Assessment of Damage Due to Hurricane Florence in Wilmington, NC

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Table of Contents

1. Introduction:

The United States has a long and tragic history of murderous hurricanes. The East coast of the US meets the North Atlantic Ocean. That's why it faces hurricanes more frequently than any other part. Hurricanes cause flooding which is the primary reason of the damage to life, infrastructure, and economy. In order to mitigate the damage from it, some precautions must be taken. That's why it's necessary to understand the pattern of inundation and plan for a better response.

1.1 Hurricane Florence:

Hurricane Florence hit the East coast during September 2018. It originated from Cape Verde as a tropical depression on August 30, 2018. Gradually, it became a category 4 major hurricane (Figure-1). Fortunately, it downgraded to a category 1 hurricane before making landfall in the US. It went on battering North Carolina, South Carolina, Virginia, and Florida. It resulted in 55 deaths in total of which 41 were in North Carolina. 3.4 million chickens and turkeys, and 5500 hogs died in the flooded farms. North Carolina alone tallied $12.7 Billion toll due to hurricane Florence.

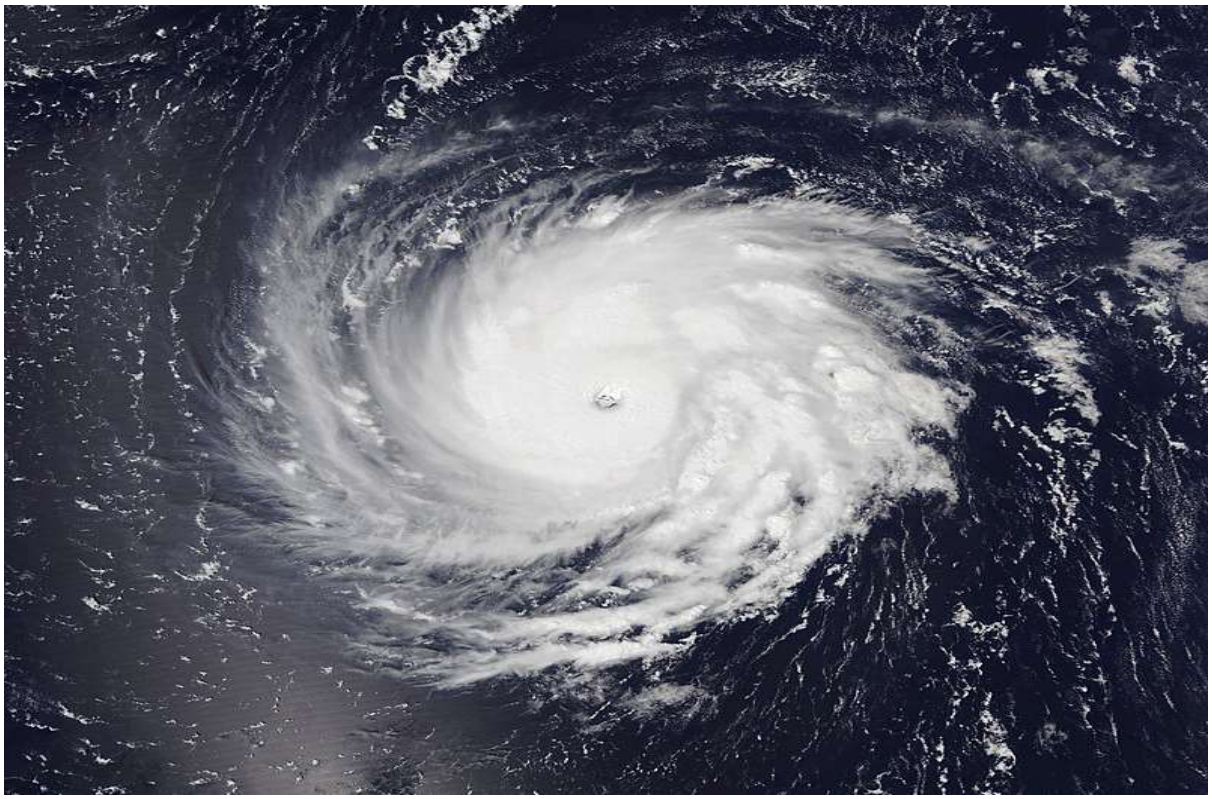

Figure-1: Hurricane Florence near its peak intensity

1.2 Study Area:

Hurricane Florence hit the North Carolina first and one of the cities that were highly damaged is Wilmington. Wilmington city is situated very close to the Atlantic Ocean and hurricane Florence also passed through South of it (Figure-2). That's why this city was chosen as the study area. Hurricane Florence caused record annual rainfall in Wilmington. As of October 1st, 86.7 inches of rainfall has occurred in 2018 while the previous record was 83.65 inches of rainfall back in 1877. This indicates how much impact Florence had on Wilmington.

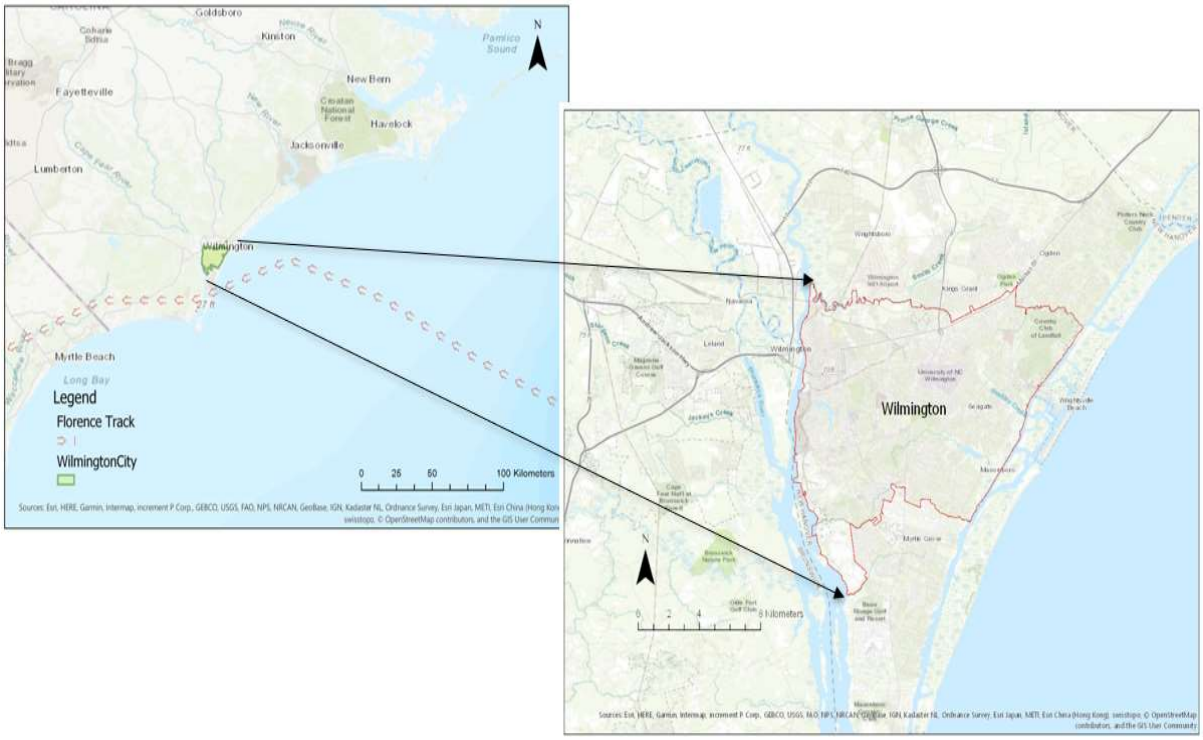

Figure-2: Study area and the track of the hurricane Florence

1.3 Objectives:

The main objective of this project is to quantify the inundated households. The objectives can be broken down as following:

a) Preparing a HAND Map
b) Preparing an Inundation Map
c) Quantify inundated households

2. Data Sources:

In this project, data from different sources were used. These data along with the sources are listed in Table-1. National Alliance for Public Safety (NAPS) GIS Foundation collected data from volunteers and prepared them to be used in ArcGIS. This is a great source of flooding data which is a contribution of people around the area. These data can be used to approximate inundation in absence of stream gauge data. Figure-3 shows the layout of the website for the crowdsource data.

Table-1: Data and their sources

Data	Source
10 m DEM	United States Geological Survey
Wilmington city shape file	United States Census Bureau
NHDPlus flowlines	United States Geological Survey
Crowdsource flooding data	National Alliance for Public Safety GIS Foundation
Hurricane Florence track	Unisys
Address points (2014)	NC One Map

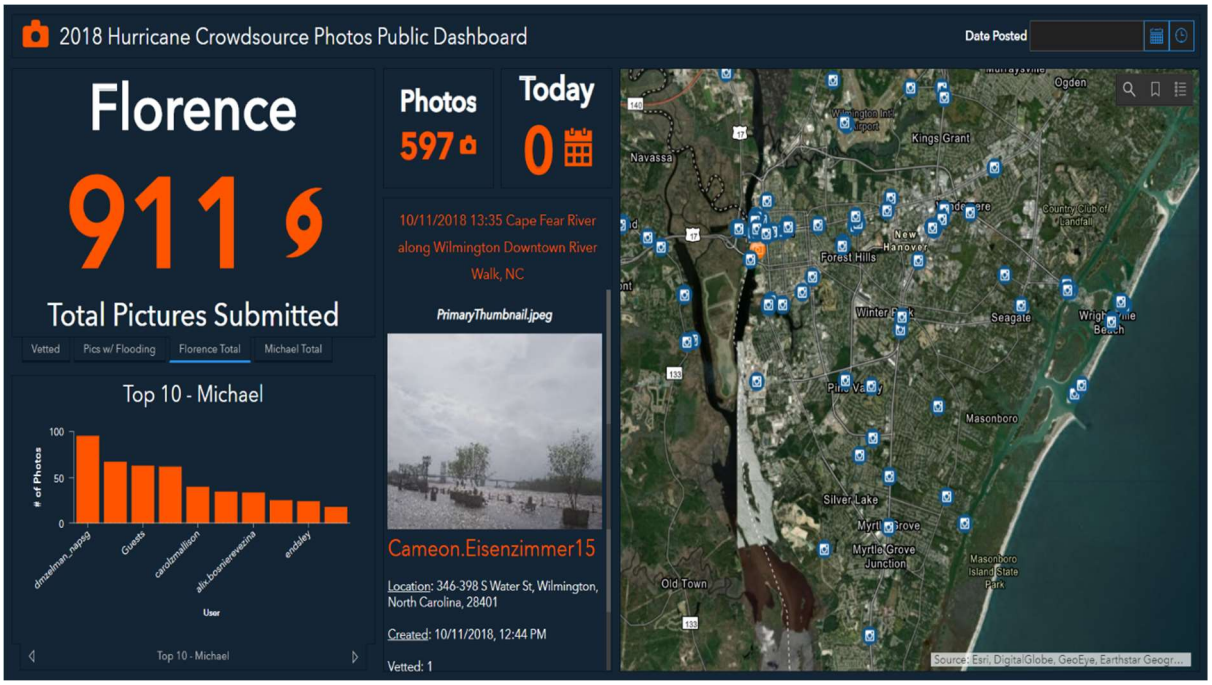

Figure-3: Crowdsource data website layout

3. Methodology:

The development of the whole project was split into several steps.

3.1 Preparation of the Base Map:

I started the project with preparing a base map (Figure-4). To prepare the base map, the downloaded data had to be edited considering the study area. A buffer of 2 km was created from the Wilmington city boundaries. This mask was used to extract the 10 m DEM in the background. The crowdsource data locations are also shown on the base map.

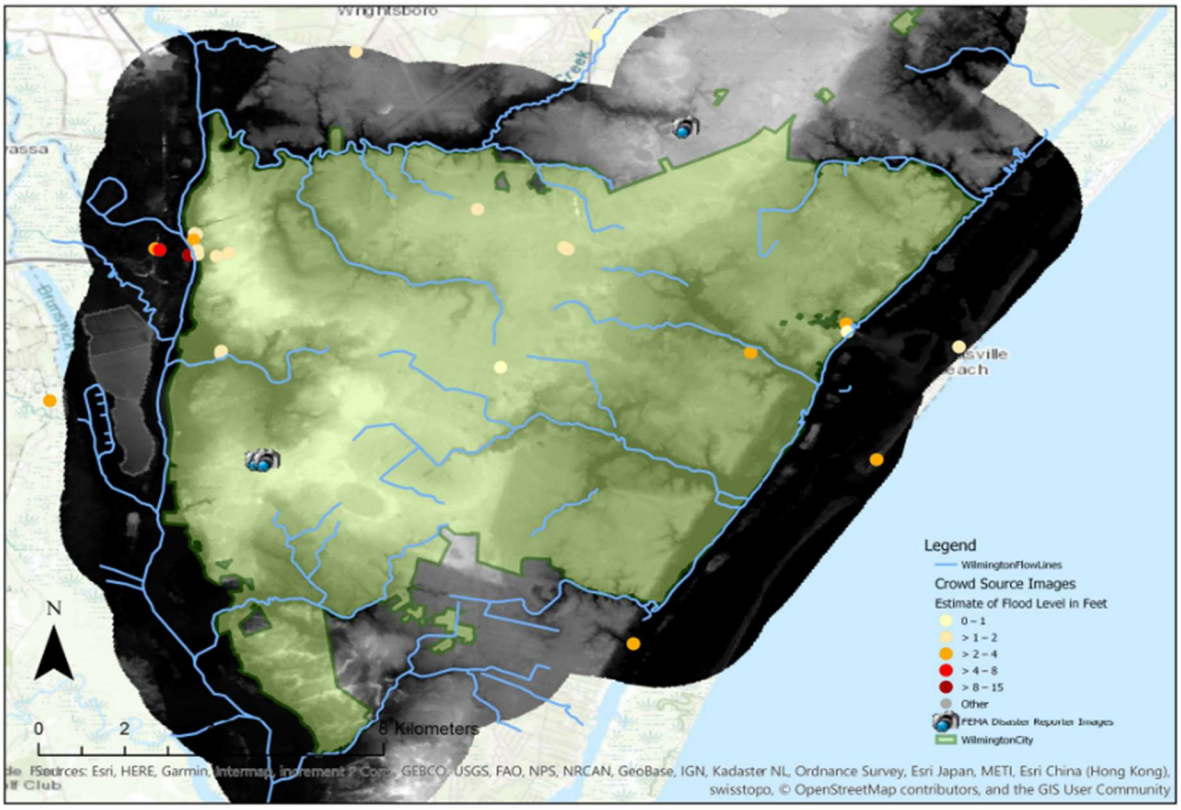

Figure-4: Base map of the study area

3.2 Building the Model:

A major portion of the project is inspired by the Exercise 5 that we did in the GIS class. Height Above Nearest Drainage (HAND) map is a great way to modify the raster to produce an inundation map. There are multiple steps to prepare a HAND map. That's why the model builder was used to build a model (Figure-5). This model can prepare a HAND map with a couple of inputs.

3.3 Preparation and Adjustment of the HAND Map:

The HAND map of Wilmington city prepared from the model was adjusted with proper symbology (Figure-6). From Figure-6, it can be seen that the HAND map goes from blue to red as the HAND values increase. The catchments for each of the drainage lines were used to divide the map into segments.

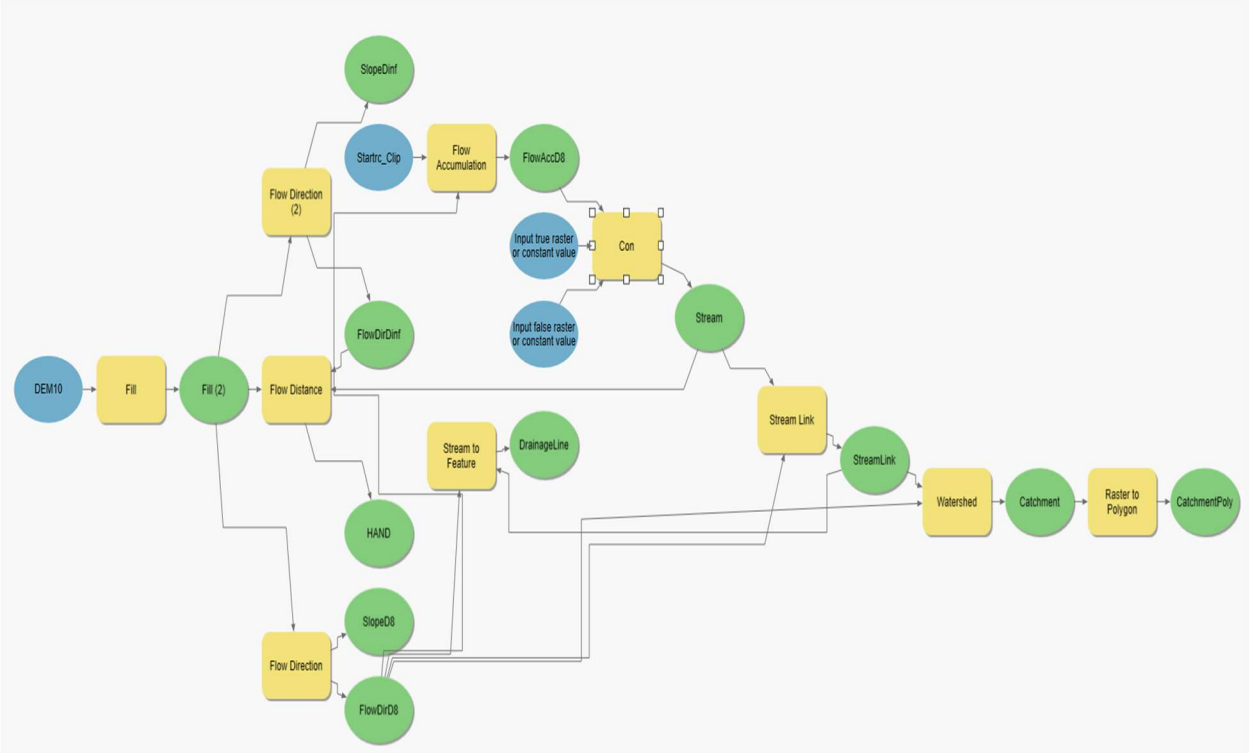

Figure-5: Layout of the model to prepare HAND map

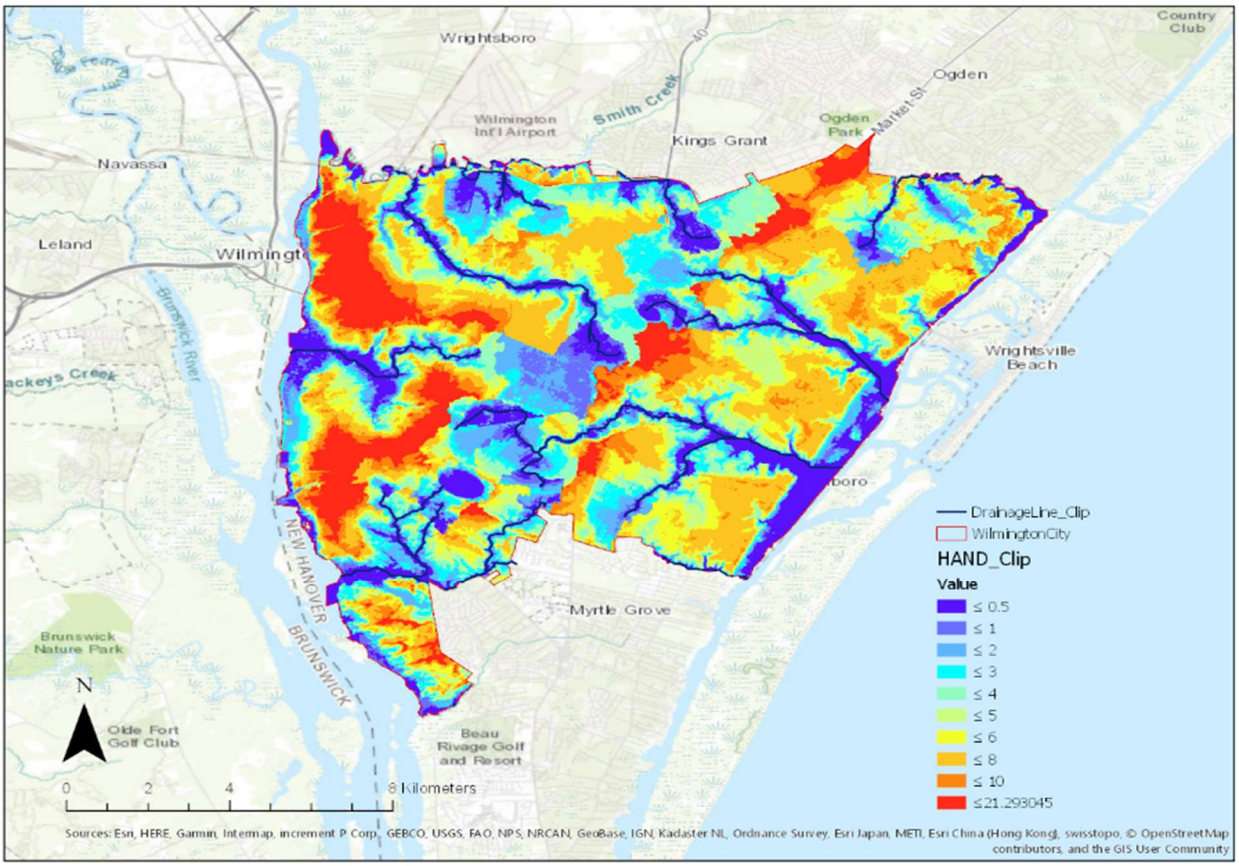

Figure-6: HAND map for Wilmington city

3.4 Preparation of the Inundation Map:

The crowdsource data were used to prepare the inundation map (Figure-7). The crowdsource data were in form of points on the map. So, each of the points were selected and the corresponding HAND value was calculated. Then, the HAND value was added to the flooding depth at that point. That summed up value was used and the HAND values for the corresponding catchment were subtracted from that. Any negative value was ignored as it meant that those points have greater elevation than the flood level. Thus, the inundation map for Wilmington city was prepared.

3.5 Quantifying Inundated Households:

The raster with inundation values was used to make polygon that consists of the inundated area. Using select by location feature the inundated households were selected from all the

address points in Wilmington. Then, they were quantified to determine the number of households inundated.

4. Results:

The inundation map (Figure-7) shows only the inundated parts in Wilmington city. The red portion has inundation depth varying from 2 to 3 m and it dominates most of the inundated area. Most of the inundation occurs at the edges and middle portion of the city. The middle portion of Wilmington city has low elevation compared to the surrounding area and that contributed to such inundation in the middle part.

Figure-8 shows the inundated households along with all the households in Wilmington. The red colored ones represent the inundated households and the purple ones are non-inundated. The calculated results are presented in Table-2. It shows that 21.43% of the households in Wilmington city were inundated due to Hurricane Florence.

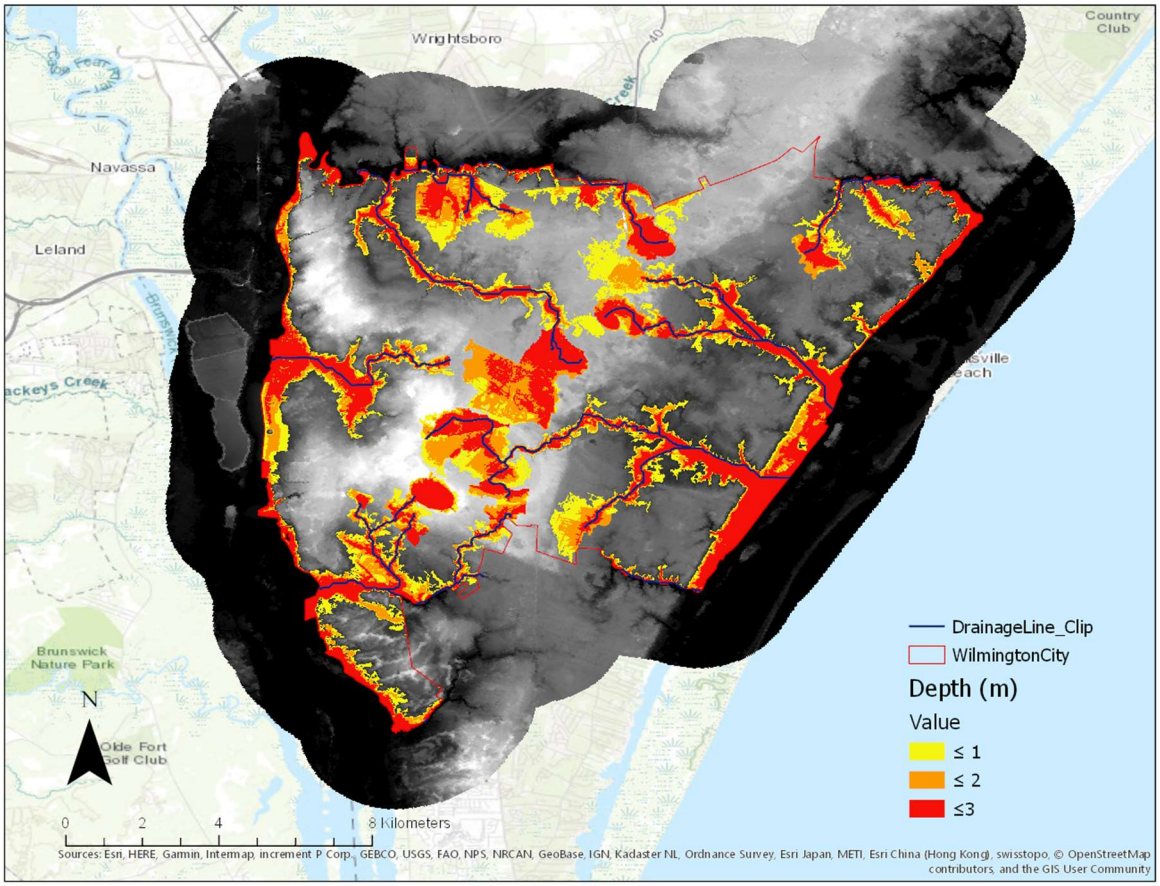

Figure-7: Inundation map for Wilmington city

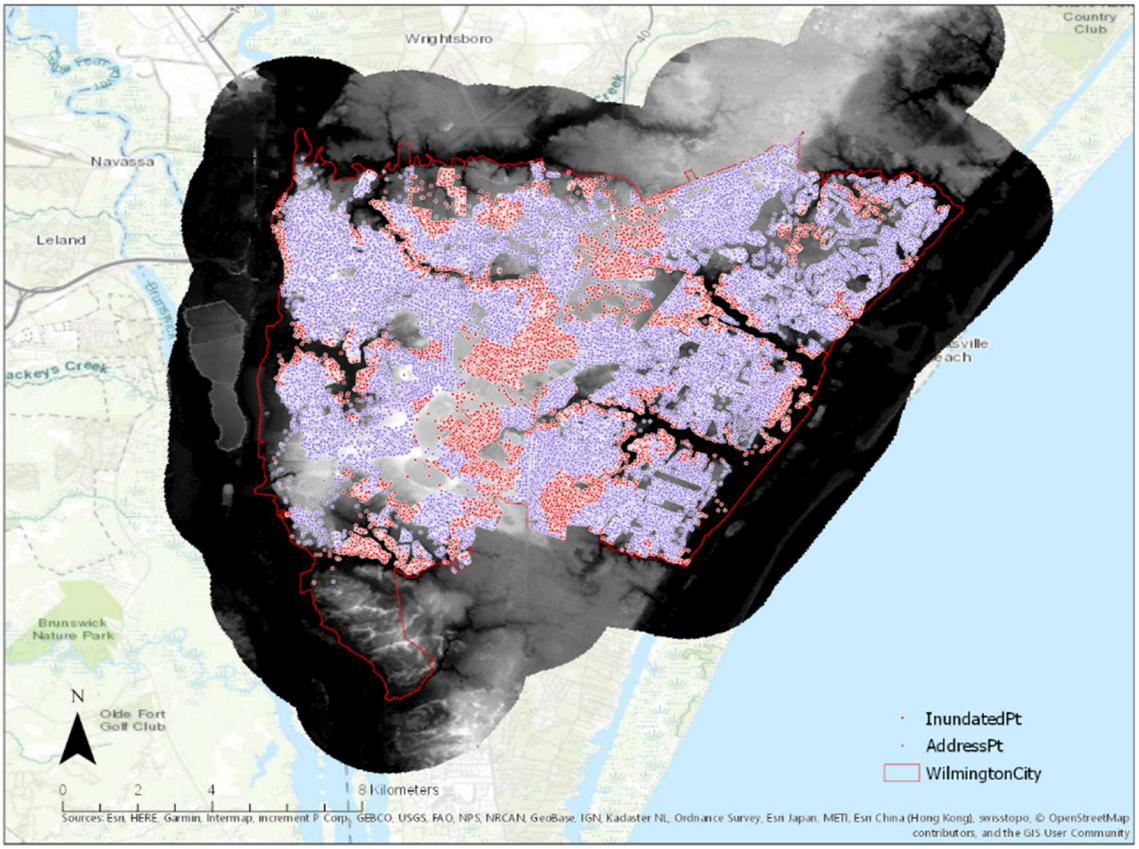

Figure-8: Map showing the inundated households in Wilmington city

Table-2: Inundated households in Wilmington

Total households	Inundated households	% of households inundated
49405	10588	21.43

5. Conclusion:

This project showcases the effectiveness of simple methods to quantify the inundation in a specific area. The HAND method is a very time consuming and relatively easier approach to produce inundation maps. Whereas other modeling approaches require a lot of time and significant amount of data, this method requires less time and data.

The use of crowdsource data in this project demonstrates that voluntary efforts by common people can be useful in the time of emergency. NAPS Foundation did a great job in collecting

all these data from the volunteers. This type of data can be used in future in larger extent in times of crisis. That's why the collection of data by volunteers should be encouraged more.

Definitely, modeling with sophisticated data gives better results. But that requires more time, effort and money. That's why the methods and data used in this project can be considered. Although that should be in cost of some accuracy. But in a crucial situation, this may come in very handy.

6. References:

[1] National Weather Service. https://www.weather.gov

[2] United States Geological Survey. https://www.usgs.gov

[3] NC One. http://nconemap.com

[4] Unisys. https://www.unisys.com

[5] United States Census Bureau. https://www.census.gov