

(Technical Paper)

(STS Paper)

A Thesis Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science University of Virginia •  
Charlottesville, Virginia In Partial Fulfillment of the Requirements of the Degree Bachelor of  
Science, School of Engineering

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On my honor as a University Student, I have neither given nor received unauthorized aid on this  
assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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## Introduction

The Meadow Creek project objectives is to address the negative environmental impacts of existing developments and future developments that will affect the water quality and the overall stream ecosystem. The project examines how green infrastructure has an impact on the water quality as well as incorporating socioeconomic issues as green infrastructure has lacked implantation in disadvantaged communities. The STS prospectus plans to examine the low environmental development in developing nations, this relates to the technical project on how socioeconomic factors are major reasons for implantation.

## Technical Topic

The purpose of this design project is to address current issues affecting Meadow Creek by conducting a multi-objective watershed analysis, where the objectives are to assess stream ecology, determine environmental impacts of the stream restoration, identify local stormwater hotspots, and propose an equitable green infrastructure plan.

Meadow Creek has 5,800-acre drainage basin it encompasses stormwater runoff from a variety sources such as residential neighborhoods, schools, shopping centers along the U.S. Route 29. Meadow Creek was identified as an impaired waterway by the Virginia Department of Environmental Quality due to sedimentation from stream erosion. A collaboration with the City of Charlottesville, Rivanna Water and Sewer Authority and The Nature Conservancy worked together in 2012 to restore the stream including a realignment of the stream channel, removal of invasive species, and adding native plants and trees.

The project consists of analysis and modeling to assess the stream ecology consisting of fieldwork collecting data from sensors along the stream. The data is used to identify the hotspots of the stream that can become future green infrastructure developments. The use of Arc GIS, Arc-X, and SWMM-CAT will be utilized to determine future climate and land use impacts to the watershed. The three software's assist in developing the muliti-criteria BMP selection procedure. The criteria include ecological, hydrologic, hydraulic, social, and economic objectives.

The ecological objective includes analyzing current and historic data, such as benthic data provided by the Rivanna Conservation Alliance and stream metabolism data gathered at the established sites along Meadow Creek, identifying beneficial practices to improve ecological integrity, reviewing the ecological impact of common best management practices (BMPs), and collaborating with other objectives to incorporate these practices and perspectives into the ultimate selection of BMPs. Data analysis will allow for the current biotic function and biological structure of Meadow Creek to be estimated. To accomplish this objective, a literature review was conducted examining major findings from the 2012 stream restoration, efficiency of various forms of stream restoration efforts, and methodologies which could be used to aid in the accomplishment of this objective. Tangentially, various GIS models were investigated for potential use in identifying environmental hotspots within the Meadow Creek watershed. The Automated Geospatial Watershed Assessment (AGWA) tool was found to have the most promise. Unfortunately, a lack of sufficient documentation for this tool prevents effective implementation. Thus, a more basic approach consisting of analyzing watershed characteristics, such as land cover, slopes, and soils, will be employed instead.

The hydrology and hydraulics objectives for this project include creating a multi-criteria analysis to select optimal best management practices to be employed, developing a future scenarios model based on climate change and shared socio-economic pathways, and developing a SWMM model using design storms to test the long-term effectiveness of the best management practices. Studies based on future scenarios modeling have been examined, and two main components have been further explored. Shared socioeconomic pathways include data on population trends, economic growth, urbanization, emissions, and land-use scenarios which can help in identifying stormwater hotspots or areas with the greatest potential to have high pollutant loads in runoff. Future climate change trends are another important consideration due to the potential effects of climate change on rainfall frequency and intensity. Additional research has been conducted to

begin developing a multi-criteria analysis for BMP selection. Specifically, a study conducted at Virginia Tech outlined a variety of criteria based on functional objectives for the project, physical constraints, aesthetics, and costs associated with a variety of different best management practices. These criteria were ranked and weighted based on project importance and imputed into a matrix calculation that produced the best option. This data will be used to develop a multi-criteria analysis based on desired criteria for this project. A list of BMP specifications to be considered for Meadow Creek has also been examined.

The social objective for our project is to identify locations in the Meadow Creek Watershed where green infrastructure can be implemented to maximize not only the environmental benefit, but also the social benefits, especially for disadvantaged communities. An initial literature review has been completed to learn more about the social benefits of green infrastructure and how to quantify or measure them. The studies have shown that green infrastructure is not distributed equitably among urban communities. In order to remedy this, we are looking to place green infrastructure in locations that would benefit disadvantaged neighborhoods. We have learned that there are physical and social constraints that must be taken into account during the identification process in order to select locations where the implementation of green infrastructure is actually feasible. Taking all of this into account, we have begun preliminary GIS analysis using ArcGIS Pro and census demographic data for the Charlottesville area.

A main economic objective is to determine the most-cost effective BMPs. In the efforts to satisfy this goal, preliminary economic models have been discussed and will determine which model most efficiently represents our situation as well as the various BMPs that can be implemented. Further, economic objectives can be seen to have some overlap with the social objectives in the sense of how the BMP has an effect on the community around it. For example, there is a decent amount of literature suggesting that an improvement to an area can increase the real estate value of neighboring houses by 5-15%. Studies of this nature will be beneficial in selecting where and how a BMP should be implemented.

## STS Prospectus

The motivation for examining the development of environmental infrastructure in developing nations is because the globe is in the midst of a catastrophic problem of climate change. It is critical from an ethical standpoint that all nations are able to adapt to increased sea levels, seasonal changes, flooding and increased frequency and intensity of extreme storms. If these nations are not prepared many lives and homes will be lost.

The purpose of the study is to examine how political influences has stagnated the growth in environmental progress in developing nations. The case study will focus around Guyana and nearby Latin American countries as to how their decisions as a nation have set them back in the race for a greener earth. The study seeks to answer the research question, how global trade hurt Guyana's health and environment? The goal is to analyse the historic decisions made by politicians and determine as well if there were other factors besides trade influencing the changes in Guyana's health and environment.

The goal of the study is to identify and verify drivers that lead to detrimental environment in Guyana and nearby Latin American nations. To do so one must examine the economic make up these areas to get an understanding of how economic factors have had an influence on these nations. It is expected that there is an upward trend of land expansion and deforestation due to an increase in globalization according to Andrade-Nunez et al. (2020). Possible other factors in the deforestation process include farming increase in native lands and a push toward commercial farming. There is also a timber harvest in the native lands according to Bellfield et al. (2015). In relation to the economic growth of Guyana specifically the main export of the nation is gold and there have been political battles disputing legislations harm on the industry but also the environment, Lowe (2014). Other industries having an impact on the environment include the logging industry that has been influenced by corrupt politics according to Bulkan and Palmer (2016). There is also a possibility that foreign investment is having influence on these Latin American countries operate as according to Gransow (2015) there has been investment from China and it is important to dissect China's motivation for investing here as well as why Latin America is accepting the investment.

In a study from Filho et al. (2019) it examined the infrastructure of cities and their preparedness to climate change and the study examined the city of Georgetown, Guyana to Shanghai and attempted to understand how wealth, population, and governance played a role in the city's resilience to future natural disasters. Research from Mahlknecht et al. (2020) concluded that Latin American countries were in demand for energy, water and food security. The urban infrastructure is going to need to step up as it projected that 90% of the population in Latin America and the Caribbean will be urban, Romero-Duque (2020), an influx of the population can have major strains on the already unsatisfactory infrastructure so there is major concern there. The article from Pelling (1998) particularly describes Guyana's vulnerability to flood hazards, representing their struggle with investing in infrastructure and the many actors involved in those means of investment.

In regards to health it can be seen that the industrial expansion of Latin America can also have a negative effective on the health of the people as a study recent study shows that toxins are being measured in adolescences and breast milk, much is still to be determined as to future effects on children, Dorea (2021).

### **Method**

The best way to conduct this study is to analyse historical documents such as newspapers, press releases, government records and GIS maps to gain qualitative and quantitative data. It will also be key to gain the perspective of those living in Guyana and their outlook on the situation; this can be done through an interview process, preferably getting perspective of all political viewpoints. The interview gives complex detail and information that a survey cannot. A STS framework of Large Technical System framework will be used to examine the research question as there are a variety of actors involved in a technological development.

The plan for the research is to have historical documents and a collection of interviews as evidence of the socioeconomic factors that contributed to the development of infrastructure in Latin America. The prospectus hopes to point out possible solutions in understanding how developing nations can make social and political changes in how they approach environmental issues. The prospectus also hopes to spotlight the severity of socioeconomic factors on environmental issues that can be used to examine other nations that are also facing hardships in environmental development.

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