

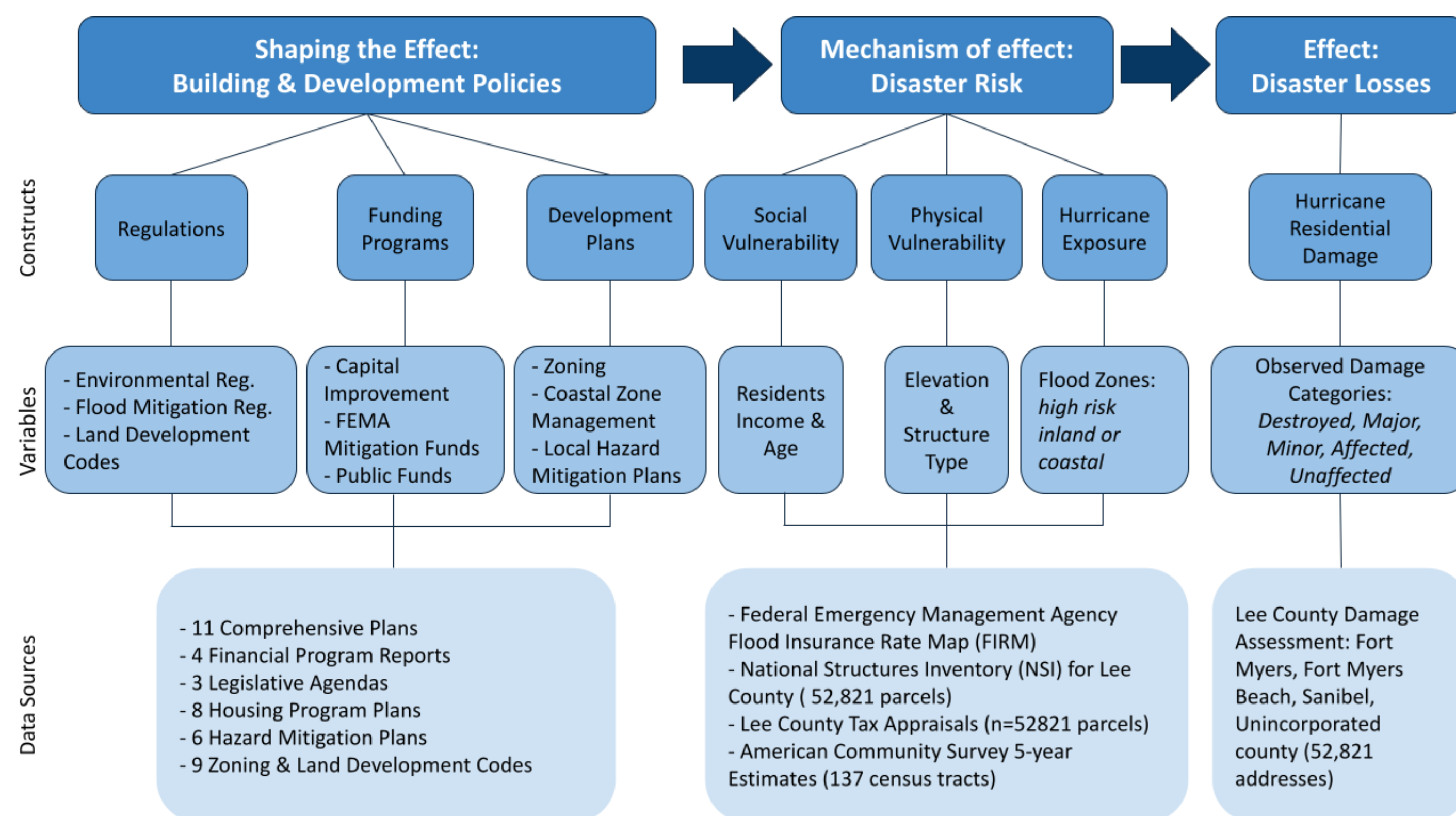
Introduction

- Exploring how planning policies and development patterns shape community vulnerability and exposure to hazards is key to developing resilient communities.
- Hurricane Ian made landfall as a Category 4 storm near Cayo Costa, Florida on September 22, 2022.
- Hurricane Ian's storm surge, brought winds of 155 mph, flooded southwest Florida 12 to 18 feet above ground level, with a 7.26-foot surge in Fort Myers.
- During Hurricane Ian, Lee County recorded 48% of the 143 confirmed fatalities.

Research Questions

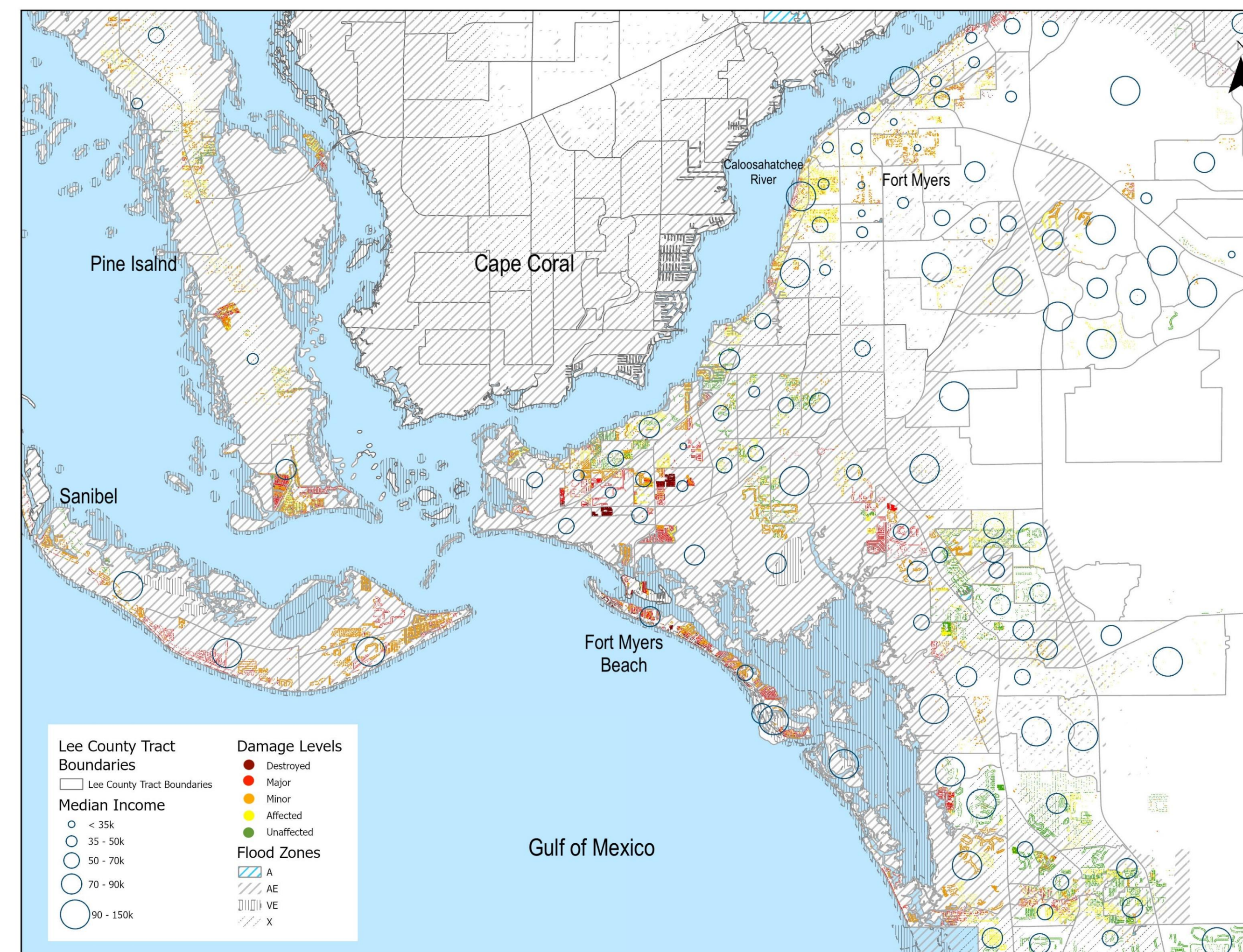
1. What are the spatial and statistical patterns of pre-disaster vulnerability and exposure and damage after Ian?
2. What is the relationship (spatial and statistical) between pre-disaster vulnerability and exposure and post disaster/Ian damages?
3. What are the connection between pre-disaster development policies and hurricane damages?

Data and Methods: Spatial, Statistical, and Policy Analyses



- Merged Lee County tax appraisal parcels data with the National Structure Inventory (NSI), 2021 American Community Survey (ACS), and Lee County Hurricane Ian damage assessments to analyze spatial and statistical patterns and connections between damage, physical and social vulnerabilities, and exposure at parcel level.
- Coded 41 policy documents in Atlas.ti software with a qualitative coding scheme designed to find instances of local policy tools (e.g. land development code) pursuing changes to built environment (e.g. construction).
- Created a co-occurrence table in Atlas.ti to examine which policy tools influence exposure or vulnerability to hurricanes in the built environment using a scoring system to assess the type and strength of influence.
- Synthesized the spatial and statistical patterns of elevation, flood zone, and structure type with the identified effects of relevant development policies to examine the how each policy has shaped these risk factors in Lee County and subsequently increased or reduced hurricane Ian damages across different areas.

Connection between Hurricane Damage, Flood Zones (exposure), Elevation, and Income (social vulnerability)



- Homes located in Zone VE (high-risk flooding and wave action, coastal) account for majority of major-damages (86%); only (0.8%) remained unaffected.
- Majority of destroyed homes (87%) are in Zone AE (1% annual chance of flooding). Mobile homes represent half of destroyed homes.
- Roughly 52% of homes outside of FEMA Flood Insurance Rate Map (FIRM) Zones or undetermined areas had no damages reported.
- 44% of homes outside of FIRM zones experienced minor or cosmetic damages.
- Special Hazards Flood Zone VE has the highest median income categories.
- Few low-income census tracts in affected areas, but 1/4 of affected census tracts are predominately elderly.
- Hurricane Ian damages are not driven only by exposure; rather damage is shaped through the combination of physical vulnerability and exposure.

FEMA FIRM Zones	Extent of damages (Count, %Row, %Column)						
		Destroyed	Major	Minor	Affected	Unaffected	All
	A (high risk inland)	0%	0%	0%	3 11.5% 0%	23 88.5% 0.1%	26
	AE (high risk inland)	2345 7.3% 87.3%	8657 26.8% 86.6%	8251 25.5% 75.4%	7342 22.7% 54.2%	5710 17.7% 36.6%	32305
	VE (high risk coastal)	316 21.1% 11.8%	703 46.9% 7.0%	427 28.5% 3.9%	40 2.7% 0.3%	12 0.8% 0.1%	1498
	Undetermined	25 0.1% 0.9%	683 3.6% 6.8%	2270 12.0% 20.7%	6158 32.4% 45.5%	9849 51.9% 63.2%	18985
	All	2686	10043	10952	13546	15594	52821

- Mean ground elevation varies significantly by damage level, with destroyed and majorly damaged properties located at much lower elevations (Destroyed: 4.6 ft; Major: 5.4 ft) compared to unaffected properties (12.7 ft).
- A one-way ANOVA test confirms these differences are highly significant ($F = 5207.56$, $p < 0.001$), highlighting a strong relationship between elevation and flood damage severity.

Qualitative Scoring Framework for Assessing Policy Impacts on Built Environment Risk Outcomes

Policy Tools →		Capital Improvement Plan			FEMA Mitigation Fund			Public fund			Zoning			Coastal Zone Management			Local Hazard Mitigation Plan			Environ mental Regulation		Flood Mitigation Regulation		Land Development		Code		Outcome Risk Effect Sum
↓ Built Environment Outcomes	Exposure Score	Physical Vulnerability	Social Vulnerability	EXP	PV	SV	EXP	PV	SV	EXP	PV	SV	EXP	PV	SV	EXP	PV	SV	EXP	PV	EXP	PV	EXP	PV	SV			
Construct	0	-1	-1	0	0	0	0	-1	-20	1	0	0	0	0	0	-1	-1	0	0	0	0	0	0	-1	-2	-27		
Retrofit	0	0	0	0	0	0	0	-7	-2	0	0	0	0	0	0	0	-2	0	0	0	0	0	0	-2	-1	-14		
Buyout/ Relocate	0	0	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	-1	0	-4		
Segregate	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2		
Preserve	0	0	-1	0	0	-1	0	0	-1	-1	0	-1	-1	0	0	0	0	-2	-10	0	-5	-6	0	0	0	-29		
Make Affordable	0	0	0	0	0	1	0	-37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-37		
Restrict Growth	0	0	0	0	0	-3	0	-2	-9	-6	-2	-1	-1	0	0	0	0	0	0	-1	0	-9	-4	0	-2	-4	0	-44
Condemn	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1		
Replace	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3	0	-4	
Revitalize	0	0	-2	0	0	0	0	-7	0	0	-2	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	-12	
Hazard Protection	0	-2	0	0	0	-9	-14	0	0	0	0	-4	-6	0	-2	-9	-8	0	-5	0	-5	-23	0	0	-6	0	-93	
Increase	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
Tool Risk Effect Sum by Component	1	-4	-4	-1	-1	0	-11	-23	-68	-7	-7	-3	-6	-8	0	-3	-12	-8	-2	-16	0	-20	-34	0	-3	-16	4	
Tool Risk Effect Sum		-7			-2		-102		-17		-14		-23		-18		-54		-23									

- All pre-disaster development policies that shape the built environment have some stated risk reduction effects.
- Physical vulnerability was addressed 121 times throughout all policy documents, compared to 56 times for exposure.
- Public funds and flood mitigation regulation are the most utilized policy tools for addressing hurricane risks.
- Very few tools (in public funds and local hazard mitigation plans) have a potential effect on reducing social vulnerability.
- Flood mitigation regulations reduce exposure frequently by restricting growth.
- Public Funds aims to reduce exposure by establishing hazard protections.
- Few pre-disaster development policies such as zoning have the potential effect of increasing risk through increasing exposure.

Conclusions & Recommendations

- Exposure has a non-linear relationship with income and age while physical vulnerability and destruction have a negative relationship with income.
- Development policies in Lee County are more effective in addressing physical vulnerability for middle-and-high income single-family homeowners compared to addressing exposure.
- Social vulnerability or priorities for vulnerable residents are rarely addressed in development policies compared to physical vulnerability and exposure.

Priorities for reducing residential hurricane risks in Lee County:

- Reduce physical vulnerability of housing of vulnerable residents with funding tools to reduce the number of destroyed houses or major damage homes without displacing vulnerable people: short-term (~5 years).
- Reducing exposure for residential structures with high physical vulnerability in high exposure through buyouts for residential structures with high physical vulnerability in high exposure neighborhoods to move development out of harm's way with those who are not vulnerable and can handle relocation more easily: : long-term (~20 years).
- Prevent new exposure in AE-VE with zoning and land development codes: long-term (~50 years).