Developing a Flood Warning System to Reduce the Impact of Flooding
(Technical Topic)

Environmental Gentrification: An Analysis of the Unforeseen Consequences of Environmental Infrastructure on Marginalized Communities
(STS Topic)

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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

Flooding causes significant damage and loss of life. Hazardous weather events increase in frequency each year and bring higher intensity rainfall that threatens to overwhelm local storm water systems. Due to climate change, sea level has been increasing globally at an average rate of around 3.1 ± 0.3 mm yr^{-1} since 1993 (Dangendorf et al., 2019). The rise of sea level is further illustrated in Figure 1 which shows how annual basin-scale averages have increased between the years 1900 and 2015. Sea level rise will lead to an increase in the frequency and severity of coastal floods. In addition, the most frequent natural disaster in the United States is flooding (Vitousek et al., 2017). Flooding results in significant damage and loss of life each year and has caused the United States to accumulate billions of dollars of debt due to national flood insurance (Amadeo, 2020). In order to mitigate the impacts of flooding, decision makers need knowledge of which populations and neighborhoods are most vulnerable, along with an understanding of the social, cultural, and economic factors that lead to this vulnerability (Liu et al., 2016). Flood warning systems can help reduce the impact of flooding by providing early warning within areas prone to flooding. This project proposes the development of a flood warning system to alert communities, along with the creation of flood models to predict floods based on rainfall forecasts.

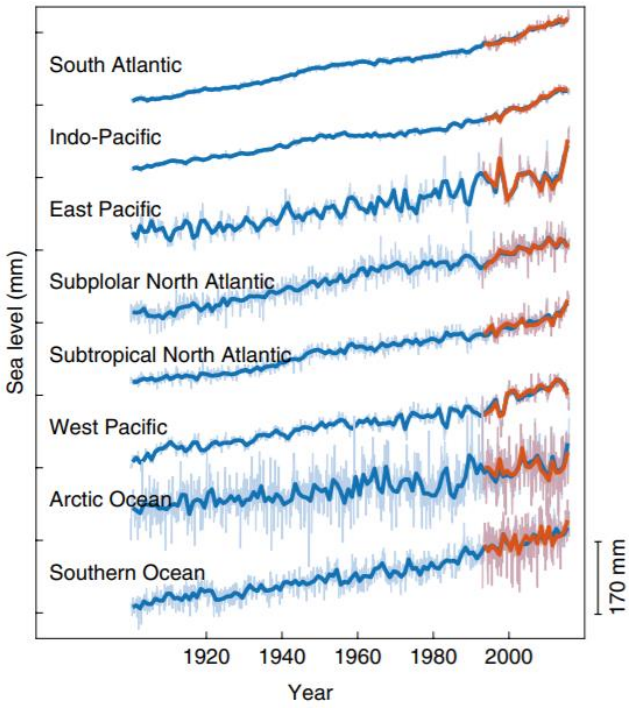

Figure 1: Global and Regional Sea Level During 1900–2015. *There has been a persistent acceleration in the global mean sea level since the 1960s (Dangendorf et al., 2019, p. 706).*

Climate change and flooding do not impact people equally; residents of low-income communities and marginalized groups typically face a disproportionate amount challenges from environmental disasters. There is currently a growing inequality of access to sustainability projects. Environmental sustainability practices such as a flood alert system only benefit those who are able to afford it. Environmental gentrification is the process in which supposedly progressive sustainability practices are used to drive up property values and displace low-income residents. Quastel, Moos, and Lynch epitomize this in their argument that "sustainability planning actively contributes to, rather than simply exists alongside, growing urban inequality as it reinforces rising house prices and social exclusion associated with the new economy" (Quastel et al., 2012, p. 1060). Sustainability initiatives can paradoxically enhance gentrification and threaten to displace vulnerable people by increasing property prices.

Technical Topic: Developing a Flood Warning System and Predictive Flood Models to Reduce the Impact of Flooding

The degree and scale of flood hazards have increased immensely with the changing climate in the last decades (Vitousek et al., 2017). Floods can result in tremendous life and property losses as well as social disruption worldwide (Amadeo, 2020). The dangers of flooding increase for cities that cannot predict where severe flooding will occur and when residents are not quickly made aware of a flood event. Flash flooding can make it nearly impossible for residents to evacuate safely in time (Silva Souza et al., 2017). Transportation routes will especially be significantly affected by increased flooding. Low-lying communities near bodies of water have already started seeing drastic changes in the impacts of floods. These cities must adjust their current systems to handle the onslaught of road hazard from flooding. Although sea level rise is a very real and dangerous issue, it is occurring gradually. Therefore, cities have time to adapt their infrastructure to better prepare for increased frequency and severity of flooding.

Chang, Yang, Kao, Chang, Ku, Kuo, and Amin declare that "Building resilience to natural disasters is one of the most pressing challenges for achieving sustainable urban development in flood-prone regions" (Chang et al., 2019, p. 1). Sustainable developments include early flood warning systems which are potential countermeasures against flood hazards and losses. Information systems such as flood warning systems provide integrated multi-disciplinary platforms that combine data management, visualization, analysis, modeling, and information communication capabilities. This plays an important role in environmental and geoscience disciplines including in flood resilience methods. Real-time access, analytical processing, and interactive visualizations are crucial to deliver a better understanding of flood-related issues (Chang et al., 2019).

This project will be building upon previous research on intelligent hydroinformatics integrated platforms and work conducted by past capstone teams. The deliverable will provide guidance for the county on what modifications can be made to the storm water utilities to handle a massive storm event. The deliverable will also recommend a system for warning residents and county officials of imminent flooding conditions, along with a system to predict which roadways are likely to flood and to notify residents when flooding occurs. The warning system will require accurate continuous measurements of the amount of flooding on a given road. In order to collect data, this project will utilize existing ultrasonic distance sensors to collect pressure and liquid levels. These sensors will be placed on roads around Greenbrier Dr in Charlottesville, Virginia. The real time data collected will be used to create a web application which city officials and residents will have access to, along with an alert system which will notify residents if flooding occurs. In order to accomplish this, a database will be created to store, update, and manipulate the collected data. Relevant statistics of flood water levels will then be created for alerting. When flood water reaches a certain level based on the statistics, the web application will send warning notifications out. Interactive visualizations will also be designed and placed in the application for residents and government officials to view. The system will allow users to access real-time predictions of flood likelihood to better plan transportation routes and implement preparedness tactics.

Along with real-time data for the warning system, historical data, elevation, and land cover will be utilized in order to assess what areas are more prone to severe flooding. A system for managing and monitoring the watershed conditions will be recommended for implementation to city officials. This analysis of the watershed utilities will allow county officials and residents to see how well the local infrastructure can handle a large storm disaster event. The ability to

predict flooding events on specific roadways and be alerted to flooding early will aid in averting disaster and injury due to an unexpected rise in water levels.

STS Topic: Environmental Gentrification: An Analysis of the Unforeseen Consequences of Environmental Infrastructure on Marginalized Communities

In the past few decades, it has become abundantly apparent that sustainability must become a fundamental element of designing modern cities. Many communities throughout the country have embraced the concept of sustainability and have made efforts to include sustainable developments into their plans. However, there is typically an inconsistency between achieving environmental goals and creating equity. Sustainable development addresses the economic growth and environmental aspects of sustainability, but has traditionally neglected to address the social justice and equity issues that can occur in communities. Gentrification is a social equity problem that pushes out low-income residents in favor of high-income in-migrants (Gould & Lewis, 2016). Similarly, environmental gentrification, or green gentrification, is the process of creating and reinforcing environmental privilege for elites and represents how green initiatives can enhance gentrification (Anguelovski et al., 2019).

Figure 2 depicts a model of the relationship between environmental gentrification and the health of community residents. The dynamic social and political environment in which green practices take place and the possible adverse effects of such upstream interventions should be recognized and understood by policy makers and researchers interested in promoting health through environmental projects. Along with having detrimental effects on health, environmental initiatives can also lead to an increase in property prices. Browne (2018) emphasizes that “The

loss of affordable housing is a major consequence of implementing ecological enhancements and environmental amenities; therefore, this issue should be addressed prior to rapid development and real estate market speculation" (p. 2). Residential and commercial developers view providing green amenities as part of a plan to attract the desired affluent consumer market to the area. Sustainable projects often emphasize economic development and have shown to lead to the increase of property values in nearby neighborhoods and have decreased the availability of affordable housing (Maantay & Maroko, 2018). Increases in the cost of living causes low-income families to become displaced, and with the decrease of affordable housing, they are left with nowhere to go.

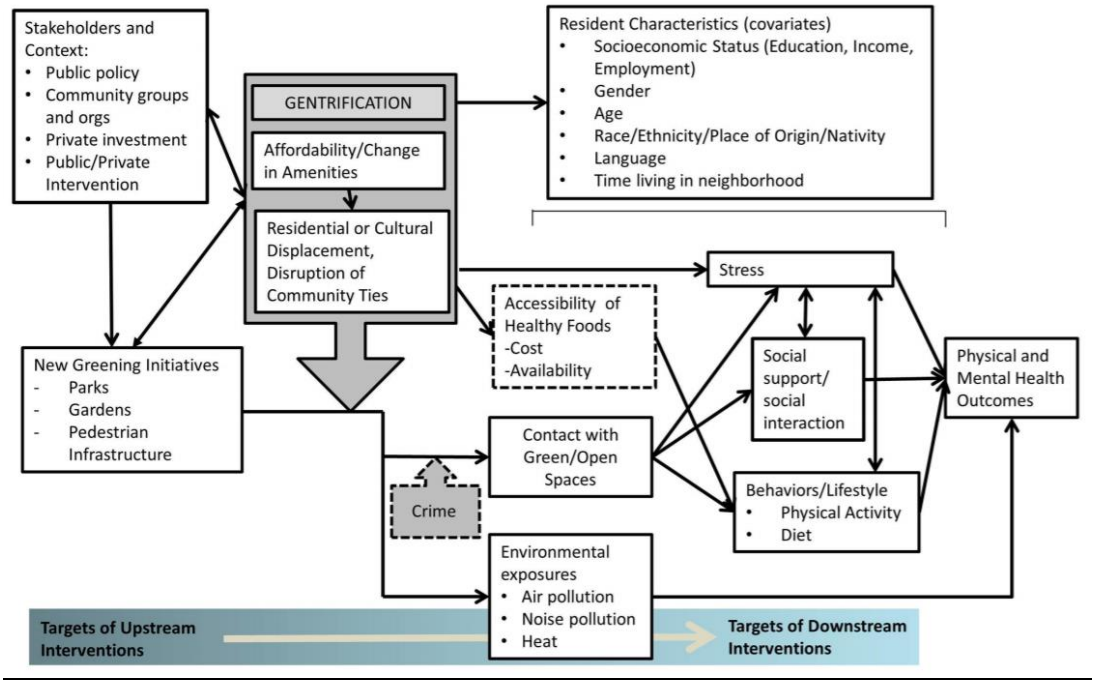

Figure 2: The Association of Environmental Gentrification and Health Equity. Gentrification that is related to green initiatives can impact the relationship between exposure to green spaces and health. Green practices take place in dynamic social and political contexts in which there are possible adverse effects of such upstream interventions (Cole et al., 2017, p. 1120).

The STS portion of this project will pursue a better understanding of the possible social and economic consequences of implementing sustainable practices. Environmental gentrification

will be examined in the context of the creation of flood control technology in the city of Charlottesville. This knowledge will provide an insight into the conflicts between environmental, social, and economic factors that persist in sustainable development. Browne (2018) illustrates how "Sustainability initiatives should not undermine the social fabric of a community; rather, it should coincidentally preserve and protect the physical and social environment" (p. 2). Although green projects should benefit both the environment and those that are most vulnerable, this is hardly the case in many U.S. cities. In order to prevent negative consequences of environmental practices, this project will conduct research on strategies to reduce the effects of green gentrification. Possible mitigation and prevention strategies for preserving affordable housing during the implementation of sustainability initiatives will be recommended to Charlottesville city officials. The question of whether the implementation of environmental enhancements and amenities, such as the features proposed in the technical portion of this prospectus, will lead to gentrification and the loss of affordable housing within the community will be examined. In order to prevent environmental gentrification from becoming inevitable, activists must form alliances and create a new vision of a sustainable city that is more democratic, diverse, and promotes equality (Curran & Hamilton, 2012). Potential strategies to mitigate environmental gentrification include conducting assessments on the projected impact of environmental developments and providing all stakeholders with an opportunity to be involved in environmental projects.

Conclusion

Inadequate flood control strategies bring many social and economic dangers. The deliverable for the technical work of this project will provide guidance on what modifications can be made to the storm water utilities to handle a massive storm event. A system for warning

residents and county officials of imminent flooding conditions will also be recommended. The flood warning system will benefit community residents by alerting them to flooded areas ahead of time and potentially reducing damage, loss of life, and inconvenience from floods.

Green practices provide ecological benefits, but still have unforeseen consequences for vulnerable communities. It is an environmental contradiction that the people most vulnerable to natural disasters are also the most negatively impacted by environmental interventions that were meant to protect them. The STS research will provide an improved understanding of the unintended consequences of sustainable practices and technology on vulnerable communities. Environmental strategies to improve social and economic equity will be recommended to city officials. If implemented, these strategies will reduce environmental gentrification in Charlottesville and assure that flood mitigation techniques will benefit all residents.

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