UNIVERSITY OF GEORGIA
Institute for Resilient Infrastructure Systems

Strengthening Athens-Clarke County, Georgia's Resilience to Future Flood Risks

Final Report: AT&T Climate Resiliency Community Challenge Grant

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February 25, 2021

Executive Summary

This report summarizes the research and outreach activities conducted by the Institute for Resilient Infrastructure at the University of Georgia for the AT&T Climate Resiliency Community Challenge Grant program. Flooding is one of the most frequent and costly natural disasters in the United States. Importantly, the impacts from flooding are not equal, with socially vulnerable populations at higher risk and less able to cope. For this research, we partnered with the Athens-Clarke County, GA, government to assess current and future flood risk and social vulnerability in the county.

As part of the grant program, AT&T provided us with model data produced by Argonne National Laboratory on current flood exposure and future flood risk under various climate change scenarios. We used these valuable data with flood risk estimates from other sources in three different analysis: (1) a flood index to comprehensively assess current flood risk in the county, (2) a social vulnerability analysis to determine where minority populations (i.e. Black, Hispanic, and economically disadvantaged persons) are over-represented in high flood risk areas, and (3) a climate change analysis to assess how flood risk and social vulnerability will change under projected climate change.

Flood Risk: We found that traditional data sources on flood risk - flood insurance rate maps from the Federal Emergency Management Administration (FEMA) - do not fully represent flood risks. There are many areas outside this "regulatory floodplain" that have significant flood risk. Our flood index uses multiple data sources to more comprehensively assess flood risk, which may be neglected by FEMA maps. We found the highest flood risk was primarily concentrated in the densely populated center of Athens-Clarke County.

Social Vulnerability: We identified several locations where Black, Hispanic, or economically disadvantaged populations were disproportionately at risk of flooding. Depending on location, these communities had 40% - 185% higher flood risk compared to the average risk.

Climate Change: Flood risk is expected to increase in Athens-Clarke County due to climate change. This increase is consistent for smaller, more frequent floods and larger, rarer floods. We found the social effects of increased flooding to be more variable – social vulnerability metrics either increased, decreased, or stayed the same, depending on location in the county. However, we still identified significant social disparities in flood risk exposure, and the flood risk experienced by these vulnerable populations will only increase in the future.

The results of this research are valuable for the Athens-Clarke County government and citizens to inform planning efforts, decisions, and infrastructure investments for reducing flood risks and associated social impacts. This study has identified locations with significant social disparities that can be prioritized for equitable investments in flood risk reduction. We have presented these results to the Oconee Rivers Greenway Commission, a chartered citizen committee that advises the Athens mayor and county commission on matters related to managing the two major river systems and associated floodplains that flow through Athens-Clarke County. They are interested in using this information for prioritizing greenway projects that reduce flood risks while enhancing mobility, recreation opportunities, water quality, habitat, and other benefits. We are

also working with Athens-Clarke County to incorporate this work into their Sustainability Plan in order to support future flood preparedness, adaptation, and community well-being. The Sustainability Plan should be released in late spring of this year.

1 Introduction

According to FEMA, flooding is the most frequent and costly natural disaster in the United States (National Flood Insurance Program and National Oceanic and Atmospheric Administration, 2010). The risk flooding poses to people and property is only expected to increase. Expanding urban development and heavier rainfall caused by climate change are increasing storm runoff. This has the potential to overwhelm existing infrastructure designed for smaller storms, leading to more frequent and damaging flood events.

Flooding does not impact communities equally. On a national level, socially vulnerable populations, characterized by unemployment, poverty, single-mother households, and no health insurance, are more likely to be exposed and less able to respond to flooding (Qiang, 2019). In the region stretching from Atlanta, GA, to Charlotte, NC, the Black population is over-represented in the flood zone due to historical discrimination of Black communities during the development of these major cities (Debbage, 2018). We expected to see similar trends in Athens-Clarke County since it neighbors this region. These socio-economic and racial inequalities in flood risk need to be considered when analyzing flood impacts and designing equitable solutions.

It is vital that local governments have updated data on current and future flood risk to make wise investments in infrastructure so that members of communities can be protected equally from the growing risk of flooding. Unfortunately, local governments often lack the resources to develop these data themselves and may rely on outdated or incomplete data from other sources. For this reason, we used the hydrologic data developed by Argonne National Laboratory and AT&T to provide the Athens-Clarke County government in Athens, GA, with an updated analysis of current and future flood risk, including an analysis of social vulnerability to flooding. Specifically, we conducted three analysis: (1) a flood index, which incorporates flood data from multiple sources to describe flood risk across the county; (2) a social vulnerability analysis, determining the demographic makeup of who is in the flood zone; and (3) a climate change analysis, predicting how climate change may increase flood risk in the future.

2 Flood Index

2.1 Methods

Typical flood risk analyses rely on flood insurance rate maps developed by FEMA. While these maps are useful for determining flood insurance rates, they suffer from several deficiencies. First, they are only created for a single flood event (the “100-year” flood that has a one percent chance of being exceeded each year). Second, they are unavailable for many areas in the United States, even in areas that experience flooding. Finally, they may be outdated and not reflect

current conditions, and do not project future flood risk due to climate change and land use change. For these reasons, we developed an integrated flood index to represent flood risk more comprehensively in Athens-Clarke County by combining data from three different sources: Argonne National Laboratory and AT&T, FEMA National Flood Hazard Layer (FEMA Flood Map Service Center, 2016), and recent, parcel-level flood analysis from the First Street Foundation (First Street Foundation, 2020).

Each data source has different methods that account for certain factors of flooding but have holes in other areas. FEMA provides a 100-year floodway which results in a binary flood risk (either you are in the flood zone or you are not) for only one storm size, but Argonne and First Street provide flood depths at specific locations for multiple flood sizes. FEMA thoroughly analyzes rivers, but not smaller creeks and waterways that could lead to flooding (FEMA Flood Map Service Center, 2016). The flooding outside of the rivers is captured by Argonne and First Street because they consider the entire area of the county, Argonne with a spatial grid of data and First Street with parcel scale data. Both Argonne and First Street considered flooding resulting from rainfall ponding on surfaces. First Street also considered flooding of rivers to generate their flood data (AT&T, 2019; Wing et al., 2017). Argonne and First Street consider climate change in their analysis and provide projected future flood data, but FEMA does not (First Street Foundation, 2020). Considering these three data sources and lines of evidence together provides a more comprehensive picture of flooding in Athens-Clarke County.

For this analysis, we considered the 100-year flood and looked at whether a parcel was inundated or not. We used a weighted average of the three data sources described above to calculate an index value of risk for each parcel in Athens-Clarke County (from 0 to 1, with 1 being the highest flood risk). We averaged the flood index of flooded parcels according to census tract and watershed.

2.2 Results

Figures 1 and 2 show average flood index in Athens-Clarke County by census tract and watershed, respectively. The central census tracts that have the greatest flood risk are the areas in the county with the most development. This contains the downtown area and the University of Georgia and a lot of housing. The surrounding areas are less developed and have more pervious land, which is why the flood risk is likely lower in those areas. This pattern is also reflected in the watershed analysis as the central sections of the county have the greatest risk. The reason for the flood risk expanding outside of the central area to the north and south portions in the watershed analysis is likely due to how the watersheds are delineated.

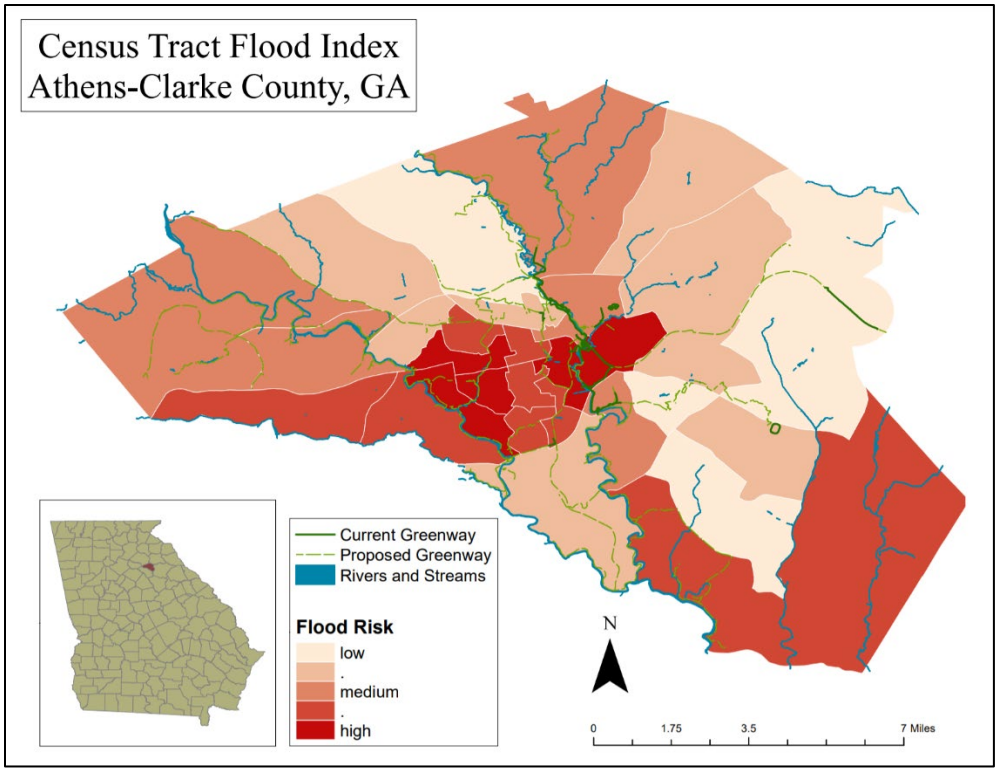

Figure 1 - Flood Index by census tract for Athens-Clarke County.

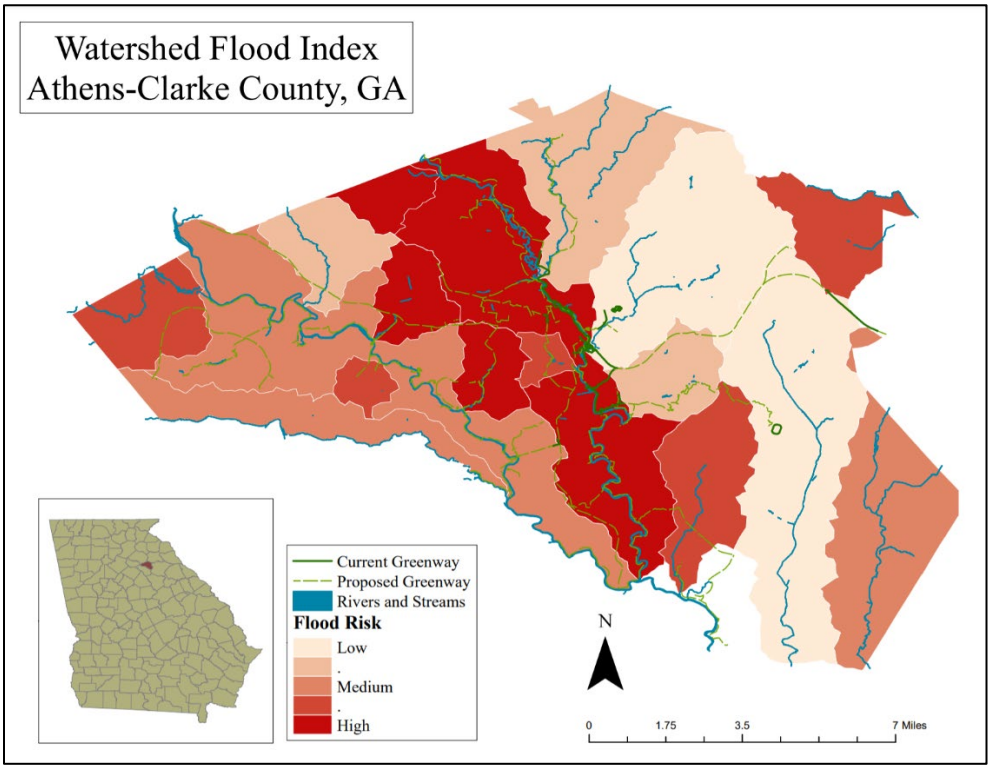

Figure 2 - Flood Index by watershed in Athens-Clarke County.

In Figure 3, the FEMA 100-year flood zone is overlayed with the parcel flood index map. This analysis shows that there are approximately 1,500 parcels that are at risk of flooding, despite being located outside of the FEMA 100-year flood zone. This is to demonstrate that there is flood risk outside of the FEMA flood zone that needs to be accounted for in flood prevention/mitigation efforts.

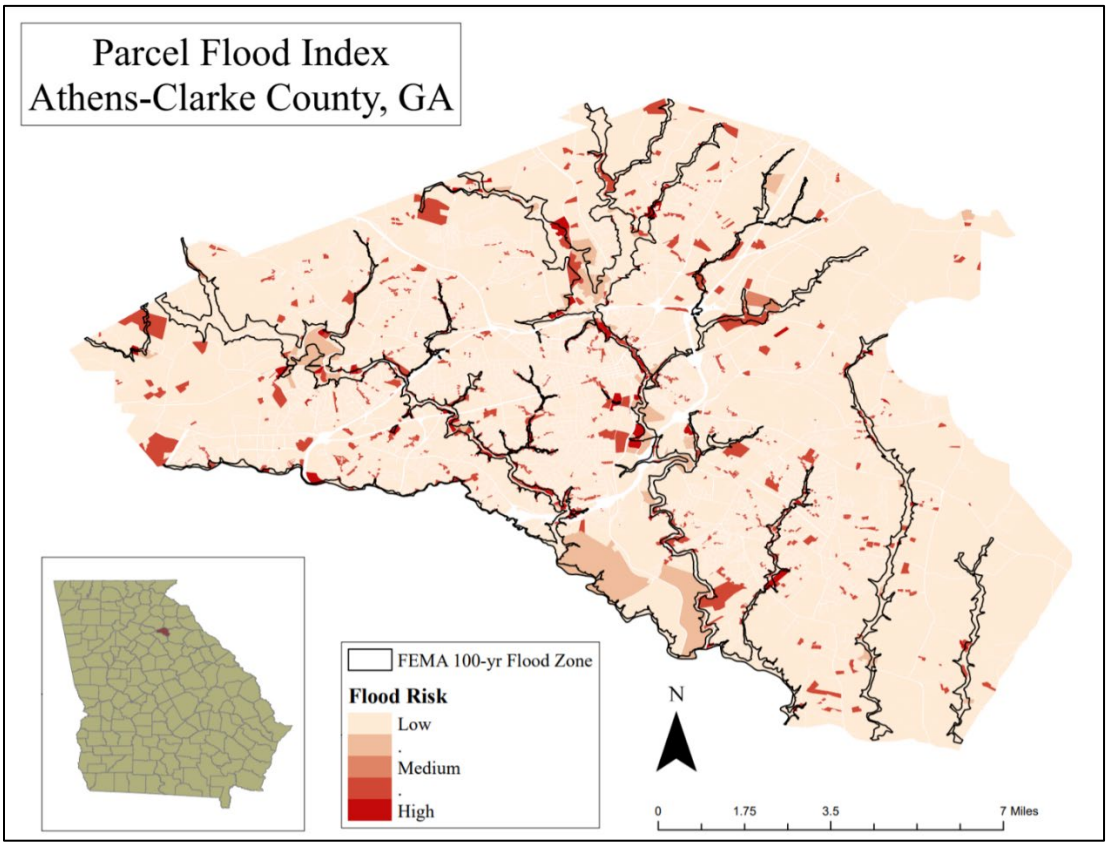

Figure 3 - Parcel Flood Index with FEMA 100-yr Flood Zone

3 Social Vulnerability

3.1 Methods

The flood index shows the areas of greatest flood risk. The next step was to determine who is in this flood zone. We wanted to compare the presence of socially vulnerable populations based on race, ethnicity, and income status in the flood zone to the presence of non-socially vulnerable populations to determine if there was overrepresentation.

We used the First Street flood data because it was available at the highest spatial resolution and was more conducive to this kind of analysis (Wing et al., 2017). For this analysis, we followed methods used by Neil Debbage who did a similar study of the I-85 urban corridor from Atlanta to Charlotte. In his methods, he used flooded, developed area to correspond to the people at risk

and used that factor with census data to compare the presence of demographic populations in the flood zone (Debbage, 2018).

For each of the 72 census blocks in Athens-Clarke County, we calculated a factor that was equal to the proportion of flooded, developed land in the block. We only used developed land based on the assumption that people are not residing in undeveloped properties to prevent over-estimating the at-risk population (Debbage, 2018). We then multiplied this factor by the population data for each block to calculate at risk populations (National Research Council, 2007). Census blocks are grouped into census tracts, so to find the at-risk population for each tract, we summed the at-risk population for each block in the tract. The total at-risk populations for each census tract were used to calculate risk ratios.

Risk ratios compare the percent of one demographic present in the flood area to the percent of a different demographic in the same flood area. Because risk ratios use percentages, the results are not affected by having more of a certain population in the census tract. We performed the following comparisons with the equation below:

$$Risk\ Ratio = \frac{\frac{at-risk\ population\ \#1}{total\ population\ \#1}}{\frac{at-risk\ population\ \#2}{total\ population\ \#2}}$$

Population #1	Population #2	Results
Black Population	White Population	> 1, Black population overrepresented
Hispanic Population	Non-Hispanic Population	> 1, Hispanic population overrepresented
Poverty Population	Non-Poverty Population	>1, poverty population overrepresented

We calculated all three risk ratios (i.e., for Black, Hispanic, and populations in poverty) for each of the 30 census tracts in Athens-Clarke County. We then performed the same analysis at the watershed scale.

3.2 Results

Figure 4 indicates the census tracts with statistically significant risk ratios for the 100-year flood. The results from the watershed scale analysis are pictured in Figure 5. We found that eight census tracts and four watersheds in Athens-Clarke County have Black, Hispanic, or low-income status people overrepresented in the flood area when compared to their counterparts. Even though the values of risk ratios were different between the two analyses, there are similarities in the location of social vulnerability issues, indicated by statistically significant risk ratios. In both analyses, the risk ratios are present in the central portion of the county that is most developed where the greatest flood risk is. There were no instances of more than one statistically significant risk ratio occurring in the same area. We were surprised at these results because we expected these factors of social vulnerability to overlap within the same population.

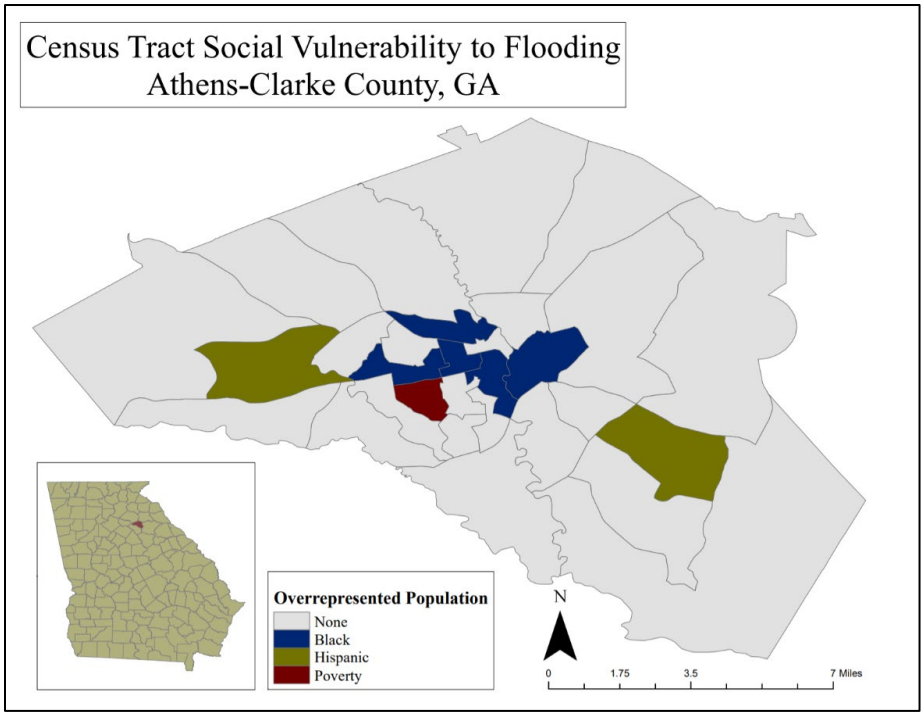

Figure 4 - Social vulnerability in Athens-Clarke County by census tract. Colored tracts represent statistically significant risk ratios indicating Black, Hispanic, or those in poverty are over-represented in flood prone areas for the 100-year flood event.

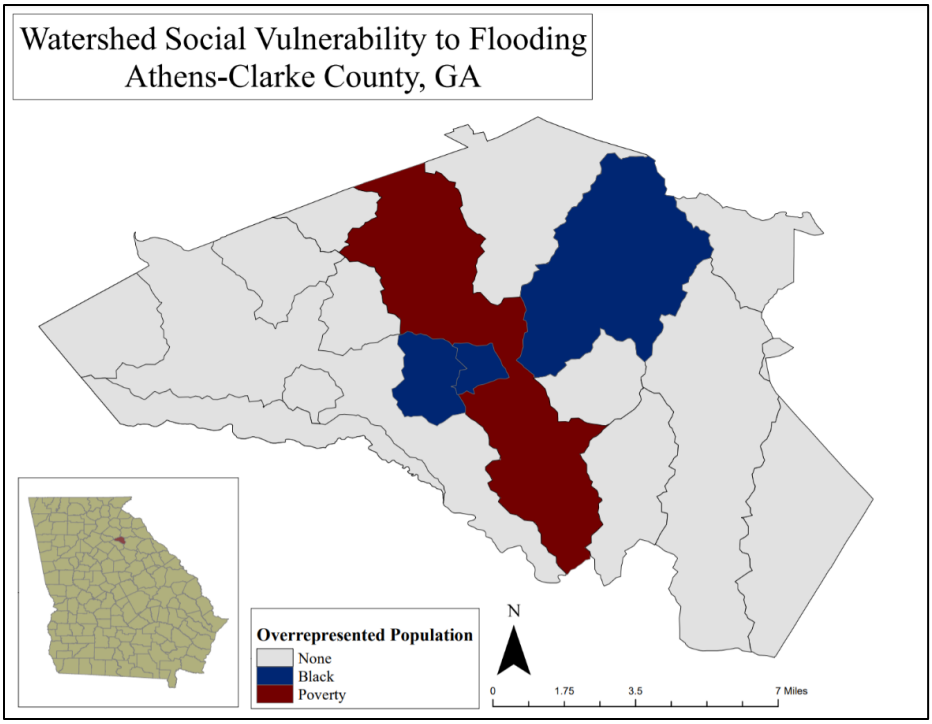

Figure 5 - Social vulnerability in Athens-Clarke County by watershed. Colored watersheds represent statistically significant risk ratios indicating Black populations or those in poverty are over-represented in flood prone areas for the 100-year flood event.

Next, we wanted to compare the risk ratios - indicators of social vulnerability - to the populations of census tracts and watersheds with significant results. These results are displayed in Figures 6 and 7. We found in almost every scenario, the population that was overrepresented in the flood zone is the minority in the census tract or watershed. The overrepresented socially vulnerable population was between 38% and 185% more likely to be in the flood zone than their non-vulnerable counterpart.

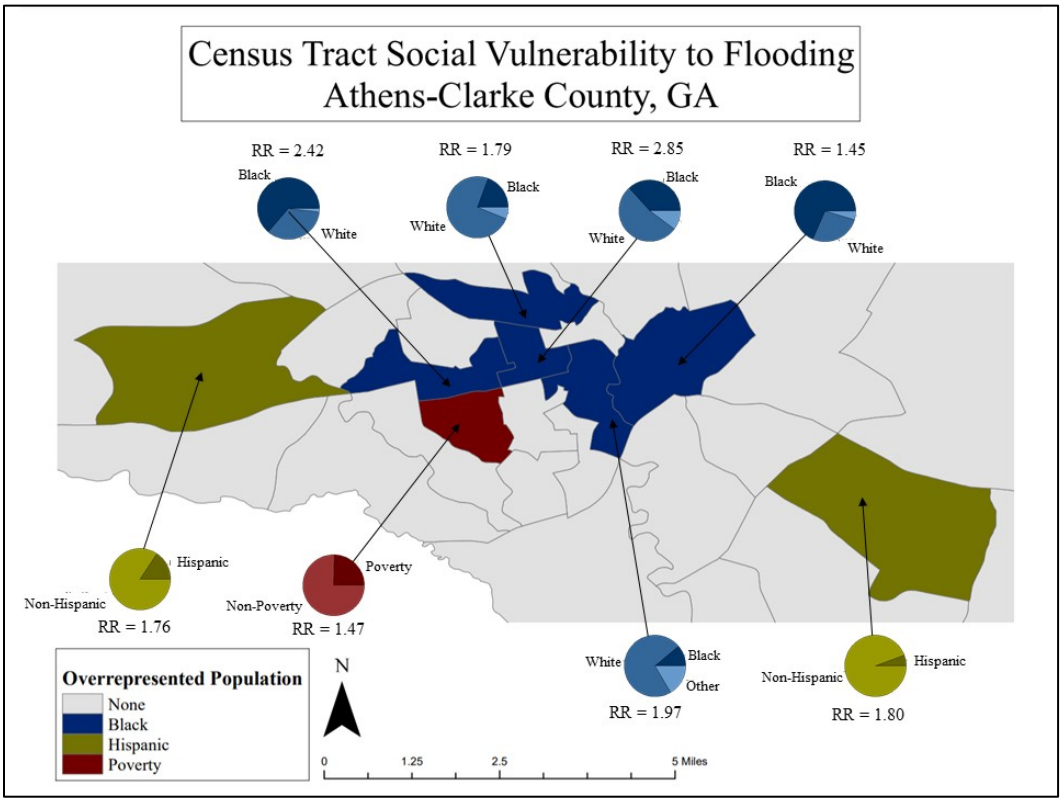

Figure 6 - Social Vulnerability with Demographics

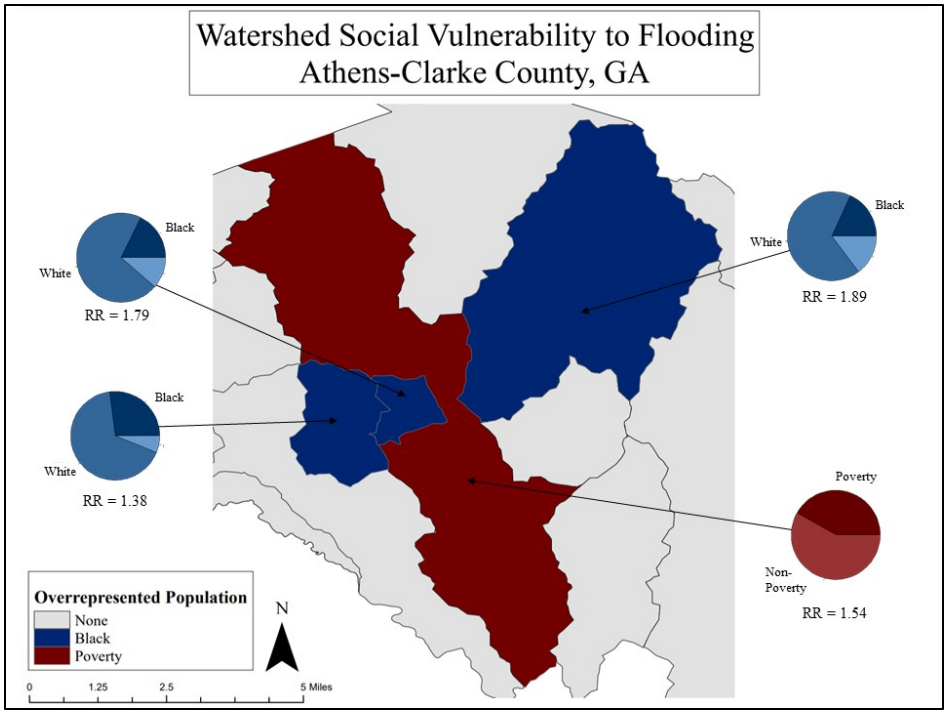

Figure 7- Watershed Social Vulnerability zoomed in

We also wanted to investigate how social vulnerability changes according to flood size. We looked at the 5, 10, 20, 50, and 100-year floods and found that as flood size increased, more areas had significant risk ratios. This means that the effect of flooding on socially vulnerable populations increases as floods increase in size.

4 Climate Change

4.1 Methods

Because flooding is expected to increase, it is important to have updated flood data to know current and projected flood risk. Our final analysis considered how climate change would impact flood risk and the social vulnerability in the future. We used parcel scale data from First Street to compare flood risk and social vulnerability risk ratios between 2020 and 2050 for the 5, 10, 20, 50, and 100-year storms.

4.2 Results

The number of affected people and the number of flooded properties increased due to climate change for all flood events and storms (Table 1). We found that under climate change the number of affected people increases the most for smaller floods. The opposite is true of the number of flooded properties; they increase the most under large floods. The reason for this difference is that a portion of the flooded properties are undeveloped, so no structures and residences are affected. However, if these properties were developed in the future, the number of affected people would increase even more.

Table 1 – Effects of Climate Change on People and Properties across Flood Sizes				
Flood Size	**2020 Number of Affected People**	**Increase in Number of Affected People by 2050**	**2020 Number of Flooded Properties**	**Increase in Number of Flooded Properties by 2050**
5-year	1414	535	734	69
10-year	3661	486	1625	100
20-year	4388	223	1955	88
50-year	4702	152	2030	132
100-year	4702	152	2030	132

When it came to changes in social vulnerability resulting from climate change, there was no consistent pattern. In some instances, risk ratios increase, indicating that as flooding increases, disparities in social vulnerability also increase. Flooding did not change drastically in some instances; therefore, social vulnerability was not substantially affected. In other instances, flooding increased but the risk ratio values decreased, indicating that disproportionate levels of social vulnerability are most apparent in the area of flooding closest to waterways. While the risk ratio is relatively lower in this instance, social vulnerability is still present.

To further illustrate the effects of climate change on flooding, we present Census Tract #600 in Athens-Clarke County as an example. Under the 10-year flood, we found that in 2020 there was no flooding indicated, but in 2050 under climate change, there was flooding (Figure 8). This amount of flooding corresponds to 9.6 acres of land and 123 people affected. Because there is no flooding in 2020, there is no way to calculate the risk ratio. However, the risk ratio is 2.19 in 2050, meaning that a Black person is 2.19 times more likely to reside in the flood zone.

In this situation, social vulnerability issues were exposed by flooding of new areas. This presents a concern for potential flooding under climate change to not only affect new areas and people, but also affect the socially vulnerable most.

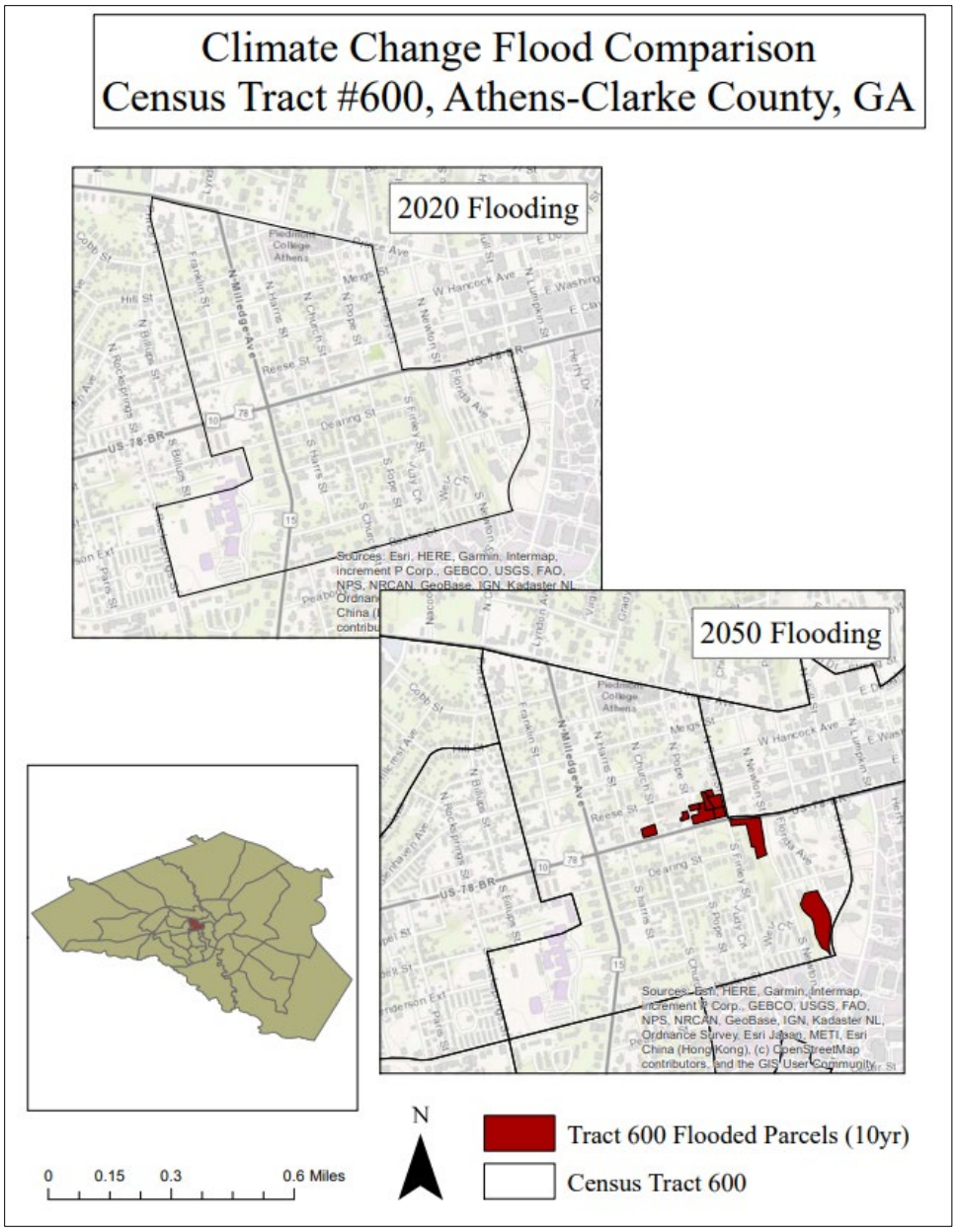

Figure 8 – Flooding in Census Tract #600 in 2020 compared to projections for 2050.

5 Conclusions

This research compiled flood data from multiple sources to provide a more complete picture of flood risk for Athens-Clarke County, GA. Specifically, we show significant flood risk outside the traditional "100-year flood zone" indicated by FEMA flood maps. Additionally, we identify locations where socially vulnerable populations (Black, Hispanic, and low-income populations) are disproportionately represented in areas with high flood risk. We also assessed the implications of increasing flood risk due to climate change, and show an increase in social vulnerability due to flooding in new areas. These results can be used by the Athens-Clarke

County government to help prioritize investment in flood infrastructure and develop equitable solutions that can reduce risk for vulnerable populations. We have already discussed these findings with local decision makers and multiple Athens-Clarke County departments.

Most recently, we presented these results to the county's Oconee Rivers Greenway Commission. This commission is comprised of citizens selected by the mayor and by the University of Georgia. The commission is responsible for developing the network of greenways along the Oconee Rivers to protect the rivers and provide recreation. The riparian buffers along these greenways reduce flood risks in addition to providing recreation, conservation, and other benefits.

This committee was very interested in using the flood index and social vulnerability information in their network planning efforts. The results of this study can help to prioritize greenway establishment in high risk watersheds to reduce flood hazards and address social vulnerability concerns. Additionally, we are in discussions with Athens-Clarke County on the best way to incorporate these results into their Sustainability Plan. The methods and data developed in this study can also be extended beyond this area to assess flood risk and social vulnerability in other cities and towns across the United States.

6 Citations

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