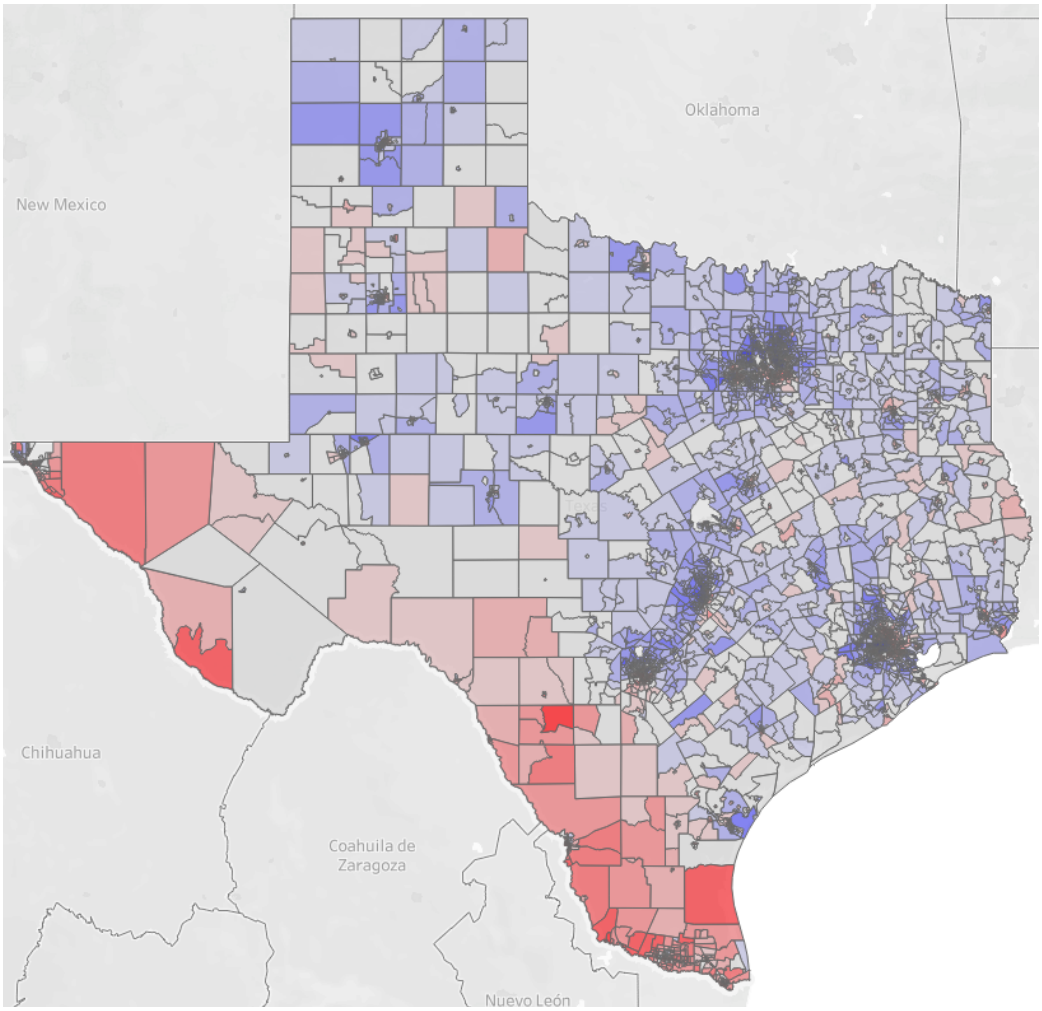
Social Vulnerability in Texas:
Implications for Resilience, Equity, and Climate Policy



A project of Texas Metropolitan Observatory of Planet Texas 2050
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Interactive Maps:

Social Vulnerability Index at Census Tract:

https://public.tableau.com/profile/rgk.center.for.philanthropy.and.community.service#!/vizhome/TexasSocialVulnerabilityMappingCensusTractLevel_15847263560350/TexasSocialVulnerabilityScoreCensusTractLevel

Social Vulnerability Index at Census Block Group:

https://public.tableau.com/profile/rgk.center.for.philanthropy.and.community.service#!/vizhome/SocialVulnerabilityMappingBlockGroupLevel_15807454023970/TexasSocialVulnuerabilityIndexBlockGroupLevel

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1. Introduction

Climate change refers to natural or human-induced changes in the climate that persists for an extended period, typically decades or longer. Climate-related hazards – hurricane, flood, wildfire, extreme heat, among others – cause damage and loss to property, infrastructure, livelihoods, service provision and environmental resources. Climate change is likely to further increase the exposure to multiple hazards by affecting the magnitude, frequency and spatial distribution of disastrous events (Field et al., 2012). This report focuses on spatially-distributed quantitative estimates of vulnerability to climate change related hazards across the State of Texas.

Our interest in social vulnerability is explicitly linked to policy considerations and resilience planning throughout the State. Although varying definitions for resilience exist, common characteristics include the ability to absorb disturbance and return to a desired state (Folke, 2006); recover, learn, and adapt from adverse events (Adger et al., 2005); and a process to link community capacities in response to disturbance (Norris et al., 2008). Resilience is thus a process, a capacity, and an outcome – from a policy perspective we want resilient communities and cities. Vulnerability is a measure of exposure to hazards, as well as the sensitivity of a population to a natural hazard and its ability to respond and recover from the impact of hazards (Cutter et al., 2003). Vulnerability and resilience are tightly coupled concepts where increasing resilience is likely decreasing vulnerability. Figure 1 visually depicts the relationships between hazard exposure, sensitivity, and adaptive capacity.

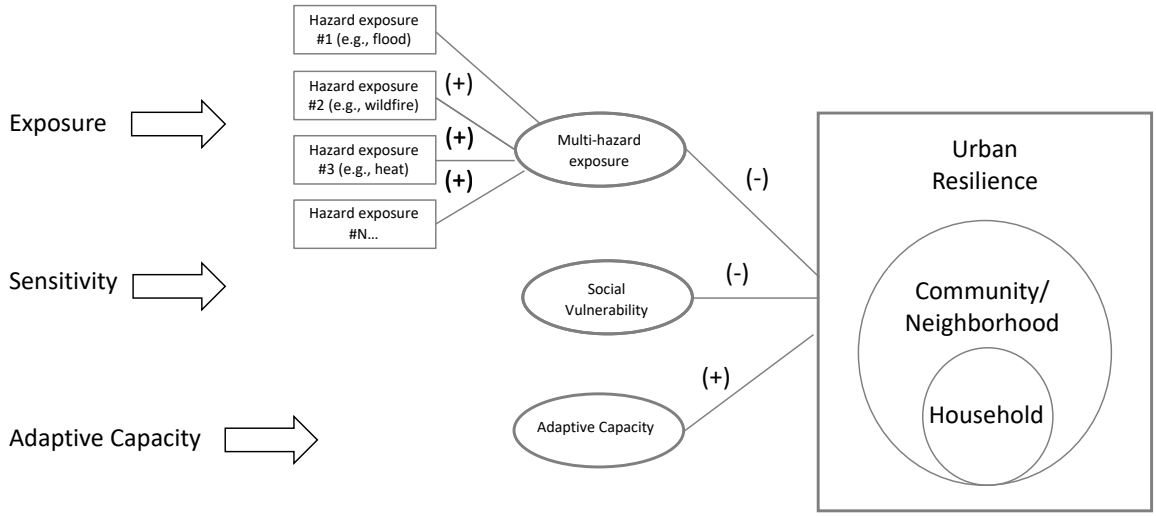

Figure 1. Conceptual framework of hazard exposure, sensitivity, and adaptive capacity.

The findings of our statewide study provide a quantitative estimate of social vulnerability at two levels of resolution (1) census tracts and (2) census block groups. We normalize these scores across the state so that relatively low and high social vulnerability is identified. Our hope is that this information can be utilized in statewide or metropolitan specific research and planning by combining social vulnerability with estimates of hazard exposure. See Bixler and Yang (2020) for an example.

2. Social Vulnerability Across Texas

2.1 Background

Vulnerability represents the predisposition of a community, system, or asset (in our case, a neighborhood) to be adversely affected by a certain hazard. Social vulnerability is a measure of both the sensitivity of a population to natural hazards and its ability to respond to and recover from the impacts of hazards. It is a multidimensional construct, one not easily captured with a single variable, and varies across time and space since potential for losses vary temporally and geographically and among different socio-demographic characteristics, such as income, education, occupation, household composition, home ownership, minority status, gender, age (elderly and children), housing tenure, and vehicle access (Cutter and Finch 2008; Flanagan et al. 2011; Cutter, Ash, and Emrich 2014; Haron 2016; Scherzer, Lujala, and Rød 2019).

Reducing social vulnerability can decrease both human suffering and economic loss (Flanagan et al. 2011). Since the late 1990s, it has generally been acknowledged that a holistic assessment of risk needed to include socioeconomic and demographic factors (Cutter et al., 2003; Flanagan et al., 2011, 2018; Huynh & Stringer, 2018; Vincent, 2007). The Social Vulnerability Index (SoVI®), created by Hazards and Vulnerability Research Institute at the University of South Carolina (Cutter et al., 2003), is the most frequently cited tool for estimating social vulnerability in the United States. Appendix A includes a broader set of variables utilized in different vulnerability indices derived from the literature.

The original calculation of the social vulnerability index (Cutter et al., 2003) synthesized 42 socioeconomic and built environment variables to quantify the social vulnerability to environmental hazards and generate a comparative metric that facilitates the examination of the differences between U.S. counties. After modifications and omissions over time, the newest

version (SoVI® 2010-14) contains 29 variables (listed in Table 2). Appendix A includes a broader set of variables utilized in different vulnerability indices derived from the literature.

This study quantifies a Social Vulnerability Index score of Texas State at **census tract level** and **block group level** using the index (SoVI®) created by Hazards and Vulnerability Research Institute at the University of South Carolina. (Cutter et al., 2003) first synthesized 42 socioeconomic and built environment variables to quantify the social vulnerability to environmental hazards and generate a comparative metric that facilitates the examination of the differences between U.S. counties. After modifications and omissions over time, the newest version (SoVI® 2010-14) contains 29 variables (listed in Table 3).

Table 1. Full List of variables and description (n=29) in SoVI® (2010-2014)

	Variable	Description
1	MDHSEVAL	Median Housing Value
2	HOSPTPC	Hospitals Per Capita
3	MDGRENT	Median Gross Rent
4	MEDAGE	Median Age
5	PERCAP	Per Capita Income
6	PPUNIT	People per Unit (Average household size)
7	QAGEDEP	Percent Population under 5 years or 65 and over
8	QASIAN	Percent Asian
9	QBLACK	Percent Black or African American Alone
10	QCVLUN	Percent Unemployment for Civilian in Labor Force 16 Years and Over
11	QEDLESHI	Percent Less than high school education for population over 25 years and older
12	QESL	Percent Speaking English as a Second Language with Limited Proficiency
13	QEXTRCT	Percent Employment in Construction and Extraction Industry
14	QFAM	Percent Children Living in Married Couple Families
15	QFEMALE	Percent Female
16	QFEMLBR	Percent Female Participation in Labor Force
17	QFHH	Percent Female Headed Households (Out of unmarried-partner households)
18	QINDIAN	Percent Native American (American Indian and Alaska Native alone)
19	QMOHO	Percent Mobile Homes
20	QNOAUTO	Percent Housing Units with No Car
21	QNOHLTH	Percent population without health insurance
22	QNRRES	Percent population living in Nursing Facilities/Skilled Nursing Facilities
23	QPOVTY	Percent Poverty
24	QRENTER	Percent Renters (Percent out of total Occupied housing units)
25	QRICH	Percent Households Earning over $200,000 annually
26	QSERV	Percent Employment in Service Industry

27	QSPANISH	Percent Hispanic
28	QSSBEN	Percent Households Receiving Social Security Benefits
29	QUNOCCHU	Percent Unoccupied Housing Units

2.2. Social Vulnerability Index at Census Tract Level

Data for SoVI variables at all census tracts in Texas is derived from the Input data are derived from the U.S. Census Five-Year American Community Survey (ASC) 2013-17. Number of hospitals per capita (HOSPTPC) and percent of population living in nursing facilities (QNRRES) were not included due to the data availability at census tract level. Of the total number of tracts (6,265), census tract IDs that correspond to military bases (28), airports (26), University campus (8), correctional facilities (6), and ocean basin (i.e., Gulf of Mexico, Trinity Bay; 12) have been excluded from the data. The process of calculating the Social Vulnerability Index score is summarized in Figure 1.

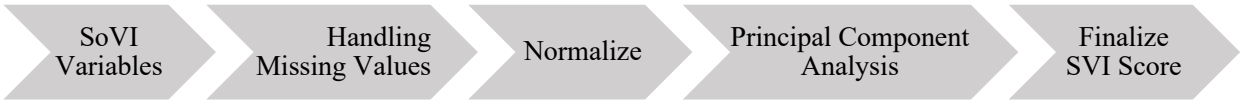

Figure 2. Process of SVI score calculation

In order to conduct statistical procedure, all missing values from the ASC survey data were replaced by the mean value of the surrounding census tracts or the mean value across the corresponding county. Then, data was normalized using the Min-Mx Feature Scaling method (see equation below).

$$X_{Normalized} = \frac{X_{original} - X_{min}}{X_{max} - X_{min}}$$

With the normalized dataset, a principal component analysis (PCA) with varimax rotation was performed to reduce the dimensionality of a data set with statistically optimized components. The variables are evaluated based on eigenvalue (greater than 1.0), variance explained by each component, loading score for each factor ($\geq |0.50|$), and meaningfulness of each component. After eliminating 7 variables, six components (i.e., Social Status, Wealth, Elderly, Housing Status, Black and Unemployed, Female) were obtained (summarized in Tables 4-5), explaining 79.08% of the total variance.

Table 2. Texas State census tract level social vulnerability principal component summary (n=22)

Variables		Category/ Cardinality	Components / Loading scores					
			1	**2**	**3**	**4**	**5**	**6**
1	QESL	**Social Status (+)**	**0.840**	-0.09	-0.154	0.172	-0.066	-0.085
2	QED12LES		**0.813**	-0.337	0.040	0.258	0.112	-0.177
3	QSPANISH		**0.765**	-0.267	-0.136	0.325	-0.178	-0.014
4	QNOHLTH		**0.756**	-0.396	-0.088	0.104	0.136	-0.182
5	QPOVTY		**0.728**	-0.304	-0.034	-0.114	0.369	0.027
6	QNOAUTO		**0.600**	-0.077	0.071	-0.368	0.460	0.115
7	QEXTRCT		**0.555**	-0.293	0.090	0.206	0.073	-0.421
8	QRICH	**Wealth (-)**	-0.256	**0.907**	0.033	0.054	-0.096	-0.050
9	MDHSEVAL		-0.175	**0.897**	-0.076	-0.138	-0.113	0.004
10	PERCAP		-0.377	**0.850**	0.053	-0.167	-0.196	0.009
11	MDGRENT		-0.460	**0.591**	-0.318	0.194	-0.080	0.021
12	QSSBEN	**Elderly (+)**	-0.013	-0.170	**0.918**	0.065	0.054	0.065
13	QAGEDEP		0.005	0.021	**0.875**	-0.066	-0.093	0.191
14	MEDAGE		-0.396	0.285	**0.740**	-0.123	-0.114	-0.059
15	QUNOCCHU		0.094	-0.270	**0.547**	-0.327	0.137	-0.224
16	PPUNIT	**Housing Status (+)**	0.309	-0.136	-0.161	**0.868**	0.002	-0.077
17	QFAM		0.296	-0.084	-0.152	**0.817**	0.087	0.133
18	QRENTER		0.445	-0.136	-0.450	**-0.645**	0.205	0.093
19	QBLACK	**Black and Unemployed (+)**	-0.106	-0.140	-0.175	-0.092	**0.823**	0.117
20	QCVLUN		0.296	-0.166	0.130	0.159	**0.689**	-0.004
21	QFEMALE	**Female (+)**	0.035	0.065	0.108	0.115	0.001	**0.855**
22	QFEMLBR		-0.272	-0.156	0.002	-0.084	0.182	**0.781**

*Rotation Method: Varimax with Kaiser Normalization.

Table 3. Principal component analysis summary (variance) at tract level

Component		Cardinality	Variance Explained (%)	Variables	Loading scores
1	Social Status	(+)	33.66	QESL	0.840
				QED12LES	0.813
				QNOHLTH	0.765
				QSPANISH	0.756
				QPOVTY	0.728
				QNOAUTO	0.600
				QEXTRCT	0.555
2	Wealth	(-)	14.44	QRICH	0.907
				MDHSEVAL	0.897
				PERCAP	0.850
				MDGRENT	0.591
3	Elderly	(+)	11.37	QSSBEN	0.918
				QAGEDEP	0.875
				MEDAGE	0.740
				QUNOCCHU	0.547
4	Housing Status	(+)	8.73	PPUNIT	0.868
				QFAM	0.817
				QRENTER	-0.645
5	Black and Unemployed	(+)	6.07	QBLACK	0.823
				QCVLUN	0.689
6	Female	(+)	4.81	QFEMALE	0.855
				QFEMLBR	0.781
Total Variance Explained			**79.08**		

Then, a directional adjustment is applied to the components' cardinality an entire factor to ensure that the signs of defining variables are appropriately describing the tendency to increase or decrease vulnerability. Positive component cardinalities were associated with increasing vulnerability, while negative cardinalities were associated with decreasing vulnerability. Once the cardinalities of the components were determined, normalized values were summed together to determine the numerical composite social vulnerability score for each census tract.

The SVI scores are mapped to visually compare at census tract level (shown in Figures 3 & 4). The normalized SVI score ranged between 0.0173 and 0.4314 with mean value of 0.2140. The SVI score of 0.0 indicates the least vulnerable (Blue in the figures), and 1.0 indicates the most vulnerable (Red in the figures). This can be used to identify where in Texas has uneven

capacity for preparedness and response and where resources might be used most effectively to reduce the pre-existing vulnerability.

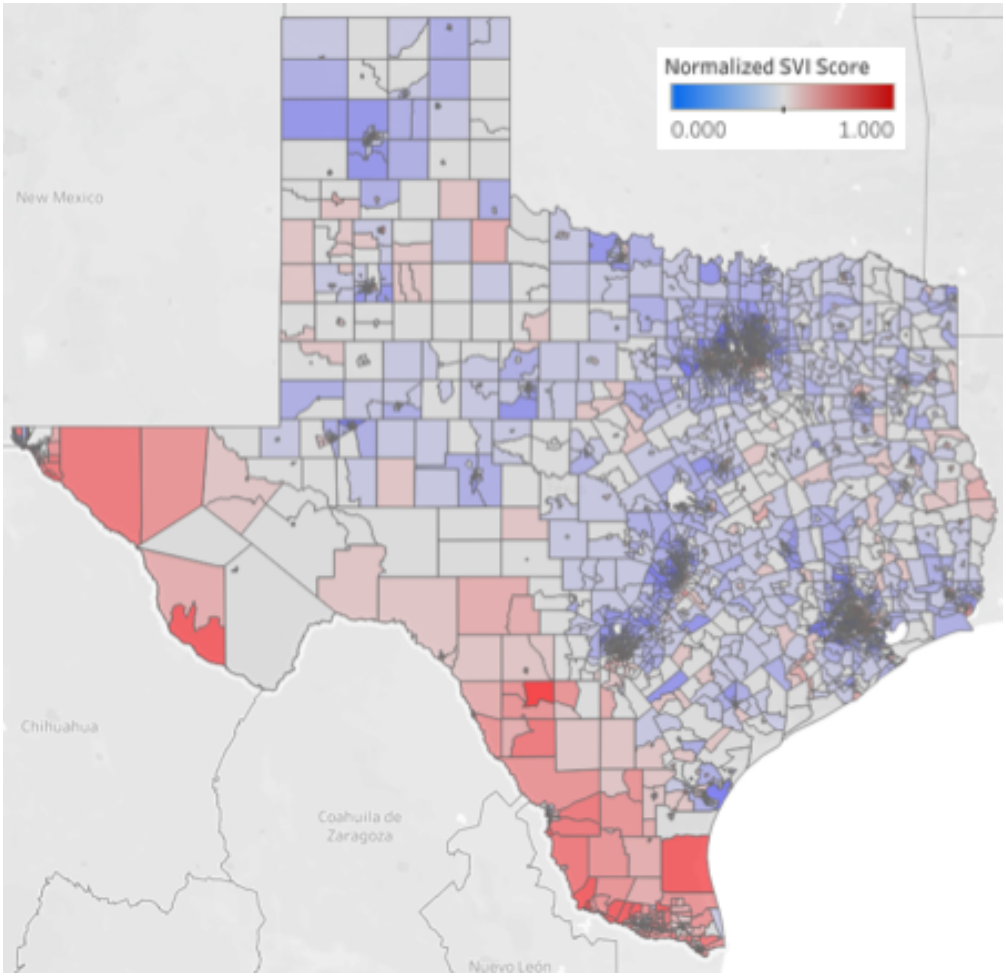

Figure 3. Census Tract Level SVI Score (Texas)

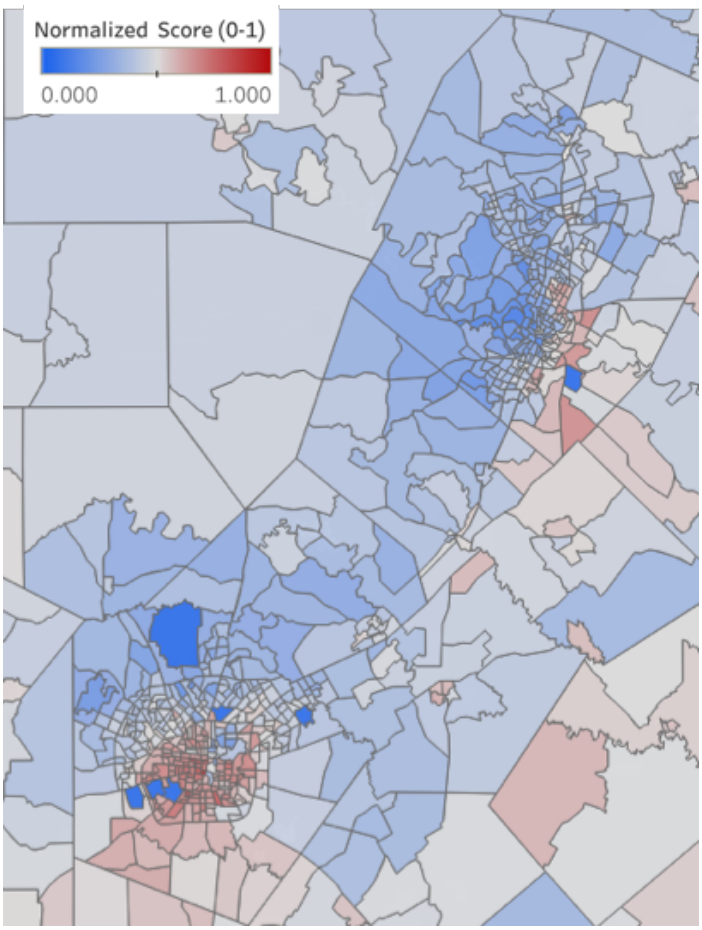

Figure 4. Census Tract Level SVI Score (Austin and San Antonio MSAs)

2.3 Social Vulnerability Index at Census Block Group Level

Data for SoVI variables (see Table 3) at all block groups in Texas is derived from the Input data are derived from the U.S. Census Five-Year American Community Survey (ASC) 2013-17. Four variables—i.e., percent of female headed households (QFHH), percent of population without health insurance (QNOHLTH), number of hospitals per capita (HOSPTPC), percent of population living in nursing facilities (QNRRES)— are not available at the block group level. Of the total number of block groups (15,811), block group IDs that correspond to military bases (45), airports (26), University campus (8), correctional facilities (6), and ocean basin (i.e., Gulf of Mexico, Trinity Bay; 12) have been excluded from the data. Overall process of calculating SVI score at block group level was identical to the census tract level (see Figure 1). All missing values at block group level from the ASC survey were replaced by the mean value of the surrounding block groups using GIS software. As a result of principal component analysis, 7

variables were eliminated and 6 components (i.e., Social Status, Wealth, Elderly, Housing Status, Black and Unemployed, Female) were obtained (summarized in Tables 6-7), explaining 74.48% of the total variance.

Table 4. Texas block group level social vulnerability principal component summary (n=18)

Variables		Category/ Cardinality	Components / Loading scores					
			1	2	3	4	5	6
1	QRICH	**Wealth (-)**	**0.915**	-0.13	0.059	0.014	-0.085	-0.042
2	MDHSEVAL		**0.892**	-0.09	-0.065	-0.145	-0.072	-0.006
3	PERCAP		**0.86**	-0.258	0.093	-0.223	-0.2	-0.016
4	MDGRENT		**0.61**	-0.384	-0.177	0.158	-0.171	0.03
5	QESL	**Language & Education (+)**	-0.134	**0.806**	-0.105	0.175	-0.002	-0.09
6	QSPANISH		-0.288	**0.739**	-0.104	0.379	-0.104	-0.066
7	QED12LES		-0.365	**0.732**	0.022	0.291	0.131	-0.126
8	QSSBEN	**Elderly (+)**	-0.161	-0.041	**0.896**	-0.02	0.053	0.022
9	QAGEDEP		-0.003	-0.001	**0.859**	-0.116	-0.012	0.114
10	MEDAGE		0.235	-0.181	**0.658**	-0.357	-0.196	-0.008
11	PPUNIT	**Housing Status (+)**	-0.083	0.216	-0.138	**0.874**	-0.038	-0.067
12	QFAM		-0.064	0.159	-0.162	**0.844**	0.055	0.096
13	QCVLUN	**Social Status (+)**	-0.09	0.054	0.135	0.243	**0.723**	-0.097
14	QBLACK		-0.185	-0.278	-0.178	-0.056	**0.666**	0.151
15	QNOAUTO		-0.12	0.486	0.039	-0.299	**0.559**	0.095
16	QPOVTY		-0.144	0.432	-0.166	-0.111	**0.533**	0.082
21	QFEMALE	**Female (+)**	0.052	0.031	0.146	0.067	-0.021	**0.877**
22	QFEMLBR		-0.081	-0.173	-0.021	-0.048	0.105	**0.836**

*Rotation Method: Varimax with Kaiser Normalization.

Table 5. Principal component analysis summary (variance) at block group level

Component		Cardinality	Variance Explained (%)	Variables	Loading scores
1	Wealth	(-)	17.53	QRICH	0.915
				MDHSEVAL	0.892
				PERCAP	0.86
				MDGRENT	0.61
2	Language & Education	(+)	14.51	QESL	0.806

				QSPANISH	0.739
				QED12LES	0.732
3	Elderly	(+)	12.17	QSSBEN	0.896
				QAGEDEP	0.859
				MEDAGE	0.658
4	Housing Status	(+)	11.91	PPUNIT	0.874
				QFAM	0.844
5	Social Status	(+)	9.61	QCVLUN	0.723
				QBLACK	0.666
				QNOAUTO	0.559
				QPOVTY	0.533
6	Female	(+)	8.75	QFEMALE	0.877
				QFEMLBR	0.836
	Total Variance Explained		**74.48**		

The Figures 5-8 shows the SVI scores mapped to visually compare at block group level. The normalized SVI score ranged between 0.1180 and 0.3752 with mean value of 0.2242. The SVI score of 0.0 indicates the least vulnerable (Blue in the figures), and 1.0 indicates the most vulnerable (Red in the figures).

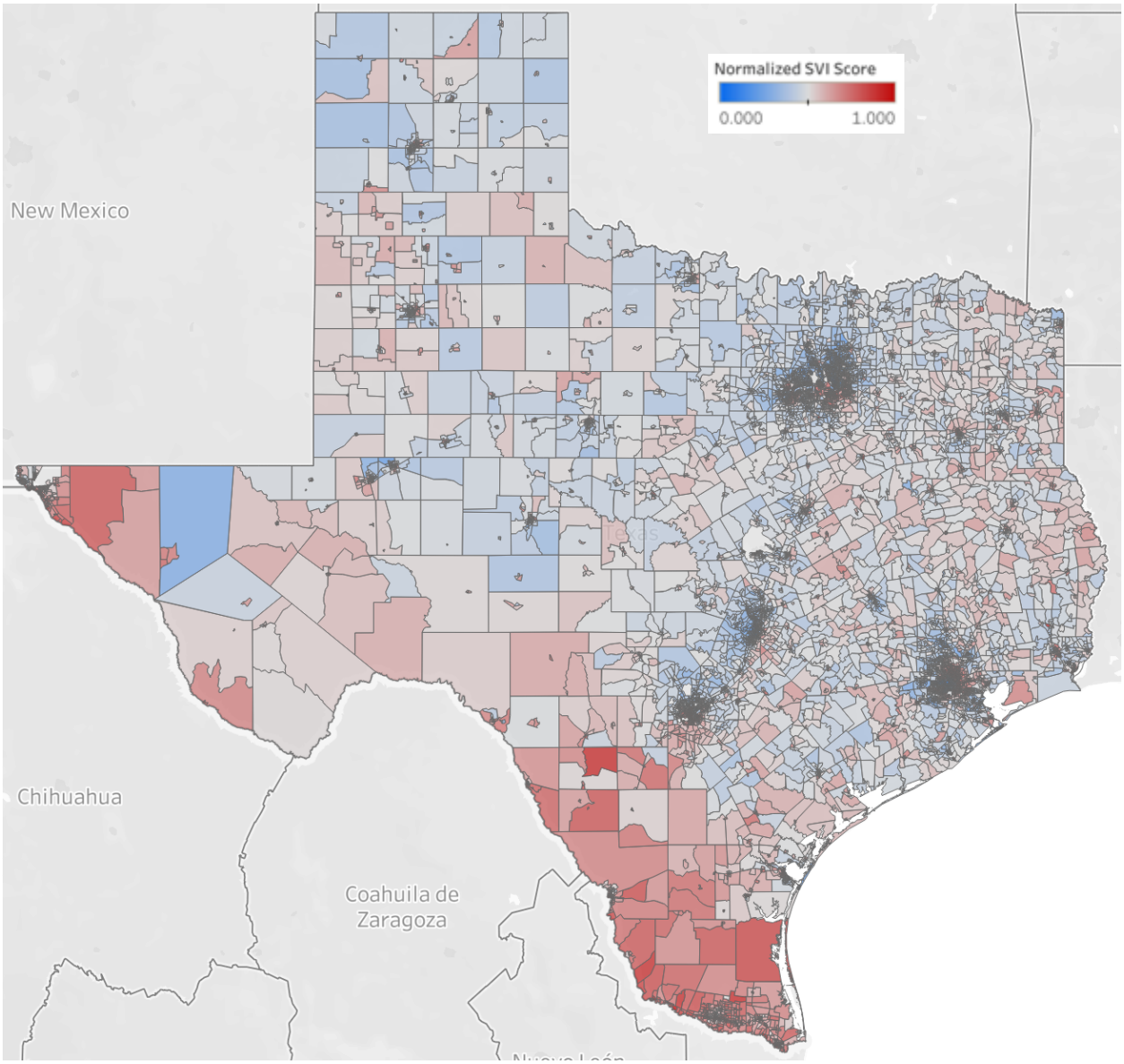

Figure 5. Census Block Group Level SVI Score (Texas)

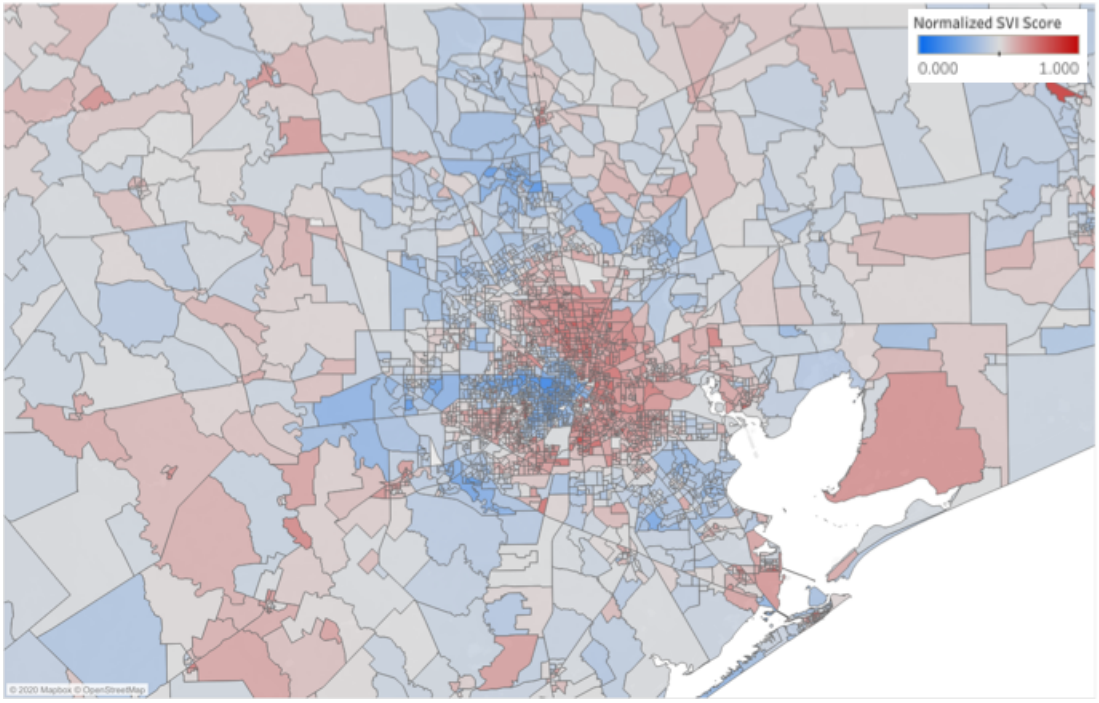

Figure 6. Houston MSA, Census Block Group Level SVI Score

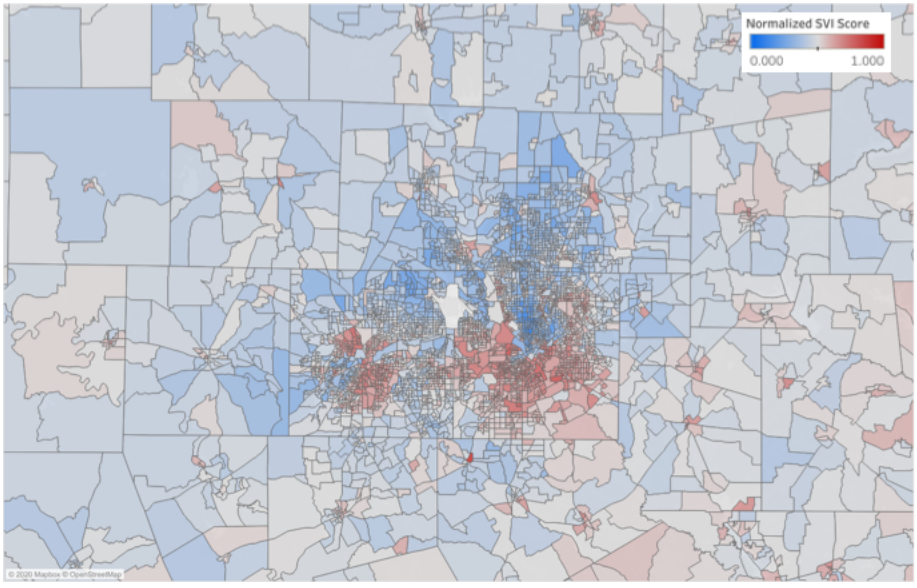

Figure 7. Dallas-Fort Worth MSA, Census Block Group Level SVI Score

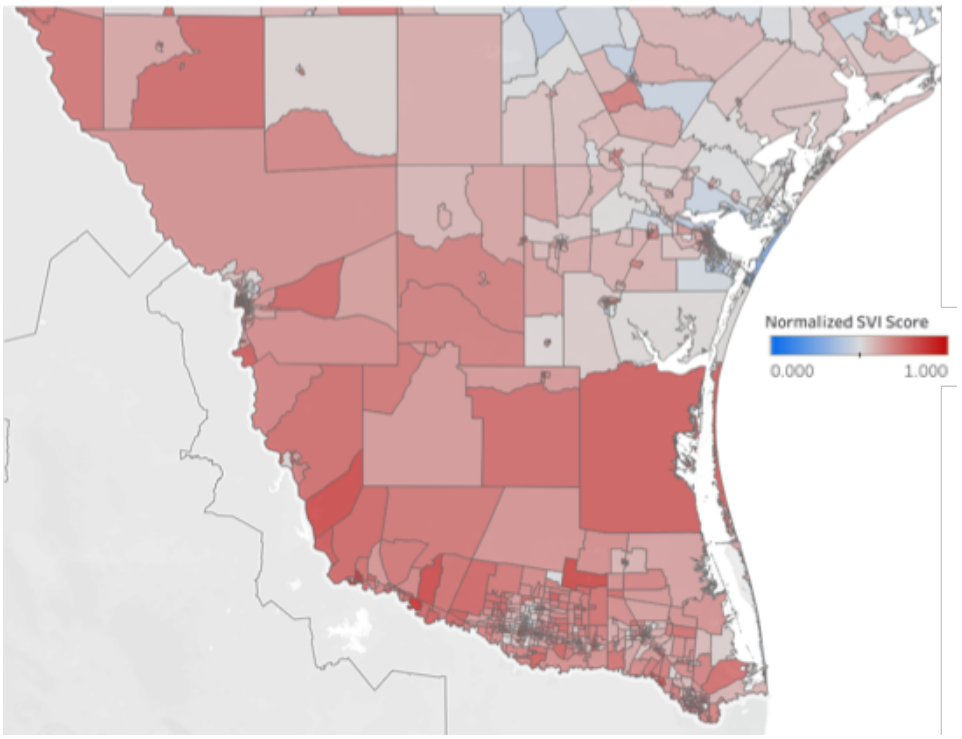

Figure 8. Rio Grande Valley, Census Block Group Level SVI Score

3. Conclusion

Our interest in social vulnerability is to provide data and information that decision-makers can use to consider vulnerability and advance resilience across the state of Texas. The information provided can be useful to urban policy-makers at the municipal, county, or regional planning authority level, or from the perspective of the state as a whole. The method applied here is easily replicated and can be updated on an annual basis as new data becomes available by American Community Survey, U.S. Census Bureau.

Utilizing this tool, specific geographies can be identified with relative high degrees of social vulnerability (populations with characteristics associated with high sensitivity to the impacts of hazards and characteristics of low ability to adapt, respond, and bounce forward to shocks or long-term climate related stressors). There are leverage points where policy can work to decrease exposure and/or increase adaptive capacity See figure 12.

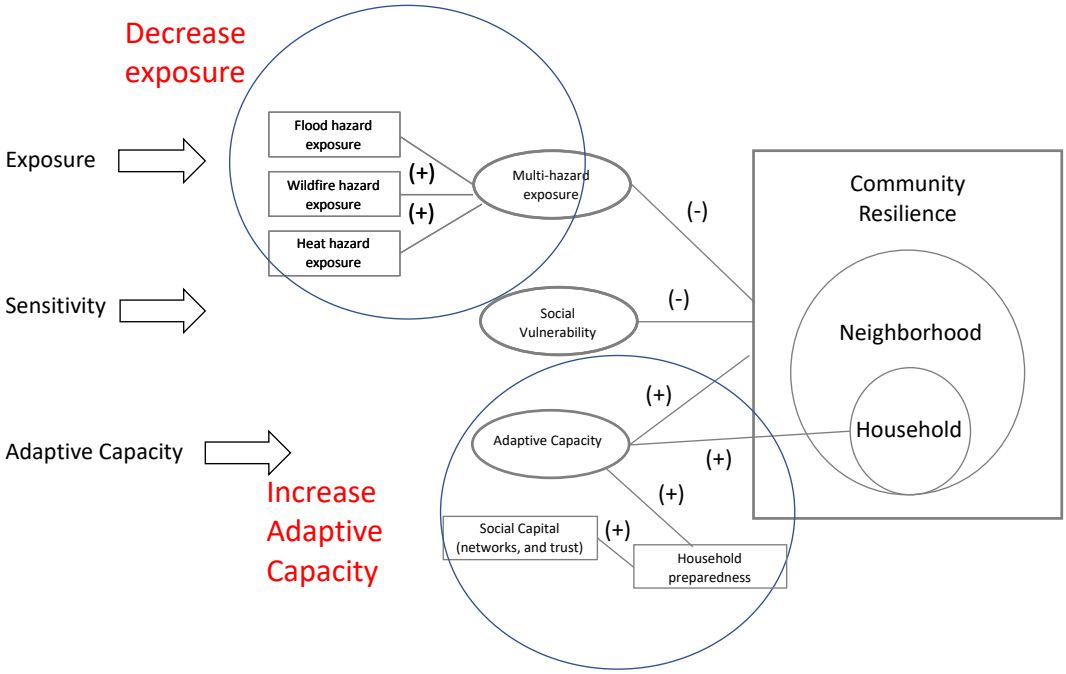

Figure 9. Intervention points to reduce increase community resilience.

Investments in nature-based solutions (green and blue infrastructure) and/or grey infrastructure can decrease exposure to hazards, and effective community engagement can increase household preparedness and increase social capital, thus increasing adaptive capacity and increasing community resilience. Assessment and prioritization of options will require additional research.

Works Cited

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockström, J. (2005). Social-ecological resilience to coastal disasters. *Science*, *309*(5737), 1036–1039.

Balica, S. F., Wright, N. G., & van der Meulen, F. (2012). A flood vulnerability index for coastal cities and its use in assessing climate change impacts. *Natural Hazards*, *64*(1), 73–105. https://doi.org/10.1007/s11069-012-0234-1

Cutter, S. L., Ash, K. D., & Emrich, C. T. (2014). The geographies of community disaster resilience. *Global Environmental Change*, *29*, 65–77. https://doi.org/10.1016/j.gloenvcha.2014.08.005

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*, *84*(2), 242–261.

Field, C. B., Barros, V., Stocker, T. F., & Dahe, Q. (Eds.). (2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change* (1 edition). Cambridge University Press.

Flanagan, B. E., Gregory, E. W., Hallisey, E. J., Heitgerd, J. L., & Lewis, B. (2011). A Social Vulnerability Index for Disaster Management. *Journal of Homeland Security and Emergency Management*, *8*(1). https://doi.org/10.2202/1547-7355.1792

Flanagan, B. E., Hallisey, E. J., Adams, E., & Lavery, A. (2018). Measuring community vulnerability to natural and anthropogenic hazards: The Centers for Disease Control and Prevention's Social Vulnerability Index. *Journal of Environmental Health*, *80*(10), 34–36.

Folke, C. (2006). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change*, *16*(3), 253–267.

Gallina, V., Torresan, S., Critto, A., Sperotto, A., Glade, T., & Marcomini, A. (2016). A review of multi-risk methodologies for natural hazards: Consequences and challenges for a climate change impact assessment. *Journal of Environmental Management*, *168*, 123–132. https://doi.org/10.1016/j.jenvman.2015.11.011

Haron, A. J. (2016). Standardized Versus Localized Strategy: The Role of Cultural Patterns in Society on Consumption and Market Research. *Journal of Accounting & Marketing*, *05*(01), 5–8. https://doi.org/10.4172/2168-9601.1000151

Huynh, L. T. M., & Stringer, L. C. (2018). Multi-scale assessment of social vulnerability to climate change: An empirical study in coastal Vietnam. *Climate Risk Management*, *20*(February), 165–180. https://doi.org/10.1016/j.crm.2018.02.003

Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F., & Pfefferbaum, R. L. (2008). Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *American Journal of Community Psychology*, *41*(1–2), 127–150. https://doi.org/10.1007/s10464-007-9156-6

Scherzer, S., Lujala, P., & Rød, J. K. (2019). A community resilience index for Norway: An adaptation of the Baseline Resilience Indicators for Communities (BRIC). *International Journal of Disaster Risk Reduction*, *36*(October 2018), 101107. https://doi.org/10.1016/j.ijdrr.2019.101107

Singh-peterson, L., Salmon, P., Goode, N., & Gallina, J. (2014). International Journal of Disaster Risk Reduction Translation and evaluation of the Baseline Resilience Indicators for Communities on the Sunshine Coast, Queensland Australia. *International Journal of Disaster Risk Reduction*, *10*(A), 116–126. https://doi.org/10.1016/j.ijdrr.2014.07.004

Vincent, K. (2007). Uncertainty in adaptive capacity and the importance of scale. *Global Environmental Change*, *17*(1), 12–24. https://doi.org/10.1016/j.gloenvcha.2006.11.009

Appendix A. Literature review generated vulnerability and community resilience variables

Cutter, Ash, and Emrich 2014

Social	Economic	Community	Institutional	Housing/Infrastructure	Environmental
1. Educational attainment equality	1. Homeownership	1. Place attachment-not recent immigrants	1. Mitigation spending	1. Sturdier housing types	1. Local food suppliers
2. Pre-retirement age	2. Employment rate	2. Place attachment-native born residents	2. Flood insurance coverage	2. Temporary housing availability	2. Natural flood buffers
3. Transportation	3. Race/ethnicity income equality	3. Political engagement	3. Jurisdictional coordination	3. Medical care capacity	3. Efficient energy use
4. Communication capacity	4. Non-dependence on primary/tourism sectors	4. Social capital-religious organizations	4. Disaster aid experience	4. Evacuation routes	4. Pervious surfaces
5. English language competency	5. Gender income equality	5. Social capital-civic organizations	5. Local disaster training	5. Housing stock construction quality	5. Efficient Water Use
6. Non-special needs	6. Business size	6. Social capital-disaster volunteerism	6. Performance regimes-state capital	6. Temporary shelter availability	
7. Health insurance	7. Large retail-regional/national geographic distribution	7. Citizen disaster preparedness and response skills	7. Performance regimes-nearest metro area	7. School restoration potential	
8. Mental health support	8. Federal employment		8. Population stability	8. Industrial re-supply potential	
9. Food provisioning capacity			9. Nuclear plant accident planning	9. High speed internet infrastructure	
10. Physician access			10. Crop insurance coverage		

Flanagan et al. 2018

Social	Economic	Institutional	Housing/Infrastructure	Community Capital	Environmental
1. Working age	1. Owner-occupied	1. Operating expenditure on Fire & Accident protection	1. Hotels	1. Employed to creative class	1. Not flood area
2. Cars	2. Employed	2. Operating surplus	2. Fire, police, ambulance stations, shelter	2. R&D Firm	2. No impervious surface
3. Internet	3. Female employed	3. Distance to county capital	3. Distance to fire or police station	3. Places of worship	3. Not landslide zone
4. Not-non-western immigrants	4. Ratio female to male avg. income	4. Employed to public admin, defense, social security, or municipal activities	4. Distance to hospital	4. Museum, libraries, zoos, botanic gardens	4. Not covered by water
5. Not-single-parent	5. Employed Not primary industry or tourism		5. Schools	5. Sports facilities	5. Natural flood buffer
6. Not-social assistance	6. Ratio large to small business (# of employees)		6. Traffic accidents	6. Voting age population	6. Developed open space
7. psychologists	7. Commercial enterprises		7. Length of major road	7. Cinemas, youth center, clubs	7. Arable (cultivated) land
8. Doctors	8. Banks		8. Length of railway	8. Kindergartens	8. Extreme weather events
9. Gender equality index	9. Turnover retail		9. Distance to airports	9. Broadcasts	9. Agricultural holdings
			10. Employed to public utilities	10. In- & out-migration	
			11. Living in urban area		

(continued…)

Scherzer, Lujala, and Rød 2019

Socioeconomic Status	Household Composition & Disability	Minority Status & Language	Housing & Transportation
1. Below poverty	1. Age 65 or older	1. Minority	1. Multiunit structures
2. Unemployed	2. Age 17 or younger	2. Speaks English "Less than well"	2. Mobile homes
3. Income	3. Older than age 5 within a disability		3. Crowding
4. No high school diploma	4. Single-parent household		4. No vehicle
			5. Group quarters

Balica, Wright, and van der Meulen 2012

Hydro-geological	Socio-economic	Politico-administrative
1. Sea-level rise	1. Cultural heritage (CH)	1. Existence of Flood hazard maps (FHM)
2. Storm surge	2. Population close to coastline (PCL)	2. Existence of Institutional organizations (IO)
3. # of cyclones	3. Growing coastal population (GCP)	3. Uncontrolled planning zone (UP)
4. Max River discharge	4. # of Shelters (S)	4. Flood protection (FP)
5. Foreshore slope	5. % of disabled persons (%Disable)	
6. Soil subsidence	6. Awareness and preparedness (A/P)	
7. Length of Coastline	7. Recovery time (RT)	
	8. Length of canalization (Drainage)	