Flood Monitoring and Mitigation Strategies for Flood-Prone Urban Areas
(Technical Paper)

Exploring How Climate Change Related Flooding Impacts Existing Housing Inequality

(STS Paper)

A **Thesis Prospectus Submitted to the**

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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

Signature _____ Date _____
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Approved _____ Date _____
Jonathan Goodall, Department of Civil Engineering

Approved _____ Date _____
Michael Gorman, Department of Engineering and Society

Instructor Comments and Peer Reviews

In this section, I will address the comments I have received on the content and topic of my prospectus from my instructor and my peers.

When discussing my topic initially in class and on the forums, I received feedback from my technical project teammates, on scoping my prospectus. I had initially planned on focusing only on the Norfolk, VA area, but was advised that I look into policies surrounding flooding all the way to the federal government level. By broadening my scope, I was able to conduct research that can ultimately apply to a wider audience.

When doing a peer review with my classmate Kiri Nicholson, I received advise on how to restructure parts of my paper for clarity. I have edited my paper to include those recommendations. She also offered that my paper read too much as a persuasive essay rather than a research paper at points, and I have updated my paper to become more neutral in tone.

Professor Gorman provided valuable feedback during my in-class presentation on my prospectus. He mentioned that I am focusing on how the incentive-structure currently works for the purchase of homes in flood-prone areas, and I intend to look into this further in my thesis. I also received feedback to analyze how disaster relief is handled at the state level versus the federal level, and I will include this analysis in my thesis. I did not include it in the prospectus because I feel that it might be too detailed for this stage of the writing process.

Introduction

Climate change is causing an increase in variability in weather patterns around the world. While governments grapple with solutions to negate or lessen how severely the Earth warms, citizens are forced to deal with the impacts of climate change. Hurricanes have displayed a disturbing pattern of making landfall and just "sitting" in one place, effectively dumping water in one concentrated location rather than across a geographic region. Coastal cities have seen an increase in sea levels, with the city of Norfolk, VA, experiencing the largest sea-level increase of the United States and globally at 1.5 feet (Hensley 2018). The purpose of my thesis will be to discuss how climate change is affecting living conditions for those in coastal cities. In particular, I am interested in learning about how increasing sea levels impact communities of color and those with disabilities. As solutions for combating the effects of climate change are discussed, do existing social inequalities need to be examined? In my thesis I will explore what course of action governments at the local, state, and federal levels have taken that will mitigate the effects of climate change without exacerbating existing equality gaps in the United States' population.

The technical portion of my thesis will regard my capstone on Flood Warning and Mitigation Strategies for Flood Prone Areas in Charlottesville, VA. As my capstone is a team effort with six other members, Jane Long, Kevin Corcoran, Kiri Nicholson, Grayson Gatti, Pat Finley, and Mac Nelson, this portion will be written by the team in collaboration. The technical portion will remain distinct from the STS portion of my thesis portfolio.

II. Effects of Extreme Flooding Events

In the past decade, hurricanes have shown to come to a complete stop upon making landfall. This causes devastating flooding to the unfortunate areas that receive the full brunt of the storm. For example, Hurricane Florence, a Category 3 Storm, was projected to wreak havoc

up the East Coast in 2018 after making landfall in North Carolina. Instead of steadily moving up the coast, however, Florence stagnated in North Carolina, causing damage to many homes in the state's smaller cities (Kusisto 2018). According to the Wall Street Journal, the town of Wilmington, N.C. only had an apartment vacancy rate of 6.6% prior to the hurricane. As homes were destroyed, citizens left looking for temporary housing could not do so in their own towns, unable to find an apartment to rent. The high demand for rental units also increases the cost of living, making housing inaccessible for the most vulnerable members of society. The problem is only exacerbated by the fact that towns like Wilmington and Fayetteville had fewer than 1,500 empty apartment units each (Kusisto 2018). Price and limited supply make housing inaccessible for lower-income victims of natural disasters like Hurricane Florence. Prior to Florence, North Carolina had a shortage of 190,000 affordable housing units, a figure which ballooned to 300,000 in the aftermath of the hurricane (Wiltz 2019). In addition, federal disaster relief is focused on homeowners rather than renters (Wiltz 2019). This, coupled with the issue that renters are "more likely than homeowners to be low-income and struggle with paying for basic needs" skews disaster relief towards those who are more economically secure (Wiltz 2019). The current disaster relief system is not inclusive of lower-income citizens.

After Hurricane Harvey delivered severe flooding damage to the Houston area in 2017, the waiting list for affordable public housing increased from 14,000 to 112,000 (Wiltz 2019). This number includes not only those who are newly looking for affordable housing but also those who already lived in affordable housing that needs new accommodations due to damage from the hurricane. Extreme weather events like Hurricane Harvey only make existing shortages of affordable housing worse. Additionally, it was announced in October of 2019 that federal aid for Harvey recovery (a hefty $4.3 billion) would be under Texas state authority for dispersion, rather

than counties and cities (Wallace 2019). A report by the U.S. Government Accountability Office concluded that, as of 2018, states were unable to manage disaster recovery housing programs when given money by the federal government (Wiltz 2019). As state governments learn to adapt to increased severity and frequency of flooding events, protocols must be developed to appropriately disburse recovery funds such that the most vulnerable populations get the help they need as soon as possible. It seems as if federal assistance to individuals filing claims is also severely limited, with 364,000 applications for individual aid have been filed with FEMA and only 103,000 were approved, an acceptance rate of less than thirty percent ("September 1: Latest," 2017). Currently, federal and state governments are both responsible for disbursing disaster relief at the individual citizen level. In the future, the US government may need to consider consolidating this process to effectively distribute aid. In my thesis, I will compare and contrast effectiveness of disaster relief at the local, state, and federal levels of government.

Hurricane Maria is another example of what can happen when local and federal government groups are unprepared for a natural disaster. After the hurricane hit Puerto Rico in 2017, roughly one million people applied for federal assistance (Wiltz 2019). Of those individuals, roughly seventy-five percent of owners and eighty-eight percent of renters reported an income of less than $30,000 (Wiltz 2019). The victims of Hurricane Maria were not in the position to pick up their lives and move to an area that had greater economic opportunity and protection from natural disasters such as Maria. This is but one example of what is occurring globally as the effects of climate change become more and more clear. The people that are impacted the most are the ones who are least able to protect themselves from adverse impacts. As the United States has faced increasing expenses due to disaster relief, this is a crucial time to determine how to most effectively prepare for severe weather such that its citizens are protected.

III. Impacts of Rising Sea Levels

Another threat from climate change is rising sea levels. In a world where some of the most populous cities are coastal, coastal flooding will affect millions of people in their every day lives. Coastal flooding threatens to inundate places of work, homes, and transportation infrastructure. One of the biggest challenges cities face is how to increase resilience to flooding to ensure that they can continue to exist in the coming century and beyond. Flooding is also a large financial threat, as it is estimated that by 2045, roughly 300,000 homes and properties may face chronic flooding, threatening $135 billion in property (Sisson 2018). The city of Norfolk, VA has seen a sea-level rise of six inches since 1992 (Kusnetz 2018). It has become a model for other cities that are facing coastal flooding, as Norfolk has to rapidly adapt to continue to exist. Virginia on the whole, including cities of the Hampton Roads area, is estimated to require "more than $31 billion" to build protective sea walls (Hafner 2019). As Norfolk grapples with solutions to sea-level rise, there is a budding nationwide crisis with homeowners whose properties risk flooding. Coastal flooding also intensifies social inequity, as homes in flood-prone areas are already generally occupied by lower-income citizens. As the threat of flooding increases, the individuals that are most affected also have the least ability to pick up and move to higher ground due to monetary constraints.

Norfolk, VA is regarded as a "case study of cities that are adapting to sea-level rise" (Kusnetz 2018). The city is working to fortify vulnerable areas by raising streets, installing pumps, and planning major floodwalls (Kusnetz 2018). This effort is bolstered by the fact that the Hampton Roads area is a hub for the U.S. Navy. While the city is able to make bold, broad-strokes efforts to prepare for coastal flooding, some of its most vulnerable citizens are at risk of being left behind. The development of Tidewater Gardens is an area that some low-income

citizens call home. The median annual household income of Tidewater Gardens is roughly $12,000 and more than 95 percent of its residents are black (Kusnetz 2019). As Norfolk plans to redevelop the area, its citizens are at risk of being forced out of the community through rising home prices and a greater cost of living. The city is planning on removing 65 percent of subsidized housing units in the area (Kusnetz 2018). What are residents to do when their homes no longer exist? They will face the option of entering the private rental market with vouchers or being transitioned out of assisted rental housing (Kusnetz 2018). Norfolk and other cities must pursue other options when fortifying their city against the effects of flooding to ensure that all of their citizens are included, not just the ones who can afford to move.

The subsidized households of Tidewater Gardens are just one example of the nationwide affordable housing situation. Across the country, about 450,000 government-subsidized households are in flood plains (Mervosh 2019). These properties are generally funded by HUD, the federal department of Housing and Urban Development. HUD has the ability to allocate money to states to incentivize moving communities out of high-risk areas. In North Carolina, a housing authority plans to relocate two public housing properties out of flood zones through HUD money (Mervosh 2019). Citizens who reside in public housing properties are also concerned about the impact of flooding and feel trapped as they are dependent on government subsidies to afford a home. The HUD has the capability to work with the states, and should, in order to create new solutions to fix the affordable housing crisis while also keeping new developments out of high-risk areas. Further examination is also required for the sale of homes in flood-zones. Currently, banks transfer mortgages that bear the risk of flooding due to climate change to entities such as Fannie Mae and Freddie Mac, since they cannot factor in flooding risk when assessing loans. This missed risk is only going to threaten the mortgage markets with time,

as even now $60 to $100 billion in new mortgages are issued for coastal homes each year (Beals 2019). In my thesis, I will examine the incentive structure for sales of homes in flood prone areas. I will also pursue research into areas that, if coastal flooding reaches catastrophic levels, could become unlivable.

Conclusion

Flooding due to climate change is a real threat that affects Americans throughout the country. Hurricanes have increased in intensity and severity and as such affect the southeast and east. Heavy rains have recently wreaked havoc down the Midwest. Coastal flooding due to rising sea levels affects both coasts, where a vast proportion of the U.S. population lives. In my thesis I will continue to explore how cities are adapting to flooding threats and what policies they are pursuing to prepare for more severe weather. Additionally, I want to explore the various technologies cities are deploying to mitigate flood risks, such as sea walls, living barriers, draining systems, and the like. I will be using Actor-Network Theory as my framework for analysis, as I understand that there are several complex relationships at play between the federal, state, and local governments as well as with the citizens.

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