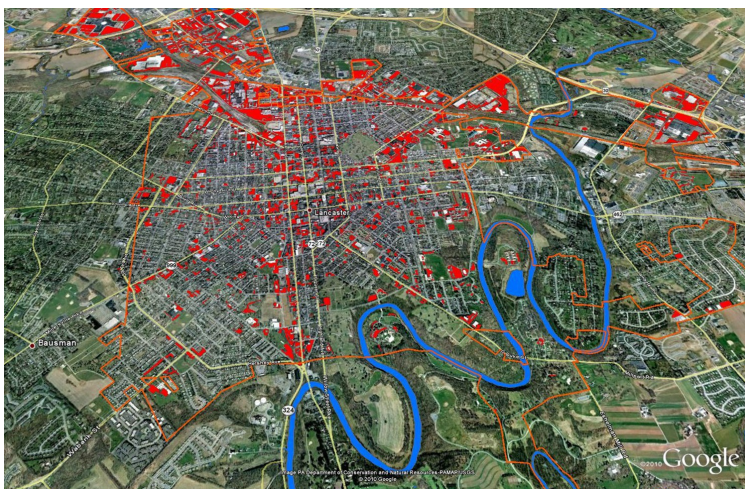
Use less energy managing water

How does it work? Treating and moving water and wastewater takes a lot of energy. By reducing rainwater flows into sewer systems, recharging aquifers and conserving water, green infrastructure can significantly reduce municipal energy use.

Plan it. Start by prioritizing where to place distributed green infrastructure practices in your community for maximum rainwater storage and infiltration. Communities with combined sanitary and stormwater sewers may want to use hydrologic and hydraulic (H&H) modeling to identify ideal combinations of green and gray infrastructure within a given treatment area.

Build it. After projects are in the ground, cities, may want to tie energy efficiency savings back to reduced demand at local power plants. EPA recently developed a tool called AVERT (Avoided Emissions and geneRation Tool) to do just this. Using county-wide datasets, AVERT can help estimate emissions reductions at electric power plants from energy efficiency or renewable energy upgrades.

Reduce urban heat island effect

How does it work? Trees, green roofs, and vegetative cover can help reduce the urban heat island effect by shading building surfaces, deflecting radiation from the sun, and releasing moisture into the atmosphere.

Plan it. Although space in urban areas is limited, small green infrastructure practices can easily be integrated into grassy or barren areas, vacant lots or street rights of way. Green roofs are an ideal heat island reduction strategy since they provide both direct and ambient cooling effects.

Build it. Make trees business as usual in your community. Require green infrastructure improvements as part of regular street upgrades to ensure continued investment. Make water quality practices do double duty by adding trees in or around infiltration-based practices such as roadside planters to help boost roadside cooling and shading.

Lower building energy use

How does it work? Through shading, windbreak, and evapotranspiration, trees, green roofs and vegetative cover can lower ambient air temperatures in urban areas, lessening the need to turn up the AC in summer months.

Louisville, Kentucky *recently began a canopy assessment to determine how the city can use trees to address urban heat, stormwater management and other concerns. "Knowing where we lack canopy, down to the street and address level, will help our efforts exponentially." says Mayor Greg Fischer.* Photo credit: Love Louisville Trees

Plan it. Communities may find it useful to estimate cooling and energy efficiency benefits provided by trees and green roofs. Using USFS's publicly available i-Tree suite, the Mid-America Regional Council (MARC) recently produced a study that quantifies multiple benefits from urban trees in the Kansas City area. By mapping existing canopy concentrations, MARC was able to estimate the monetary value of building energy efficiency gains from tree canopy in the region.

Need more tools and resources?

For more information on planning, funding and maintaining green infrastructure investments in your community, visit U.S. EPA's Green Infrastructure Program website here: www.epa.gov/green infrastructure

For a clearinghouse of resources to measure the multiple benefits of green infrastructure for climate resiliency, access our new Green Infrastructure and Resiliency landing page here: www.water.epa.gov/infrastructure/greeninfrastructure/climate_res.cfm

For more information on green infrastructure visit: www.epa.gov/green infrastructure