Thesis Project Portfolio

Sustainable Redevelopment of Fashion Square Mall

(Technical Report)

Rethinking Green: Understanding Inequitable Green Infrastructure Distribution through Actor-Network Theory and the Multi-Level Perspective Framework

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Shreya Moharir

Spring, 2022

Department of Engineering Systems and Environment

Table of Contents

Sociotechnical Synthesis

Sustainable Redevelopment of Fashion Square Mall

Rethinking Green: Understanding Inequitable Green Infrastructure Distribution through Actor-Network Theory and the Multi-Level Perspective Framework

Prospectus

Sociotechnical Synthesis

My capstone team and I share a love of two things: nature and Charlottesville, Virginia. For this reason, we focused our civil engineering capstone on a design that protects the environment while making Charlottesville even more enjoyable for its residents. We created a green redesign proposal for the Fashion Square Mall, with one of the main components being green infrastructure (GI). We spent a major part of our first few weeks figuring out what the Charlottesville community would want in a redesign and how our proposal would affect it. During this time, my team considered the financial cost of GI construction as well as existing examples of GI, which were often found in wealthier locations. This led me to consider the difficulty in giving lower-income communities access to GI and whether a lack of sustainable infrastructure was hindering their residents' quality of life. Therefore, I chose to do my sociotechnical thesis on the inequitable distribution of GI between high- and low-income classes.

The technical portion of my thesis produced a thorough redesign plan for the Fashion Square Mall. We ultimately included rainwater harvesting, permeable pavement, and solar roofs as environmental solutions. We also decided to completely remove the mall's interior to create an outdoor walkway, and we added a garden, athletic field, transportation hub, and parking garage. We drew the design plan in AutoCAD Civil 3D using existing GIS coordinate data. Then, we performed several environmental analyses to ensure that the redesign would improve the site's environmental health. PCSWMM showed that for 1-year storms, our design achieved peak stormwater runoff reductions of 31% due to land-use changes and 48% due to BMP additions. The i-Tree model showed that the added vegetative cover led to a 12-25.5% decrease in total annual runoff. Less runoff is equated with less flooding and a lower impact on downstream habitats. Additionally, the Virginia Runoff Reduction Model demonstrated a 7.8

lb/year reduction in total phosphorus, a major contributor to water quality deterioration. Finally, an urban heat island analysis showed that the decrease in impervious surface in our redesign would reduce the site's surface temperature by 6 °C. Altogether, these results prove that our redesign would successfully improve the environmental health of the Fashion Square Mall site.

For my STS research, I aimed to understand how and why GI is inequitably distributed between income classes. GI is currently more commonly found in high-income communities, but low-income communities could highly benefit from GI for its human health and socioeconomic benefits. My sociotechnical analysis applied Actor-Network Theory and the Multi-Level Perspective framework to understand the roles of the less obvious actors in the GI sociotechnical system. I found that lower-quality education in low-income communities limits the GI knowledge and awareness of professionals and residents of those areas, making them less likely to consider GI as a solution. Another concern is policy structure because GI falls under a wide range of policy domains, and updating all of them again requires policymakers to be well-educated on GI. Finally, community influence is an important actor because community support is required for construction to take place, but once again, a community that is not educated on GI is less likely to support its implementation. This analysis concluded many of the actors in the GI sociotechnical system can be influential toward GI adoption in low-income areas. However, altering such a complex system requires these actors to be consistently supported and in communication with each other.

By completing both my technical and STS research, I was better able to understand how engineering both influences and is influenced by society. If I had completed the STS portion on its own, I would not have had such a strong appreciation for GI's ability to mitigate environmental hazards. On the other hand, if I had completed just the technical portion, I would

not have understood the need for organizational and legislative involvement in GI adoption. Doing both parts simultaneously allowed me to see the complexity of creating a sustainable future and how low-income communities receive limited opportunities for environmental improvement. However, equity in infrastructure can promote equal opportunities to achieve environmental health and bridge the lifestyle disparities between income classes. I now realize that this influence that technology has over society is what makes ethics in engineering so important. Engineers should be aware that their technical abilities give them great power to protect others and do good. Going forward, I will always consider engineering as not only an endeavor to innovate but also a tool to progress society.