Undergraduate Thesis Prospectus

Flood Mitigation Strategies for Flood-Prone Areas in Charlottesville

(technical research project in Systems Engineering)

Coastal Virginia Communities and Their Response to Increased Flooding

(STS research project)

by

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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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General Research Problem

How can flooding in the United States be mitigated? Floods are caused by the overflow of inland waters or tidal waters, or by the unusual accumulation of water from sources such as dam breaches and heavy rains. They are one of the most common natural disasters and are affecting a growing number of US communities, both coastal and inland. Sea level rise, extreme weather, and other climate change impacts are mainly to blame. Wuebbels et al. (2017) projects that the global sea level will increase 4-8 inches by 2030. Our nation's floodplains are estimated to rise by approximately 45% by the end of the century, and the effects of global warming are growing more apparent (Denchak, 2019).

Major floods often cause mass property damage and loss of life. Floods are responsible for more than 100 U.S. fatalities per year, and the expense for repairing impaired infrastructure cost FEMA an estimated $48.6 billion between 1998 and 2014. Many homes are exposed to repeated flooding. The National Flood Insurance Program has covered more than 30,000 properties each an average of five times (Denchak, 2019). Floodwaters can also carry disease and contamination through leaked toxic chemicals, raw sewage, and other hazardous substances. Defiled floodwater can pollute drinking water and cause infections and respiratory illnesses. Floods lead to economic loss, contribute to mental health problems, and destroy entire communities. And though flooding affects people of all backgrounds, it disproportionally affects people of lower-income, minority communities, and the elderly.

Flood Mitigation Strategies for Flood-Prone Areas in Charlottesville

How can flooding events in the City of Charlottesville be mitigated? Led by Jon Goodall, Professor of Civil Engineering in the Department of Engineering Systems and Environment, my

capstone team will conduct research and data analysis to develop and implement solutions for a more flood resilient Charlottesville. Throughout the city, there currently exist several areas prone to flooding during periods of heavy rain. Because a large portion of these areas are residential and privately-owned, the city's utility services are unable to fix them without owner permission. In many cases, the flooding of one owner's property is due to the design of a neighbor's property, and these neighbors usually aren't concerned with repairing something that doesn't directly affect them. So while Charlottesville's utility services are ready to provide resources and recommendations to private property owners, most owners do not have enough incentive to spend money on fixing these problems, and flooding continues to inconvenience civilians and damage local real estate.

Our team will improve the current scenario's flaws by altering current incentives and solutions to create a less flood-prone city. For our research and analysis, we have established a three-group approach. The first group will build upon the existing sensor and database system to introduce a flood monitoring capability to the City of Charlottesville, and they will investigate how to ruggedize sensor housings to improve their water-resistance. Group 2 will use past rainfall data to create a model for predicting which areas are the most flood-prone. By locating these areas, group 2 can construct a ranking system to help the city's engineers better understand the most-affected areas. The final group will develop a diagnostic tool that takes in information about flood-prone areas and recommends infrastructure changes that can help alleviate flooding at local sites. Overall, our team will tackle flooding through city-wide flood-mapping, water level sensors, and infrastructure changes.

Coastal Virginia Communities and Their Response to Increased Flooding

How are coastal Virginia communities combatting flooding? One of Virginia's most challenging policy issues, flooding has both infrastructural and social costs. Sea level rise, increased coastal flooding, subsidence, and climate-fueled storms are growing a burden for communities across Virginia. Floods are especially affecting Virginia's eastern shore and surrounding islands. Tangier Island, for example, resides in Chesapeake Bay and has lost 67% of its landmass since 1850, and most of its remaining landmass is likely to be fully submerged within the next 50 years (Belt, 2019). Mitchell et al. (2013) estimates a 4.5 to 7-foot rise in sea level on the Eastern Shore by 2100, four times the global average. Sea level has risen only about 3 inches since 1993, but "tidal flooding has increased by 132% in some areas of Virginia since 2000" (SLR, n.d.).

The Norfolk-Virginia Beach MSA ranks 10th globally in value of assets exposed to increased flooding from sea level rise. Exposed assets include places such as Naval Station Norfolk, which would require up to $460 million to replace aged piers already affected by sea level rise and millions more to protect ocean-bordering infrastructure crucial to the base's training, logistics missions, and maintenance. Over 45,000 properties in Chesapeake, Norfolk, Virginia Beach, Portsmouth, and other nearby cities are already exposed to repeated tidal flooding, and that number is only expected to increase. Virginia must act to protect its communities. The state is currently planning over $4 billion in sea level rise mitigation.

Virginia was recently awarded a $120.5 million grant from the U.S. Department of Housing and Urban Development to fight sea level rise in Hampton Roads. These funds support a nonprofit called RISE, which aims to "accelerate innovation in resilience-building solutions and demonstrate how adaptation to the impacts of climate change can be turned into an economic

growth and job creation engine for coastal regions" (RISE, n.d.). RISE recently awarded between $160,000 and $310,000 each to six entrepreneurs with promising resilience-building proposals to protect communities. For example, InfraSGA is piloting innovative urban retrofit bio-retention systems to relieve flooding at reduced cost of operation, maintenance, design, and construction. Another group, GROW Oyster Reefs, LLC, is building an organic seawall to improve the water quality in the Chesapeake Bay and mitigate flooding (RISE, n.d.).

Also fighting flooding is the Chesapeake Climate Action Network, a nonprofit targeting the effects of global warming in Maryland, Virginia, and Washington, D.C. (CCAN, n.d.). Sea Level Rise strives to "enlighten and enable elected officials to implement widespread solutions to sea level rise" and stresses that Hampton Roads is "second only to New Orleans as the largest population center at risk from sea level rise in the country" (SLR, n.d.). The Chesapeake Bay Foundation "highlights natural solutions for adapting to sea level rise in Virginia that can both protect cities and suburbs and improve local water quality" (CBF, n.d.).

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