Climate Resilience & Sustainability: Georgia's Freight System

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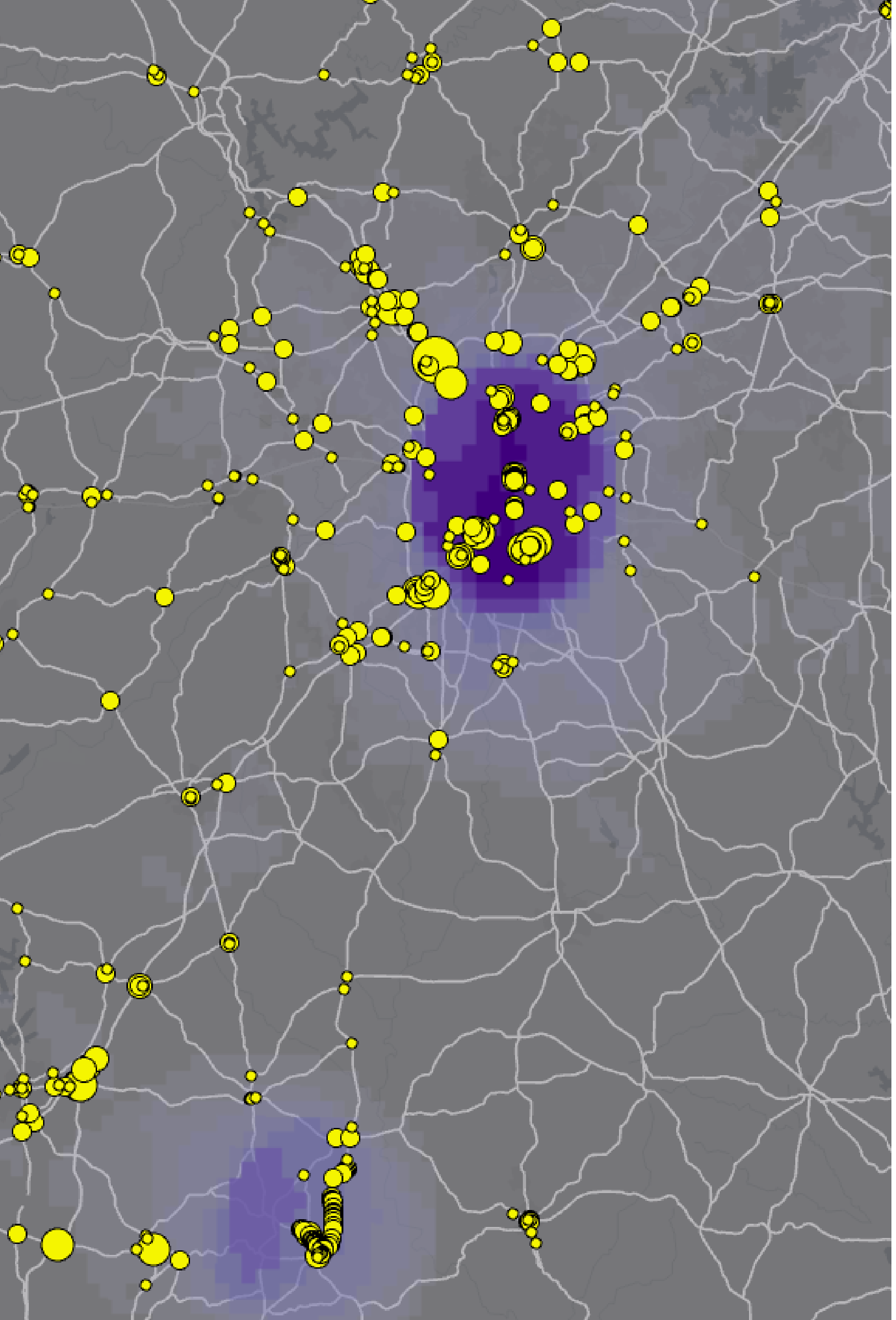
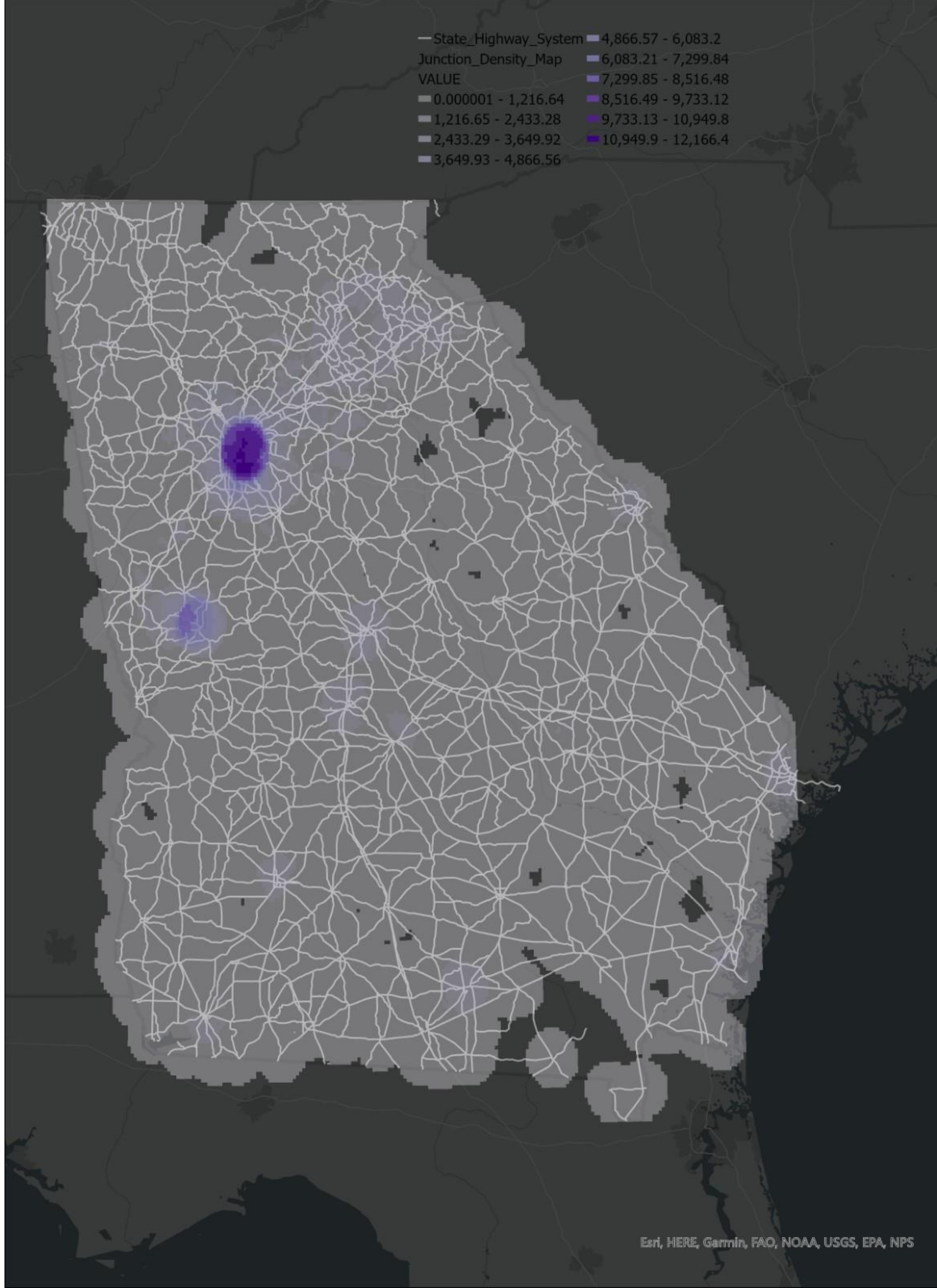


GA PRESENTATION FRAMEWORK

1. Introduction to the GA Freight System
2. Georgia's Climate Hazards
3. Analysis Framework
4. Analyzing Resilience: Heat Waves, Flooding, Coastal Sea Level Rise

GA FREIGHT GEOGRAPHIC LOCATION

- A Nearest Neighbor Analysis of High Volume AADT shows that there is one major Freight Hotspot in Metro Atlanta followed by Savannah.
- Smaller Clusters exist North of Columbus and at Macon.
- Hartsfield-Jackson Atlanta International Airport is one of the busiest airport in the world.
- Savannah is one of the largest ports on the East coast.



GA FREIGHT SYSTEM

- The statewide freight system is planned for and maintained primarily by GDOT
- The logistics industry makes up 18% of the state's gross state product
- Over 30,000 companies employing 700,000 people in the state rely on the freight system to move goods and services through supply chains
- Highest truck volumes are found on I-75 just north and south of I-285 and to the west of I-285
- Atlanta region has the highest concentration of tonnage generated

GA FREIGHT NETWORK

NATIONAL HIGHWAY FREIGHT NETWORK - GEORGIA				
PRIMARY HIGHWAY FREIGHT SYSTEM (PHFS) ROUTES				
State	Route No	Start Point	End Point	Length (Miles)
GA	I16	I75	2.28 Miles East of I516	165.44
GA	I185	I85	Columbus, GA	48.39
GA	I20	AL/GA Line	GA/SC Line	201.69
GA	I24	TN/GA Line	GA/TN Line	3.95
GA	I285	I85	I85	61.35
GA	I475	I75	I75	15.58
GA	I516	GA26R	GA25P	2.03
GA	I75	FL/GA Line	I475	156.89
GA	I75	I16	GA/TN Line	190.08
GA	I85	AL/GA Line	I285	70.39
GA	I85	I285	GA/SC Line	83.81
GA	I95	FL/GA Line	GA/SC Line	111.93
GA	S166	GA5R	I75	0.82
GA	S21	GA24P	I95	4.69
GA	S6	I20	U278	2.64
GA	U19	GA60R	GA28L	1.96
GA	U278	S6	6.62 Miles North of S6	6.62
Subtotal				**1128.29**

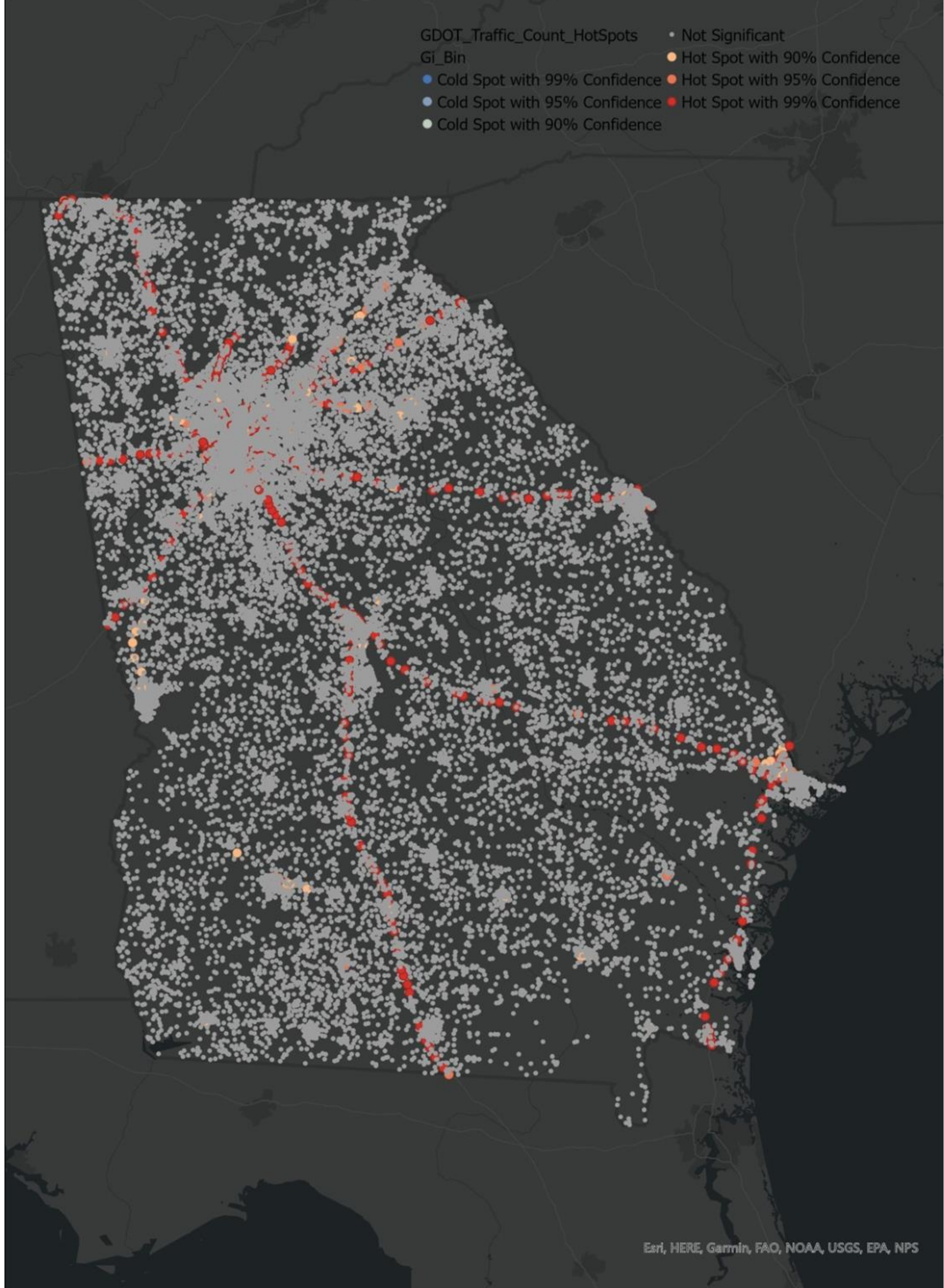
Primary Highway Freight System (PHFS) Routes (GDOT)

FREIGHT RESILIENCY NETWORK

Hotspot Analysis Shows that the Major Freight Corridors (shown in Red) are predominantly on the State Expressways. But the State Expressways overlap significantly with Census Tracts affected by Climate Hazards. Non-Expressway Routes should also be considered in Resiliency Planning.

Major High-Tonnage Routes are:

- I-16: Savannah
- I-20: connects AL and SC
- I-75: connects FL and TN
- I-85: connects AL and SC
- I-95: along East coast



FUTURE PROJECTION OF THE RESILIENCY NETWORK

- Metro Atlanta's total freight volume is projected to grow 76% from 2013 to 2040
- Currently one-third of the employment depends on reliable freight shipments
- By 2040, more than 400,000 jobs to 40% of all new employment

FREIGHT RESILIENCY NETWORK

- Focus specifically on the infrastructure and operations structure of in response to natural weather events like flooding and storms

Will be determined in terms of

- (1) infrastructure impact as (2)network connectivity response to simulations in node and segment disruptions based on Hazard.

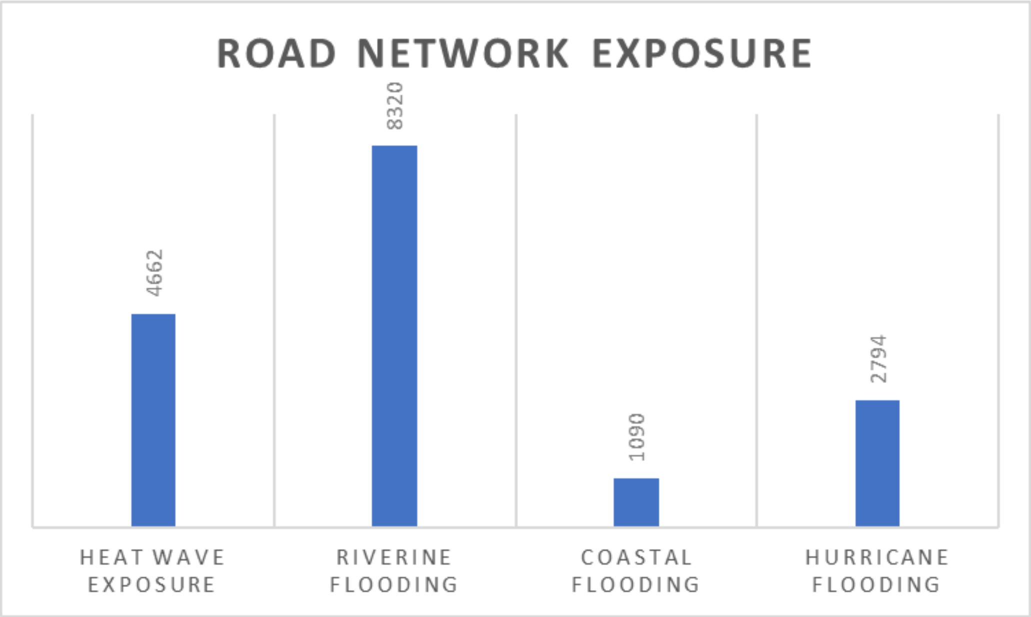
SUSTAINABILITY OF THE FREIGHT NETWORK

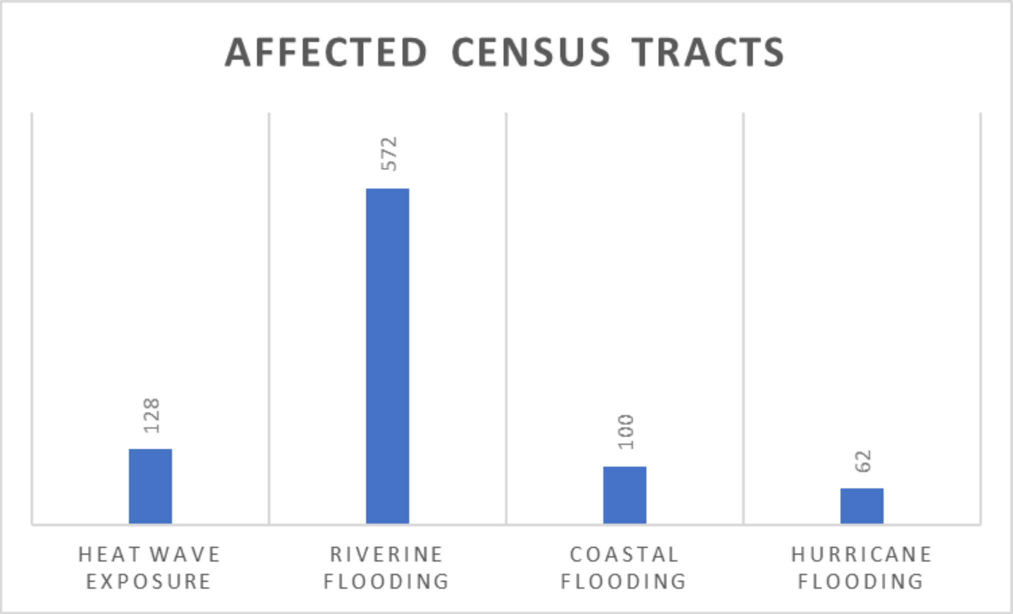
- Based on carbon emissions of freight vehicles and congestion related environmental costs such as air pollution
- Will be analyzed with respect to its impact on the UN sustainable development goals in terms of tradeoffs and complementariness

- Our analysis will be focusing on:
  - Simulation of percentage increases in Electric Freight Vehicles
  - Increase freight volume to a freight rail network along the principal corridor connecting Savannah and Atlanta in terms of potential impact on carbon emissions

GA CLIMATE HAZARDS

What are the Climate Hazards GA is prone to?



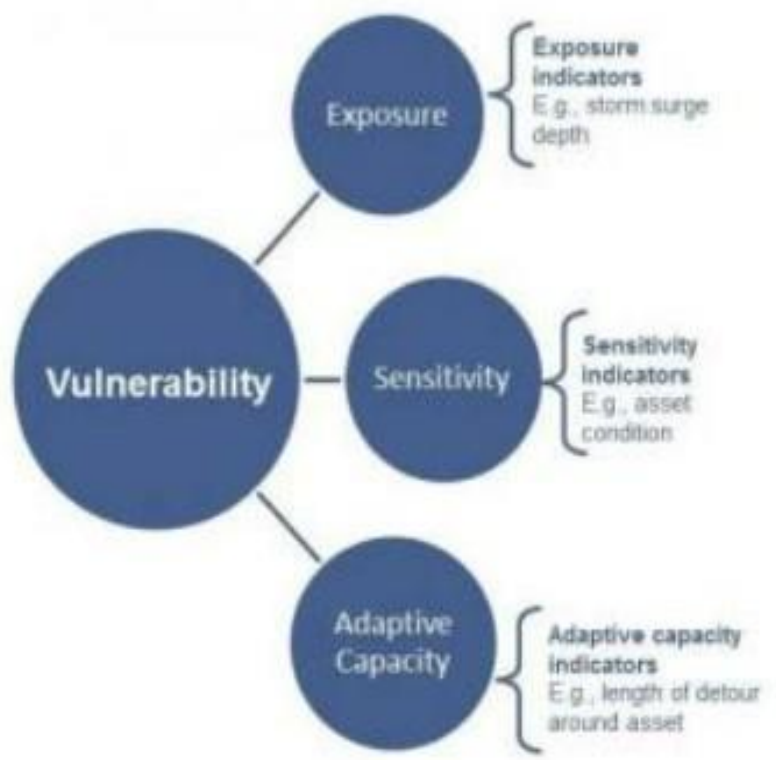


RESEARCH QUESTION

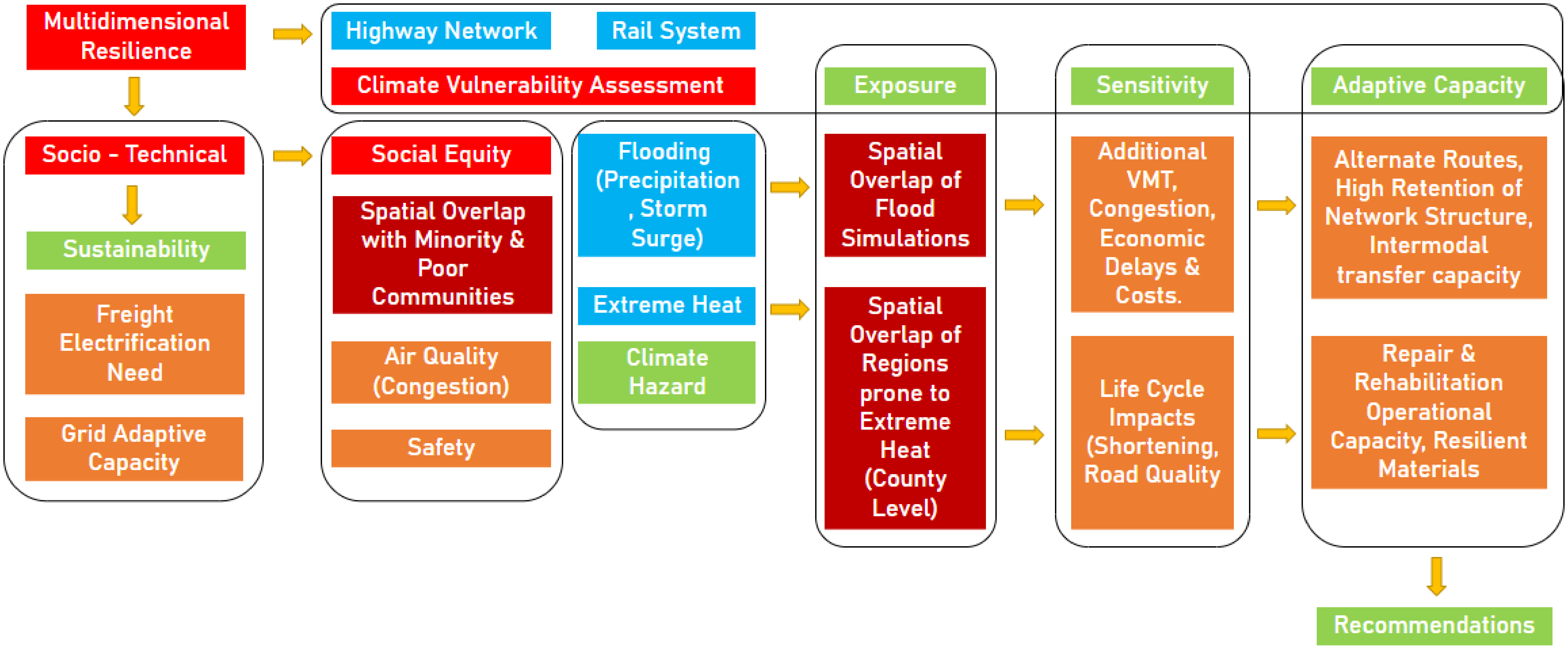
How do we determine the vulnerabilities of the Georgia Freight System, and how might its resiliency and sustainability be improved through infrastructure asset management practices to enhance its long-term performance?

In accordance with DOT VAST we define Vulnerability as

Exposure + Sensitivity – Adaptive Capacity



RESILIENCE ROADMAP + APPROACH

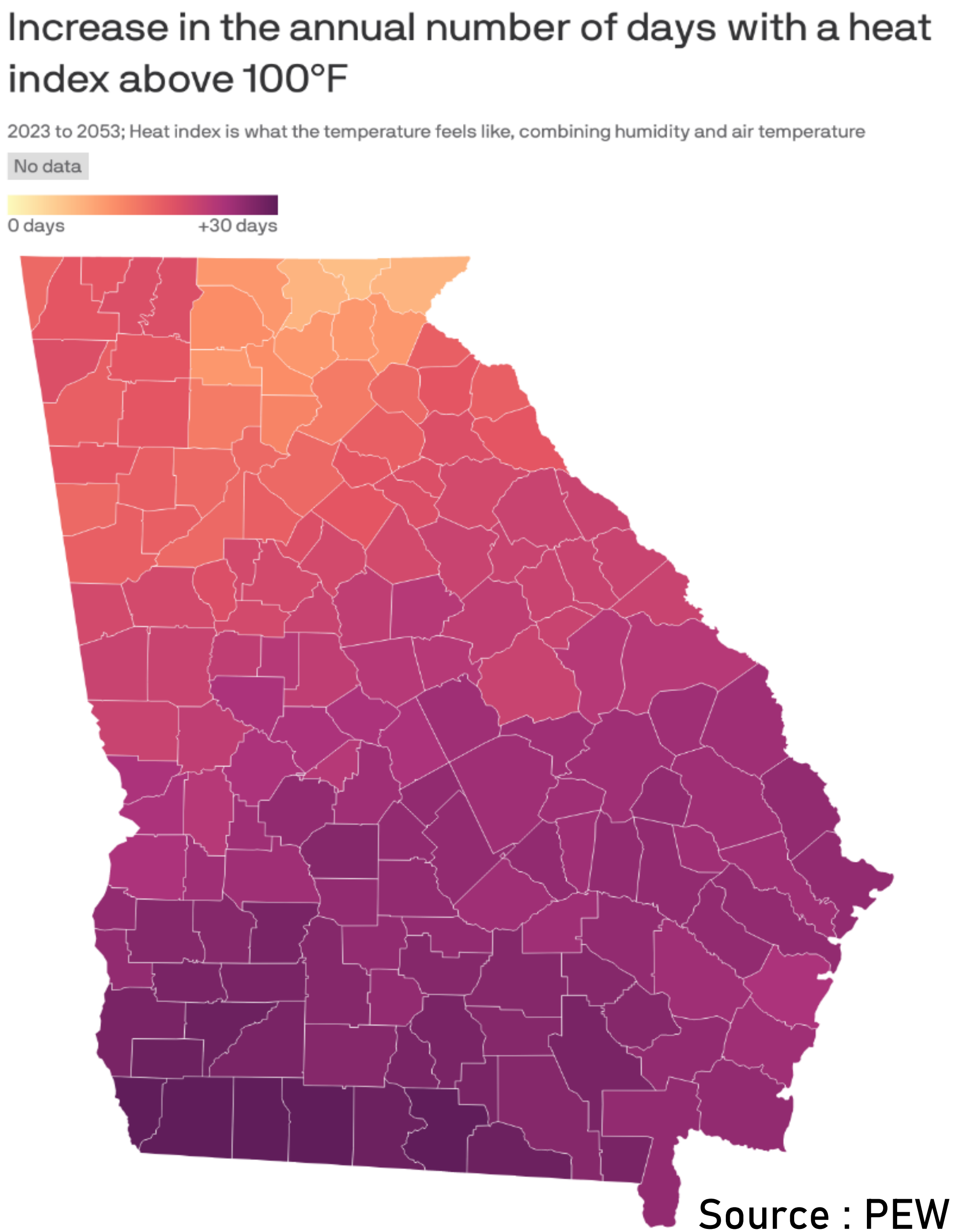


ANALYSIS METRICS

- Hazards Considered: Heat Waves and Flooding.
- Spatial Unit of Analysis: Census Tracts
- Climate Data Source: FEMA Vulnerability Risk Maps
- Defining Sensitivity & Adaptive Capacity through Asset Condition and Choice of Alternatives, respectively
- We have a multidimensional analysis through a sustainability lens and climate vulnerability lens

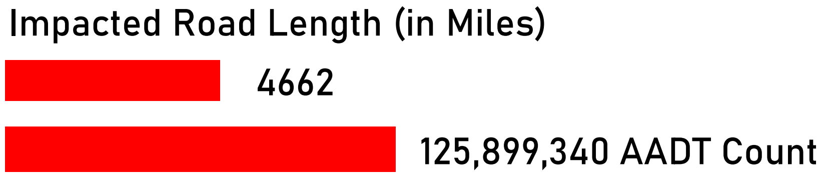
HEAT WAVES

The map showcases the geographical distribution of extreme heat in Georgia. We find that many southern routes will be exposed to 30 more days with temperatures above 100°F justifying the need for infrastructure management practices to adapt to create resiliency.



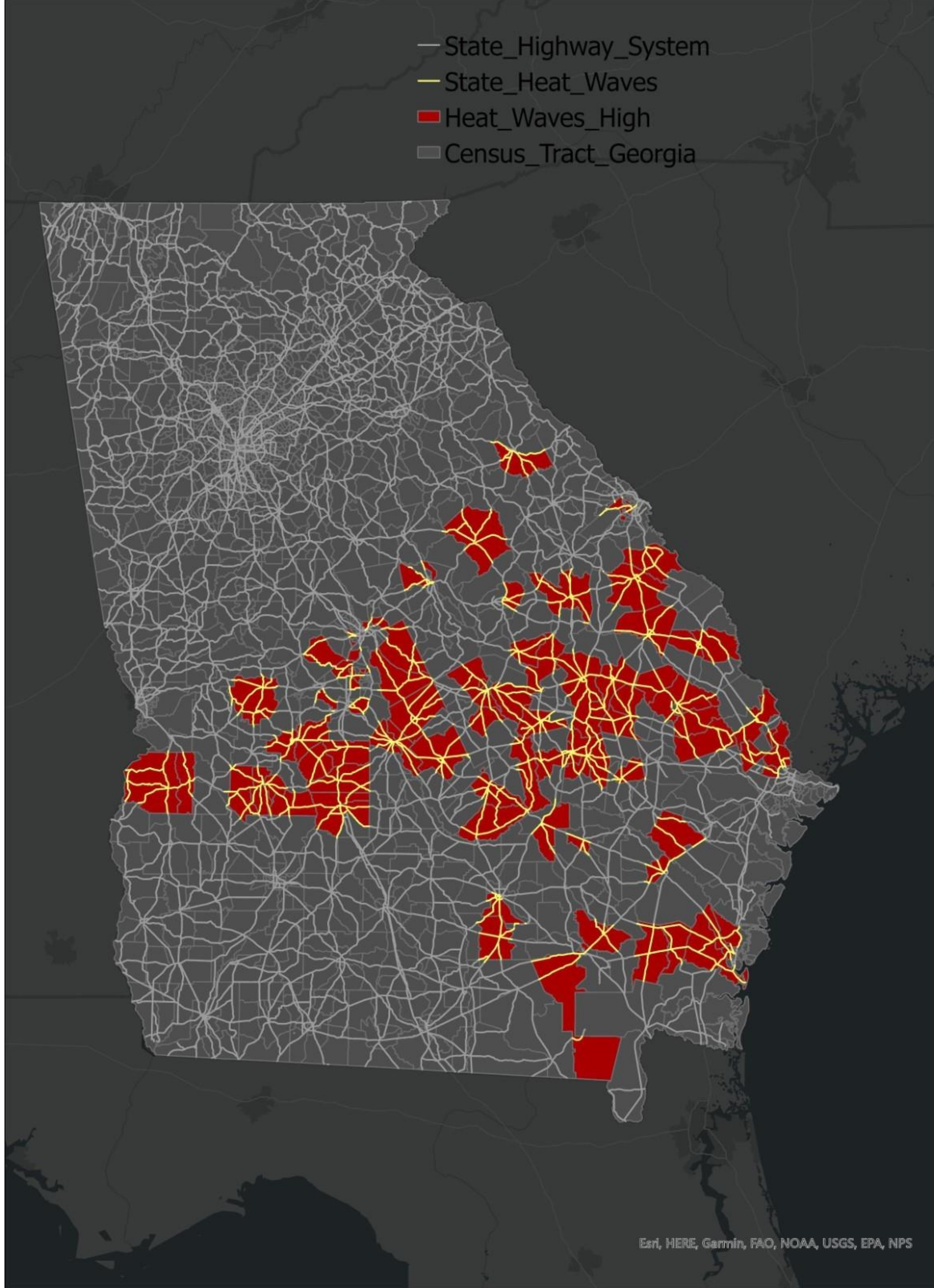
Source : PEW Charitable Trusts

HEAT WAVES



- Georgia currently averages about 20 dangerous heat days a year. By 2050, it is projected to see more than 90 such days a year.
- Heat itself is one of the leading weather-related killers, and it's also a significant contributing factor in creating ground-level ozone, which is a serious health hazard.
- More than 310,000 people living in Georgia are especially vulnerable to extreme heat.

Source : Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS



HEAT WAVES SENSITIVITY

- Heat waves can impact the system by increasing deterioration rates for roadways thereby increasing maintenance costs over longer periods of time.
- Research undertaken in past efforts shows that asphalt tends to age faster in extreme heat.
- Additionally rigid pavements can exhibit buckling or blowups in response to limitations in expansion capacity.
- Similarly, steel rail tracks can expand in extreme heat causing unintended deformations.

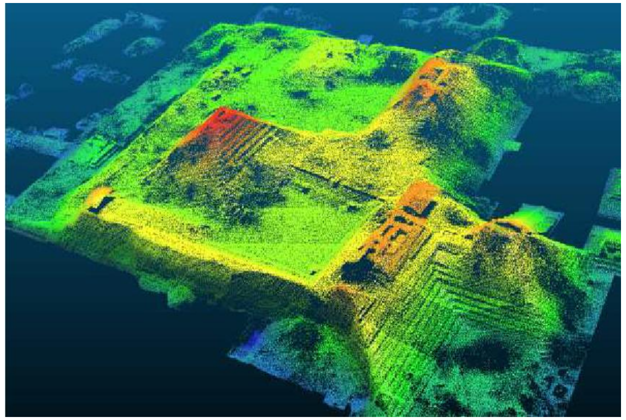
RECOMMENDATIONS

Use developed Targeted Weather Data to Identify Priority Heat Corridors. Use Point Laser or Lidar based Methodologies to analyze deterioration impact for immediate maintenance by vehicle-based assays. HYPERCONNECTIVITY

Develop an Inventory of all Electrical Equipment such as Traffic Control Boxes and Signals. Replace with Equipment that display greater resilience through enhanced cooling. INFRASTRUCTURE

Add Green Infrastructure along High Heat Priority Corridors utilizing Nature-Based Resiliency Methods. Will result in more equity-oriented outcomes in Noise and Air Quality.

NATURE –BASED MITIGATION



RECOMMENDATIONS

Address GDOT Worker Safety Policies to reduce Health-related impacts of high heat exposure.

SOCIAL EQUITY

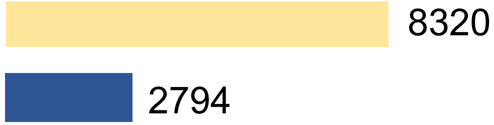
Adopting Widespread Use of Hot-Mix Asphalt in Impacted Freight Routes that has more robust performance and is resistant to heat impact deterioration. INFRASTRUCTURE

Study of State Roadway Resilience Plans with known High Heat Impact such as Arizona to understand transferable recommendations. PLANNING

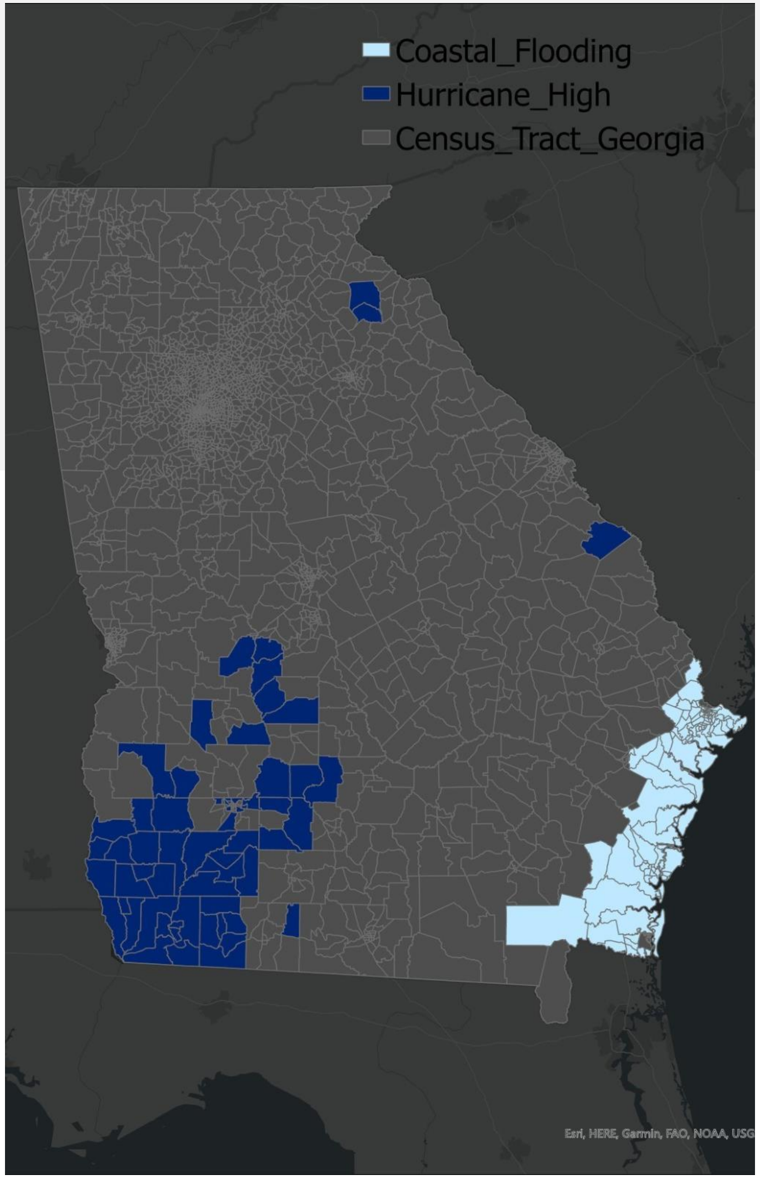
Develop a Real-Time Spatial Database of Road Temperatures by interfacing asphalt temperature prediction models with data from local weather stations. HYPERCONNECTIVITY

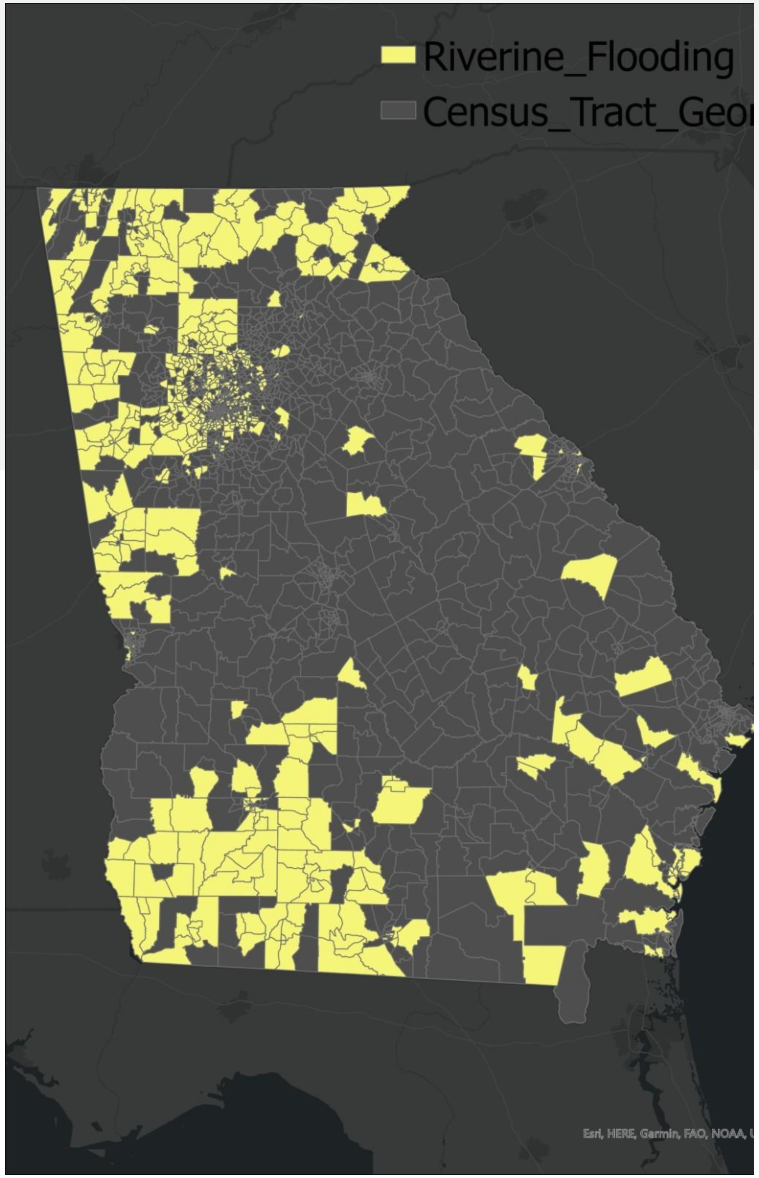
Flooding – Riverine & Storms Exposure

Impacted Road Length (in Miles)



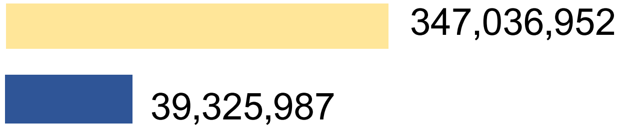
Exposure can be identified using these three principal questions -
What distance is being impacted?
How many access points are being impacted?
How many vehicles are being impacted?



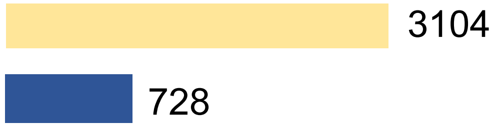


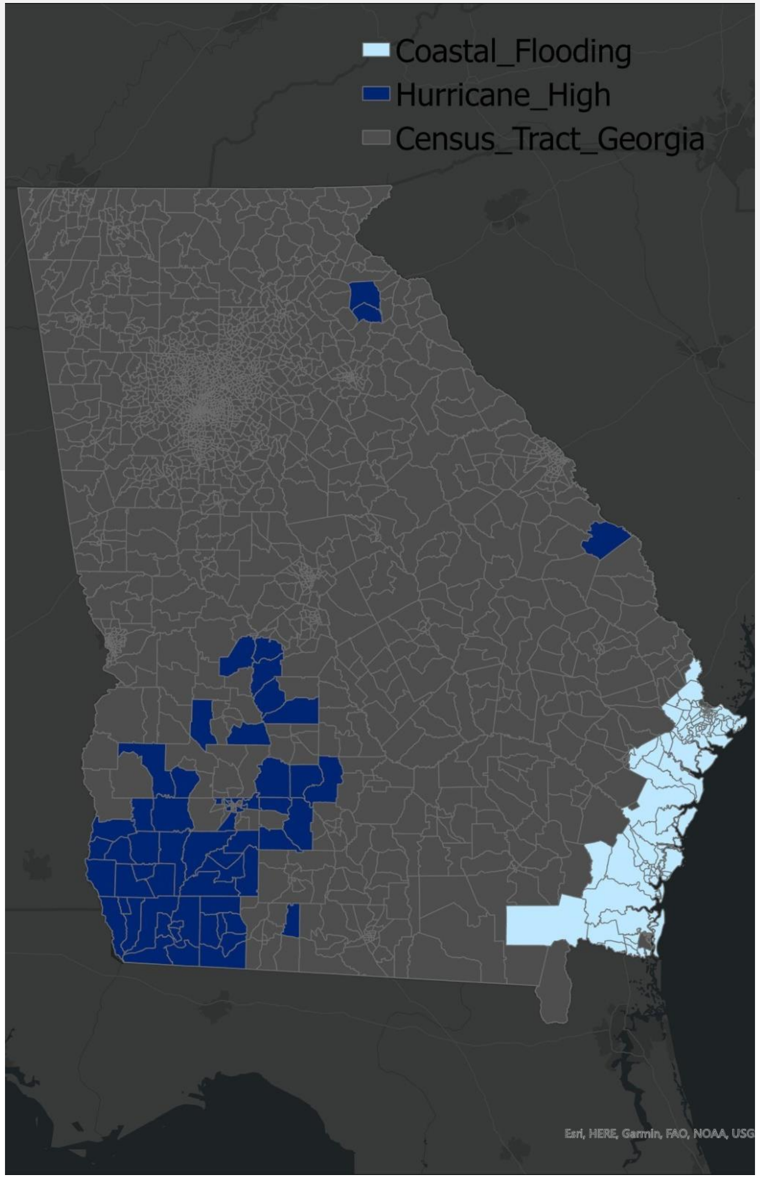
Flooding – Riverine & Storms Exposure

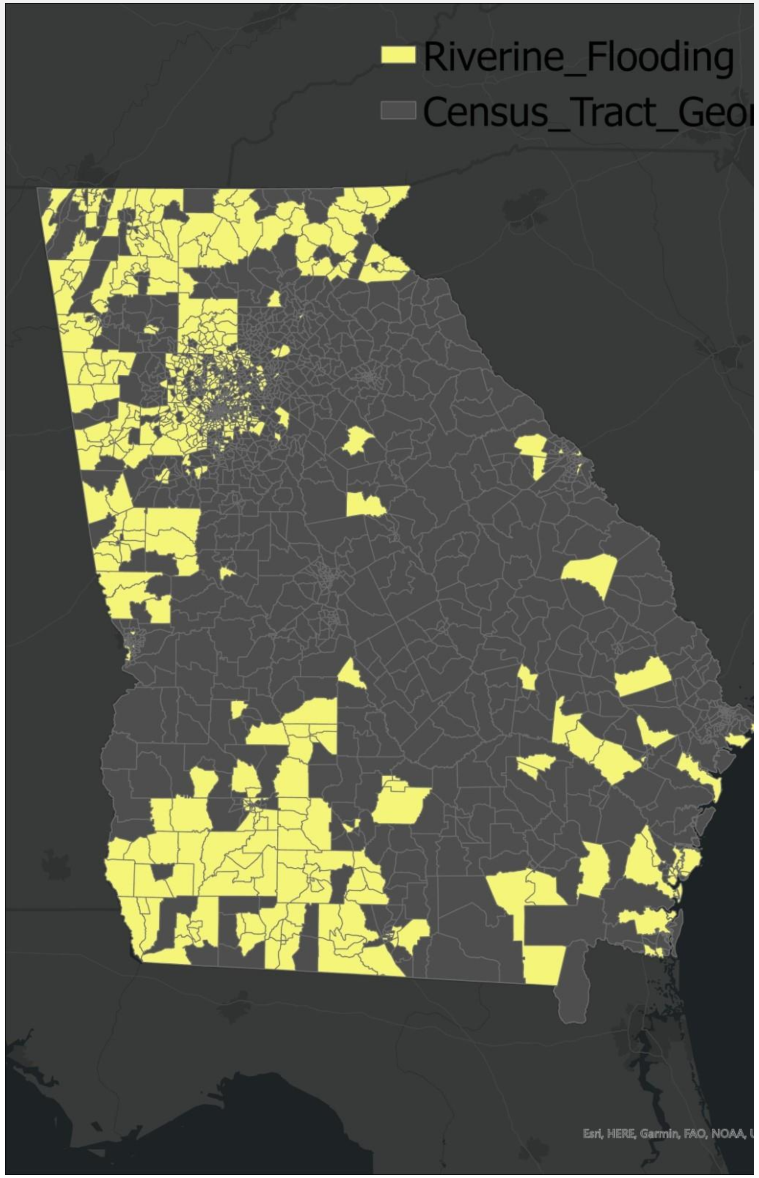
Impacted AADT (in Vehicle Counts)



Impacted Junction Nodes (in Numbers)







RECOMMENDATIONS

Flooding Events possess a greater threat to the performance of the roadway as a Network as opposed to Infrastructure.

In Networks, Sensitivity is tied to the Flow of Goods from Origin to Destination. Therefore, it is best modelled using Scenario Analysis that models a specific flow. Summation of various scenarios will then determine System Sensitivity.

Sensitivity = Change in Vehicle Miles Travelled [Scenario]+ Change in Congestion[Scenario]+ Economic Delay Costs Assuming Free Flow (in Hours)[Scenario]

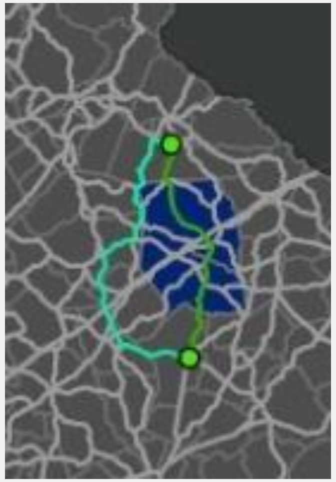
Adaptive Capacity is tied to a combination of Scenario Specific Factors and Systemic Potential.

Adaptive Capacity = Alternative Routing Potential [Scenario] + Level of Loss in Integrity of Network Structure[Systemic] + Intermodal Transfer Capacity [Systemic]

We will model two Scenarios to understand the Methodology.

Storm Flooding Sample Computation

Alternate Routing Potential: Yes



Number of Segments Travelled:

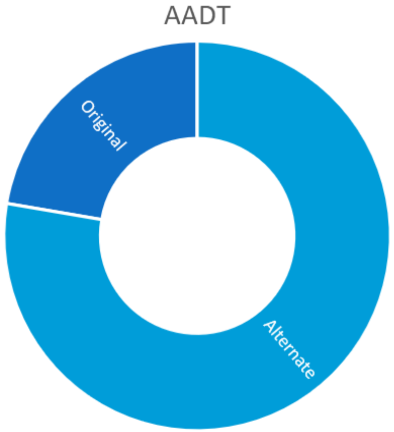
95 - 107

Number of Intersections Crossed:

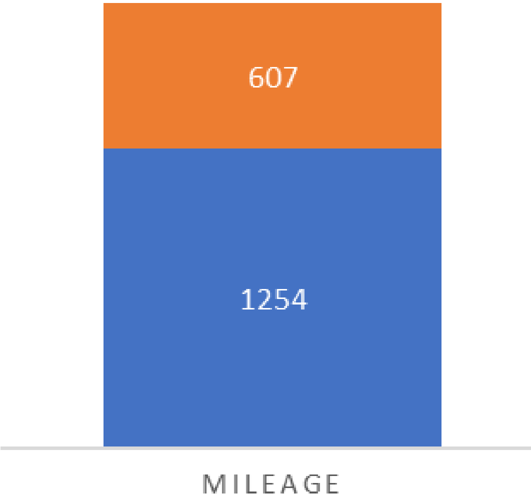
409 - 531

16

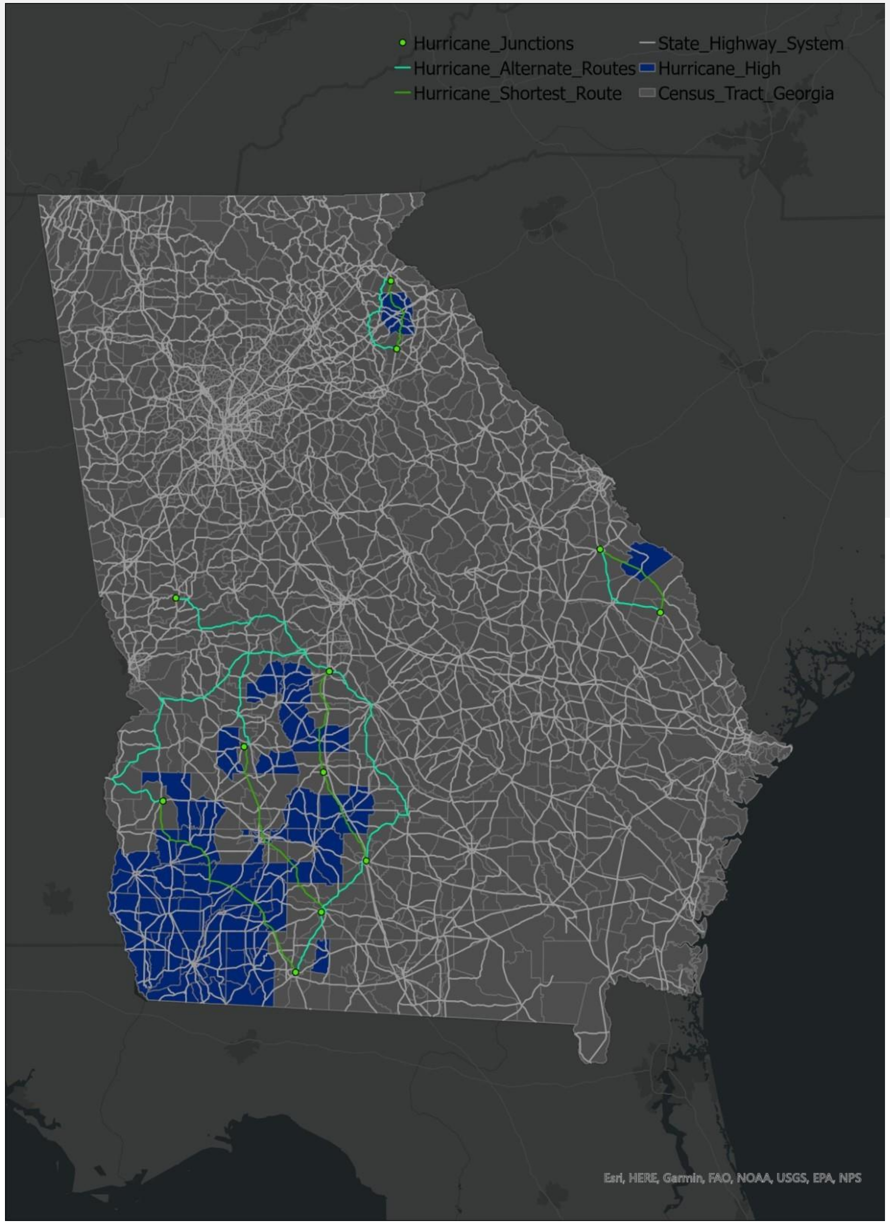
Economic Delay per Vehicle (In Hours)



% Increase in Vehicle Volume

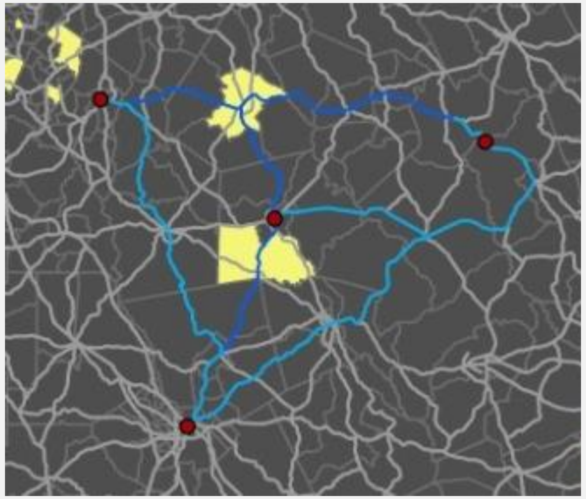


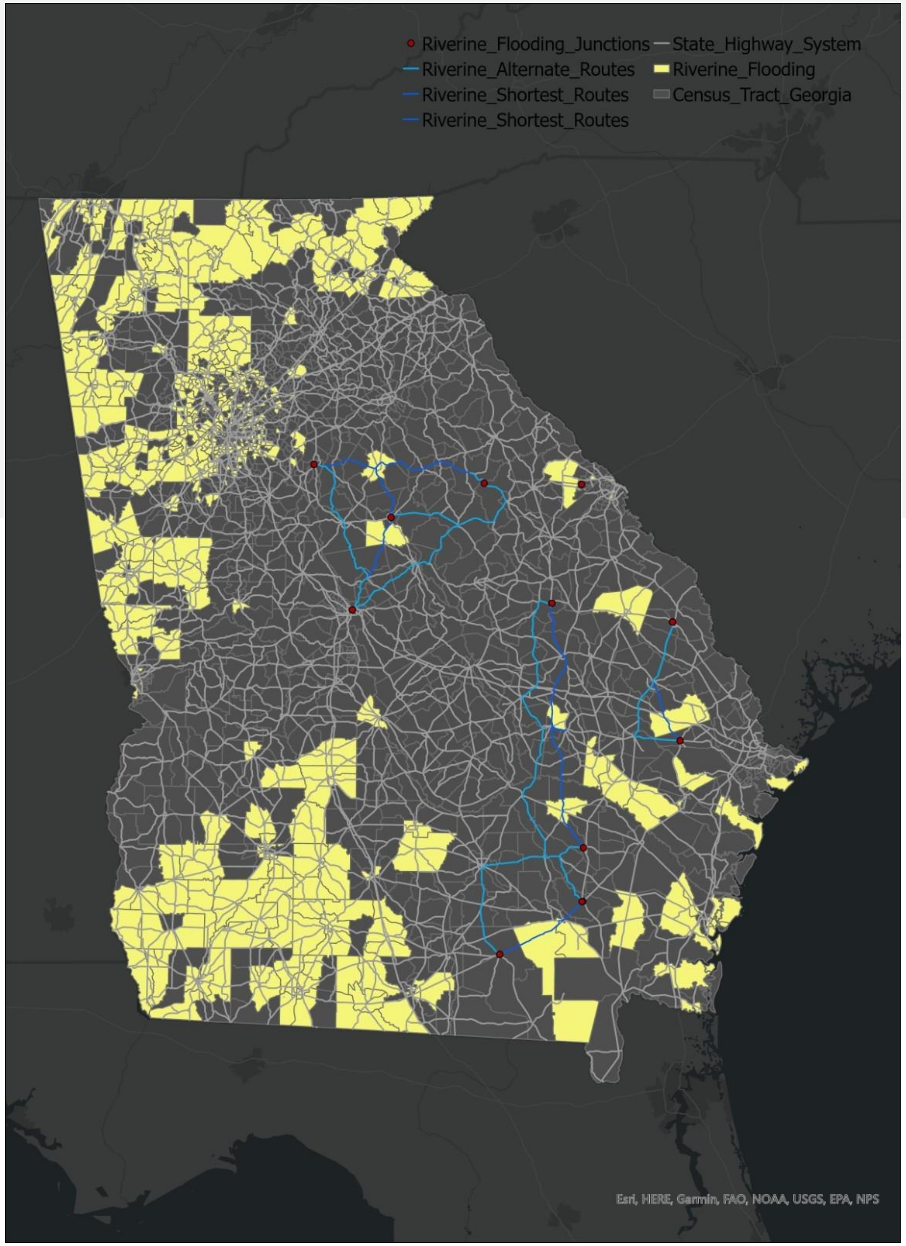
28.75%



Riverine Flooding Sample Computation

Alternate Routing Potential: Yes





Number of Segments Travelled:

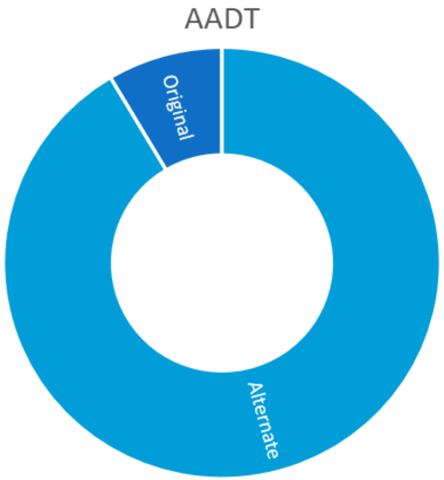
54 - 75

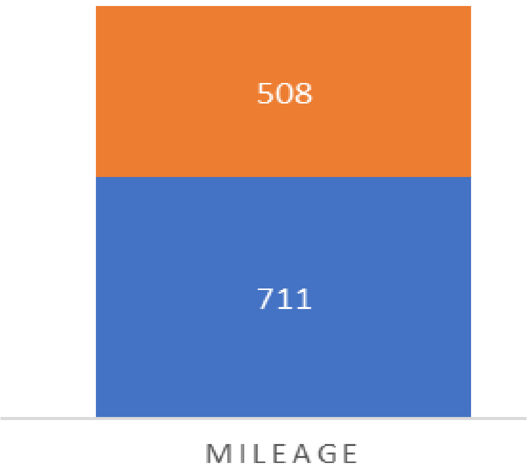
Number of Intersections Crossed:

650 - 696

5

Economic Delay per Vehicle (In Hours)



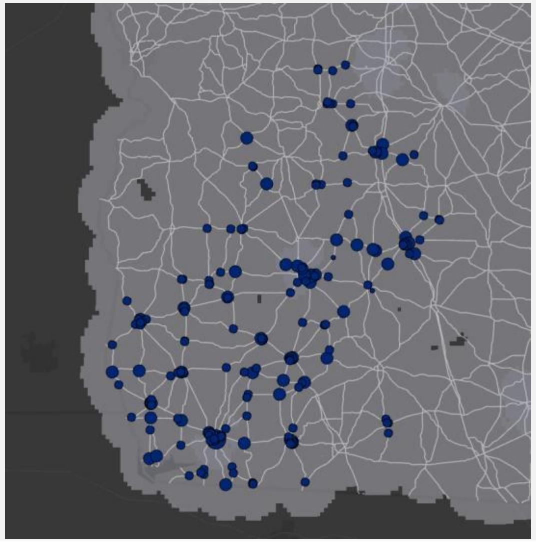


Percentage Increase in Vehicle Volume

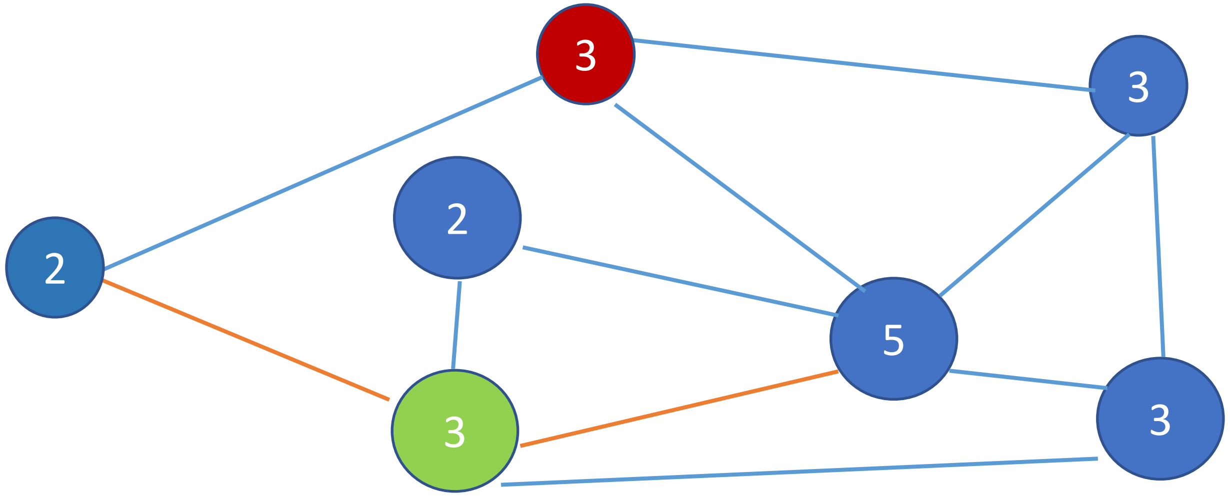
9.8%

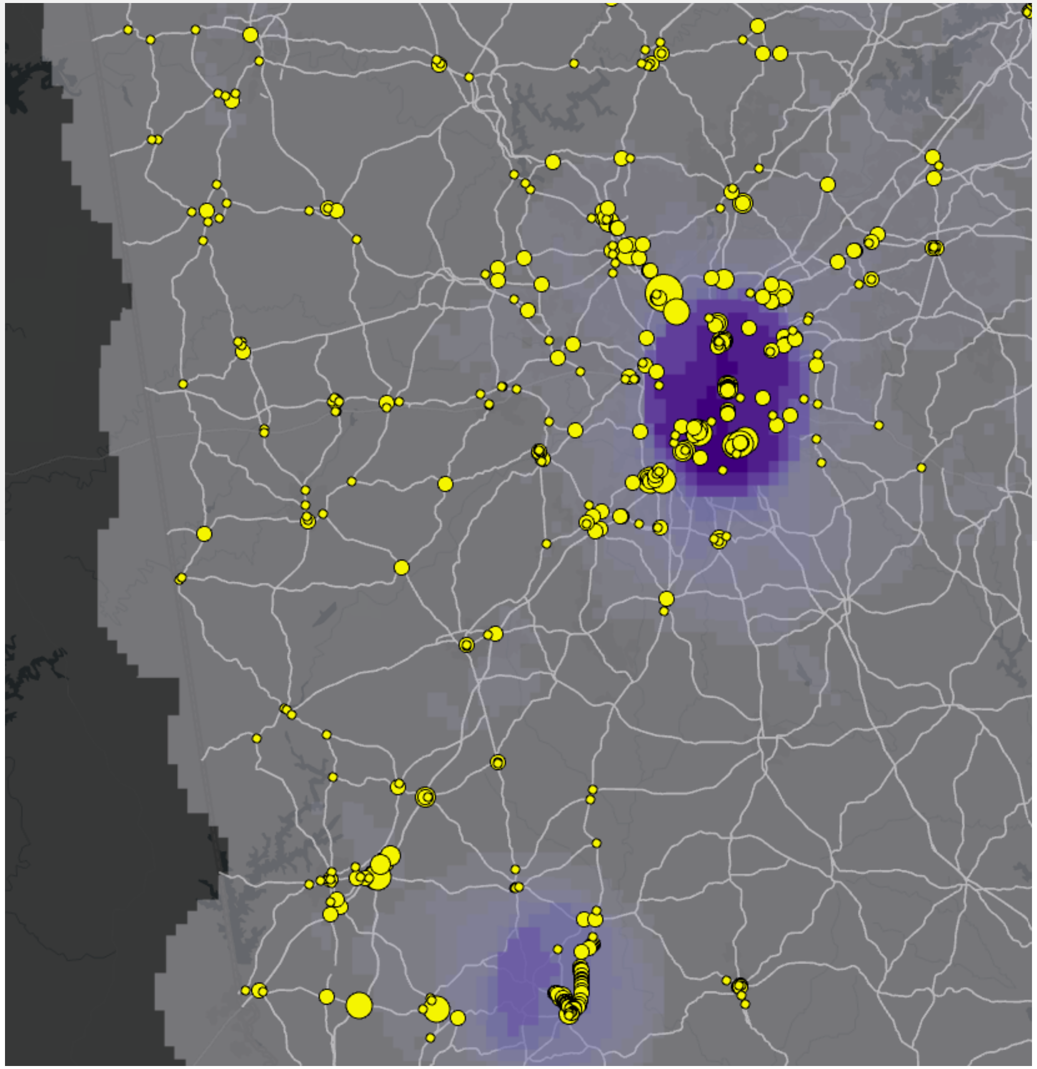
Systemic Adaptive Capacity

Intermodal Transfer Capacity: No



Integrity of Network Structure: Measure [Degree Centrality: Number of Segments a Road Junction is Connected to]. This determines Distributive Capacity. 5 Below has High DC.



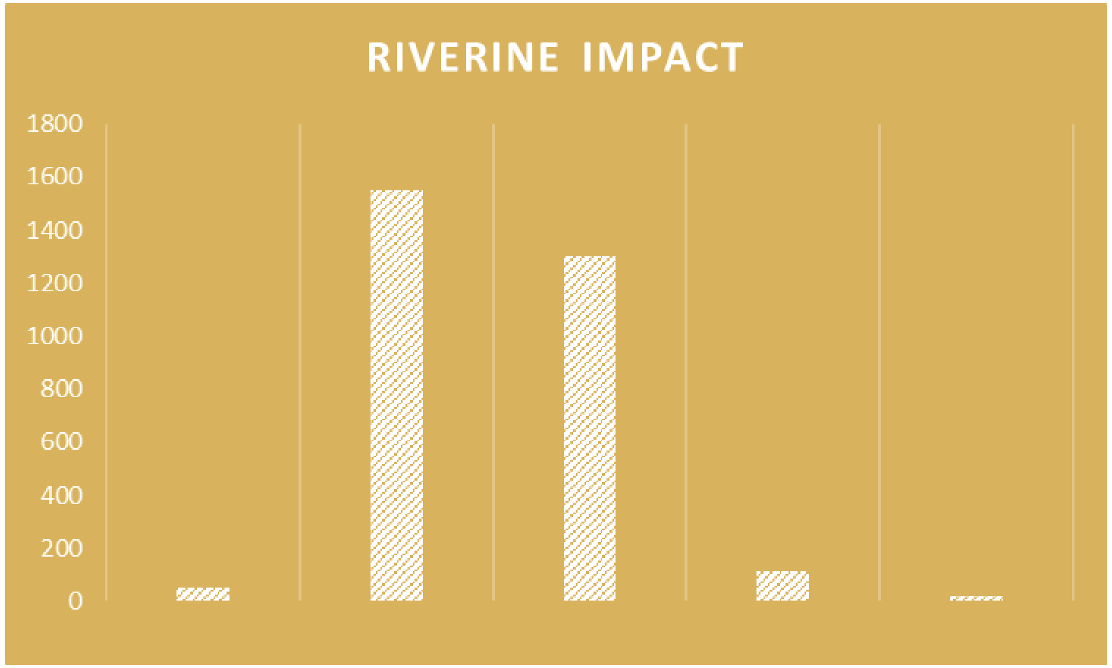


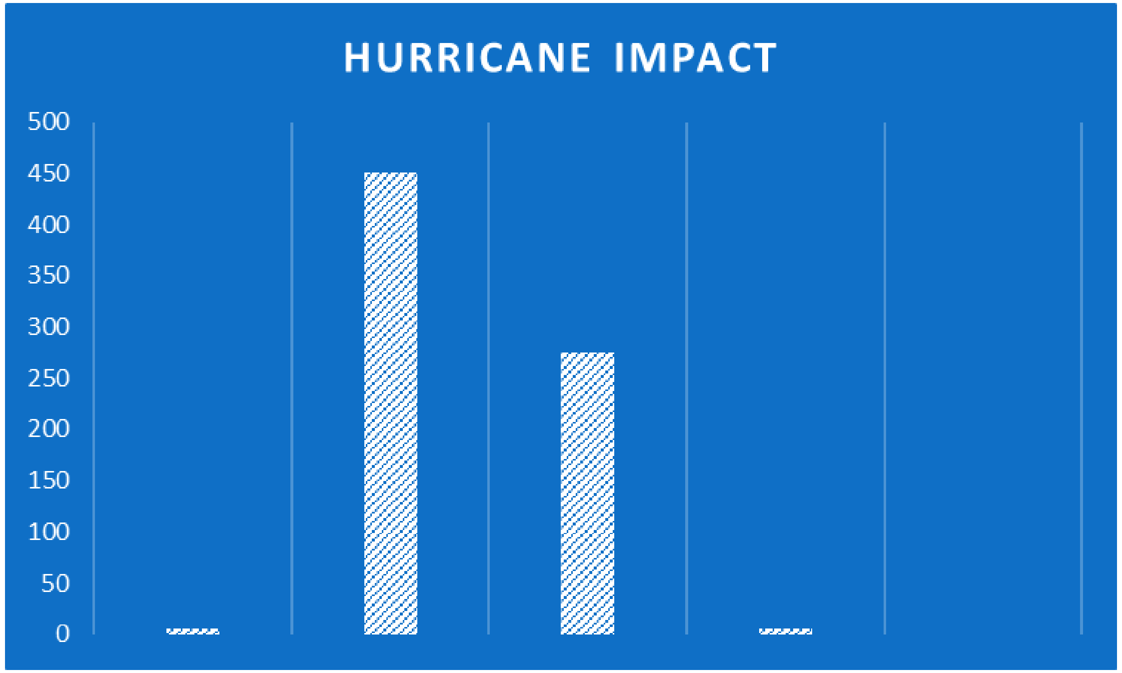
High Degree Nodes Impacted in Riverine & Storm Hazard Events feature majorly in High AADT Zones which are predominantly Urban.

Systemic Adaptive Capacity

Outcome: High Loss Count of Three-Way Intersections in addition to Two-Way Segments. **Implies A Loss in Distributive Capacity.**

This is an issue as loss in distributive capacity can result in freight bottlenecks and congestions limiting capacity of rerouting.





VULNERABILITY

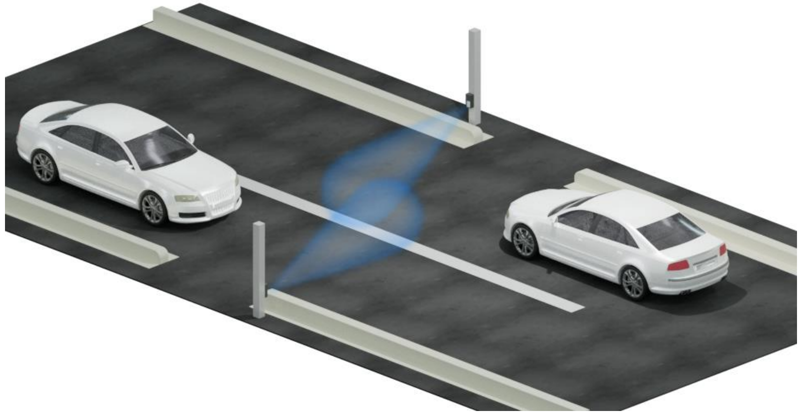
	Measures 1	Measures 2	Measures 3
Exposure	Distance	Direction	Volume
Performance Indicator	Impacted Road Length (Miles)	Impacted Road Junctions (Count)	Impacted AADT (Count)
Sensitivity	Distance Change	Congestion Change	Economic Delay Cost
Performance Indicator	Added VMT	Added AADT Volume	Time Cost in Hours
Adaptive Capacity	Rerouting Capacity	Loss of Network Integrity	Intermodal Transfer Capacity
Performance Indicator	Categorical Alternate Routes	Degree Centrality Loss	Categorical Transfer Potential

A Scoring Matrix and Criteria to Amalgamate the Above into Vulnerability must be developed.

From a Higher-Level Analysis Perspective, Georgia's Freight System is Highly Vulnerable to these Specific Climate Issues.

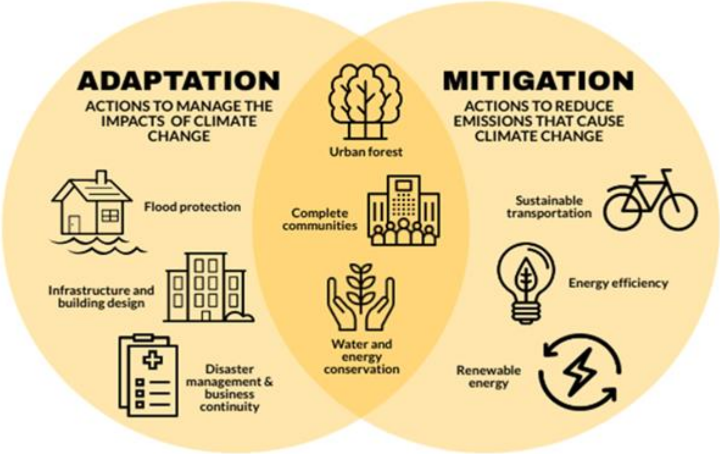
A System Scale Analysis will need to be undertaken with greater granularity to understand large-scale impacts.

RECOMMENDATIONS LONG TERM



DEVELOP **INTELLIGENT FREIGHT TRANSPORTATION SYSTEMS** THAT PROVIDE ACCURATE VEHICLE DATA POINTS WITH IOT. HIGH VALUE OF FREIGHT EFFICIENCY WILL PROVIDE LONG TERM BENEFITS BY PROVIDING REAL TIME REROUTING CAPACITIES AND BETTER TRAFFIC MANAGEMENT.

HYPERCONNECTIVITY



INCORPORATE A CLIMATE RESILIENCE SECTION IN THE GDOT STATE FREIGHT & LOGISTICS PLAN THAT IDENTIFIES RISKS AND VULNERABILITIES TO THE VARIOUS SPECIFIED CLIMATE HAZARD EVENTS.

PLANNING

IN THE EVENT OF CLIMATE HAZARDS, INTER-MODAL FREIGHT TRANSFER CAPACITY IS CURRENTLY LIMITED IN GEORGIA SINCE THEY ARE EXPOSED TO SAME IMPACTS. INTERMODAL TRANSFER POINTS NEED TO BE REVISED. FUTURE NETWORK EXPANSION OF RAIL & ROAD FREIGHT SHOULD CONSIDER JOINT CAPACITY DEVELOPMENT AND ENHANCE POTENTIAL FOR INTER-MODAL CAPABILITIES.

INFRASTRUCTURE

RECOMMENDATIONS

CONSENSUS BUILDING

Actively Interface with all Stakeholders in Resiliency Building.
[Freight Operators, Local Governments, GDOT]

A Potential Outcome could be Dissemination of Scenario Models that predict Road Closures and other outcomes of Hazards to Freight Operators to allow them to actively reduce system stress and restructure their logistics plan.

PLANNING & ACTION PLANS

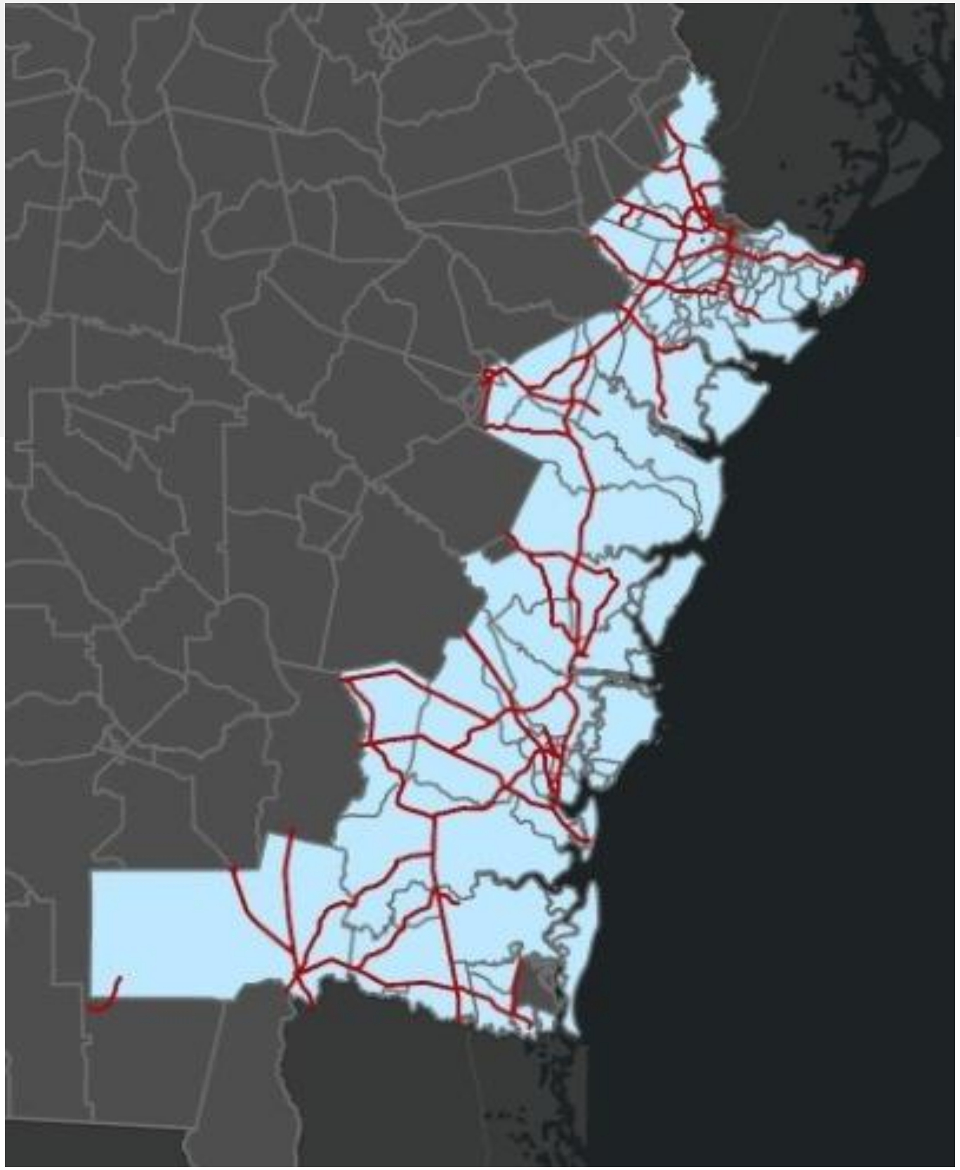
Development of Performance Based Prioritization Methodology for Climate Action. This includes Climate Specific Goals, Objectives, Performance Metrics and Outcome Indicators.

Develop Priority Zones based on Metrics. High level Analysis shows that Atlanta, North of Columbus, Augusta, Macon are Important Connectors.

Flooding – Coastal

64,830,737 Count

The Coastal Freight Network is Vital to the Economic Prosperity of Georgia. It consists of the Ports of Savannah and Brunswick and the Vital I-95 Corridor that connects the Coastal Region to Florida.



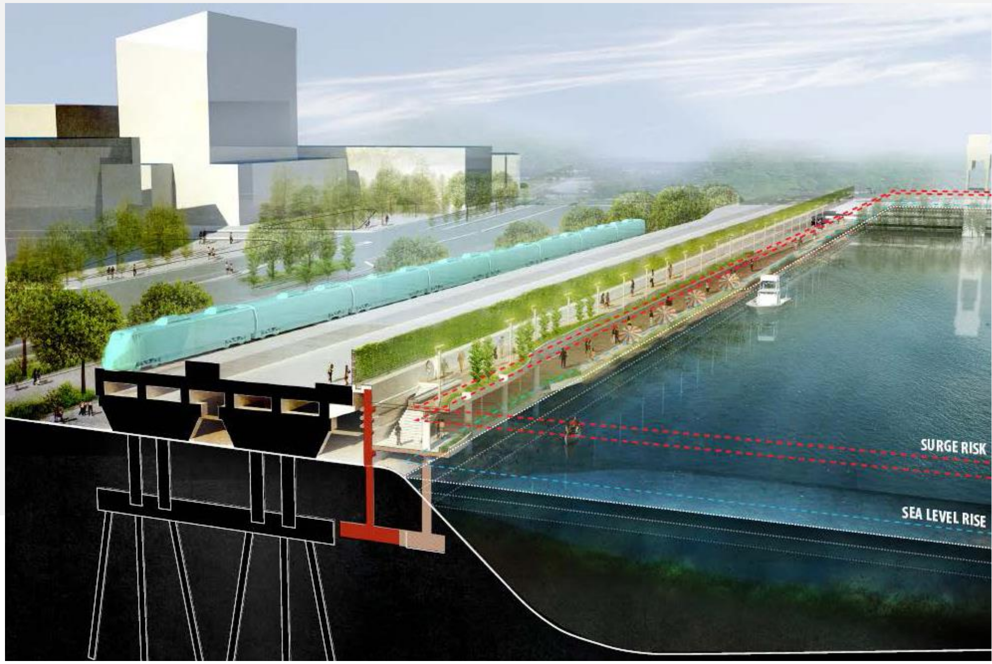
Unlike the previous two Hazards, the Coastal Freight Network's Resilience suffers the question of Survival due to Sea Level Rise and Storm Surge. With Two Nodal Points (Points) and a Connecting Corridor, it is less a question of Network Alternatives and rather a question of Mitigation of Hazard and Adaptation of these three critical infrastructure.

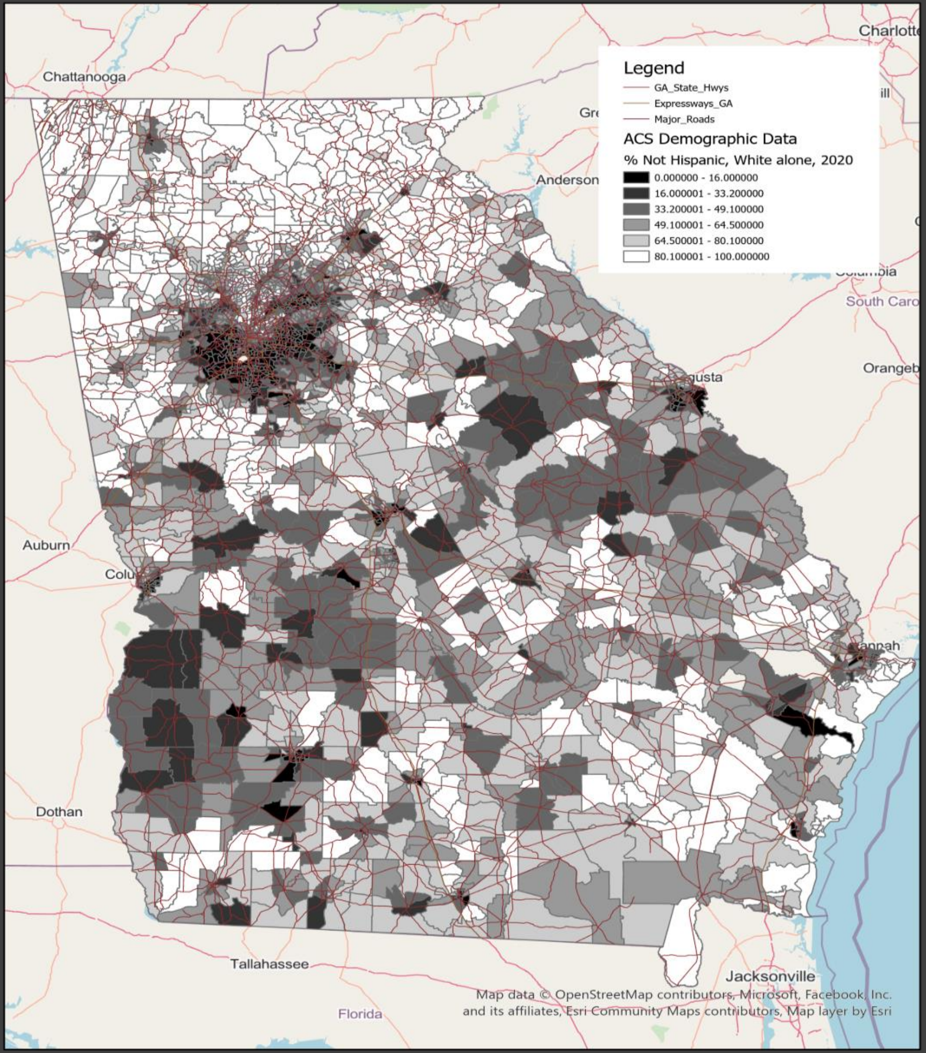
Sensitivity: A Cost Benefit Analysis of Mitigation Measures and Economic Loss due to Lifecycle costs associated with Hazard Events.

RECOMMENDATIONS

Adaptive Capacity: If Mitigation across entire corridor proves unsuccessful or unfeasible due to high degree need of Robustness and Financial Commitment , the adaptive capacity can be ascertained by doing an economic analysis of a new corridor facility bolstered by environmental suitability studies. This follows the principle of "Building Back Better".

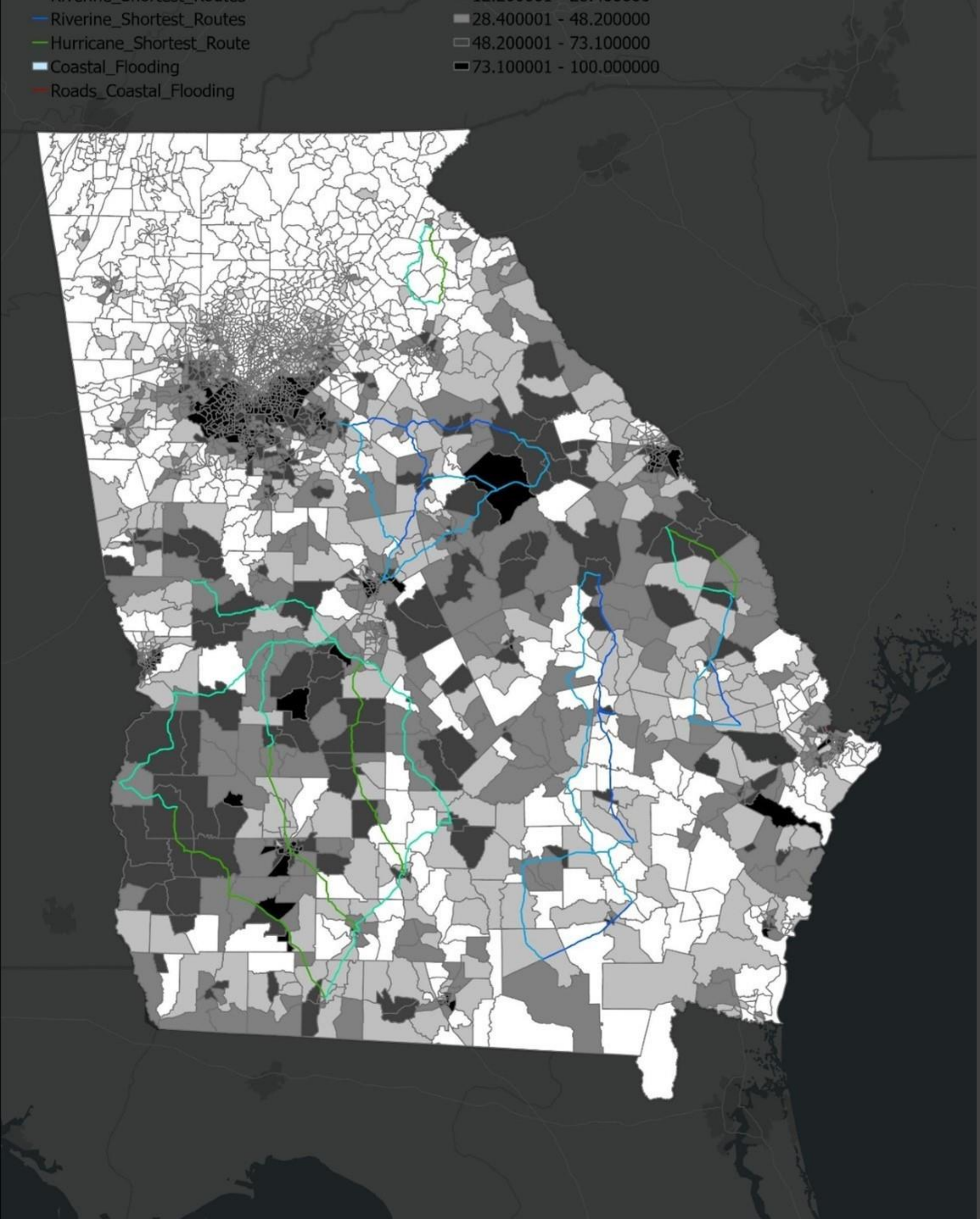
- Targeted Resiliency Recommendations:
- Focusing on High AADT Corridors of Savannah and Brunswick may prove more financially feasible.
- Highly Granular Studies of Hazard Vulnerability with Corridor-specific Analyses.
- Increase Nature based Resiliency Measures such as Mangrove Planting in Vulnerable and Ecologically Sensitive Zones.
- Interface with Climate Prediction Models based on Sensor Detection of Sea Level and Tide.
- Develop Robust Mitigation Infrastructure such as Raised Berms where Necessary and Appropriate.





INTERSECTION WITH SOCIAL EQUITY

- Increased freight volume leads to a decrease in air quality. This inverse relationship is heightened in predominately minority census tracts as evidenced by our geospatial analysis.
- Furthermore, increased freight volume leads to an increase in crashes and road fatalities.



INTERSECTION WITH SOCIAL EQUITY

- We find that in all alternate routes mapped as part of the Flooding & Storms Scenario, a significant number of census tracts with 48 – 100% African American population are impacted and have additional freight traffic because of these climate events. This shows that a social equity impact should also be considered when considering alternate routes.
- Addition of Sustainability & Social Equity Impacts concerning Electrification and Congestion add holistic value and depth to efforts at improving system resilience.

LEARNINGS AND TAKEWAYS

- Learning: Each Hazard has Different Types of Impact on the Transportation System. There is no one size fits all Solution.
- Our recommendations are possible:
  - New York State Department of Transportation (NYSDOT) considers resiliency and sustainability, comparable GDOT does not
  - Recommendations are within GDOT's vast scope, missing the right vision
- Takeaway - The most dangerous areas GDOT should focus on:
  - For coastal flooding & hurricanes: Southeast Coast > most important because potential to disrupt the entire supply network
  - For riverine flooding: Northwest & Southwest Georgia
  - For heat: Central Georgia

LIMITATIONS AND NEXT STEPS

Limitations	Next Steps
Our analysis was very high-level and may have missed more granular key findings and opportunities for recommendations.	Engage FHWA to fund a Climate Resiliency Pilot for more detailed analysis in identified vulnerable areas.
Data used for analysis was very broad, and we were missing freight origin and destination information.	GDOT should collect this data on a more granular level, and if they do already, make it publicly available.
Recommendations' effectiveness are limited by the political context that GDOT operates within.	GDOT staff should look for ways to inject innovation into their strategic direction.

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Questions?

Thank you for listening!