CRP 5680 Final Project Proposal

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**Spatial Analysis of Social Vulnerabilities and Urban Flooding in Baltimore, MD**

**Introduction**

Flood risk is commonly calculated as a combination of hazard occurrence (probability), exposure, and vulnerability. Traditional risk analysis applications commonly derive vulnerability estimates based on physical characteristics, such as elevation or housing quality, but sociodemographic characteristics can be used to identify communities’ susceptibility to harm from flood hazard. These characteristics, defined as social vulnerability metrics, can be used to determine equitable adaptation strategies to ensure all population groups can cope with disaster. Failure to account for the sociodemographic makeup of the exposed population can lead to unequal protection measures towards uncertain flood events, and thus disproportionate damages experienced across the city.

**Problem Statement**

This study seeks to address the spatial heterogeneity of flood exposure within the city of Baltimore. Specifically, this study seeks to identify the sociodemographic variables that best explain the variance in flood exposure across all Baltimore census block groups. While previous studies have addressed the influence of social vulnerability on flood exposure in multiple regions (Collins et al., 2017; Oulahen et al., 2015), such an empirical study has not been applied to Baltimore. For this study, key questions include the following:

1. What is the spatial distribution of flood exposure throughout the city of Baltimore? Are there certain urban areas particularly prone to flood risk?
2. What socioeconomic factors are most correlated with flood risk? Are there identifiable relationships between certain demographic variables and flood exposure?

In the context of Baltimore, I anticipate that neighborhoods with predominantly high income and white populations are associated with high flood risk levels, as determined by the FEMA 100-year floodplain. I suspect this relationship due to the locational benefits and cultural amenities associated with Baltimore’s waterfront neighborhoods. The results from this analysis can help to provide insights on which urban areas have high visibility in terms of flood risk, and which areas require additional investment.

**Background**

Severe flood events pose a threat to coastal cities and are anticipated to become worse under a changing climate. In the United States, spatial flood risk is officially delineated through flood maps published by the Federal Emergency Management Agency (FEMA), based on a 100-year flood level. Federal flood mitigation investments are determined from these floodplain areas, and they are often managed by the US Army Corps of Engineers (USACE), are typically based on cost-benefit analyses (McGee, 2021). However, the cost benefit analyses used by USACE implicitly prioritize white, affluent neighborhoods and excludes marginalized, low-income areas from protection (Anguelovski et al., 2016). Marginalized communities thus can experience greater damages and longer recovery periods after major flood events. In short, the flood risk estimates calculated by Federal agencies may not adequately represent the true risk within the urban environment. This disparity in part can be addressed by local city planners, but given their limited budgets, city hazard-mitigation agencies must be selective about which urban regions to invest in. Robust urban flood risk management strategies will benefit from a holistic approach towards future exposure assessment that factors in social vulnerability to appropriately manage risk.

Baltimore is the study area for this project due to their high flood exposure levels and wide social disparity among urban populations. Flood events are anticipated to become more frequent within the city, and Baltimore’s downtown area is particularly prone to nuisance flooding events (EPA, 2021). Furthermore, historical redlining practices segregated African American families to certain sections of Baltimore, resulting in patters of environmental disamenities (Grove et al., 2017). Developing a causal inference framework to characterize the interactions between adaptive risk management, city infrastructure, and flood dynamics, as well as the ensuing population vulnerability within the urban environment, will decrease biases and identify equitable policy pathways.

**Methodology**

This study will utilize a combination of demographic and physical flood exposure data to understand the urban characteristics of the city of Baltimore. The independent variables of this study will be socioeconomic variables that describe the Baltimore population at the block group level, such as race/ethnicity, population density, household income, and education level. These demographic variables have been associated with vulnerability towards environmental hazards (Cutter, 2003) and provide a starting point for describing the variance in the dependent variable of interest. To represent the dependent variable (flood risk), I will use 100-year floodplain area at the block group level, as determined by FEMA’s Flood Insurance Rate Maps for Baltimore. Access to this dataset can be found here: <https://www.baltimoresustainability.org/floodplain-management-program/#FEMARiskMap> . The floodplain spatial area dataset will be merged with the Baltimore census block group layer to calculate the percent block group area that intersects with the floodplain. This calculated dependent variable can then be spatially joined with the socioeconomic variables at the block group level.

To address the overall research question, I will apply an ordinary least squares (OLS) and geographically weighted regression (GWR) approach to the data. Because multiple regions within Baltimore are near bodies of water, I anticipate there to be spatial dependence among the spatial datasets. I will assign spatial weights to the flood exposure dependent variable to incorporate a spatial lag estimate within these models. Spatial autocorrelation is expected to be present in urban flood risk based on the delineation of the floodplain. The need to account for spatial heterogeneity is better handled with a GWR approach in order to reduce biased estimates (Wang and Wu, 2020). Similar approaches have been conducted by Fahy et al. (2019) and Chakraborty et al. (2022), highlighting the suitability of this methodology towards understanding the spatial heterogeneity of flood risk exposure. Ultimately, the results from this analysis should provide some insight on how the existing urban population distribution influences Baltimore’s flood exposure.

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