Fulton County Resilience Study

James Dickey and Evie Lee

July 2024

Table of Contents

Executive Summary

Fulton County, Georgia, faces significant climate risks exacerbated by socio-economic disparities, necessitating a focused evaluation of its climate resilience. This study emphasizes the vulnerabilities and adaptive capacities of underserved communities, aligning with the county's 2019 Sustainability + Resilience Plan and the 2022 Multijurisdictional Hazard Mitigation Plan. Employing a comprehensive methodological approach, the study utilized data from federal, state, and local sources, including climate predictions from the Climate Mapping for Resilience & Adaptation (CMRA) website, socioeconomic data from the 2020 Fulton County Census, and the U.S. Climate Vulnerability Map. Key findings identified extreme heat, increased flooding, and air pollution as significant risks disproportionately affecting disadvantaged communities. Existing resilience initiatives were evaluated for effectiveness and scalability, with successful adaptation practices from other urban areas informing recommendations. The study proposes actionable strategies to enhance resilience, including green job training programs, public awareness campaigns, and partnerships with local organizations. These strategies aim to ensure equitable and accessible protective measures for all demographic groups. Implementing these recommendations will require collaboration, monitoring, adaptive management, and community involvement to foster a resilient environment where all communities in Fulton County can thrive, mitigating the impacts of climate change and enhancing overall community resilience.

Introduction

Climate risks pose an escalating threat to communities worldwide, with its impacts felt most acutely by those already facing social and economic disadvantages. Fulton County is no exception and is poised to experience the effects of changing weather. As Georgia's most populous county[1], Fulton County's diverse landscapes and climatic conditions intersect with a socioeconomically varied population, creating unique challenges for resilience planning. This study aims to evaluate Fulton County's climate resilience, focusing particularly on the vulnerabilities and adaptive capacities of underserved or disadvantaged communities. Additionally, it will recommend actionable steps that Fulton County can take.

This evaluation is aligned with Fulton County's 2019 Sustainability + Resilience Plan to address emerging climate challenges and propose solutions to make progress within the county's capacity. This report is also aligned with Fulton County's 2022 Multijurisdictional Hazard Mitigation Plan, which aims to lessen the severity of impacts caused by environmental hazards. Similar to this study, the Hazard Mitigation Plan identifies major climate hazards, previous occurrences, major impacts, and provides a vulnerability assessment. This new resilience study has the purpose of identifying key vulnerabilities and risks posed by climatic variations, proposing actionable strategies to enhance resilience, and ensuring that protective measures are equitably distributed across all demographic groups.

The urgency of this research comes from the disproportionate impact on disadvantaged communities. Whether it is extreme heat, increased flooding, or the release of harmful pollutants in the air, disadvantaged communities are the ones on the front lines. They often lack the resources to effectively respond and recover from climate related events like rising temperatures and more severe weather. By focusing on these populations, this study seeks to highlight the critical need for inclusive and equitable resilience planning.

The content of this study will include a comprehensive background on Fulton County's geographic and climatic context, a detailed methodology outlining data collection and assessment tools, an analysis of current vulnerabilities and risks, an evaluation of existing resilience efforts, and finally, recommendations for policy and community-based solutions designed to foster a resilient Fulton County where all communities can thrive.

Methodology and Data Collection

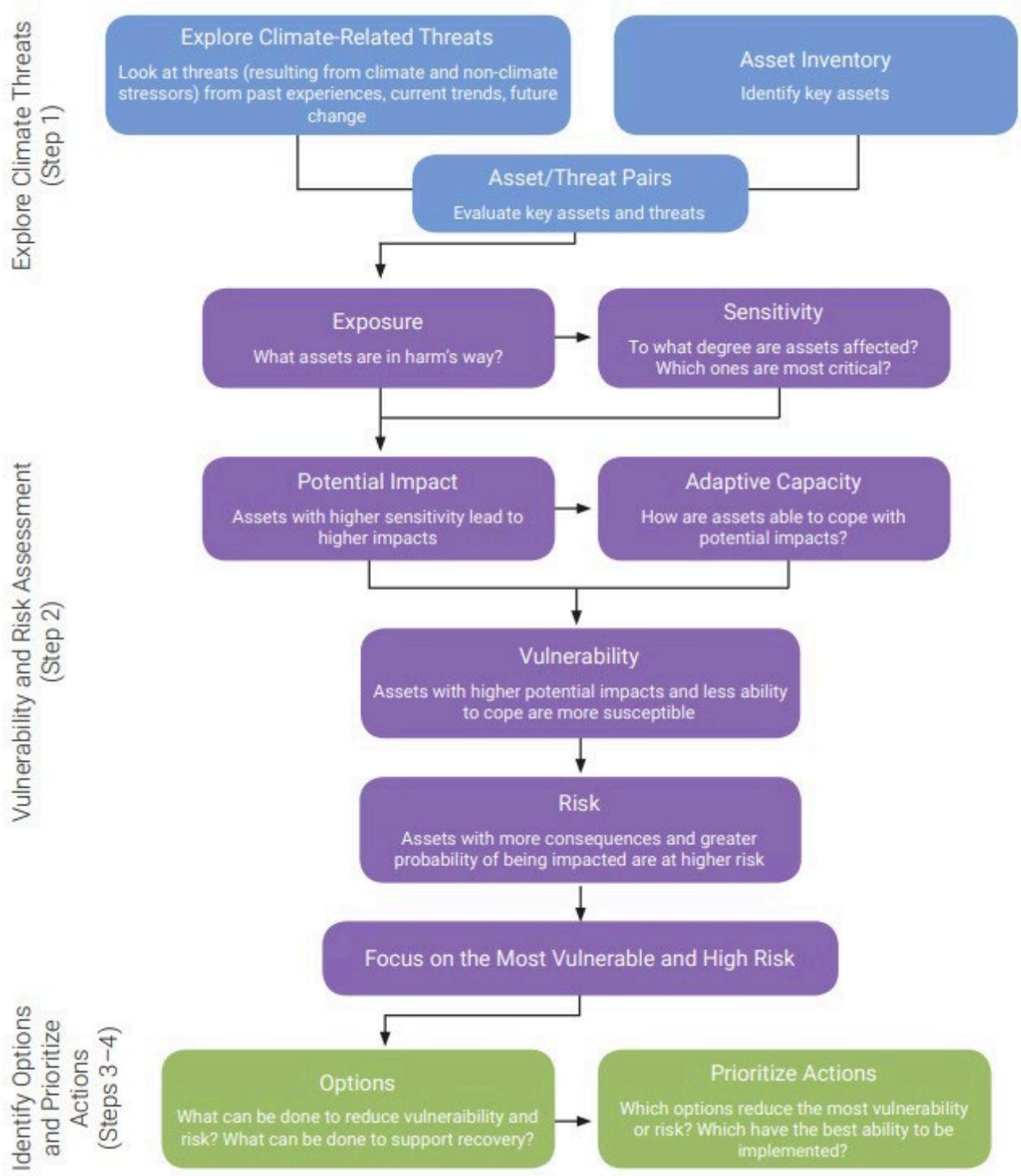
This study utilized a comprehensive methodological approach to identify climate vulnerabilities, assess risks, and propose actionable strategies for Fulton County, with a focus on underserved communities. To effectively evaluate the county's climate resilience, this study began by gaining an understanding of its climate and geographic context such as the varied landscapes with high density urban areas to sprawling rural areas. Primary data sources include government documents from agencies such as the Federal Emergency Management Agency (FEMA), The U.S. Climate Resilience Toolkit, and several other federal, state, and local data sources. These documents and maps provide foundational data and guidelines essential for assessing climate resilience at the local level. Additionally, climate and weather data from the Climate Mapping for Resilience and Adaptation (CMRA) website were used to predict future climate patterns in Fulton County, enhancing our understanding of potential climatic variations over time.

[1] U.S. Census Bureau. n.d. "Explore Census Data," (Data.census.gov.).

In addition to government reports and mapping software, this study will use socioeconomic data found in the 2020 Fulton County Census as well as the U.S. Climate Vulnerability Map published by the Environmental Defense Fund and Texas A&M University. The U.S. Climate Vulnerability Map shows climate vulnerability on a local scale going so far as to show the vulnerability of different census tracts within the county. This quantitative data identifies the most at-risk communities and neighborhoods within the county. The data from the map is very specific as well, going into detail about future climatic conditions, financial stressors, health effects from pollution, and adverse effects on infrastructure. It combines all of these categories to accurately predict the vulnerability of local communities in the coming decades. In addition, the U.S. Climate Vulnerability Index allowed for the analysis of the correlation between climate hazards and health outcomes while focusing on climate-sensitive health conditions such as asthma and heat-related illnesses.

Successful resilience initiatives in other urban areas were examined to inform the research methodology and potential next steps. Asheville, North Carolina's Planning for Climate Resilience study provides helpful steps towards successfully reaching resilience by focusing on the most vulnerable communities and thinking about future impacts and capacities for adaptation. Asheville's Plan for Climate Resilience highlights the steps shown below as a framework that was used for proposing this study's adaptation measures.[2]

[2] City of Ashville. "COA_Climate_Resilience_Final_Report_April_2018_reduced for Web.pdf," (Ashvillenc.gov, 2018).



Through the assessment of Fulton County's 2019 Sustainability + Resilience Plan and the Hazard Mitigation Plan, this study identified covered priority areas for the county as well as existing gaps in climate efforts. Evaluating specific projects, such as the resilience hub at the Metropolitan Library, showed the effectiveness and scalability of community-serving facilities.

Outside of the county, a review of the Low-Income Home Energy Assistance Program (LIHEAP), the Weatherization Assistance Program (WAP), and other national programs gave an understanding of their reach and impact on vulnerable communities. Based on this analysis, the study proposes actionable strategies that are evaluated for cost-effectiveness, scalability, and feasibility, with a focus on solutions that offer the most significant benefits for vulnerable populations. This methodology ensures the study's recommendations are established from data analysis and best practices to strengthen equitable climate resilience in Fulton County.

Background

Fulton County is the home to more than 1,000,000 people who live in diverse areas that range from dense urban centers to suburban neighborhoods to rural farmland.[3] Atlanta, the state capital, lies at the heart of the county and is a major metropolitan hub. Fulton typically experiences a humid subtropical climate with mild winters and hot, muggy summers.[4] This climate paired with the varied topography of the county makes the area susceptible to a range of climate related effects.

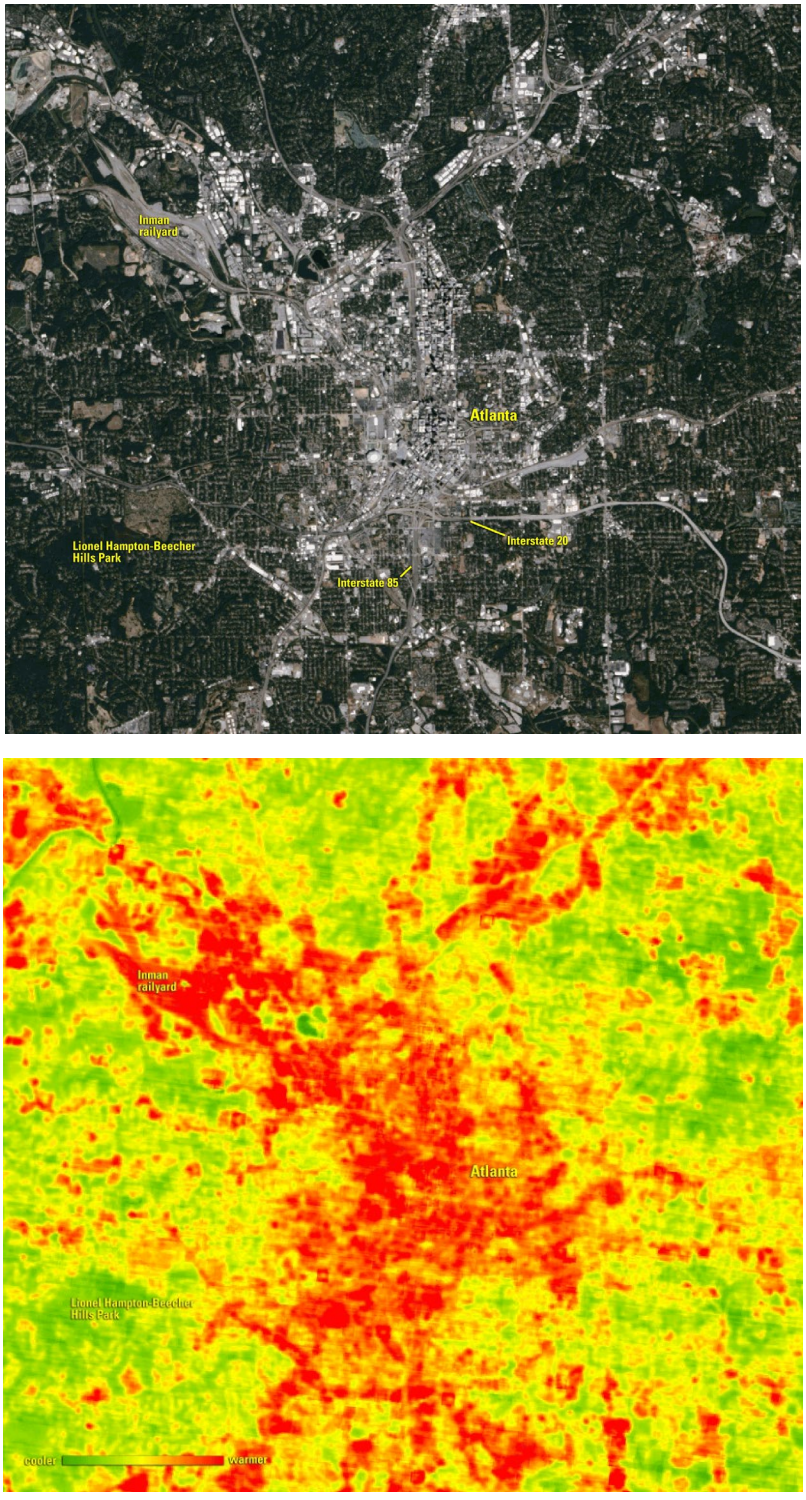
The population of Fulton County is socioeconomically varied, encompassing rich, affluent neighborhoods alongside underserved and disadvantaged communities. The median household income in Fulton County is $90,346 which is significantly higher than the average median income for the rest of the state. However, 12.7% of the county's population lives in poverty which is in line with the rest of Georgia. The federal government has a poverty level of annual earnings lesser than or equal to $15,000 for one person and increases by about $5000 for each additional person in a family.[5] Most of those living in poverty in Fulton County reside in the southern and western areas of the county which are historically BIPOC (Black, Indigenous, and People of Color) communities.

Fulton County's stark socioeconomic contrasts mean there are areas with a much lower median income than others within the county. These underserved neighborhoods have less accessibility to healthcare, adequate housing, education, and other resources essential to building a resilient community. This makes these communities all the more vulnerable to the adverse effects of climate risks, facing greater exposure to environmental hazards and possessing fewer resources for recovery and adaptation.

Fulton County's geographic diversity also includes significant green spaces, waterways, and varied land use patterns. Atlanta is colloquially known as "the city in the forest" as the city boasts a tree canopy cover of almost 50%.[6] Despite the ample number of trees in the metro Atlanta area, the densely built urban areas mean that the county experiences an urban heat island effect. The urban heat island effect is displayed in the images below[7], but the formal definition is when urbanized areas experience higher temperatures than outlying areas. This is because infrastructure like buildings and roads absorb and re-emit the sun's heat more intensely than natural landscapes like forests, grasslands, and water bodies.

[3] "Fulton County Census Data," (United States Census Bureau, 2020).
[4] "Fulton County, GA Climate," (BestPlaces, accessed May 22, 2024).
[5] Office of the Assistant Secretary for Planning and Evaluation, "Poverty Guidelines," (U.S. Department of Health and Human Services, 2023).
[6] Johanna Baidya, "A City in the Forest: Atlanta's Effort to Preserve Nature in the City | Trees Atlanta," (www.treesatlanta.org, n.d.).
[7] United States Geological Survey, "Atlanta Surface Temperature | U.S. Geological Survey," (www.usgs.gov, 2019)

This can lead to temperatures being 1-7 degrees higher than temperatures outside the city during the day and 2-5 degrees higher at night.[8] The urban heat island effect will exacerbate the impacts of rising temperatures and heatwaves.



[8] United States Environmental Protection Agency, "Heat Island Effect," (EPA, 2024).

Climatic Conditions

While the county will experience risks such as drought and tornados, they are not as prevalent in the county or occurrences will not increase as much with a changing climate. Fulton County has had only 2 day-long droughts since January of 2020, and both were in 2023 in North Fulton. There have been 3 tornados since 2020 with 1 occurring in January 2024.[9] Unlike the major identified risks, these two do not pose a major threat to Fulton County as they are not frequently occurring.

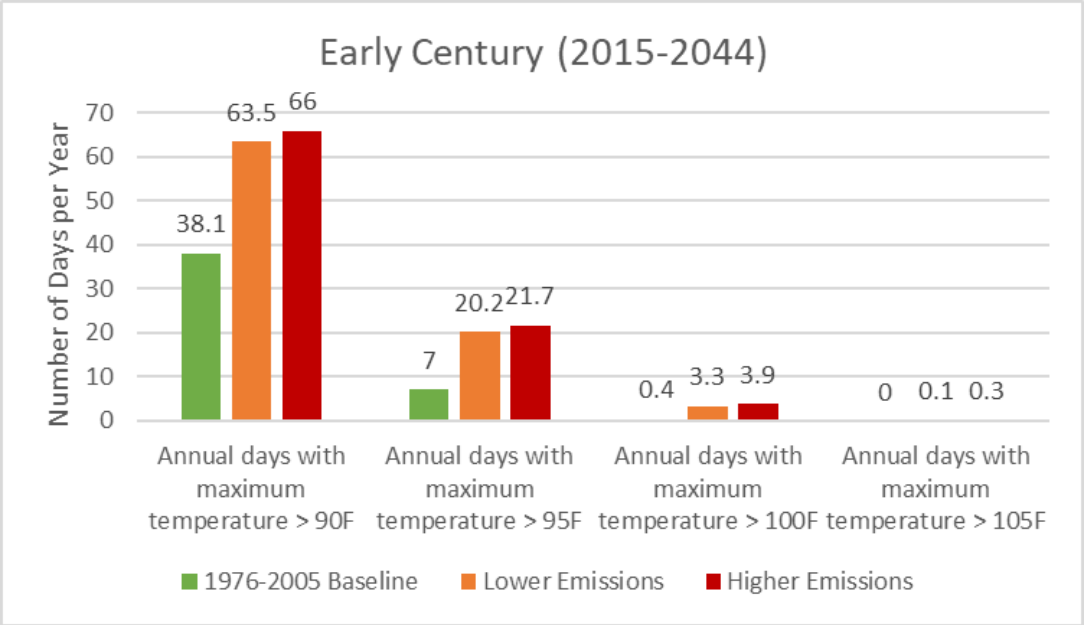
Instead, the main climate stressors that pose a threat to Fulton County's most vulnerable communities are extreme heat, flooding, and air pollution.

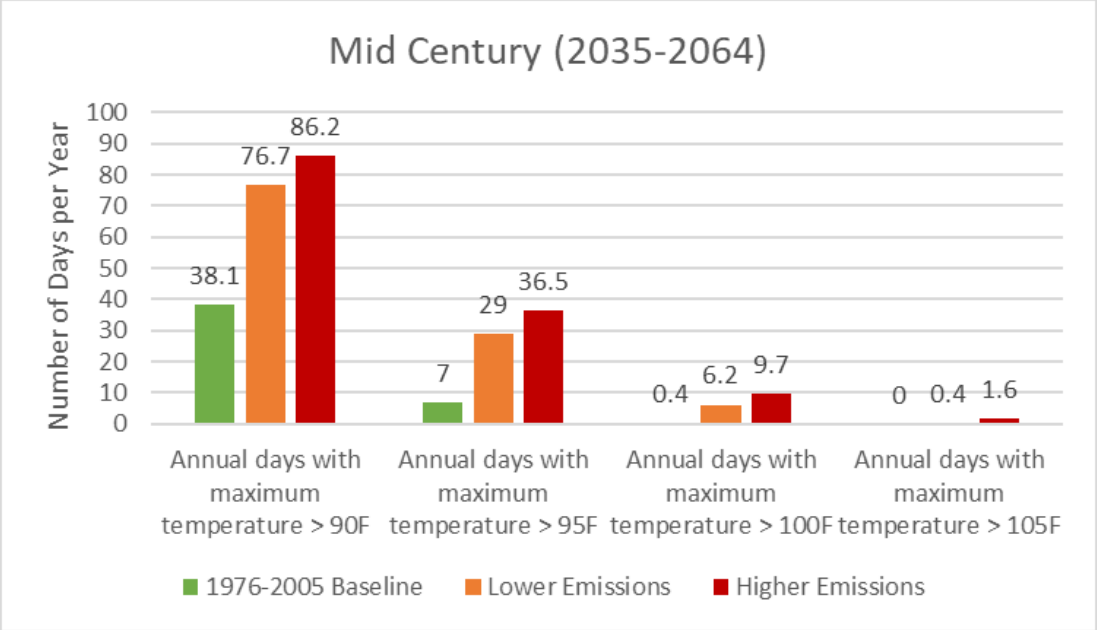
Extreme heat

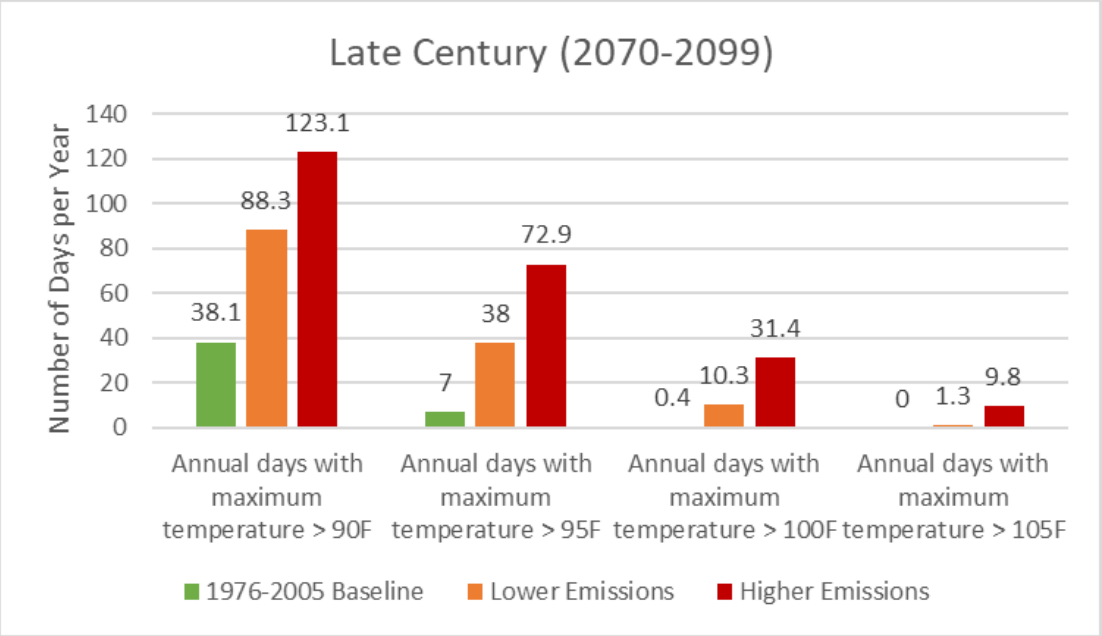
Previous occurrences: The CDC's Climate and Health Program published a heat exposure data tool that records the annual number of days with a daily maximum above the 95th percentile out of all of the U.S. In 2019, Fulton County had 5 days with temperatures above the 95th percentile. There is also a dramatic increase in the occurrence of days above this percentile in 2007-2011 compared to previous years.[10]

Predicted increase: The three graphs below show data from the *Climate Mapping for Resilience and Adaptation (CMRA)* website.[11] With the probability of higher emissions in Fulton County, the tool predicts 86.2 annual days with a maximum temperature of 90°F by mid-century (2035-2064). As shown in the figure below, this is 48.1 more annual days than the baseline years of 1976-2005. It is projected there will be 36.5 days per year, by mid-century (2035-2064), with a maximum temperature of 95°F (29.6 increase in days from the baseline years). The number of annual days with a maximum temperature of 100°F is predicted to be 9.7 days by mid-century (9.3 increase in days from baseline). The highest temperature of the year is predicted 103.4°F by mid-century which is a 5.6°F increase since the baseline years. This data is with the probability of higher emissions and was found on the *Climate Mapping for Resilience and Adaptation 's* (CMRA) website. The scenario of higher emissions bases predictions on a future in which we continue to increase our emissions while the scenario of lower emissions bases predictions on a future in which emissions are decreased.

[9] NCEI. "Storm Events Database | National Centers for Environmental Information," (Noaa.gov, 2019).
[10] U.S. Centers for Disease Control and Prevention. n.d. "Heat & Health Tracker." (Ephtracking.cdc.gov. Climate & Health Program).
[11] CMRA. n.d. "Climate Mapping for Resilience & Adaptation," (Resilience.climate.gov. CMRA).


Early Century (2015-2044)
Number of Days per Year
70
60
50
40
30
20
10
0
38.1
63.5
66
7
20.2
21.7
0.4
3.3
3.9
0
0.1
0.3
Annual days with maximum temperature > 90F
Annual days with maximum temperature > 95F
Annual days with maximum temperature > 100F
Annual days with maximum temperature > 105F
1976-2005 Baseline
Lower Emissions
Higher Emissions

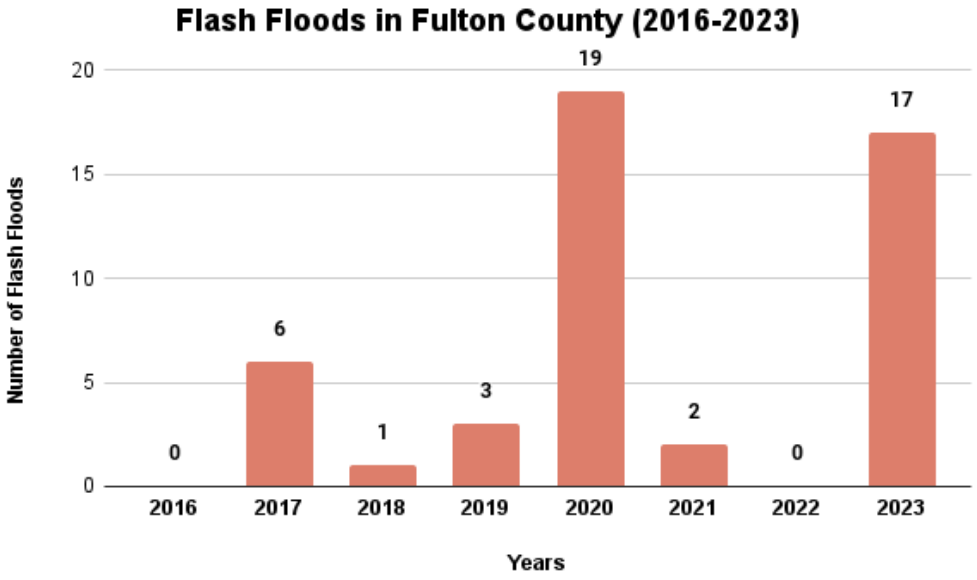

Mid Century (2035-2064)
Number of Days per Year
100
90
80
70
60
50
40
30
20
10
0
38.1
76.7
86.2
7
29
36.5
0.4
6.2
9.7
0
0.4
1.6
Annual days with maximum temperature > 90F
Annual days with maximum temperature > 95F
Annual days with maximum temperature > 100F
Annual days with maximum temperature > 105F
1976-2005 Baseline
Lower Emissions
Higher Emissions



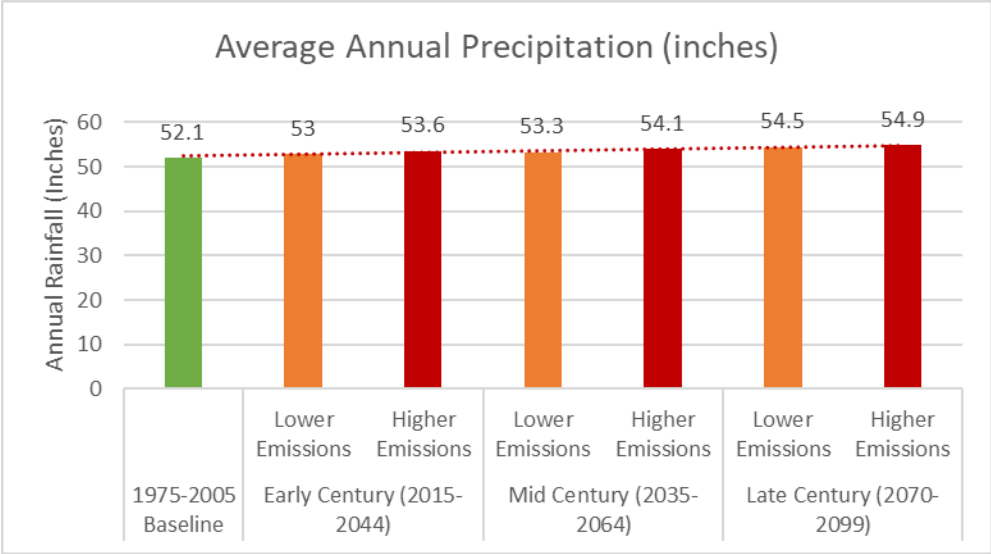
Flooding

Previous occurrences: The Fulton County Hazard Mitigation Plan shows there were 29 flash flood events recorded from January 2016 to December 2020. A major increase in flash floods was seen in 2020 with 19 occurring just that year. This means, that out of the 5 years recorded, the majority of the 29 events happened in 2020.[13] The National Oceanic and Atmospheric Administration (NOAA) recorded flash flood events from January 2021 to February 2024. Out of the 19 recorded, 17 were reported in 2023.[14] This data is visualized in graph form below.

[13] Georgia Emergency Management and Homeland Security Agency. "Hazard Mitigation Planning," (GEMA, 2019).
[14] NCEI. "Storm Events Database | National Centers for Environmental Information," (Noaa.gov, 2019).



Predicted increase: According to CMRA's website, by mid-century (between 2035-2064), [15] it is predicted the average annual total precipitation will be 54.1 inches with higher emissions in Fulton County which is a 2-inch increase from the baseline years. An increase in precipitation will increase the probability of floods.



Air quality/Air pollution

Previous occurrences: As found on the *EPA* website, in 2023, harmful ozone pollution was found in the air. There were 2 days when air quality was reported as unhealthy and 10 days that were reported as unhealthy for sensitive groups. The overall Air Quality Index (AQI) on the 2 unhealthy air quality days was 172 (June 29, 2023) and 156 (August 24, 2023). On the unhealthy for sensitive groups days, the highest

[15] CMRA. n.d. "Climate Mapping for Resilience & Adaptation," (Resilience.climate.gov. CMRA).

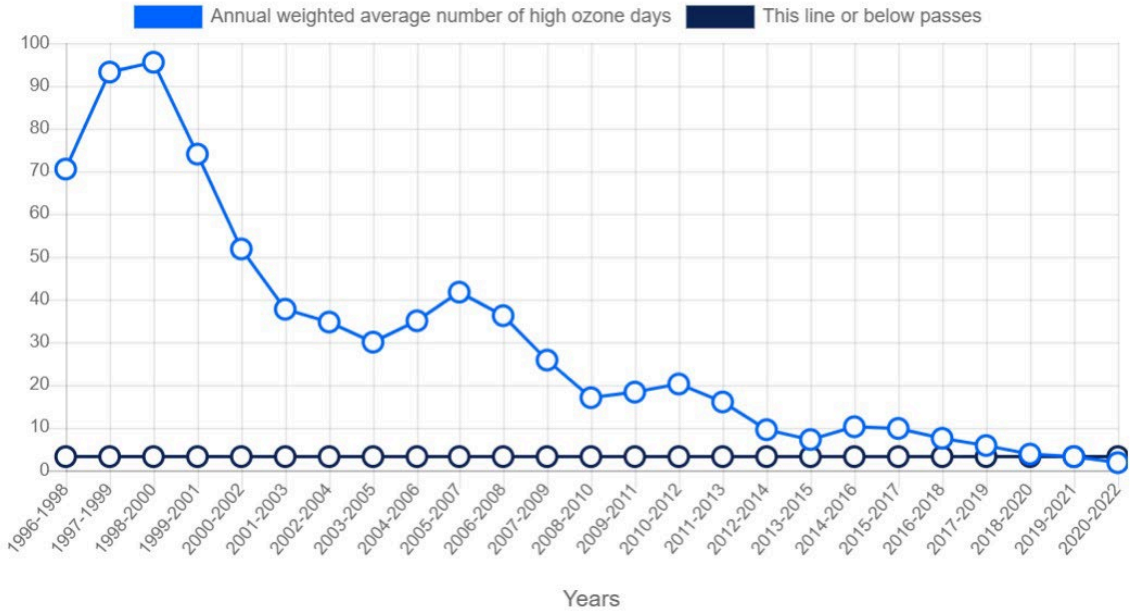
overall AQI was 122. Ozone and PM2.5 were the pollutants that contributed to bad air quality the most.[16] PM 2.5 is fine particulate matter that increases risk of asthma and other respiratory issues, especially in children and the elderly. PM 2.5 typically comes from automobile's combustion engines. Ozone can be a harmful pollutant when at ground level as it is the main component of smog. A bad air quality day can worsen or trigger symptoms of asthma and other respiratory conditions such as emphysema. Fulton County received its first passing grade for air quality from the American Lung Association in 2023 with a D.[17] This passing grade was due to a decrease in high ozone days. Failing grades were received from 1996-2022 with there being high ozone pollution until 2023, a great number of high particle days from 2000-2009, and gaps in data of average annual concentration of particle pollution.

Predicted increase: Although there is not much data on predicted air pollution increase, the trend of bad air quality in Fulton County has been going down over the years.

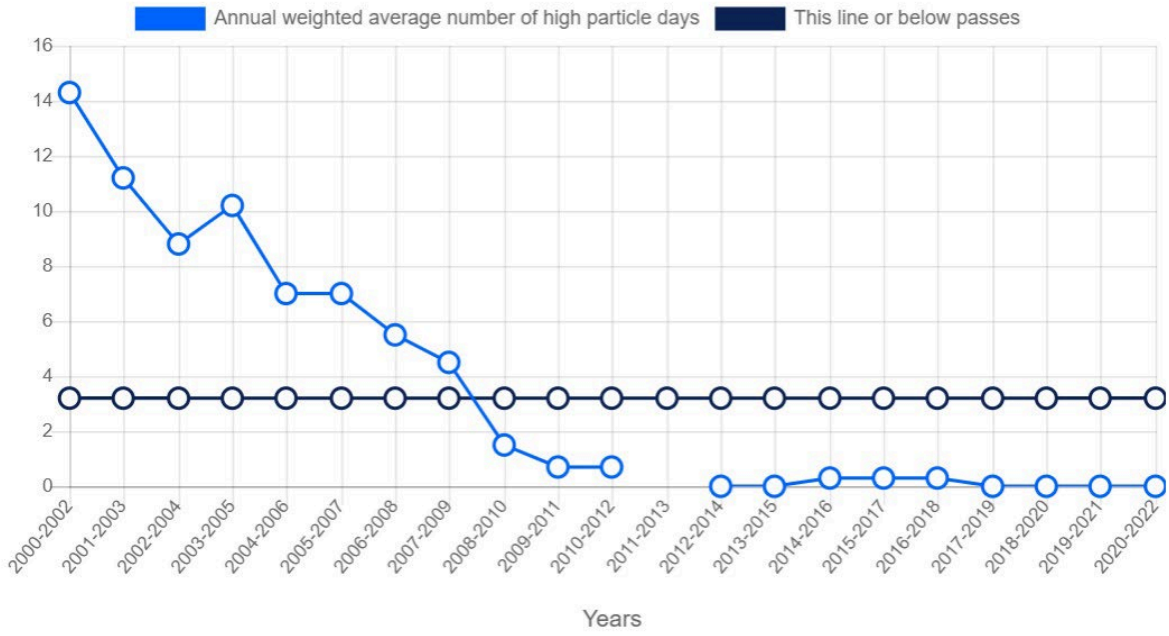
Below are three graphs displaying high ozone days, number of high particle days, and annual average concentration of particle pollution as recorded by the American Lung Association. The last two additional graphs display the Air Quality Index in 2023 as discussed in previous occurrences.[18]

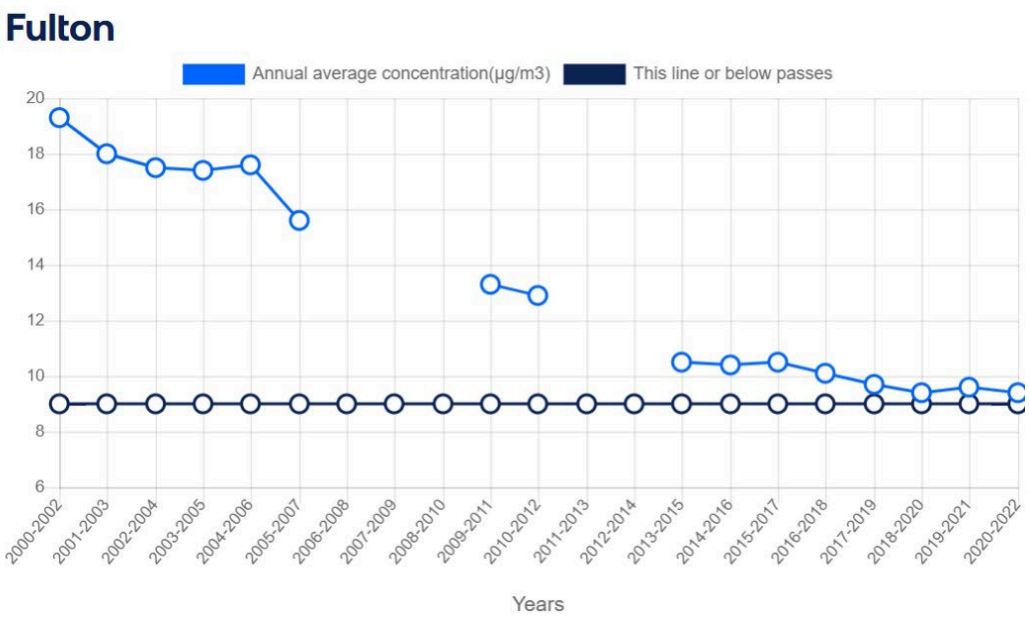
[16] U.S. Environmental Protection Agency. "Air Quality Index Daily Values Report," (EPA, 2016).
[17] Smith, Jill. "American Lung Association Report: Atlanta's Air Quality Improves; 1 in 3 Nationwide Exposed to Unhealthy Air," (Www.lung.org, 2023).
[18] American Lung Association. "Fulton," (Www.lung.org, 2024).

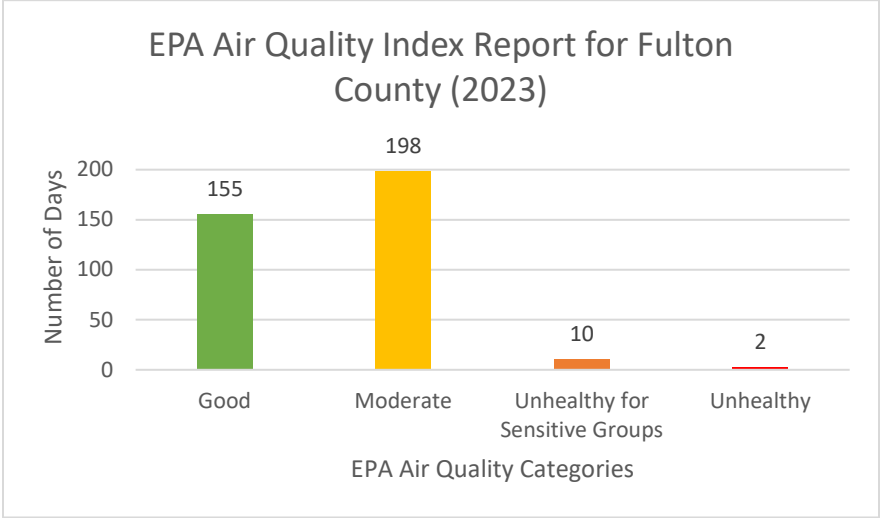
Fulton

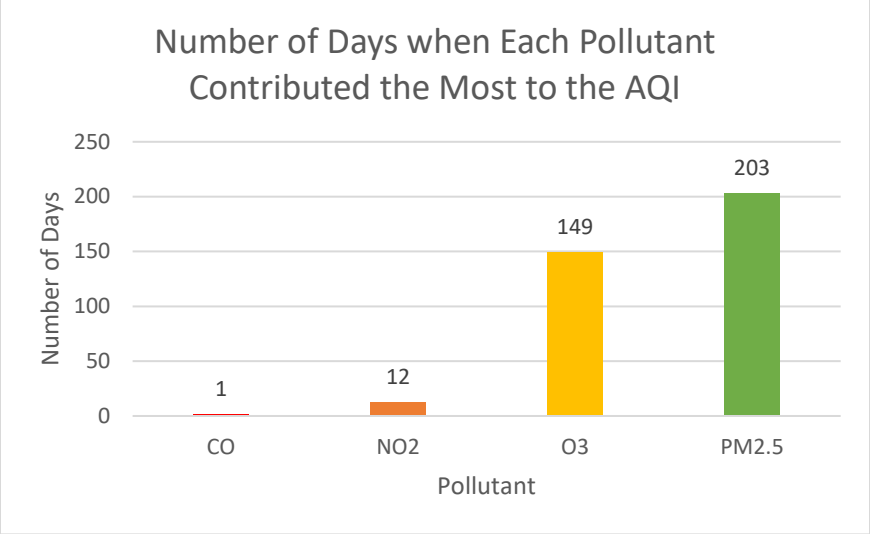


Fulton

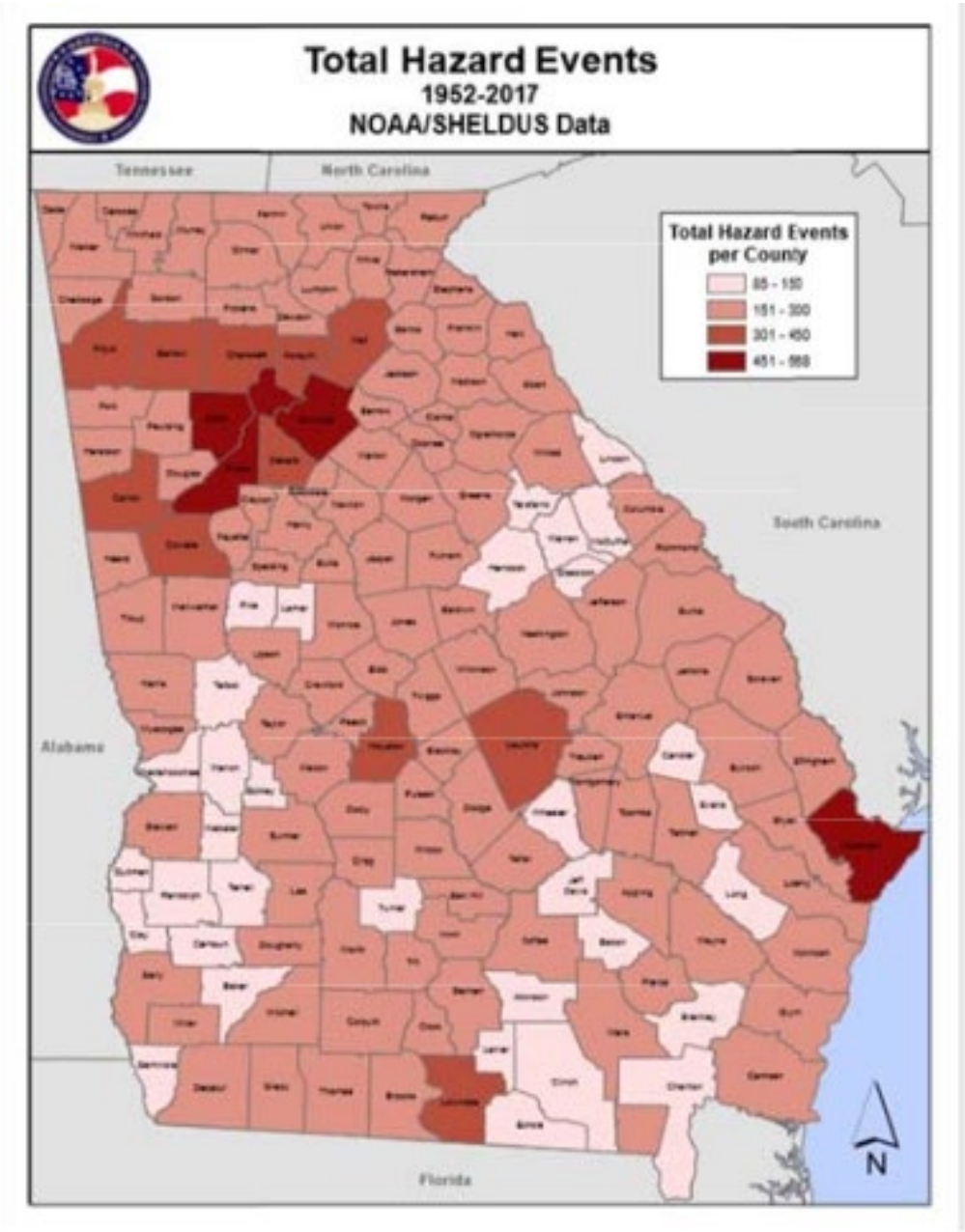



Fulton
Annual average concentration(µg/m3)
This line or below passes
20
18
16
14
12
10
8
6
2000-2002
2001-2003
2002-2004
2003-2005
2004-2006
2005-2007
2006-2008
2007-2009
2008-2010
2009-2011
2010-2012
2011-2013
2012-2014
2013-2015
2014-2016
2015-2017
2016-2018
2017-2019
2018-2020
2019-2021
2020-2022
Years


EPA Air Quality Index Report for Fulton County (2023)
Number of Days
200
150
100
50
0
155
198
10
2
Good
Moderate
Unhealthy for Sensitive Groups
Unhealthy
EPA Air Quality Categories


Number of Days when Each Pollutant Contributed the Most to the AQI
Number of Days
250
200
150
100
50
0
1
12
149
203
CO
NO2
O3
PM2.5
Pollutant

The Georgia Emergency Management Agency released their hazard mitigation plan for the state in 2019 with an update expected in 2024. The 2019 plan listed the hazards most likely to affect the state with an emphasis on using historical data to predict future events. As seen in the map below, they found that between 1952 and 2017, the Metro Atlanta area (with Fulton County at its core) experienced the most hazard events by far with more than 400 hazards being reported in each county.



Above: A map of total hazard events in the state of Georgia by county from 1952-2017. Fulton and the surrounding counties had the most hazard events, totaling more than 400 each.[19]

[19] Georgia Emergency Management Agency, "Hazard Mitigation Planning," (Georgia Emergency Management and Homeland Security Agency, 2019).

Major contributors to climate stressors in Fulton County

Drawdown GA is an initiative that researches and facilitates reaching net zero greenhouse gas emissions for the state of Georgia. It uses a framework of 20 climate solutions encompassing different sectors of the economy. In its greenhouse gas emissions tracker, it displays the CO_2 emissions in 2023 by economic sectors including agriculture, commercial, forestry, industrial, residential, and transportation. Drawdown GA identified transportation, commercial, and residential as the top 3 contributors to CO_2 emissions in Fulton County. It also found that in 2023, Fulton County surpassed its five neighboring counties - Clayton, Cobb, Dekalb, Douglas, and Paulding - as having the highest CO_2 emissions in the sectors of commercial, residential, transportation, and thus, overall. The continued CO_2 emissions from these sectors are liable to cause risks that are a threat to the wellbeing of people and community assets as increased emissions cause an increase in floods, bad air quality, and extreme temperatures.[20]

‘‘GHG Emissions Tracker.” n.d. (Drawdown Georgia).

Vulnerability and Risk Assessment

The three major risks that are impacting all communities in Fulton County include: **flooding, extreme heat, and air pollution**

Potential hazards in Fulton County[21]:

	Flooding	Extreme heat	Air quality/pollution
People	Injuries caused by flash floods and standing water- potential chemicals in standing water	Physiological stress and risk of developing chronic conditions	Long-term exposure to air pollution can lead to birth defects and cancer
	Delay of emergency services to reach affected areas	Illness conditions worsened by exposure and harmful effects on cardiovascular health	Damage to the cardiovascular, nervous system, and skin (irritation)
	Spread of disease due to standing water (CDC)	Increased risk of death by heat stroke and other causes impacted by heat exposure	Potential of acid rain which may cause respiratory illness, worsen symptoms of asthma and bronchitis, exacerbate cardiovascular problems, and lead to lung cancer
Community Assets	Damage to public infrastructure	Damage to roads, infrastructure, electrical wires, and power grids- potential power outages	Corrosion to infrastructure caused by acid rain
	Damage to homes and businesses	Stress on water supply- drought is likely	Ozone pollution damages plants' gas exchange mechanism, and smog/reduced visibility can reduce the rate of photosynthesis
	Damage to personal cars and other vehicles (public transportation)	Stress on AC units, refrigerators, and other crucial infrastructure that can be impacted in constantly running during extreme heat occurrences	Acid rain chemicals can be harmful to plants, and when these chemicals reach the soil, they can make nutrients unavailable for plants

The data for this section was found on the *U.S. Climate Vulnerability Index* website, curated by the *Environmental Defense Fund*, *Texas A&M University*, and their partners and stakeholders such as the *Morehouse School of Medicine* and the *NASA Health and Air Quality Applied Sciences Team*. Overall vulnerability is defined by 184 indicators. These indicators help visualize the overall vulnerability of

[21] Blog Administrator. "Prep Your Health for Floods | Blogs | CDC," (Centers for Disease Control and Prevention, 2022).

different census tracts within the county and fall under the categories of health, social and economic, environment, extreme events, and infrastructure. Lower results in these five categories make a community all the more vulnerable to climate risks. Many health conditions and diseases are exacerbated by bad air quality or extreme heat, especially respiratory and cardiovascular conditions. The neighborhoods and towns within Fulton County that have the highest vulnerability (90th national vulnerability percentile and above) can be found in the appendix section of this study.

The top five most vulnerable are:

- Pomona Park (99th percentile)
- Carroll Heights (98th percentile)
- Center Hill (98th percentile)
- Glenrose Heights (98th percentile)
- Harland Terrace (98th percentile)

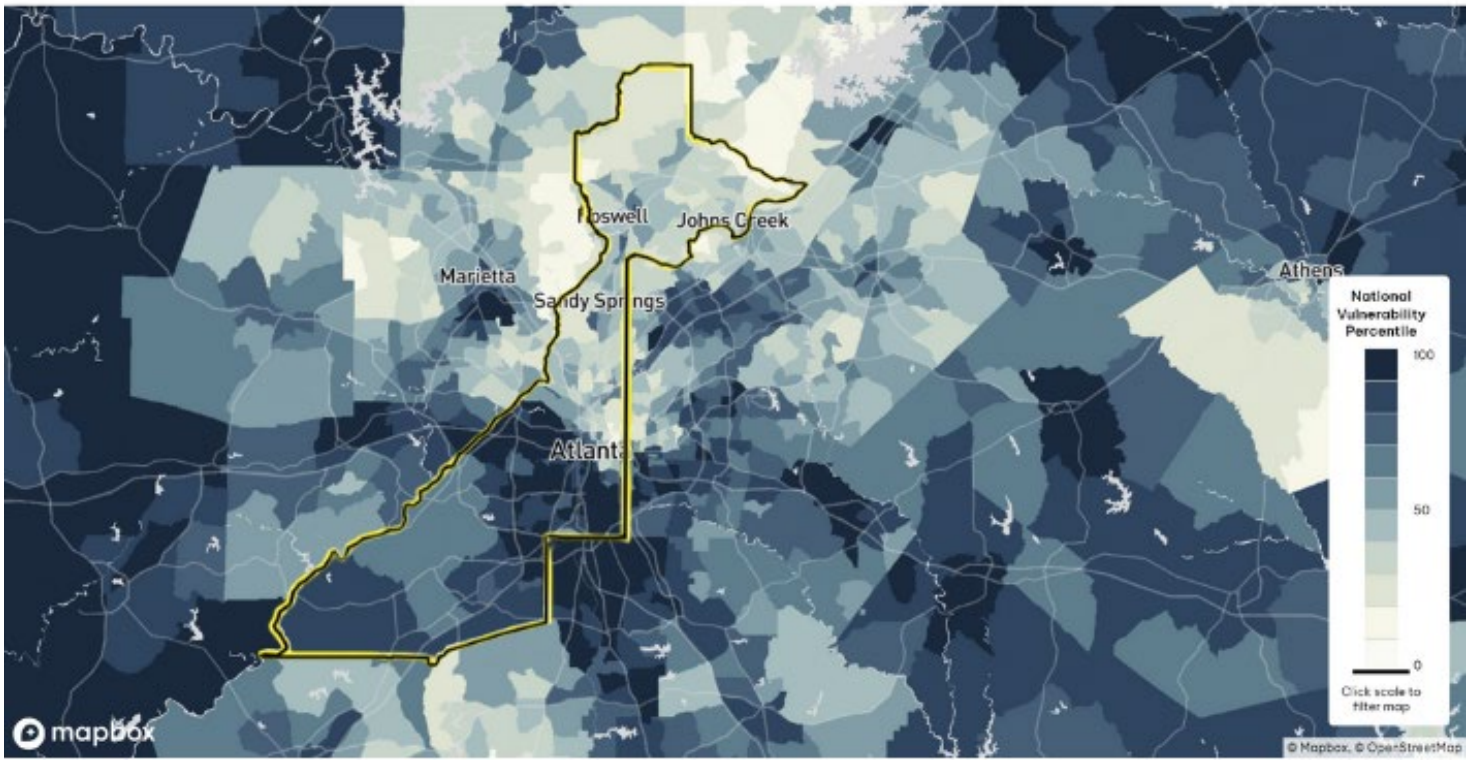
The visuals below identify the most vulnerable communities on a scale with the darker colors being the most vulnerable and lighter colors being the least vulnerable.

- 1st map displays overall vulnerability
- 2nd map displays overall population health
- 3rd map displays expected changes in health resulting from warming climate
- 4th map displays social and economic stressors that impact community resilience
- 5th map displays social and economic costs and impacts related to change in climate
- 6th map displays environmental factors that are a threat to community's well-being
- 7th map displays historical and predicted extreme events
- 8th map displays vulnerability based on structures, services, and resources that affect community resilience.[22]

[22] CMRA. n.d. "Climate Mapping for Resilience & Adaptation," (Resilience.climate.gov. CMRA).

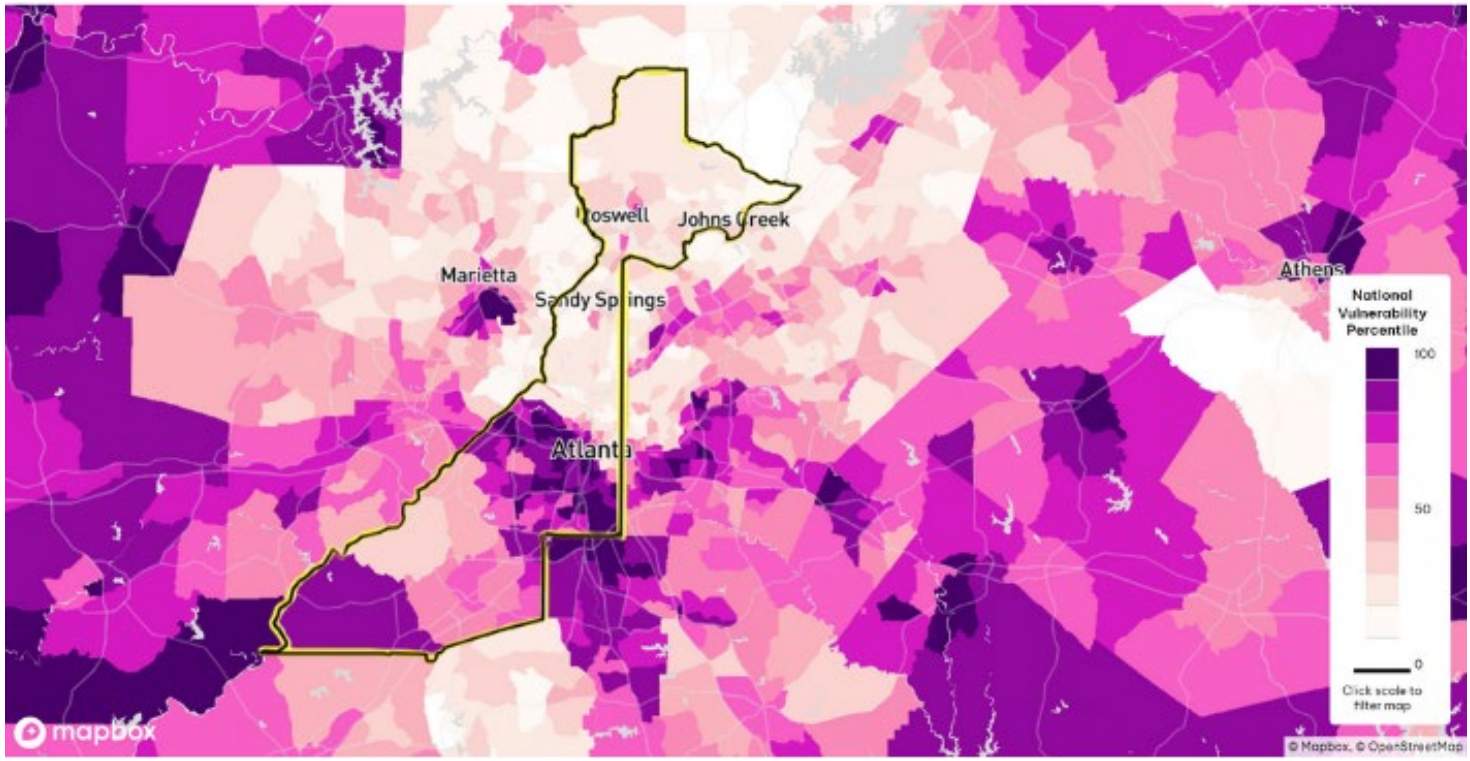
Overall Climate Vulnerability

Score combining environmental, social, economic, and infrastructure effects on neighborhood-level stability.



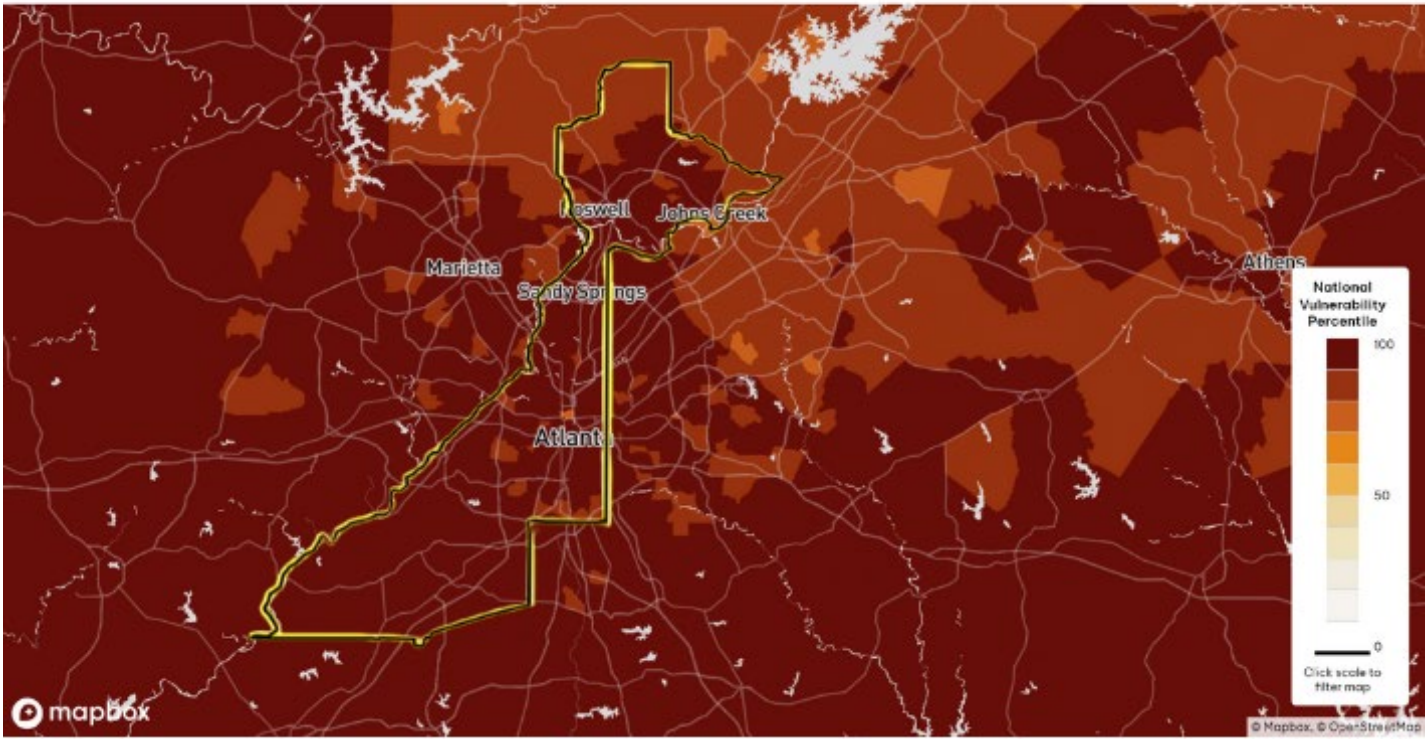
Health

Factors reflecting baseline or overall state of population health.



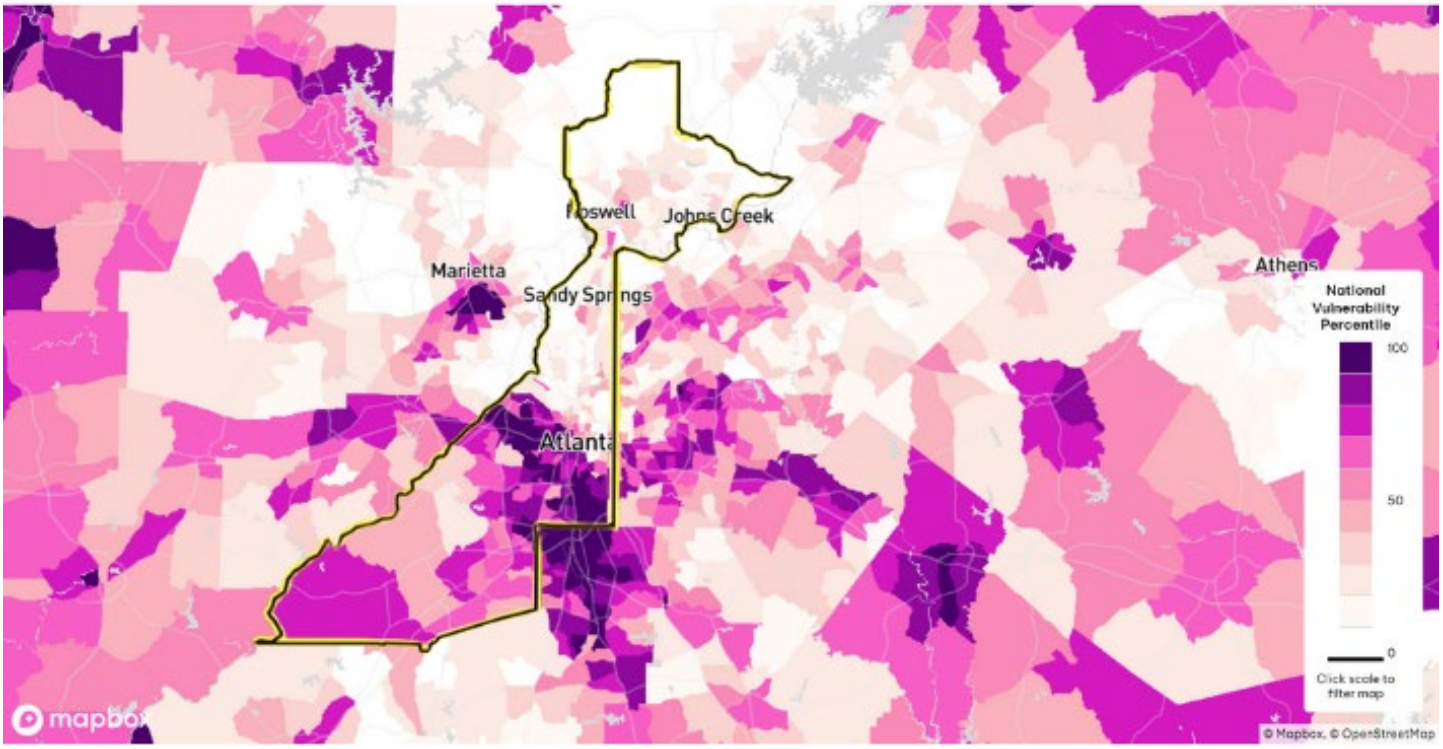
Health

Expected changes in community health resulting from warming climate.



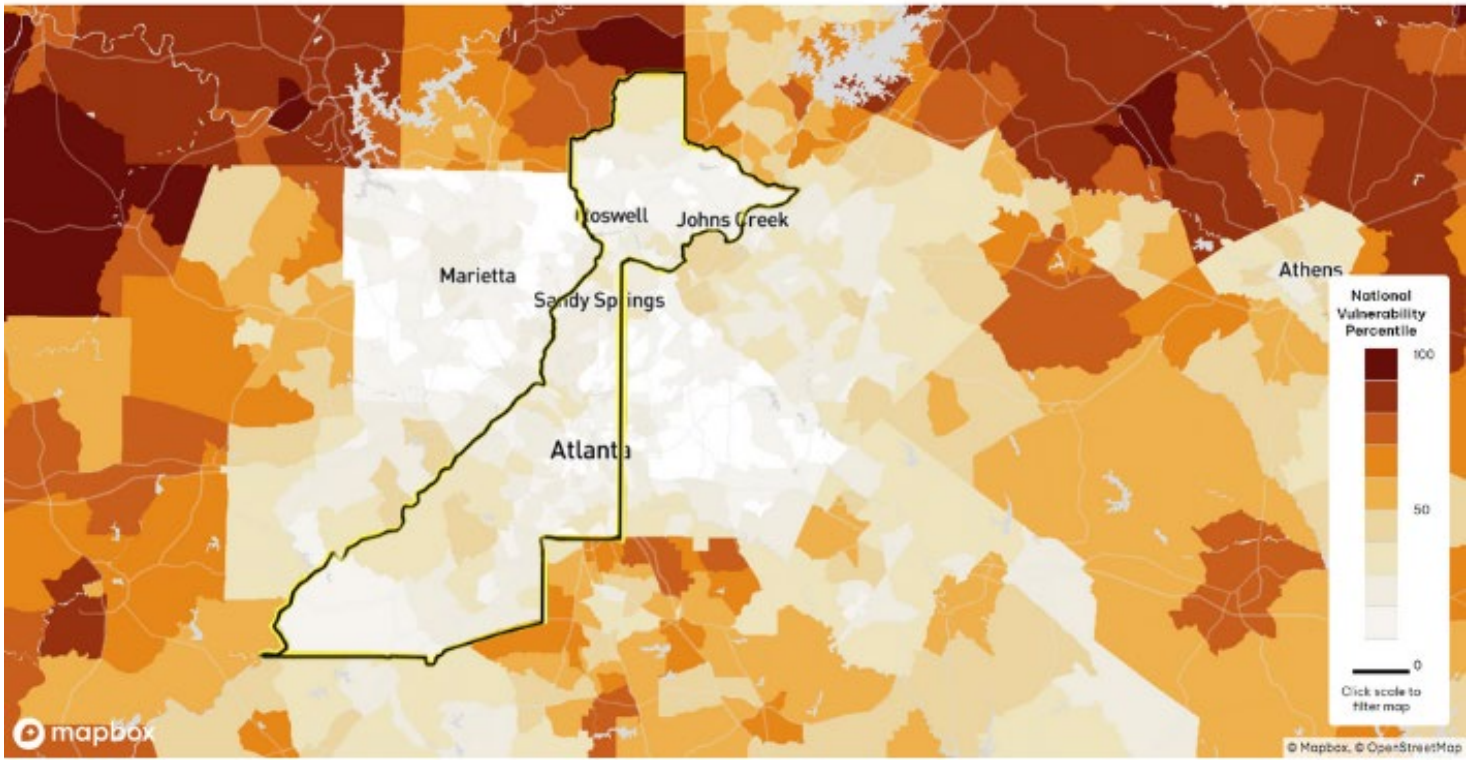
Social & Economic

Social and economic stressors that impact community resilience.



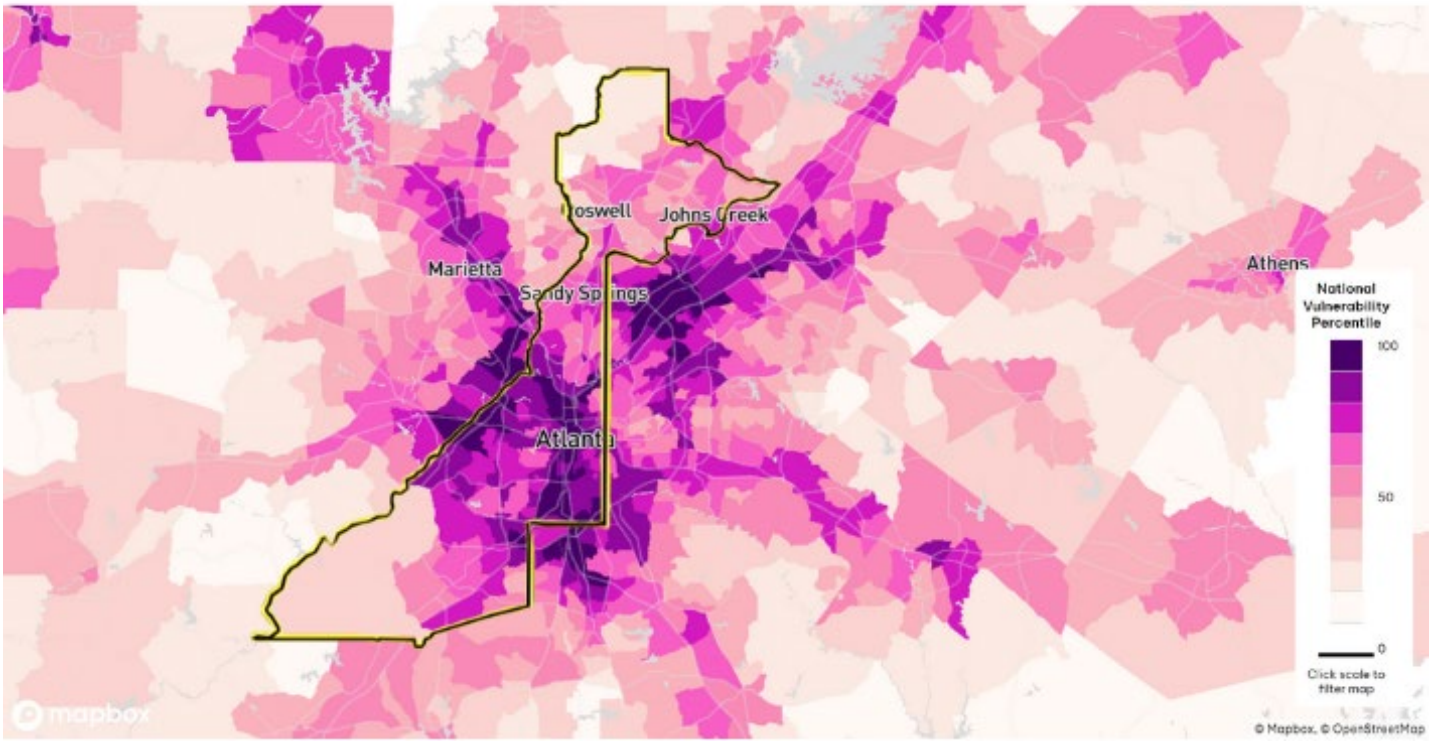
Social & Economic

Social and economic costs and impacts associated with change in climate.



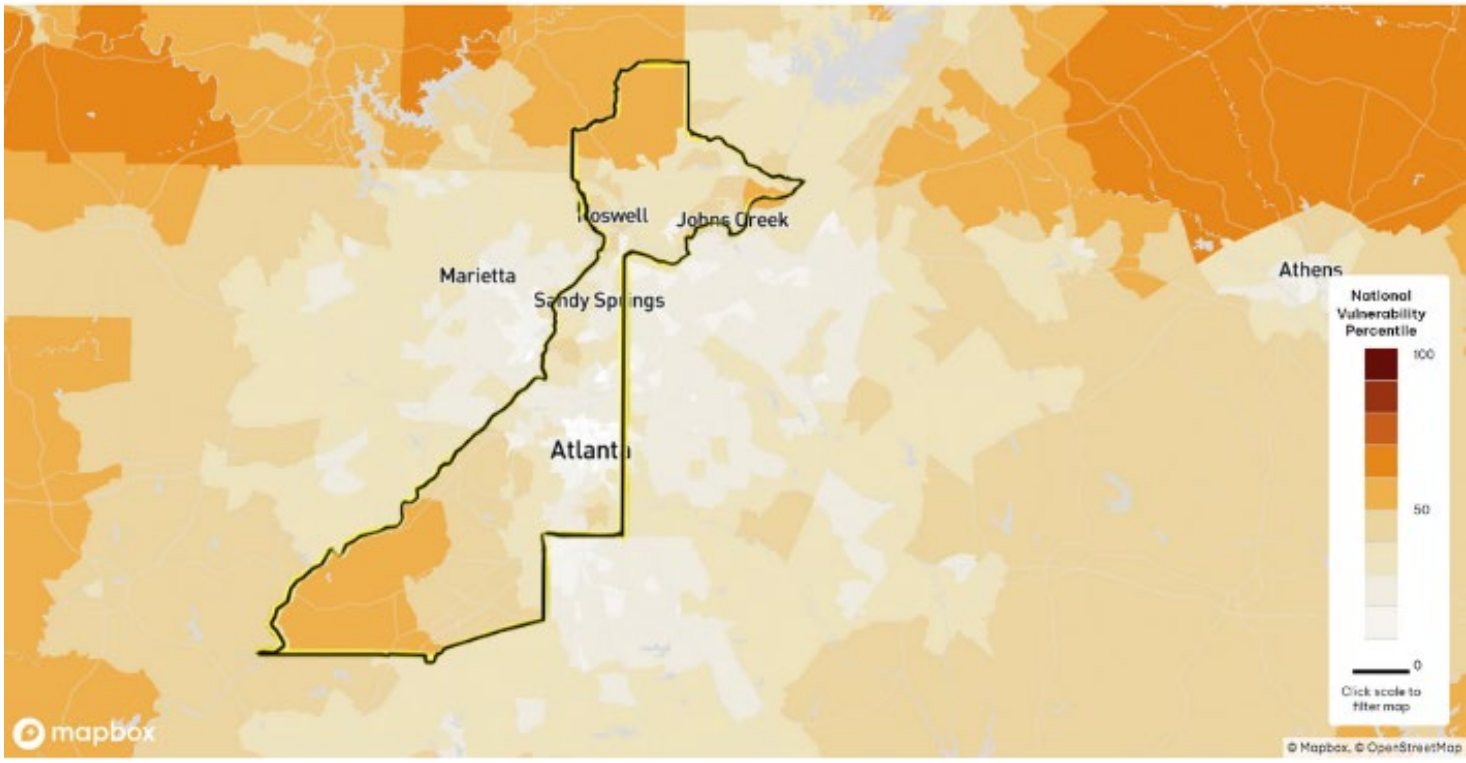
Environment

Environmental factors that pose a threat to community's well-being.



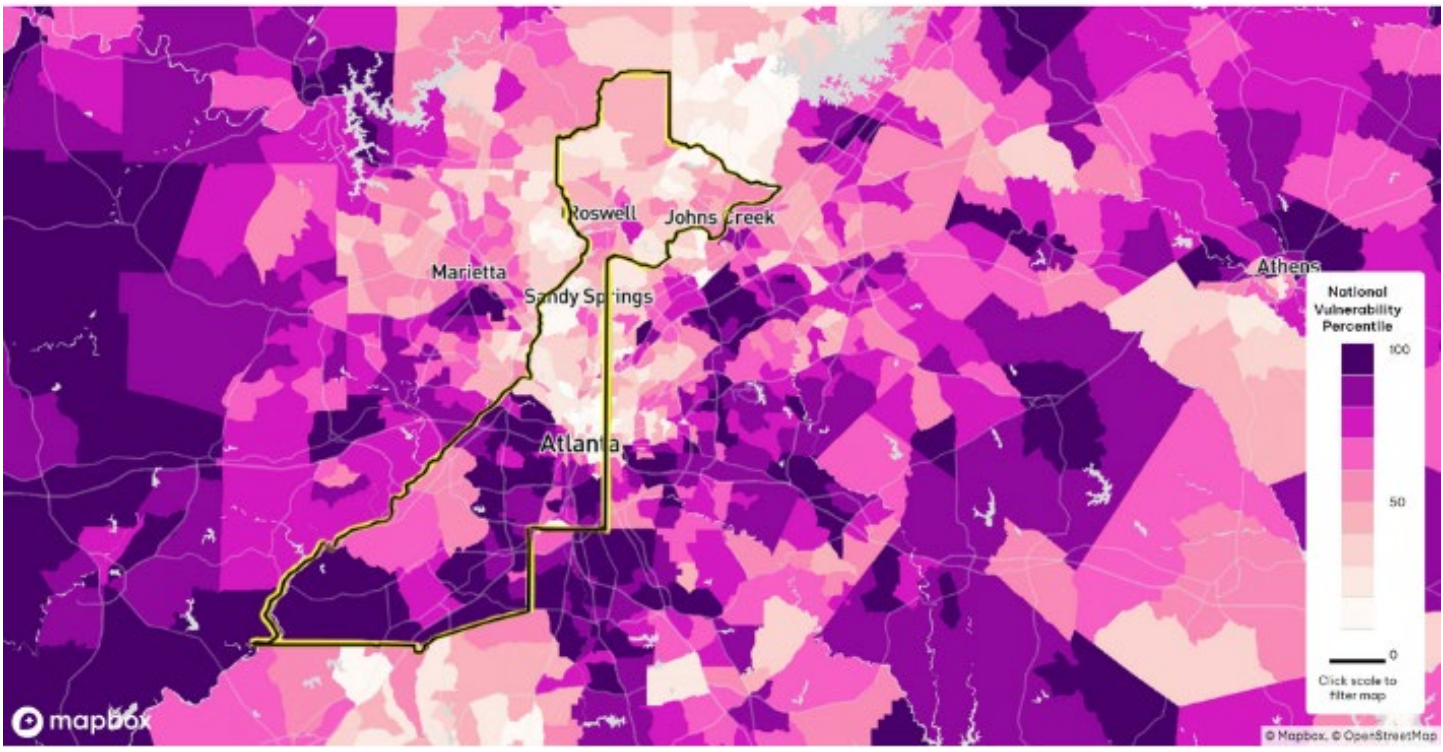
Extreme Events

Historical and projected extreme weather event occurrences.



Infrastructure

Essential structures, services, resources that affect community resilience.



All the 34 neighborhoods/towns with the highest overall vulnerability in Fulton County are majority-minority communities while 33 out of 34 are majority BIPOC (Black, Indigenous, and People of Color). This pattern reflects a systemic issue where BIPOC communities are disproportionately affected by climate hazard impacts. These neighborhoods often lack the resources and infrastructure needed to respond and adapt to extreme climate events. This vulnerability is heightened by social and economic inequalities that lead to limited healthcare access and limited access to quality housing and education. Access to these resources is critical to building resilience. Therefore, BIPOC communities generally face greater challenges. With impactful and cost-effective solutions, these communities can be provided with the resources to become more resilient.

Current Resilience Efforts

The Fulton County Sustainability + Resilience plan first looks at where the county has been and then where the county wishes to go by identifying six priority areas of sustainability and resilience. These six measures are climate change mitigation, social equity and smart transit, high performance county infrastructure, green education and jobs training, fostering partnerships, and budgetary appropriation.[23] The primary resilience project that Fulton County is currently working on is the Metropolitan Library Resilience Hub in Southwest Atlanta.

A Resilience Hub is a community-serving facility that supports residents before, during, and after emergencies. The Metropolitan Library hub was planned based on the framework put forth by the Urban Sustainability Directors Network. The hub will operate in three modes: everyday, disruption, and recovery. Everyday operations focus on daily community services and relationship building. Disruption operations focus on acting as a center for preparedness and response, while recovery operations focus on the return to everyday while assessing and addressing community needs. To date, the resilience hub at the Metropolitan Library has installed solar panels, handed out resilience kits, and given programmable thermostats to the local community with future plans to install and maintain a backup battery storage system, EV chargers, and a community garden to strengthen community resilience in the area.[24] This resilience hub serves as an excellent demonstration project to assess the viability of hubs as a mechanism for shoring up community resilience and scoping out the possibilities of installing resilience hubs in communities across the county.

Fulton County currently has two community gardens that are in operation: the North Fulton Community Garden and the Camp Truitt Community Garden. To participate in either of these gardens, there is a $35 fee per plot. Similarly, AgLanta has programs that support local food production and community gardens such as the Urban Food Forest at Browns Mill. This is the first urban food forest in Atlanta, and the yields will be available to the public.[25]

In addition to the creation of a resilience hub at the Metropolitan Library, Fulton County has the support of multiple agencies to build resilience towards hazards. These include the Atlanta-Fulton County

[23] "2019 Sustainability Plan + Resilience," (Fulton County, February 2022).
[24] Fulton County, "The Metropolitan Library Becomes Fulton County New Community Resilience Hub," (www.fultoncountyga.gov, 2021).
[25] "Programs — AgLanta - Urban Agriculture Atlanta." n.d. (AgLanta, Accessed June 4, 2024).

Emergency Management Agency and the Georgia Emergency Management and Homeland Security Agency, both of which contribute to resilience by preparing for natural disasters.

The City of Atlanta, Fulton County's largest municipality, has set goals to reduce emissions from city facilities including 100% clean energy for city buildings by 2035. These goals are outlined in the city's *Clean Energy Atlanta* plan and focus on distributing these benefits equitably throughout the city.

As far as nationwide efforts go, the USDA started a program known as the *People's Garden Initiative* which became a nationwide effort in 2022 that encourages the creation of more gardens for communities. Utilizing these national programs could be helpful in building resilience within Fulton County.[26] Additionally, President Joe Biden signed Executive Order 14008 in his first week in office.[27] This ordered federal agencies to utilize their assets and leadership to assist in climate action with the goal of reaching net-zero by 2050. Biden also re-signed the Paris Climate Agreement which allows for the United States to address climate crises at home and abroad with international support.[28]

Recommendations

County-Level Solutions are desirable to shore up climate resilience on the countywide level. They can provide outreach, funding, and support for individual and neighborhood solutions. County-level solutions are typically more comprehensive than what a neighborhood could be able to achieve on its own.

Neighborhood-Based Solutions focus on localized areas or NPUs (Neighborhood Planning Units) within a city or town such as a specific district. Each neighborhood has specific needs and vulnerabilities.

Individual-Based Solutions encourage resilience at the single-home or family level. This involves personal actions that people can make to reduce their vulnerability and build resilience to risks.

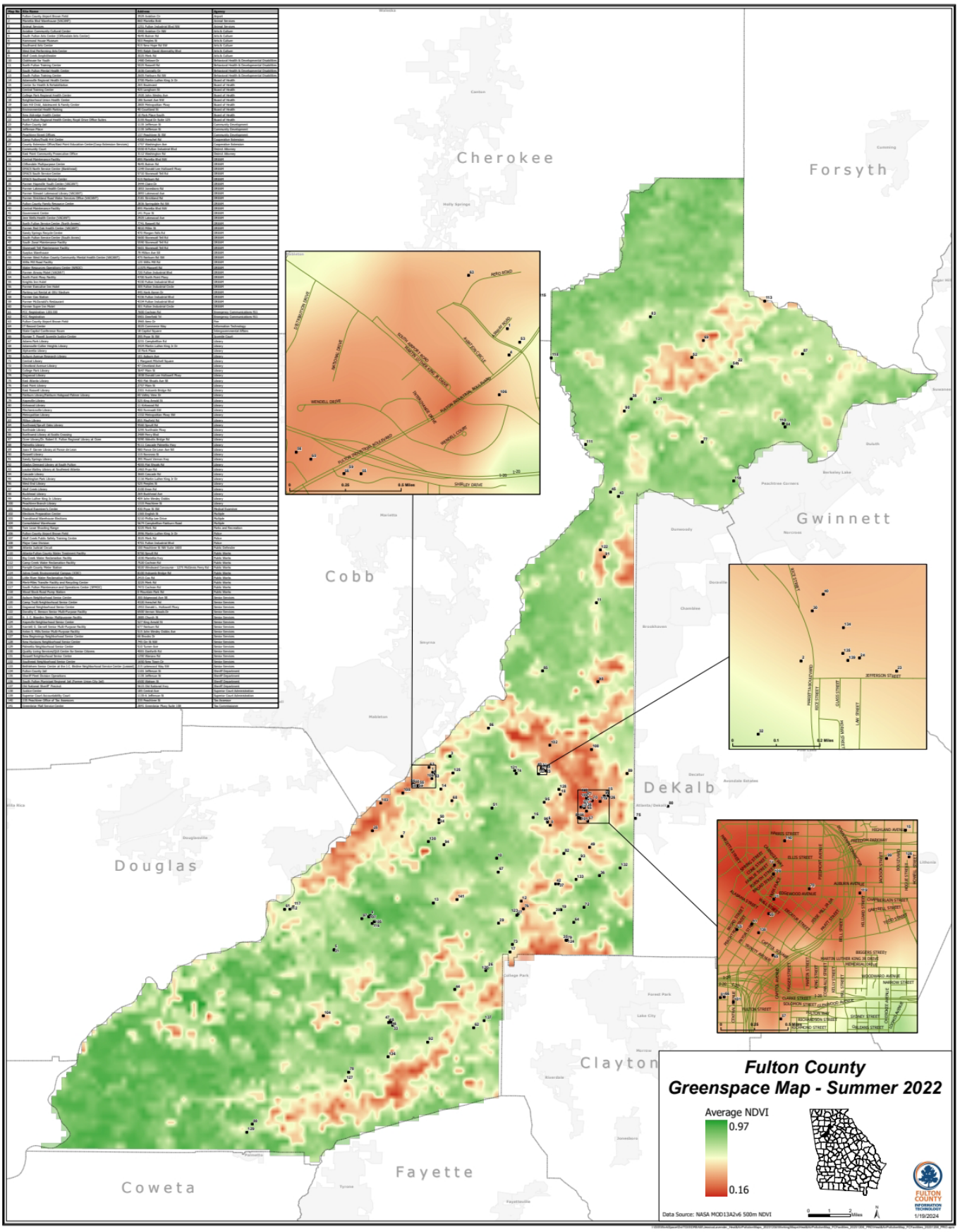
County-Level Solutions

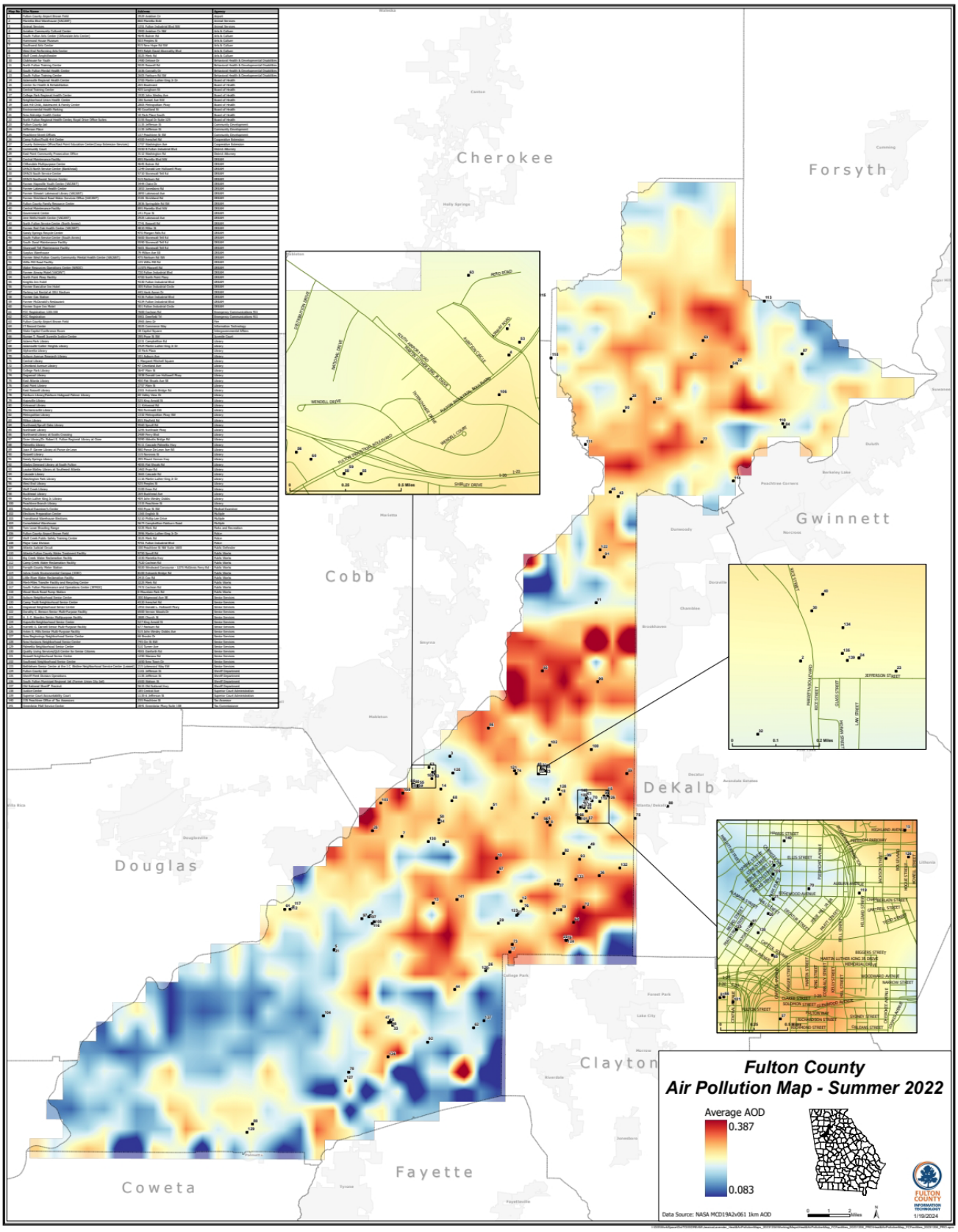
Below is data recorded by NASA in 2022 and made accessible to the community by Emory Scientists, the Center for Sustainable Communities, and residents of Fulton County. The scientists and the Center for Sustainable Communities hosted workshops with residents to utilize their feedback. They started by asking the residents, "What will the impacts of climate change be in your community?" Based on their answers, data was collected from NASA and presented to the residents, and their feedback was used to finalize the visuals and next steps for publishing this information. The first map is a Fulton County Green space Map (data recorded July 12th - July 27th) that visualizes the Normalized Difference Vegetation Index (NDVI). The 2nd map displays the average land temperature using degrees Fahrenheit (data recorded July 3rd - July 18th). The 3rd map measures Aerosol Optical Depth (AOD) to create an air pollution map (data recorded July 3rd - July 18th). There is a major correlation between less greenspace and higher temperatures and somewhat of a correlation between less greenspace and bad air quality.

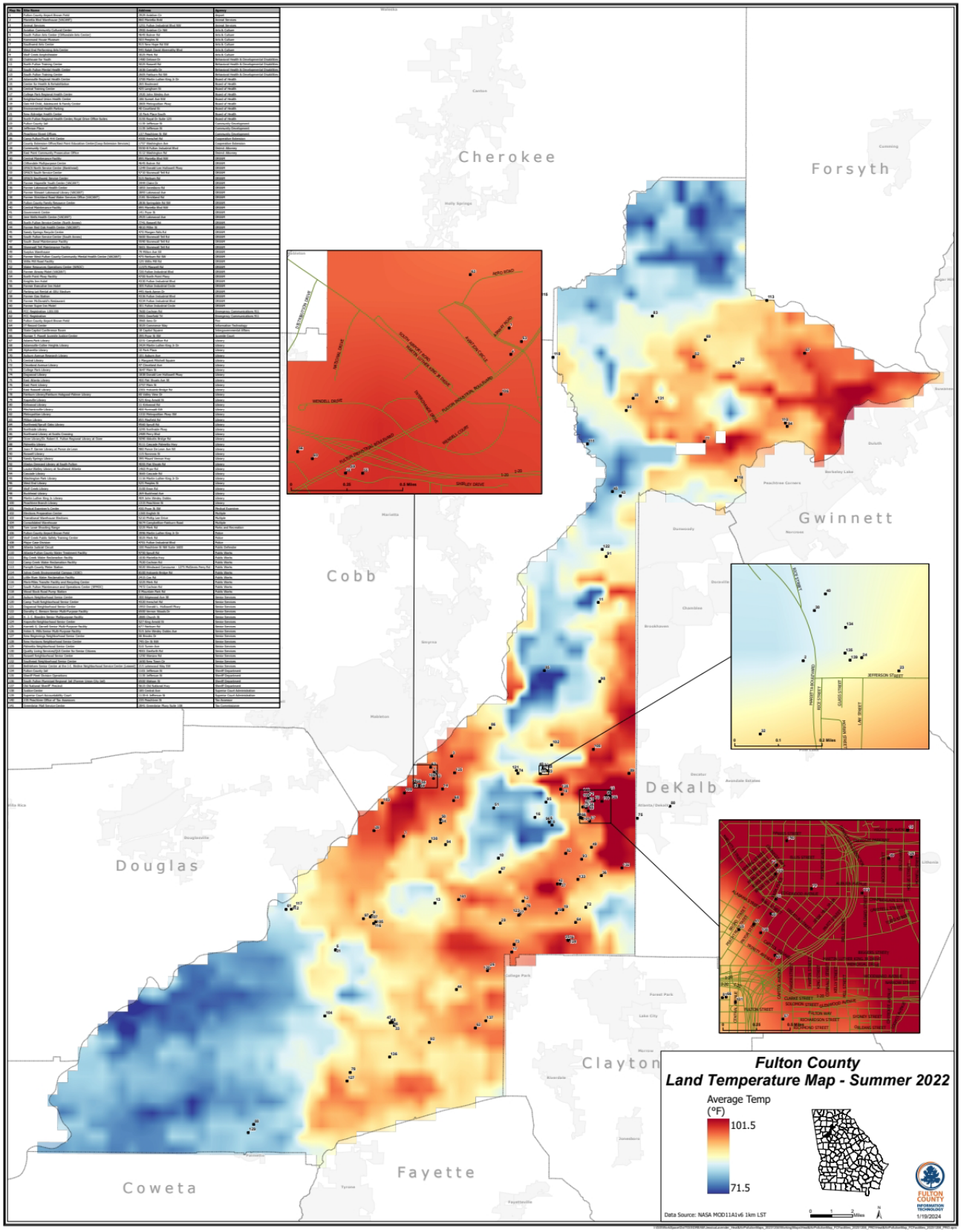
[26] US Department of Agriculture. "USDA Opens People's Garden Initiative to Gardens Nationwide," (National-Post-News-Release, 2022).
[27] White House. "National Climate Resilience Framework," (2023).

[28] The White House. "FACT SHEET: President Biden Takes Executive Actions to Tackle the Climate Crisis at Home and Abroad, Create Jobs, and Restore Scientific Integrity across Federal Government," (The White House, 2021).

These maps also show the locations of all county facilities. Fulton County can prioritize resilience projects in the areas of the map that have the highest temperatures and poorest air quality. For example, Fulton County can add trees or shade cover at these facilities, or open resilience hubs or cooling centers.


Cherokee
Forsyth
Gwinnett
Cobb
DeKalb
Douglas
Clayton
Fayette
Coweta
Fulton County
Greenspace Map - Summer 2022
Average NDVI
0.97
0.16
Data Source: NASA MOD13A2v6 500m NDVI
1/19/2024


Cherokee
Forsyth
Gwinnett
Cobb
DeKalb
Douglas
Clayton
Fayette
Coweta
Fulton County
Air Pollution Map - Summer 2022
Average AOD
0.387
0.083
Data Source: NASA MCD19A2v061 1km AOD
FULTON COUNTY
INFORMATION TECHNOLOGY
1/19/2024


Cherokee
Forsyth
Gwinnett
Cobb
DeKalb
Douglas
Clayton
Fayette
Coweta
Fulton County
Land Temperature Map - Summer 2022
Average Temp
(°F)
101.5
71.5
Data Source: NASA MOD11A1v6 1km LST
1/19/2024

Green spaces in vulnerable areas address all of the major risks identified in this study: flooding, extreme heat, and air pollution. Fulton County could plant trees and other vegetation on their own government property and make connections with organizations like Trees Atlanta to facilitate the process. Fulton County can encourage individuals and neighborhoods to increase green space as well.

Green spaces help decrease temperature extremes through the process of evapotranspiration - when moisture is released into the atmosphere via leaves as water vapor. This, as well as the canopy cover provided by trees, contributes to the cooling of the area around the trees. According to the U.S. Department of Agriculture, "...tree canopy cover reduces temperatures 11-19 degrees Fahrenheit compared to communities with no tree cover."[29] Greenspaces also reduce air pollution by positively contributing to air quality. They absorb some of the pollutants in the air, photosynthesize, and release these once harmful gases as oxygen. Lastly, canopy cover is helpful in the presence of flooding. Trees and other vegetation absorb water and reduce runoff.

Public awareness campaign for participation in federal and state programs such as the Weatherization Assistance Program (WAP) and the Low-Income Home Energy Assistance Program (LIHEAP). Many times, these programs are underutilized simply because people do not know about them. Getting the word out and helping families and communities go through the process of applying for and receiving aid from these programs is essential. The WAP and LIHEAP help families and individuals living 200% below the federal poverty level retrofit their homes for energy efficiency and power their homes with renewable electricity sources.

Public awareness campaign for emergency preparedness encourages families to create plans and kits for the worst-case scenarios. Providing sample kits and information on safe evacuation routes, while also providing education on disaster readiness, enhances individual and neighborhood resilience.

Green job training programs can help build resilience by creating a knowledgeable and better-prepared workforce. A couple of these programs include the Industrial Assessment Centers (IACs) Program and the Building Training and Assessment Centers (BTAC) Program. The IACs Program provides resources to small-to-medium-sized manufacturers, workers and students seeking hiring/training, and universities and career institutions.[30] The BTAC Program provides grants to universities, community colleges, and other higher education institutions to educate students and prepare them to "lower our nation's carbon footprint."[31] Fulton County could promote and fund these and other local training programs.

Cooling centers are important during extreme temperatures to reduce the risks of extreme heat exposure. A center can serve as a place for families who may have lost power or AC, those who cannot afford AC, and those who are homeless.

Community gardens enhance local food security, promote healthy eating, and create green spaces that absorb stormwater. The *People's Garden Initiative*, as mentioned under "Current Resilience Efforts,"

[29] Hopper, Regan. "Finding Relief in the Shade," (U.S. Department of Agriculture, 2023).
[30] U.S. Department of Energy. n.d. "Industrial Assessment Centers (IACs)," (Energy.gov. Office of Manufacturing and Energy Supply Chains).
[31] U.S. Department of Energy. n.d. "Building Training and Assessment Centers," (Energy.gov, Office of State and Community Energy Programs).

could be useful to develop community gardens that will positively contribute to community resilience and wellbeing of the local community.

Green/White Roofs have been found effective in reducing cooling costs. Vegetated or "green" roofs on county buildings decrease urban stormwater runoff as well as the urban heat island effect. According to the *U.S. Department of Energy*, white-colored roofs reflect around "60-90%" of sunlight. Although green roofs help air quality, reduce temperatures, and reduce runoff, they are expected to be more expensive to implement and maintain than white roofs.[32]

Stormwater infrastructure, such as green infrastructure and riparian buffers, are beneficial in reducing flooding. **Green infrastructure** can include developing rain gardens, permeable pavers, and bioswales to manage stormwater runoff. These will reduce the burden put on Atlanta's aging stormwater/sewer infrastructure systems and decrease flooding while at the same time improving water quality. As seen in the *U.S. Environmental Protection Agency*'s (EPA) 2015 green infrastructure report, Kansas City, MO saw a "32% decrease" in sewer flow after installing 67 rain gardens, 1 bioswale, and 1100 linear feet of permeable paver sidewalk along with other infrastructure such as curb extensions.[33] **Riparian Buffers**, when maintained and restored along waterways in the county, will soak up runoff and reduce the risk of flooding. They also stabilize riverbanks and provide habitats for local wildlife. EPA recognizes riparian buffers as a stormwater BMP (Best Management Practice). Not only do they absorb water and prevent or slow down runoff, but they can also remove some of the pollutants in the water.[34]

Resilience Hubs (i.e. the metropolitan library) placed in vulnerable areas could support the community in the event of hazards.

Eco-districts integrate sustainable infrastructure, energy use, and community engagement in the planning and development of new city districts.

Heat warnings for outdoor DREAM workers could help those working directly in the heat manage their body temperature and allow them to take ample breaks during the hottest parts of the day. The Department of Real Estate and Asset Management has multiple crews that work outside whether its the HVAC team, landscaping crews, or fleet mechanics. These crews are most at risk within the department when extreme heat waves hit the county and putting policy in place to protect them should be a high priority for the DREAM team.

<u>Neighborhood-Based Solutions</u>

Raised garden beds in neighborhood gardens serve as a great adaptation measure in the event of flooding. The plants will stay protected from flood in these beds and potentially be a food source for families and individuals in neighborhoods.

Air quality monitoring systems implemented in neighborhoods can be extremely important in building resilience. Daily air quality posted on weather applications/channels is usually for the city and town rather than specific areas. Depending on the health-related vulnerability of the neighborhood's inhabitants, these systems could be extremely helpful in preventing casualties. The people of the most

[32] U.S. Department of Energy. "Cool Roofs," (Energy.gov, 2023).
[33] Hopton, Matthew et. al. "Green Infrastructure for Stormwater Control: Gauging Its Effectiveness with Community Partners," (*EPA*, 2015).
[34] U.S. Environmental Protection Agency. "Air Quality Index Daily Values Report," (EPA, 2016).

vulnerable neighborhoods in Fulton County are reported to generally have low life expectancy and chronic diseases. They are in the higher percentile of medically underserved areas and would greatly benefit from air quality monitoring systems as many suffer from conditions that can be exacerbated by poor air quality.[35] In order to stay protected during days of bad air quality, it is recommended to wear a mask when outside or limit time outdoors.

Individual-Based Solutions

Rainwater harvesting provides a supplementary water source for irrigation and graywater systems like toilets. Using rain barrels for harvesting rainwater can encourage resilience on an individual level.

Solar panels can reduce greenhouse gas emissions and monthly electricity bills. They can also be connected to back-up battery systems to power homes when the electric grid is down. Low-income assistance programs such as Low-Income Financing and Transactions Solar (LIFT Solar) and Georgia BRIGHT aim to make solar available to homeowners that would not otherwise be able to afford it.[36]

Conclusion

This study addresses the need to build climate resilience with a focus on the most vulnerable and underserved communities in the county. In all predictions of future climate variabilities, the climate stressors of extreme heat, flooding, and air pollution will increase. This study has called attention to the disproportionate impact on disadvantaged communities, which has led us to identify inclusive and equitable resilience measures. Although there are ongoing initiatives within the county, our analysis reveals that gaps remain, especially in addressing the needs of underserved communities.

The recommendations provided by this study offer an approach to improving resilience at individual, neighborhood, and county levels. These include policy recommendations, infrastructure recommendations, project ideas, and public awareness campaigns. Each recommendation is designed to create a more resilient Fulton County by ensuring that protective measures are equitably distributed and accessible to all demographic groups. Looking forward, the implementation and success of these recommendations will require collaboration and depend on monitoring, adaptive management, and the involvement of its residents.

Partnerships with community-based organizations such as AgLanta and Trees Atlanta will be needed to put these recommendations place. Utilization of grants and a reliable annual budget is essential to fund the solutions. County-level solutions including green spaces, promotion of green job training programs, community gardens, and green roofs on county buildings are the most cost-effective, because the promotion of programs can be implemented at little-to-no cost while implementing vegetation for green spaces, community gardens, and green roofs are more cost-effective in comparison to solutions that require major infrastructure changes such as building resilience hubs and eco districts. These solutions will improve resilience on all levels: individual, neighborhood, and county-wide.

[35] CMRA. n.d. “Climate Mapping for Resilience & Adaptation,” (Resilience.climate.gov. CMRA).
[36] Capital Good Fund. “WELCOME to GEORGIA BRIGHT,” (Capital Good Fund, n.d.).

This study is an important step towards building a more resilient Fulton County. By focusing on the vulnerabilities and adaptive capacities of underserved communities, and by proposing actionable strategies, this study aims to facilitate a future where all residents can thrive in the face of climate risks. The urgency of this research cannot be overstated, as the impacts of these hazards are already being felt and will only intensify in the coming years. Through collective effort and a commitment to equity and sustainability, Fulton County can become a model of climate resilience for other regions to follow.

Appendix

The neighborhoods and towns within Fulton County that have the highest vulnerability (90th national vulnerability percentile and above):

- Pomona Park (99th national vulnerability percentile)
- Carroll Heights (98th national vulnerability percentile)
- Center Hill (98th national vulnerability percentile)
- Glenrose Heights (98th national vulnerability percentile)
- Harland Terrace (98th national vulnerability percentile)
- Swallow Circle-Baywood (98th national vulnerability percentile)
- Adamsville (97th national vulnerability percentile)
- South River Gardens (97th national vulnerability percentile)
- Carver Hills (96th national vulnerability percentile)
- Jefferson Park (96th national vulnerability percentile)
- Lakewood (96th national vulnerability percentile)
- Greenbriar (95th national vulnerability percentile)
- Grove Park (95th national vulnerability percentile)
- Mozley Park (95th national vulnerability percentile)
- The Villages at Carver (95th national vulnerability percentile)
- Wilson Mill Meadows (95th national vulnerability percentile)
- Adams Park (94th national vulnerability percentile)
- Hunter Hills (94th national vulnerability percentile)
- Oakland City (94th national vulnerability percentile)
- Thomasville Heights (94th national vulnerability percentile)
- Ashview Heights (93rd national vulnerability percentile)
- East Point (93rd national vulnerability percentile)
- Venetian Hills (93rd national vulnerability percentile)
- College Park (92nd national vulnerability percentile)
- Dixie Hills (92nd national vulnerability percentile)
- Pittsburgh (92nd national vulnerability percentile)
- Southwest, Atlanta (92nd national vulnerability percentile)
- Sylvan Hills (92nd national vulnerability percentile)
- Bush Mountain (91st national vulnerability percentile)
- English Avenue (91st national vulnerability percentile)
- Fairburn Road/Wisteria Lane (91st national vulnerability percentile)
- Mechanicsville (91st national vulnerability percentile)
- West End (91st national vulnerability percentile)
- South Atlanta (90th national vulnerability percentile)

References

"2019 Sustainability Plan + Resilience." 2022. Fulton County Government. February 2022. https://www.fultoncountyga.gov/-/media/Inside-Fulton-County-Documents/Sustainability/Fulton-County-2019-Sustainability-Plan-w-2022-Updates-2023-1-6.pdf.

American Lung Association. 2024. "Fulton." Www.lung.org. 2024. https://www.lung.org/research/sota/city-rankings/states/georgia/fulton.

Baidya, Johanna. n.d. "A City in the Forest: Atlanta's Effort to Preserve Nature in the City | Trees Atlanta." Www.treesatlanta.org. Trees Atlanta. https://www.treesatlanta.org/news/a-city-in-the-forest-atlantas-effort-to-preserve-nature-in-the-city/.

BestPlaces. n.d. "Fulton County, GA Climate." BestPlaces. https://www.bestplaces.net/climate/county/georgia/fulton.

Blog Administrator. 2022. "Prep Your Health for Floods | Blogs | CDC." Centers for Disease Control and Prevention. March 14, 2022. https://blogs.cdc.gov/publichealthmatters/2022/03/floods/#:~:text=Exposure%20to%20contaminated%20floodwater%20can%20cause%20wound%20infections%2C.

City of Asheville. 2018. "COA_Climate_Resilience_Final_Report_April_2018_reduced for Web.pdf." Ashevillenc.gov. April 2018. https://drive.google.com/file/d/1X_Gr4eUCmkXPOzAcvyxCe-uZPkX84Byz/view.

Clean Energy Atlanta. 2019. "Clean Energy Atlanta a Vision for a 100% Clean Energy Future." https://static1.squarespace.com/static/5f91d62189677674f6d02ab6/t/5f91e88080fdee7a2aa54f7d/1603397764189/nrdc_100ce_plan_021319_v8_low-res.pdf.

CMRA. n.d. "Climate Mapping for Resilience & Adaptation." Resilience.climate.gov. CMRA. https://resilience.climate.gov/.

Environmental Defense Fund, Texas A&M University, and Darkhorse Analytics. n.d. "The U.S. Climate Vulnerability Index." The U.S. Climate Vulnerability Index. https://climatevulnerabilityindex.org/.

Fulton County Government. 2021. "The Metropolitan Library Becomes Fulton County New Community Resilience Hub." Www.fultoncountyga.gov. Fulton County. October 22, 2021. https://www.fultoncountyga.gov/news/2021/10/22/the-metropolitan-library-becomes-fulton-county-new-community-resilience-hub.

———. 2024. “Solar Program.” Www.fultoncountyga.gov. Fulton County. 2024. https://www.fultoncountyga.gov/inside-fulton-county/fulton-county-initiatives/sustainable-fulton/solar-program.

Georgia Emergency Management and Homeland Security Agency. 2019. “Hazard Mitigation Planning.” GEMA. 2019. https://gema.georgia.gov/hazard-mitigation-planning.

“GHG Emissions Tracker.” n.d. Drawdown Georgia. https://www.drawdownga.org/ghg-emissions-tracker/.

Hopper, Regan. 2023. “Finding Relief in the Shade.” U.S. Forest Service. U.S. Department of Agriculture. July 24, 2023. https://www.fs.usda.gov/features/finding-relief-in-the-shade.

Hopton, Matthew, Michelle Simon, Michael Borst, Ahjond Garmestani, Scott Jacobs, Dennis Lye, Thomas O’Conner, William Shuster, and Taylor Jarnagin. 2015. “Green Infrastructure for Stormwater Control: Gauging Its Effectiveness with Community Partners.” *EPA*. U.S. Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NE3S.txt.

NCEI. 2019. “Storm Events Database | National Centers for Environmental Information.” Noaa.gov. 2019. https://www.ncdc.noaa.gov/stormevents/.

Office of the Assistant Secretary for Planning and Evaluation. 2023. “Poverty Guidelines.” ASPE. U.S. Department of Health and Human Services. January 19, 2023. https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines.

“Programs — AgLanta - Urban Agriculture Atlanta.” n.d. AgLanta. Accessed June 4, 2024. https://www.aglanta.org/programs.

Ruffin, Destiny. 2022. “2022 Fulton County Multijurisdictional Hazard Mitigation Plan.” Fulton County Government. Atlanta-Fulton County Emergency Management Agency. June 2022. https://www.fultoncountyga.gov/-/media/Departments/AFCEMA/2022-Fulton-County-Multijurisdictional-Hazard-Mitigation-Plan-FEMA---GEMA-Approved-04-23-2023.pdf.

Smith, Jill. 2023. “American Lung Association Report: Atlanta’s Air Quality Improves; 1 in 3 Nationwide Exposed to Unhealthy Air.” Www.lung.org. April 19, 2023. https://www.lung.org/media/press-releases/ga-fy23-sota-press-release.

The White House. 2021. “FACT SHEET: President Biden Takes Executive Actions to Tackle the Climate Crisis at Home and Abroad, Create Jobs, and Restore Scientific Integrity across Federal Government | the White House.” The White House. January 27, 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/27/fact-sheet-

president-biden-takes-executive-actions-to-tackle-the-climate-crisis-at-home-and-abroad-create-jobs-and-restore-scientific-integrity-across-federal-government/.

———. 2023. “National Climate Resilience Framework.” https://www.whitehouse.gov/wp-content/uploads/2023/09/National-Climate-Resilience-Framework-FINAL.pdf.

United States Geological Survey. “Atlanta Surface Temperature | U.S. Geological Survey.” www.usgs.gov, 2019. https://www.usgs.gov/media/images/atlanta-surface-temperature.

U.S. Census Bureau. n.d. “Explore Census Data.” Data.census.gov. U.S. Census Bureau. https://data.census.gov/profile/Fulton_County?g=010XX00US.

U.S. Centers for Disease Control and Prevention. n.d. “Heat & Health Tracker.” Ephtracking.cdc.gov. Climate & Health Program. https://ephtracking.cdc.gov/Applications/heatTracker/.

US Department of Agriculture. 2022. “USDA Opens People’s Garden Initiative to Gardens Nationwide.” National-Post-News-Release. September 9, 2022. https://www.fsa.usda.gov/news-room/news-releases/2022/usda-opens-peoples-garden-initiative-to-gardens-nationwide.

U.S. Department of Energy. 2023. “Cool Roofs.” Energy.gov. Energy Saver. 2023. https://www.energy.gov/energysaver/cool-roofs.

———. n.d. “Building Training and Assessment Centers.” Energy.gov. Office of State and Community Energy Programs. https://www.energy.gov/scep/building-training-and-assessment-centers.

———. n.d. “Industrial Assessment Centers (IACs).” Energy.gov. Office of Manufacturing and Energy Supply Chains. https://www.energy.gov/mesc/industrial-assessment-centers-iacs.

U.S. Environmental Protection Agency. 2016. “Air Quality Index Daily Values Report.” U.S. Environmental Protection Agency. EPA. August 12, 2016. https://www.epa.gov/outdoor-air-quality-data/air-quality-index-daily-values-report.

———. 2024. “Heat Island Effect.” US EPA. March 18, 2024. https://www.epa.gov/heatislands.

———. n.d. “Stormwater Best Management Practice Riparian/Forested Buffer Minimum Measure: Post Construction Stormwater Management in New Development and Redevelopment Subcategory: Innovative Practices for Site Plans.” EPA. https://www.epa.gov/system/files/documents/2021-11/bmp-riparian-forested-buffer.pdf.