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Authors
Butt, Ali A.
Harvey, John T.
Kendall, Alissa
et al.

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RESEARCH BRIEF

A Combined Urban Metabolism and Life Cycle Assessment Approach to Improve the Sustainability of Urban Hardscapes

Ali A. Butt, John T. Harvey, and Alissa Kendall, *University of California, Davis*
Hui Li and Yuxin Zhu, *Tongji University, China*

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Research Question

The globe is becoming increasingly urbanized, a trend that is anticipated to continue. As more people move to cities, the already intense use of energy and materials in those urban areas continues to grow. It will become necessary to use resources more efficiently to sustain this urbanization trend.

Streets, sidewalks, parking areas, plazas, and other paved surfaces cover large portions of urban areas. These urban hardscapes contribute significantly to cities' resource consumption. Although urban hardscapes enable people and goods to move freely, they also have profound impacts on cities' water, air quality, energy, and material use. Construction and maintenance of hardscapes require heavy materials to be transported via truck over long distances, which uses fuel and produces emissions. Urban hardscapes are typically constructed as impermeable surfaces, which increase stormwater flooding, impede groundwater recharge, degrade water quality, and increase urban heat island effects.

Reducing the environmental impacts of hardscapes will be an important component of making cities more sustainable. The necessary first step is to quantify those impacts. UC Davis and Tongji University researchers developed a methodology that combines urban metabolism and life cycle assessment to examine the life cycle impacts of hardscapes at the urban scale rather than at the product or project scale. ***Urban metabolism (UM)*** is a method that accounts for the flow of resources such as energy, materials, and water into an urban area, their processing and consumption within the urban area, and their subsequent flows out of the area. ***Life cycle assessment (LCA)*** is a quantitative environmental assessment method that considers the total supply chain and life cycle impacts of a product or system from "cradle to grave."

Key Findings

The UM-LCA framework can be used to quantify material and water flows for urban hardscapes. The framework can account for the movement of materials—asphalt and concrete products, aggregates, crushed concrete demolition materials from buildings and other structures, additives, admixtures, and recyclable materials—through the urban system. It can also be used to assess changes in stormwater flows for different degrees of full and partial permeability of hardscape, and resulting changes in flood risk, stormwater quality and groundwater recharge (See Figure 1).

Multiple data sources and models are available for characterizing hardscape material and hydrologic flows. There is no single source of data for hardscape material flows and material life cycle information. The University of California Pavement Research Center compiled a comprehensive list of data sources for different materials and other life cycle stages in previous research conducted for a Federal Highway Administration pavement LCA framework report. The Pavement Research Center has also developed several datasets and other tools for conducting hardscape LCAs in California. The Environmental Protection Agency's Storm Water Management Model is a simulation program that can perform dynamic rainfall-runoff modeling for pervious and impervious surfaces and is a useful input for this framework. More information about these sources can be found in the full white paper on which this brief is based.

Research Implications

Use of this framework can help policymakers identify more sustainable approaches to hardscape design, management, and construction, such as use of reclaimed pavement materials and building demolition in hardscapes within an urban boundary or

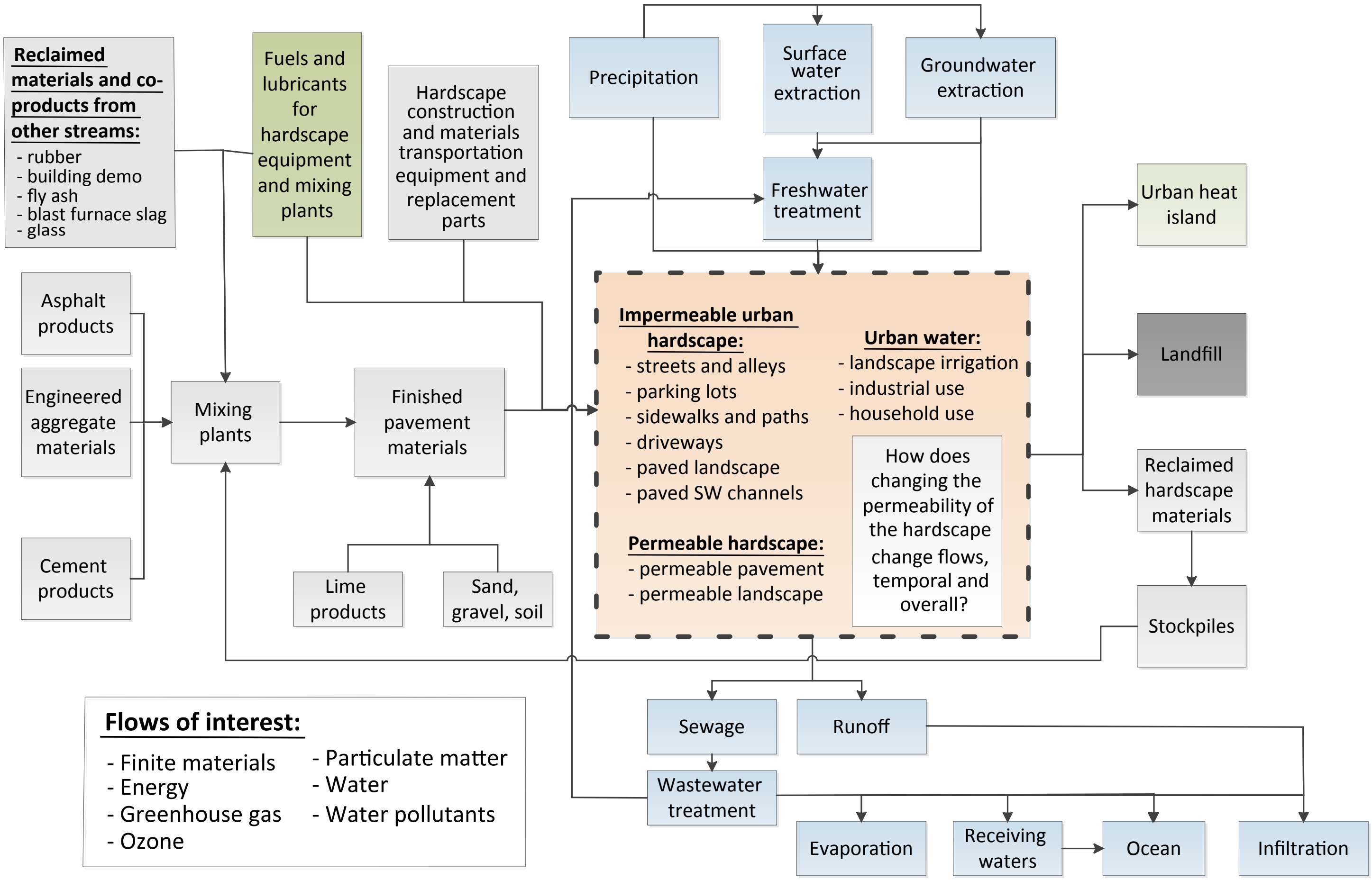

Figure 1. The Urban Metabolism and Life Cycle Assessment framework. The hydrologic cycle is represented vertically and hardscape material flows are represented horizontally.

use of permeable hardscape to reduce flooding risks and improve stormwater quality. Future research and policy work should focus on development of relevant data, models, and tools for the UM-LCA approach. Furthermore, the UM-LCA approach should be applied to two urban areas to test its ability to measure impacts and evaluate alternatives. This framework can enhance understanding of urban hardscapes as an integrated system that is costly, material-intensive, and influential in determining the mobility, safety, air quality, water quality, flood risk, noise, and thermal environment of urban areas.This shift in perspective can lead to changes in standard practices to improve the environmental, economic, and social sustainability of urban systems.

More Information

This research brief is drawn from "Framework for Urban Metabolism and Life Cycle Assessment of Hardscape," a white paper from the National Center for Sustainable Transportation, authored by Ali A. Butt, John T. Harvey, Alissa Kendall of the University of California, Davis, and Hui Li and Yuxin Zhu of Tongji University, China. The full white paper can be found on the NCST website at https://ncst.ucdavis.edu/project/framework-urban-metabolism-life-cycle-assessment-hardscape/.

For more information about the findings presented in this brief, please contact Ali Butt at aabutt@ucdavis.edu or John Harvey at jtharvey@ucdavis.edu.

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