Hydrologic Modeling and System Optimization for IoT Flood Management

Disaster Preparedness Resources for the Rio Grande Valley Region in Texass

A Thesis Prospectus

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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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Introduction

Rainstorm events have increased in severity over the years due to climate change, and with that, the number of flooding events has increased as well. Floods are the most common natural disaster in the United States and with an increase in severity, flood preparedness should be a top priority not only in flood-prone areas but also areas with a high frequency of storms (U.S Department of Homeland Security, 2021). These storms can damage or destroy properties and can be fatal to human life. Both my technical and STS project focus on flooding mitigations and strategies.

My technical project is a continuation of past years' work exploring flood mitigation tactics in urban settings specifically, Norfolk, VA and Charlottesville, VA. Broadly, placed water sensors are continuously collecting data about various water-related factors such as atmospheric pressure and an interface receives, analyzes, and visualizes that data. The overarching goal of this project is to create a system that allows cities to independently monitor their water levels in flood-prone areas. My project specifically uses water sensors to determine the correlation between soil moisture, rainfall depth, and water levels in streams within UVA and Charlottesville.

For my thesis, I'm going to explore socioeconomic and demographic factors that highly impact the level of flood preparedness for people living in flood-prone areas with frequent storms. Specifically, I'm focusing on the Rio Grande Valley area located in Texas whose population is more than 90% low-income Mexican and Mexican Americans (Donner & Lavariega-Montforti, 2018). This area consists of four counties: Hidalgo, Cameron, Willacy, and Starr. These counties have experienced seven hurricanes from 1967 to 2010. Hurricane Dolly which occurred in 2008 is the fourth most destructive Texas hurricane on record and caused over 2 billion dollars of crop and property damage due to wind and flooding (Kyne, 2018). As well as focusing on the impacts of Hurricane Dolly, I will be researching influential factors of flood preparedness because people who have taken the action plans to prepare for a storm have better chances of lowering the harm storms can cause them.

In this prospectus, I will further discuss my technical project, STS project, and key sources that will aid me in my research of flood preparedness.

Technical Project

My capstone team project explores how continuous water level sensing can support flooding emergency management in the cities of Norfolk and Charlottesville, VA. When these sensors are placed in water systems, it can increase awareness of how these systems respond during an extreme rainfall event, further aiding in emergency flood mitigation strategies.

The overarching goal within the capstone group is to look at the correlation between water level, soil moisture, and rainfall depth in streams located around UVA grounds and the city of Charlottesville. Within that goal, there are 3 different subsections: power management, cybersecurity, and the hydrological component. The team focused on power management explores the impacts that the frequency of interval sampling or data collection has on the battery usage levels of the sensors. The cybersecurity aspect is investigating which servers provide the best security when receiving data. Lastly, the hydrological team will create a flood risk model of the area to gain insight into how water travels during storms. I'm a part of the hydrological team, so I will discuss that aspect of the project.

While our Ph.D. student is looking for places to place the sensors on grounds for our project, my team is gathering data about the surrounding area. We are using a program that will give us a map of the area with a data elevation model (DEM). A DEM file provides a visual elevation baseline to an area and allows us to analyze the area. The data we collect from the analysis will aid us in creating a flood risk model. This model will show us the breakdown of peak water discharges in areas as well as the depth of water for various hypothetical storms. After the sensors are placed, we will receive real-time data on the soil moisture, water levels, and rainfall depth which we will use to determine the relationship between the three if any.

STS Project

For my STS topic, I'm researching flood preparedness and what factors influence readiness for a storm. This is important because as the severity of storms increases, people's lives can be disrupted more frequently if they are not properly prepared to handle a power outage or evacuate. Also, these storm events can be fatal if people are not fully aware of the impact storms can have. Specifically, I'm narrowing in on residents in the Rio Grande Valley area in Southern Texas. This area gets hit by an abundance of storms since it's located by the Gulf of Mexico and has a high flooding risk due to its flat surface, poor water retention in soils, and rapid development. The population predominantly consists of low-income Mexican and Mexican Americans who have a younger demographic and lower education levels (Donner and Lavariega-Montforti, 2018).

Within this topic, there are three main groups, the residents, the media, and the government. These groups are separated because the media oversees making the public aware of when these storms come, the duration, the severity, and when/where to evacuate if need be. The government is behind the decision for residents to evacuate and need to properly plan out safe evacuation routes. Lastly, the citizens are receptive to all of this and need to make decisions themselves about what they want to do and are impacted by various factors such as age, gender, socioeconomic status, and education levels (Donner and Lavariega-Montforti, 2018). During my research, I choose to focus specifically on the citizens and how the factors mentioned previously influence their flood preparedness, and how they're ultimately responsible for preparing themselves for a disaster. A group that I excluded from this topic is non-governmental organizations (NGOs) that help educate people about storm preparedness and also aid individuals impacted by storms by providing essentials such as bottled water.

To conduct this research, I will use a case study of Hurricane Dolly which hit Rio Grande Valley in 2008, and its outcomes as well as the methods of history and philosophy to analyze how the factors influence their decisions. The more data I gather about what flood preparedness objectively looks like and what factors influence decisions to prepare and evacuate, the more I can help urge and educate people about how to effectively prepare and help others prepare for storms.

Key Texts

The paper Ethnicity, income, and disaster preparedness in Deep South Texas, United States by Donner and Lavariega-Montforti written in 2018 examines the relationship between demographic and socioeconomic factors and flood preparedness of a sample of residents in Rio Grande Valley, Texas.

Specifically, they examined income, ethnicity, age, education level, gender, and flood experience. They found that age and income had a statistically significant influence on flood preparedness. This article is important to my research because it studies the relationship between influential factors on flood preparedness in the Rio Grande Valley area and mentions that the relationship between demographic and socioeconomic factors and preparedness is complex.

The paper Who Will Stay, Who Will Leave: Decision-Making of Residents Living in Potential Hurricane Impact Areas During a Hypothetical Hurricane Event in the Rio Grande Valley by Kyne et al written in 2018 focuses on factors that impact evacuation decision-making during various levels of hurricanes in the RGV region. Through a survey of 1,060 participants, this study looked at the following seven factors with evacuation decision-making: demographic factors, living conditions, authority order, decision-maker role, the reason for refusing evacuation, perception of a "safe place", and expected help from the government and non-governmental organizations (NGO). This study found that gender, age, authorities' order, and the decision-maker all had statistically significant influences on evacuation decision-making across all five hurricane categories. Additionally, this study revealed that these residents expect more help from government agencies than NGOs after hurricane events specifically with public transportation, temporary shelters, food, drinking water, medicine, and other needs. This study helps reveal more connections between influential factors and evacuation habits which helps me learn more about factors that impact flood preparedness. Additionally, this article lays out the hurricane history that this region has had from 1886 to 2010 which has helped me find a case study hurricane to focus on.

The paper Empirical evaluation of disaster preparedness for hurricanes in the Rio Grande Valley written by Kyne et al in 2020 has four research questions that it's exploring within this article through a sample survey of residents and college students within RGV. The first two questions examine the state of disaster preparedness in RGV separating objective and subjective preparedness. The third question explores any discrepancies between objective and subjective preparedness, and the fourth question identifies any relationships between 12 socio-demographic characteristics and preparedness. The authors found that there is a statistically significant difference between subjective and objective preparedness. The 12 characteristics focused on included: gender, race/ethnic group, age, medical condition, healthcare access, household size, number of children, educational attainment, employment status, income, evacuation experience, and pet ownership. Out of these 12 characteristics, four, medical condition, household size, employment status, and pet ownership were found not statistically significant. This information is important to my study because it defines what it means to objectively be prepared for hurricanes and separates it from subjective thinking and provides influential factors that help or hinder that process. It also emphasizes that individual awareness and education are key to being prepared.

The paper Differential social vulnerability and response to Hurricane Dolly across the US-Mexico border written by Ruin et al in 2008 examines the flood preparedness of residents in the RGV when hurricane Dolly hit the area. Their article studies the following four research questions: 1) How do the temporal aspects of hurricanes (warning lead time, duration, and frequency) influence community hurricane preparedness? 2) Are there any differences in hurricane preparedness between English-speaking communities and Spanish-speaking communities? 3) Are there geographical differences in hurricane preparedness across the Lower Rio Grande Valley? And 4) Which aspects of the hurricane forecast lead people to take storm preparations more seriously? This article finds that in the case of

about half of the sample believed they were at risk while the other half did not due to not trusting the information given, believing they were in a safe location, or they didn't believe that the weather report given was bad. None of the interviewees complained about preparation time before the storm, but preparation time varied from three days to six hours before the rainfall with the majority of people preparing the day before. This article is important to my research because it provides a case study about the impacts of Hurricane Dolly on the RGV. This allows me and others to understand why this research is important and how flood preparedness can help lessen the extent of risks in a storm.

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