7. VULNERABILITY TO SEA LEVEL RISE

Methods

Modeling potential sea level rise (SLR) is not a new scientific endeavor, but one steeped in a modest history based on scientific evidence (Hoffman et al., 1983; Camber, 1992; Rahmstorf, 2007; Allison et al., 2009), theory, and hypotheses as to the specific impacts that estimated SLR will have on international (Awosika et al., 1992; Stocher et al., 2010), national (Dunbar et al., 1992; FEMA, 1991; Titus et al., 1991; Smith and Tirpak, 1989; Yohe, 1990; Yohe et al., 1996), and local (Kana et al., 1984; Kana et al., 1986; Kana et al., 1988) environments and human use systems (Diaz and Murnane, 2008). However, the science behind understanding the spatial dynamics between water height and inundation area is rooted in sound geospatial processes (Engelen et al., 1981) and utilized in many discrete analyses (Dasgupta, 2009; Li et al., 2009; Neumann et al., 2010). As early as 1995, probabilities of Atlantic Ocean SLR based on non-anthropogenic climate change ranged from 55 cm to 120 cm by 2010 (Titus and Narayanan, 1995). More recent projections estimate an anthropogenic warming induced rise of between 0.5 and 1.4 m from 1990 levels by 2100 (Rahmstorf, 2007).

To represent Florida's risk to sea level rise hazards, LIDAR[24]-derived digital elevation model (DEM) data were collected from the Florida Geographic Data Library (FGDL). The final DEM[25] mosaic represents best-available elevation data, combined to provide statewide coverage. The FGDL lists four sources of the component elevation data, in order of priority:

1. Northwest Florida Water Management District (NWFWMD) DEM. Reported vertical accuracy ranges from 13 to 30 cm.
2. National Oceanic and Atmospheric Association (NOAA) LIDAR Coastal DEM. Produced using FEMA accuracy standards from the Guidelines and Specifications for Flood Hazard Mapping Partners (FEMA 2013).
3. Florida Fish and Wildlife Conservation Commission (FWC) Florida Statewide 5-Meter DEM. Produced using U.S. National Map accuracy standards (U.S. National Map 2013).
4. Contour Derived DEM - based on 2-ft contours from the coastal LIDAR project. The biggest portion of this source data is around Lake Okeechobee, where LIDAR data was provided by Merrick & Company.

Spatial identification of the potential inundation zones was accomplished with a typical "bathtub" flood modeling approach similar to those used in other studies (Mazria and Kershner, 2007; Poulter and Halpin, 2007; Rowley et al., 2007). Here, the 5-m resolution LIDAR-derived raster DEM was classified as flooded by first identifying the DEM grid cells that have an elevation at or below a given sea level rise scenario. For this work, we identified three scenarios from the IPCC Special Report on Emission Scenarios (SRES 2000), illustrating a low, middle, and high sea level rise prediction:

[24] Light Detection and Ranging (LIDAR) is a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light.
[25] Digital Elevation Model (DEM) is a digital model or 3D representation of a terrain's surface created from terrain elevation data.

1. Low scenario is based on University Corporation for Atmospheric Research's MAGICC processing of an IPCC B1 scenario implying 28.5 cm (0.9 ft) of SLR by 2100 compared to 1990 levels (see UCAR 2013).
2. Mid scenario, also based on MAGICC processing, but of the IPCC A1B scenario, implying 66.9 cm (2.2 ft) of SLR by 2100 compared to 1990 levels (see UCAR 2013).
3. High scenario is based on Rahmstorf (2007) maximum, implying 126.3 cm (4.1 ft) of SLR by 2100 compared to 1990 levels.

The resulting selection of grid cells includes all areas within the state with elevations at or below each scenario threshold, regardless of situation to the coast. We chose to include this as a potential SLR risk scenario in Florida to document possible inland water table influences. Secondarily, the selection was further dissected to remove grid cells that met the elevation criteria but are not geospatially connected or contiguous to the shore. A standard spatial cost distance algorithm (McCoy and Johnson, 2001) further culled cells based on connectivity where the "cost" to travel across a non-flooded grid cell would preclude non-adjacent cells from being counted as flooded. Each census tract was then categorized into one of five classes based on the probable land area impacted by each SLR scenario using the following equal interval classification scheme so that future changes in risk at the tract-level can be easily seen in comparison to the current risk level:

- Out = No land area in the SLR zone
- Low = Less than 25% of the tract area in the SLR zone
- Medium = Between 25%-50% of the tract area in the SLR zone
- High = Between 50%-75% of the tract area in the SLR zone
- Extreme = Greater than 75% of the tract area in the SLR zone

Caveats

Postulating about the impacts of possible sea level rise throughout Florida is an inexact science. Not only are the projections of sea level rise in 10, 20, or 100 years a moving target, but also the methods, tools, and techniques for measuring incremental changes on the surface of the earth are continuously evolving. Couple these facts with the current level of detail available from LIDAR-derived elevation datasets which are collected in piecemeal fashion with little or no regard for standardizing elevation above sea level based on tidal fluctuations, and the picture becomes less clear. However, we can, with some regional certainty, identify those areas (census tracts) where increases in sea level will interfere with the current human use system. Additionally, we can combine the current understanding of coastal elevation and projections of SLR to discover and analyze discrete entities on the ground (e.g., emergency facilities, human settlements). These feed the creation of informatics about potential impacts that are useful for planning sustainable and adaptable development strategies along coastal Florida. Caution should be taken, however, in using these types of analyses for highly resolved (local) geographic areas. In such places, the spatial differences between elevation and potential SLR could produce spatial inaccuracies and should not be employed beyond simple visual display.

State Summary

Twelve of Florida's counties have residents at extreme risk to even the lowest prediction of sea level rise investigated here, with DeSoto, Levy, and Monroe exhibiting the highest levels of risk to 28.5 cm of SLR (Figure 33). In the above counties, at least 50% of the land area (representing both high and extreme risk) in some census tracts is below this elevation (Table 45). These census tracts correspond to an estimated 67,000 people living in areas at high or extreme risk of inundation by as little as 1 ft of sea level rise (Table 46). It is important to note that some of these counties (such as Lee and Marion) contain small numbers of census tracts at risk, but in which no people reside. The picture changes drastically when a middle estimate of 66.9 cm is modeled (Figure 34). Here, 17 counties (Table 47) contain tracts with greater than 50% of land area and more than 168,000 people (Table 48) in a high or extreme risk zone. Modeling a high estimate of SLR within the next 100 years of 126.3 cm points to catastrophic impacts to coastal and inland Florida (Figure 35) without adaptation and mitigation, including 28 counties with census tracts categorized as having high or extreme risk (Table 49), corresponding to nearly 600,000 residents (Table 50).

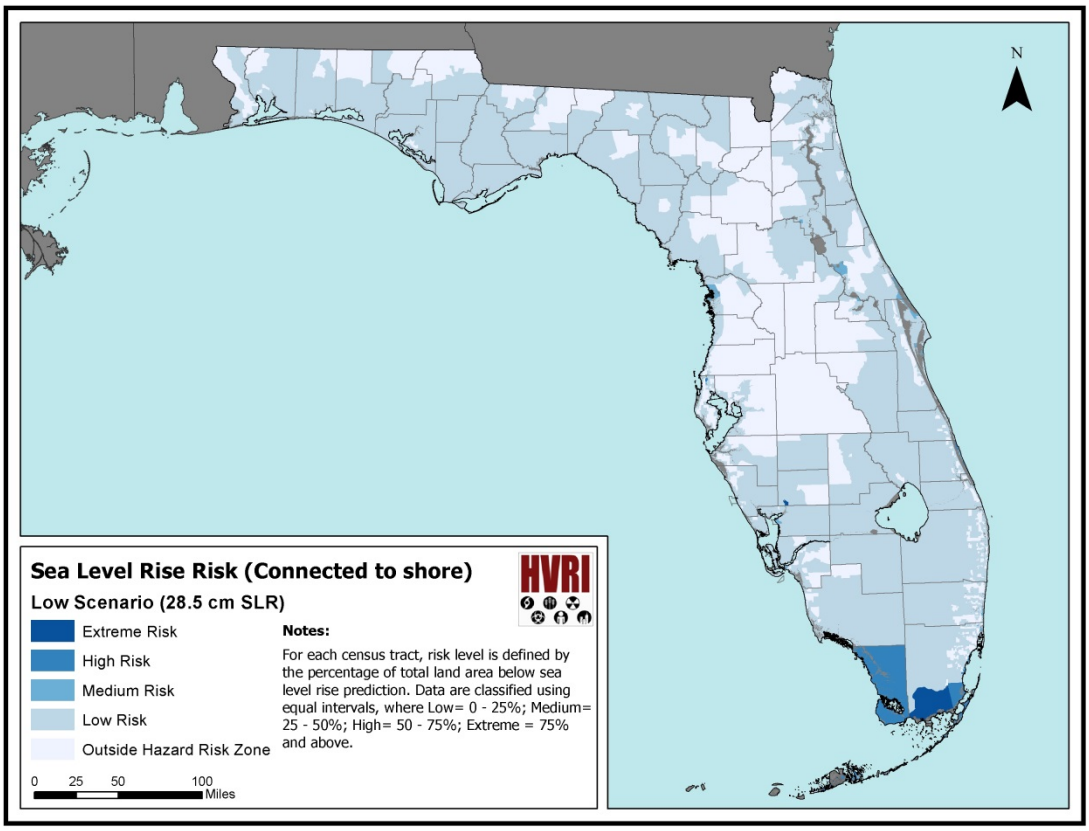

Figure 33: Sea level rise risk in Florida – low scenario (28.5 cm by 2100). Areas included are connected to the shore.

Table 45: Census tract summary for low connected SLR estimate risk.

County Name	SLR - Low Estimate (Connected Area Under 28.5 cm) Hazard Risk				
	Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out
Alachua	-	-	-	3.57%	96.43%
Baker	-	-	-	-	100.00%
Bay	-	-	-	84.09%	15.91%
Bradford	-	-	-	-	100.00%
Brevard	-	-	3.54%	62.83%	33.63%
Broward	-	0.28%	0.28%	58.73%	40.72%
Calhoun	-	-	-	100.00%	-
Charlotte	2.56%	-	10.26%	82.05%	5.13%
Citrus	3.57%	-	3.57%	14.29%	78.57%
Clay	-	-	-	60.00%	40.00%
Collier	1.35%	-	1.35%	56.76%	40.54%
Columbia	-	-	-	33.33%	66.67%
DeSoto	11.11%	-	-	66.67%	22.22%
Dixie	-	-	-	66.67%	33.33%
Duval	-	-	-	52.60%	47.40%
Escambia	-	-	-	43.66%	56.34%
Flagler	-	-	5.00%	50.00%	45.00%
Franklin	-	-	-	100.00%	-
Gadsden	-	-	-	55.56%	44.44%
Gilchrist	-	-	-	60.00%	40.00%
Glades	-	-	-	100.00%	-
Gulf	-	-	-	100.00%	-
Hamilton	-	-	-	100.00%	-
Hardee	-	-	-	83.33%	16.67%
Hendry	-	-	-	100.00%	-
Hernando	2.22%	-	-	6.67%	91.11%
Highlands	-	-	-	29.63%	70.37%
Hillsborough	-	-	-	33.02%	66.98%
Holmes	-	-	-	25.00%	75.00%
Indian River	-	-	-	80.00%	20.00%
Jackson	-	-	-	45.45%	54.55%
Jefferson	-	-	-	33.33%	66.67%
Lafayette	-	-	-	100.00%	-
Lake	-	-	-	5.36%	94.64%

County Name	SLR - Low Estimate (Connected Area Under 28.5 cm) Hazard Risk				
	Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out
Lee	0.60%	-	1.20%	61.68%	36.53%
Leon	-	-	-	7.35%	92.65%
Levy	10.00%	-	-	40.00%	50.00%
Liberty	-	-	-	100.00%	-
Madison	-	-	-	60.00%	40.00%
Manatee	-	-	-	57.69%	42.31%
Marion	1.59%	-	-	19.05%	79.37%
Martin	-	-	2.94%	73.53%	23.53%
Miami-Dade	0.39%	0.77%	1.16%	53.56%	44.12%
Monroe	12.90%	35.48%	19.35%	25.81%	6.45%
Nassau	-	-	-	83.33%	16.67%
Okaloosa	-	-	-	78.05%	21.95%
Okeechobee	-	-	-	81.82%	18.18%
Orange	-	-	-	0.97%	99.03%
Osceola	-	-	-	2.44%	97.56%
Palm Beach	-	-	-	73.21%	26.79%
Pasco	0.75%	-	-	15.67%	83.58%
Pinellas	-	0.41%	0.41%	53.47%	45.71%
Polk	-	-	-	-	100.00%
Putnam	-	-	5.88%	70.59%	23.53%
Santa Rosa	-	-	-	88.00%	12.00%
Sarasota	-	-	-	67.02%	32.98%
Seminole	-	-	1.16%	13.95%	84.88%
St. Johns	-	-	2.56%	69.23%	28.21%
St. Lucie	-	4.55%	2.27%	63.64%	29.55%
Sumter	-	-	-	-	100.00%
Suwannee	-	-	-	71.43%	28.57%
Taylor	-	-	-	50.00%	50.00%
Union	-	-	-	-	100.00%
Volusia	0.88%	-	1.75%	46.49%	50.88%
Wakulla	-	-	-	100.00%	-
Walton	-	-	-	63.64%	36.36%
Washington	-	-	-	57.14%	42.86%
State Total	**0.38%**	**0.45%**	**0.81%**	**45.72%**	**52.65%**

Table 46: Census tract population summary for low connected SLR estimate risk.

County Name	SLR - Low Estimate (Connected Area Under 28.5 cm) Hazard Risk					County Name	SLR - Low Estimate (Connected Area Under 28.5 cm) Hazard Risk				
	Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out		Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out
Alachua	-	-	-	16,164	231,172	Lee	-	-	6,011	404,477	208,266
Baker	-	-	-	-	27,115	Leon	-	-	-	18,183	257,304
Bay	-	-	-	140,824	28,028	Levy	-	-	-	14,156	26,645
Bradford	-	-	-	-	28,520	Liberty	-	-	-	8,365	-
Brevard	-	-	10,698	332,245	200,426	Madison	-	-	-	10,553	8,671
Broward	-	1,533	1,896	1,014,254	730,383	Manatee	-	-	-	183,405	139,428
Calhoun	-	-	-	14,625	-	Marion	-	-	-	45,980	285,318
Charlotte	-	-	11,094	139,481	9,403	Martin	-	-	2,691	103,156	40,471
Citrus	-	-	4,498	19,717	117,021	Miami-Dade	6,218	26,123	18,327	1,338,834	1,103,625
Clay	-	-	-	137,327	53,538	Monroe	3,067	21,512	16,756	26,233	5,522
Collier	-	-	2,939	180,544	138,037	Nassau	-	-	-	60,227	13,087
Columbia	-	-	-	24,177	43,354	Okaloosa	-	-	-	141,294	39,528
DeSoto	1,218	-	-	22,672	10,972	Okeechobee	-	-	-	30,627	9,369
Dixie	-	-	-	11,432	4,990	Orange	-	-	-	24,945	1,121,011
Duval	-	-	-	444,475	419,788	Osceola	-	-	-	7,194	261,491
Escambia	-	-	-	133,084	164,535	Palm Beach	-	-	-	967,952	351,510
Flagler	-	-	3,217	38,987	53,492	Pasco	-	-	-	59,863	404,834
Franklin	-	-	-	11,549	-	Pinellas	-	1,572	4,149	472,298	438,523
Gadsden	-	-	-	26,582	19,807	Polk	-	-	-	-	602,095
Gilchrist	-	-	-	10,510	6,429	Putnam	-	-	-	55,400	18,964
Glades	-	-	-	12,884	-	Santa Rosa	-	-	-	137,234	14,138
Gulf	-	-	-	15,863	-	Sarasota	-	-	-	251,950	127,498
Hamilton	-	-	-	14,799	-	Seminole	-	-	3,053	82,304	337,361
Hardee	-	-	-	26,772	959	St. Johns	-	-	2,455	136,694	50,890
Hendry	-	-	-	39,140	-	St. Lucie	-	5,841	3,686	203,154	65,108
Hernando	-	-	-	12,229	160,549	Sumter	-	-	-	-	87,023
Highlands	-	-	-	26,792	71,994	Suwannee	-	-	-	25,419	16,132
Hillsborough	-	-	-	376,514	852,712	Taylor	-	-	-	13,097	9,473
Holmes	-	-	-	5,544	14,383	Union	-	-	-	-	15,535
Indian River	-	-	-	97,664	40,364	Volusia	-	-	8,994	214,208	271,391
Jackson	-	-	-	25,398	24,348	Wakulla	-	-	-	30,776	-
Jefferson	-	-	-	4,380	10,381	Walton	-	-	-	34,262	20,781
Lafayette	-	-	-	8,870	-	Washington	-	-	-	16,682	8,214
Lake	-	-	-	17,380	279,672	**State Total**	**10,503**	**56,581**	**100,464**	**8,521,800**	**10,101,578**

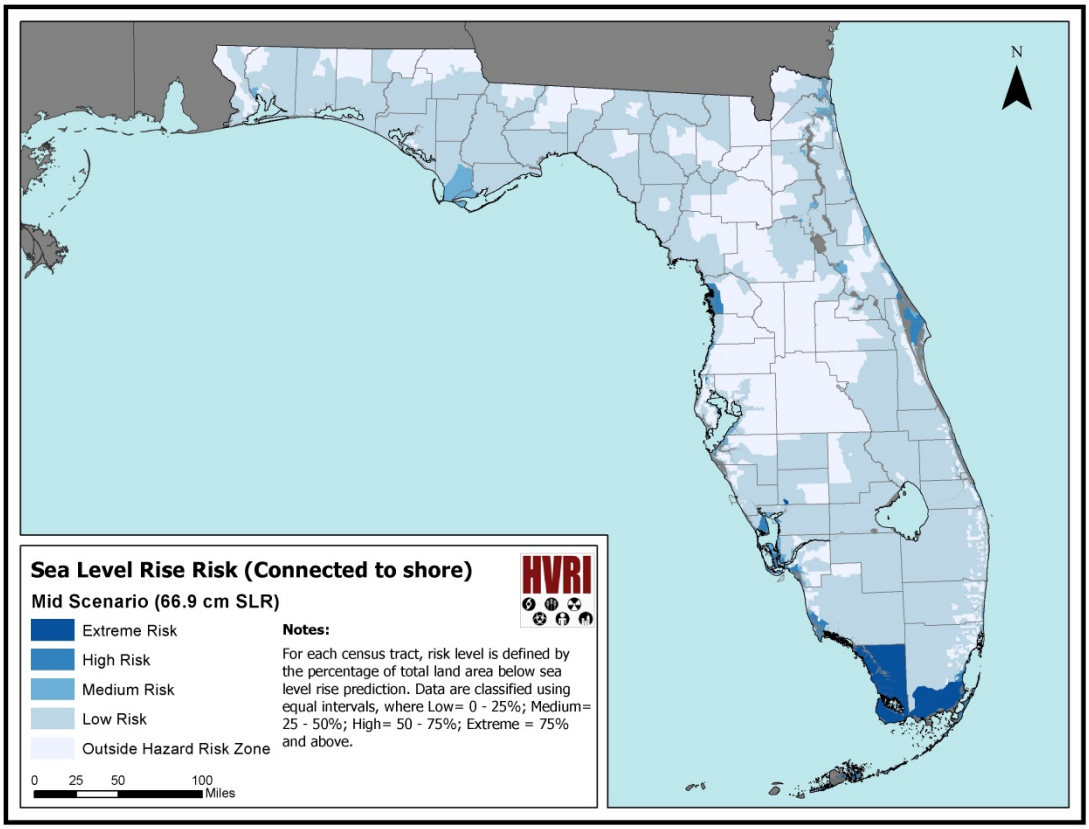

Figure 34: Sea level rise risk in Florida – mid scenario (66.9 cm by 2100). Areas included are connected to the shore.

Table 47: Census tract summary for mid connected SLR estimate risk.

County Name	SLR - Middle Estimate (Connected Area Under 66.9 cm) Hazard Risk				
	Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out
Alachua	-	-	-	3.57%	96.43%
Baker	-	-	-	-	100.00%
Bay	-	-	2.27%	84.09%	13.64%
Bradford	-	-	-	-	100.00%
Brevard	-	1.77%	4.42%	61.06%	32.74%
Broward	-	0.28%	0.83%	59.56%	39.34%
Calhoun	-	-	-	100.00%	-
Charlotte	2.56%	5.13%	12.82%	76.92%	2.56%
Citrus	3.57%	7.14%	-	10.71%	78.57%
Clay	-	-	3.33%	66.67%	30.00%
Collier	1.35%	5.41%	4.05%	51.35%	37.84%
Columbia	-	-	-	33.33%	66.67%
DeSoto	11.11%	-	-	66.67%	22.22%
Dixie	-	-	-	66.67%	33.33%
Duval	-	-	4.62%	50.29%	45.09%
Escambia	-	-	-	45.07%	54.93%
Flagler	-	-	5.00%	50.00%	45.00%
Franklin	-	-	50.00%	50.00%	-
Gadsden	-	-	-	55.56%	44.44%
Gilchrist	-	-	-	60.00%	40.00%
Glades	-	-	-	100.00%	-
Gulf	-	-	33.33%	66.67%	-
Hamilton	-	-	-	100.00%	-
Hardee	-	-	-	83.33%	16.67%
Hendry	-	-	-	100.00%	-
Hernando	2.22%	-	2.22%	4.44%	91.11%
Highlands	-	-	-	29.63%	70.37%
Hillsborough	-	0.31%	1.25%	31.78%	66.67%
Holmes	-	-	-	25.00%	75.00%
Indian River	-	-	13.33%	70.00%	16.67%
Jackson	-	-	-	45.45%	54.55%
Jefferson	-	-	-	33.33%	66.67%
Lafayette	-	-	-	100.00%	-
Lake	-	-	-	5.36%	94.64%

County Name	SLR - Middle Estimate (Connected Area Under 66.9 cm) Hazard Risk				
	Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out
Lee	0.60%	5.39%	6.59%	52.10%	35.33%
Leon	-	-	-	7.35%	92.65%
Levy	10.00%	-	-	40.00%	50.00%
Liberty	-	-	-	100.00%	-
Madison	-	-	-	60.00%	40.00%
Manatee	-	-	10.26%	48.72%	41.03%
Marion	1.59%	-	-	19.05%	79.37%
Martin	-	-	5.88%	73.53%	20.59%
Miami-Dade	0.58%	1.16%	1.93%	53.37%	42.97%
Monroe	29.03%	35.48%	16.13%	19.35%	-
Nassau	-	-	16.67%	66.67%	16.67%
Okaloosa	-	-	-	78.05%	21.95%
Okeechobee	-	-	-	81.82%	18.18%
Orange	-	-	-	0.97%	99.03%
Osceola	-	-	-	2.44%	97.56%
Palm Beach	-	-	-	73.51%	26.49%
Pasco	0.75%	-	3.73%	12.69%	82.84%
Pinellas	-	0.41%	3.27%	51.02%	45.31%
Polk	-	-	-	-	100.00%
Putnam	-	-	17.65%	64.71%	17.65%
Santa Rosa	-	-	4.00%	84.00%	12.00%
Sarasota	-	-	-	68.09%	31.91%
Seminole	-	-	1.16%	13.95%	84.88%
St. Johns	-	-	10.26%	66.67%	23.08%
St. Lucie	-	4.55%	4.55%	61.36%	29.55%
Sumter	-	-	-	-	100.00%
Suwannee	-	-	-	71.43%	28.57%
Taylor	-	-	-	50.00%	50.00%
Union	-	-	-	-	100.00%
Volusia	0.88%	1.75%	6.14%	42.11%	49.12%
Wakulla	-	-	-	100.00%	-
Walton	-	-	-	63.64%	36.36%
Washington	-	-	-	57.14%	42.86%
State Total	**0.52%**	**1.02%**	**2.56%**	**44.22%**	**51.67%**

Table 48: Census tract population summary for mid connected SLR estimate risk.

County Name	SLR - Middle Estimate (Connected Area Under 66.9 cm) Hazard Risk					County Name	SLR - Middle Estimate (Connected Area Under 66.9 cm) Hazard Risk				
	Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out		Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out
Alachua	-	-	-	16,164	231,172	Lee	-	25,592	45,451	347,809	199,902
Baker	-	-	-	-	27,115	Leon	-	-	-	18,183	257,304
Bay	-	-	-	140,824	28,028	Levy	-	-	-	14,156	26,645
Bradford	-	-	-	-	28,520	Liberty	-	-	-	8,365	-
Brevard	-	12,494	13,831	318,618	198,426	Madison	-	-	-	10,553	8,671
Broward	-	1,533	9,746	1,028,013	708,774	Manatee	-	-	23,096	165,541	134,196
Calhoun	-	-	-	14,625	-	Marion	-	-	-	45,980	285,318
Charlotte	-	7,710	13,764	136,594	1,910	Martin	-	-	6,398	106,908	33,012
Citrus	-	9,092	-	15,123	117,021	Miami-Dade	21,605	22,462	36,107	1,330,273	1,082,680
Clay	-	-	13,596	147,739	29,530	Monroe	11,580	28,234	13,711	19,565	-
Collier	-	15,145	8,317	166,584	131,474	Nassau	-	-	14,070	46,157	13,087
Columbia	-	-	-	24,177	43,354	Okaloosa	-	-	-	141,294	39,528
DeSoto	1,218	-	-	22,672	10,972	Okeechobee	-	-	-	30,627	9,369
Dixie	-	-	-	11,432	4,990	Orange	-	-	-	24,945	1,121,011
Duval	-	-	39,923	424,616	399,724	Osceola	-	-	-	7,194	261,491
Escambia	-	-	-	140,259	157,360	Palm Beach	-	-	-	972,228	347,234
Flagler	-	-	3,217	38,987	53,492	Pasco	-	-	10,571	53,587	400,539
Franklin	-	-	4,494	7,055	-	Pinellas	-	1,572	28,149	451,809	435,012
Gadsden	-	-	-	26,582	19,807	Polk	-	-	-	-	602,095
Gilchrist	-	-	-	10,510	6,429	Putnam	-	-	9,421	49,578	15,365
Glades	-	-	-	12,884	-	Santa Rosa	-	-	4,266	132,968	14,138
Gulf	-	-	4,450	11,413	-	Sarasota	-	-	-	254,581	124,867
Hamilton	-	-	-	14,799	-	Seminole	-	-	3,053	82,304	337,361
Hardee	-	-	-	26,772	959	St. Johns	-	-	11,077	144,894	34,068
Hendry	-	-	-	39,140	-	St. Lucie	-	5,841	5,429	201,411	65,108
Hernando	-	-	3,027	9,202	160,549	Sumter	-	-	-	-	87,023
Highlands	-	-	-	26,792	71,994	Suwannee	-	-	-	25,419	16,132
Hillsborough	-	-	4,562	376,649	848,015	Taylor	-	-	-	13,097	9,473
Holmes	-	-	-	5,544	14,383	Union	-	-	-	-	15,535
Indian River	-	-	10,857	95,387	31,784	Volusia	-	4,381	31,230	195,280	263,702
Jackson	-	-	-	25,398	24,348	Wakulla	-	-	-	30,776	-
Jefferson	-	-	-	4,380	10,381	Walton	-	-	-	34,262	20,781
Lafayette	-	-	-	8,870	-	Washington	-	-	-	16,682	8,214
Lake	-	-	-	17,380	279,672	**State Total**	**34,403**	**134,056**	**371,813**	**8,341,610**	**9,909,044**

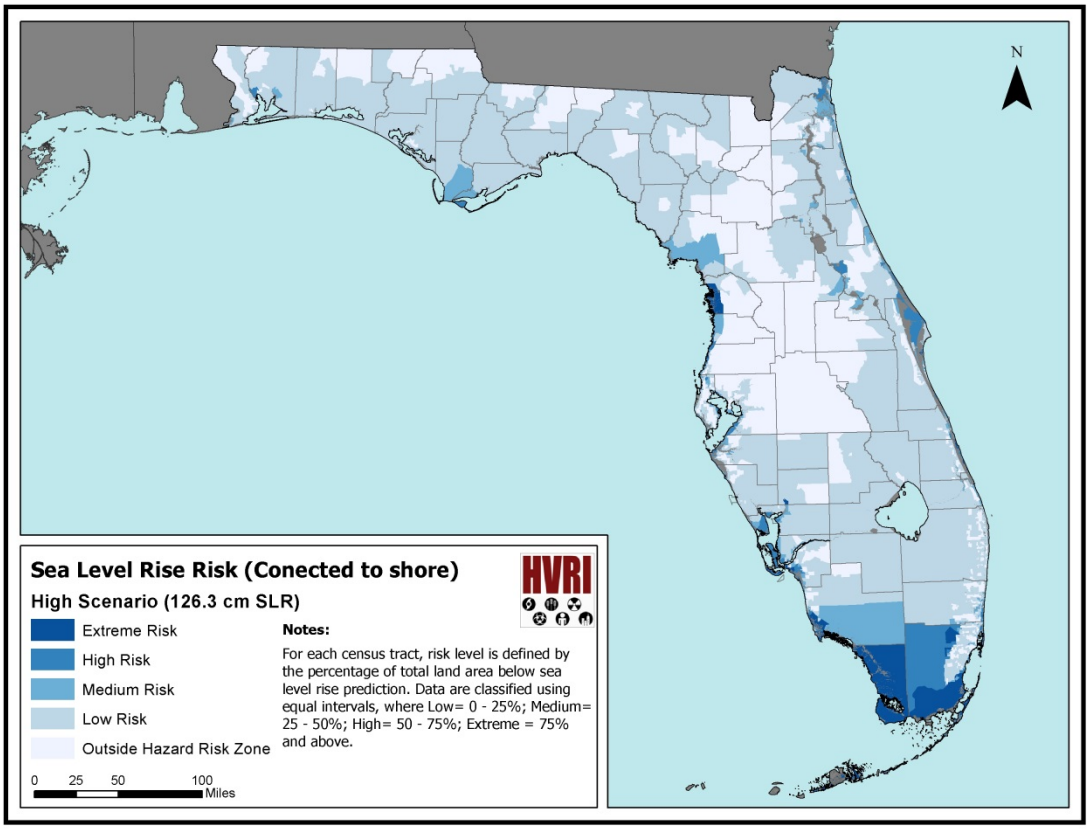

Figure 35: Sea level rise risk in Florida – high scenario (126.3 cm by 2100). Areas included are connected to the shore.

Table 49: Census tract summary for high connected SLR estimate risk.

County Name	SLR - High Estimate (Connected Area Under 126.3 cm) Hazard Risk				
	Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out
Alachua	-	-	-	3.57%	96.43%
Baker	-	-	-	-	100.00%
Bay	2.27%	-	6.82%	77.27%	13.64%
Bradford	-	-	-	-	100.00%
Brevard	0.88%	5.31%	7.08%	54.87%	31.86%
Broward	0.83%	1.94%	8.86%	53.46%	34.90%
Calhoun	-	-	-	100.00%	-
Charlotte	2.56%	12.82%	20.51%	61.54%	2.56%
Citrus	10.71%	-	-	14.29%	75.00%
Clay	-	-	3.33%	70.00%	26.67%
Collier	5.41%	5.41%	10.81%	45.95%	32.43%
Columbia	-	-	-	33.33%	66.67%
DeSoto	11.11%	-	-	66.67%	22.22%
Dixie	-	-	-	66.67%	33.33%
Duval	-	0.58%	6.94%	50.29%	42.20%
Escambia	-	-	1.41%	43.66%	54.93%
Flagler	-	5.00%	5.00%	45.00%	45.00%
Franklin	-	25.00%	25.00%	50.00%	-
Gadsden	-	-	-	55.56%	44.44%
Gilchrist	-	-	-	60.00%	40.00%
Glades	-	-	-	100.00%	-
Gulf	-	-	33.33%	66.67%	-
Hamilton	-	-	-	100.00%	-
Hardee	-	-	-	83.33%	16.67%
Hendry	-	-	-	100.00%	-
Hernando	2.22%	2.22%	2.22%	2.22%	91.11%
Highlands	-	-	-	29.63%	70.37%
Hillsborough	0.93%	0.62%	1.87%	32.09%	64.49%
Holmes	-	-	-	25.00%	75.00%
Indian River	-	6.67%	16.67%	63.33%	13.33%
Jackson	-	-	-	45.45%	54.55%
Jefferson	-	-	-	33.33%	66.67%
Lafayette	-	-	-	100.00%	-
Lake	-	-	1.79%	5.36%	92.86%

County Name	SLR - High Estimate (Connected Area Under 126.3 cm) Hazard Risk				
	Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out
Lee	3.59%	8.98%	9.58%	46.11%	31.74%
Leon	-	-	-	7.35%	92.65%
Levy	10.00%	-	10.00%	30.00%	50.00%
Liberty	-	-	-	100.00%	-
Madison	-	-	-	60.00%	40.00%
Manatee	1.28%	6.41%	7.69%	50.00%	34.62%
Marion	1.59%	-	-	19.05%	79.37%
Martin	-	-	17.65%	61.76%	20.59%
Miami-Dade	4.24%	6.55%	8.09%	44.12%	36.99%
Monroe	70.97%	16.13%	6.45%	6.45%	-
Nassau	-	8.33%	16.67%	66.67%	8.33%
Okaloosa	-	-	-	78.05%	21.95%
Okeechobee	-	-	-	81.82%	18.18%
Orange	-	-	-	0.97%	99.03%
Osceola	-	-	-	2.44%	97.56%
Palm Beach	-	0.30%	2.68%	70.54%	26.49%
Pasco	1.49%	2.99%	4.48%	11.19%	79.85%
Pinellas	0.41%	3.27%	11.84%	41.22%	43.27%
Polk	-	-	-	-	100.00%
Putnam	-	-	17.65%	64.71%	17.65%
Santa Rosa	-	4.00%	4.00%	80.00%	12.00%
Sarasota	-	3.19%	4.26%	63.83%	28.72%
Seminole	-	-	2.33%	12.79%	84.88%
St. Johns	-	5.13%	15.38%	61.54%	17.95%
St. Lucie	4.55%	2.27%	4.55%	59.09%	29.55%
Sumter	-	-	-	-	100.00%
Suwannee	-	-	-	71.43%	28.57%
Taylor	-	-	-	50.00%	50.00%
Union	-	-	-	-	100.00%
Volusia	0.88%	3.51%	12.28%	37.72%	45.61%
Wakulla	-	-	-	100.00%	-
Walton	-	-	-	63.64%	36.36%
Washington	-	-	-	57.14%	42.86%
State Total	**1.83%**	**2.70%**	**5.69%**	**40.43%**	**49.35%**

Table 50: Census tract population summary for high connected SLR estimate risk.

County Name	SLR - High Estimate (Connected Area Under 126.3 cm) Hazard Risk					County Name	SLR - High Estimate (Connected Area Under 126.3 cm) Hazard Risk				
	Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out		Extreme (75%)	High (50%-75%)	Medium (25%-50%)	Low (<25%)	Out
Alachua	-	-	-	16,164	231,172	Lee	8,607	39,046	72,318	320,537	178,246
Baker	-	-	-	-	27,115	Leon	-	-	-	18,183	257,304
Bay	-	-	6,946	133,878	28,028	Levy	-	-	3,289	10,867	26,645
Bradford	-	-	-	-	28,520	Liberty	-	-	-	8,365	-
Brevard	3,300	23,025	25,929	296,824	194,291	Madison	-	-	-	10,553	8,671
Broward	8,638	26,566	147,664	940,949	624,249	Manatee	4,849	14,032	20,278	171,894	111,780
Calhoun	-	-	-	14,625	-	Marion	-	-	-	45,980	285,318
Charlotte	-	18,010	24,122	115,936	1,910	Martin	-	-	17,752	95,554	33,012
Citrus	9,092	-	-	21,077	111,067	Miami-Dade	89,865	137,904	168,936	1,167,648	928,774
Clay	-	-	13,596	154,992	22,277	Monroe	49,345	14,453	3,548	5,744	-
Collier	11,601	11,861	23,527	159,380	115,151	Nassau	-	12,311	7,980	48,964	4,059
Columbia	-	-	-	24,177	43,354	Okaloosa	-	-	-	141,294	39,528
DeSoto	1,218	-	-	22,672	10,972	Okeechobee	-	-	-	30,627	9,369
Dixie	-	-	-	11,432	4,990	Orange	-	-	-	24,945	1,121,011
Duval	-	6,261	70,385	413,209	374,408	Osceola	-	-	-	7,194	261,491
Escambia	-	-	3,978	136,281	157,360	Palm Beach	-	1,683	14,521	956,024	347,234
Flagler	-	3,217	3,986	35,001	53,492	Pasco	1,487	8,141	16,134	50,114	388,821
Franklin	-	1,690	2,804	7,055	-	Pinellas	-	27,854	95,871	377,269	415,548
Gadsden	-	-	-	26,582	19,807	Polk	-	-	-	-	602,095
Gilchrist	-	-	-	10,510	6,429	Putnam	-	-	9,421	49,578	15,365
Glades	-	-	-	12,884	-	Santa Rosa	-	4,266	4,996	127,972	14,138
Gulf	-	-	4,450	11,413	-	Sarasota	-	6,331	8,425	253,376	111,316
Hamilton	-	-	-	14,799	-	Seminole	-	-	7,396	77,961	337,361
Hardee	-	-	-	26,772	959	St. Johns	-	6,822	17,256	142,915	23,046
Hendry	-	-	-	39,140	-	St. Lucie	5,841	3,686	4,520	198,634	65,108
Hernando	-	3,027	5,516	3,686	160,549	Sumter	-	-	-	-	87,023
Highlands	-	-	-	26,792	71,994	Suwannee	-	-	-	25,419	16,132
Hillsborough	15	4,547	16,947	377,145	830,572	Taylor	-	-	-	13,097	9,473
Holmes	-	-	-	5,544	14,383	Union	-	-	-	-	15,535
Indian River	-	3,212	19,765	88,621	26,430	Volusia	-	15,470	53,573	180,162	245,388
Jackson	-	-	-	25,398	24,348	Wakulla	-	-	-	30,776	-
Jefferson	-	-	-	4,380	10,381	Walton	-	-	-	34,262	20,781
Lafayette	-	-	-	8,870	-	Washington	-	-	-	16,682	8,214
Lake	-	-	1,634	21,594	273,824	**State Total**	**193,858**	**393,415**	**897,463**	**7,850,372**	**9,455,818**

Analyzing Sea Level Rise in Combination with SoVI and MedVI

Overlaying hazard threats and vulnerable populations provides a unique perspective into the diverse set of mitigation and adaptation possibilities that might otherwise be too complicated to tease out of tabular data. Figure 36 through Figure 41 display bivariate representations of the three different SLR scenarios coupled with social and medical vulnerability.

About Bivariate Classifications

Here, we keep the exposure constant by using the same hazard threat surface but use different vulnerability perspectives (social and medical) in bivariate representations to create an easily understood depiction of not only increased threat but also a limited ability to adequately prepare for and respond to these threats. In doing so, we are able to quickly identify three specific geographic areas of interest:

1. Areas where the hazard itself should be the focus of planning and mitigation,

2. Areas where understanding the underlying socioeconomics and demographics would prove to be the most advantageous input point to create positive change, and

3. Areas where a combination of classic hazard mitigation techniques and social mitigation practices should be utilized in order to maximize optimal outcomes.

The following maps utilize a three by three bivariate representation in which one can easily identify areas of limited to elevated SoVI in relation to areas with low to extreme hazard classifications. Places identified in item number one in the preceding list are shaded in the blue colors and can be understood as locations where hazard susceptibility is higher than SoVI or MedVI. Areas identified in item number two above, indicating where socioeconomics and demographics play an important role, are shaded in the pink/red colors and can be conceived as locations where SoVI or MedVI are greater than physical hazard threats. Places identified in item number three above are shaded either in gray-tones or in a dark burgundy color and can be understood as areas that have equal vulnerability and hazard classification scores.

Integrating Low Projected Sea Level Rise with SoVI and MedVI

Figure 36 depicts the intersection of social vulnerability and low projected SLR risk for the entire state of Florida. The hatched lines indicate areas where limited (< 25%) land area would be inundated by 28.5 cm of SLR in association with the underlying social vulnerability of the census tract. Here, southern Miami-Dade County can be clearly identified with extreme SLR risk and high social vulnerability. This is the only tract in the state with both high social vulnerability and extreme hazard vulnerability, representing a population of 6,000 (Table 51). In this purple-shaded census tract, both mitigation of the threat source (physical protection) and adaptation strategies should be utilized to combat the possible impacts of SLR. Places symbolized in red shades indicate places where social vulnerability is generally higher than hazard vulnerability (high and medium SLR risk in Table 51). In these places, with 6 census tracts and 34,000 residents, social mitigation programs aimed at assisting people can greatly influence hazard impacts. An additional 419 tracts across 32 counties containing 1.9 million people are characterized by high SoVI coincident with low risk from low estimated SLR.

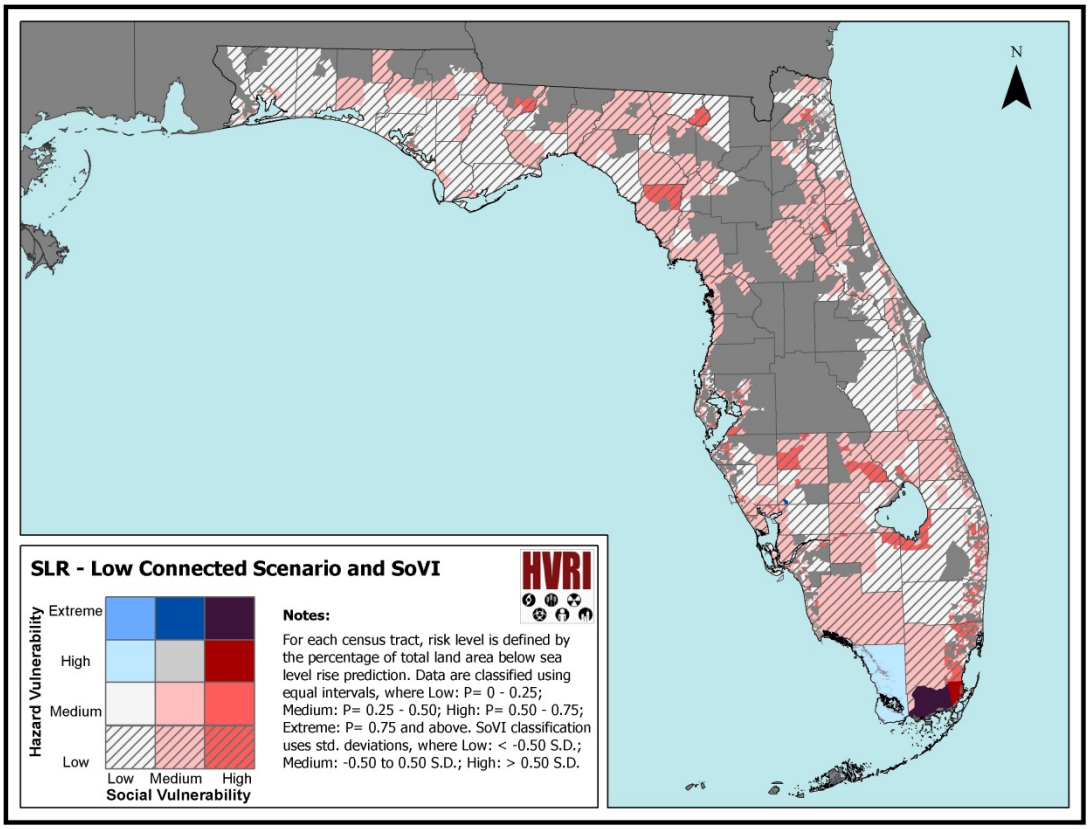

Figure 36: Bivariate representation of SoVI and low connected SLR risk in Florida.

Table 51: Tract and population summary for counties with high SoVI and medium or greater low SLR estimate risk.

County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts
Extreme Risk from Low SLR Estimate								
Miami-Dade	1	6,218		-	-		-	-
State Total	**1**	**6,218**		-	-		-	-
High Risk from Low SLR Estimate								
Miami-Dade	2	20,771		-	-		-	-
State Total	**2**	**20,771**		-	-		-	-
Medium Risk from Low SLR Estimate								
Lee	1	3,057	Miami-Dade	3	10,658		-	-
State Total	**4**	**13,715**		-	-		-	-

Figure 37 displays the combination of low SLR prediction inundation risk and MedVI. Here, a different story begins to emerge as the focus is on human health rather than underlying socioeconomics and demographics. The same census tract in southern Miami-Dade County that has high SoVI is actually one of the only tracts with low MedVI and extreme threat from low SLR inundation (Figure 37). Table 52 lists counties, tracts, and population totals for those places that have both high MedVI and extreme to medium risk from low estimate SLR. Note that only eight census tracts containing fewer than 30,000 people have high medical vulnerability coupled with a medium or higher threat from low estimate SLR. These places, although rare, face adverse impacts from hazard events and have communities and populations with less ability to medically prepare for and cope with these threats. Fifty counties contain census tracts characterized by high MedVI and low risk from a low estimate of SLR. Nearly 2 million people reside within these 448 census tracts.

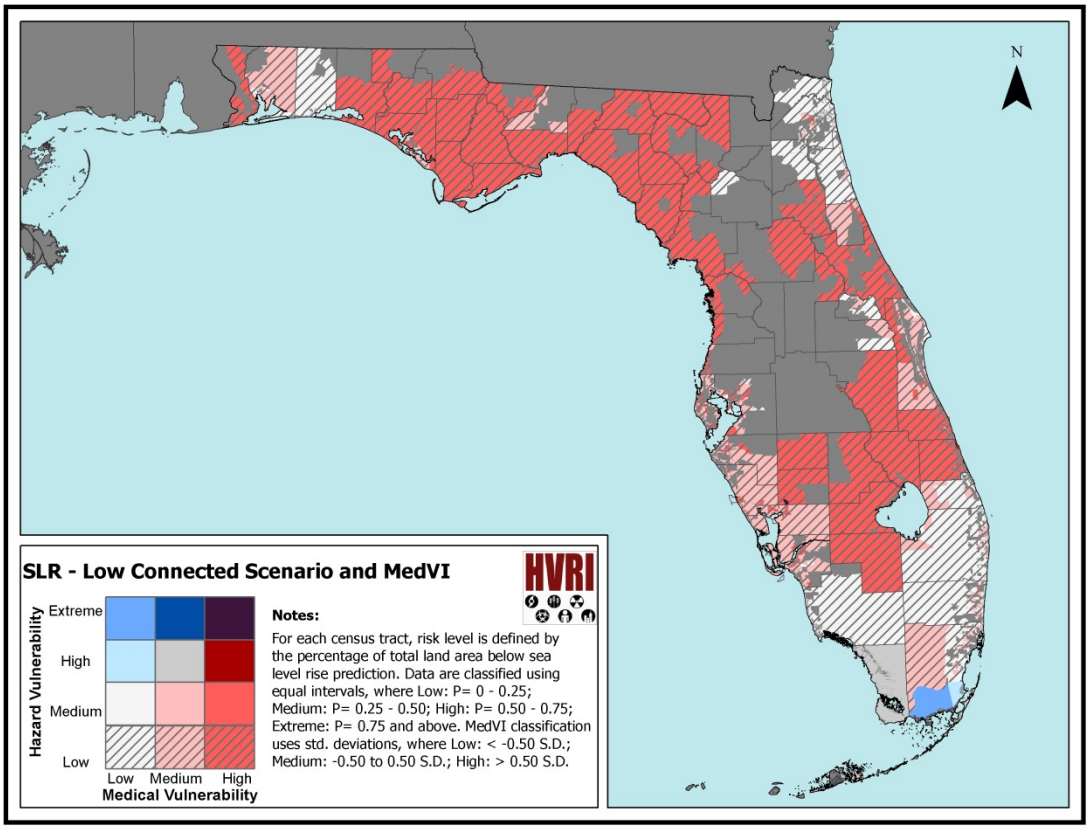

Figure 37: Bivariate representation of MedVI and low connected SLR risk in Florida.

Table 52: Tract and population summary for counties with high MedVI and medium or greater low SLR estimate risk.

County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts
Extreme Risk from Low SLR Estimate								
DeSoto	1	1,218		-	-		-	-
State Total	**1**	**1,218**		-	-		-	-
High Risk from Low SLR Estimate								
St. Lucie	2	5,841		-	-		-	-
State Total	**2**	**5,841**		-	-		-	-
Medium Risk from Low SLR Estimate								
Citrus	1	4,498	Flagler	1	3,217	St. Lucie	1	3,686
Volusia	2	8,994		-	-		-	-
State Total	**5**	**20,395**		-	-		-	-

Integrating Moderate Projected Sea Level Rise with SoVI and MedVI

Figure 38 provides a glimpse into moderate SLR threat (66.9 cm) in combination with social vulnerability. Here, much the same as the lower SLR prediction, south Florida has a higher risk and a higher social vulnerability while portions of north Florida begin to move into medium SLR risk categories coupled with lower to moderate levels of social vulnerability. Eight counties contain 18 tracts with high SoVI populations and medium to extreme risk levels related to moderate estimates of SLR (Table 53). More than 75,000 people reside in these areas that may see impacts from a moderate sea level rise in the future.

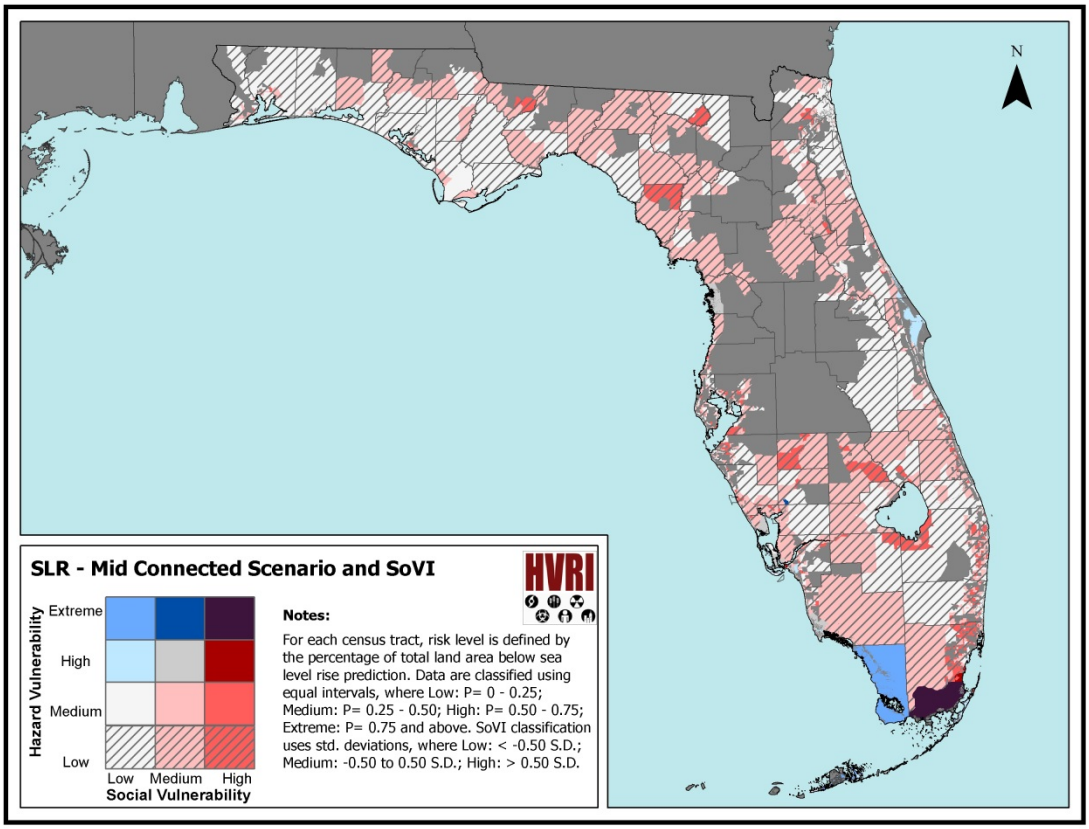

Figure 38: Bivariate representation of SoVI and mid connected SLR risk in Florida.

Table 53: Tract and population summary for counties with high SoVI and medium or greater moderate SLR estimate risk.

County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts
Extreme Risk from Moderate SLR Estimate								
Miami-Dade	2	21,605		-	-		-	-
State Total	**2**	**21,605**		-	-		-	-
High Risk from Moderate SLR Estimate								
Lee	1	3,057	Miami-Dade	3	14,721		-	-
State Total	**4**	**17,778**		-	-		-	-
Medium Risk from Moderate SLR Estimate								
Hillsborough	1	1,304	Indian River	3	5,566	Lee	1	2,768
Manatee	1	4,914	Miami-Dade	3	15,575	Pasco	1	1,487
Putnam	1	3,107	St. Lucie	1	1,743		-	-
State Total	**12**	**36,464**		-	-		-	-

When MedVI is coupled with moderate risk, a few areas appear as priorities. Much of the northwest coast of Florida has a low to moderate high SLR threat and high MedVI (Figure 39). Included here are 12 counties in which over 100,000 people reside in 32 medium to extreme SLR risk tracts (Table 54). An additional 50 counties containing 432 census tracts and 1.9 million people have coincident low risk from moderate SLR and high medical vulnerability. While these places are less threatened by the possibility of sea level rise, they have a higher pre-disposition to adverse impacts based on their medical characteristics.

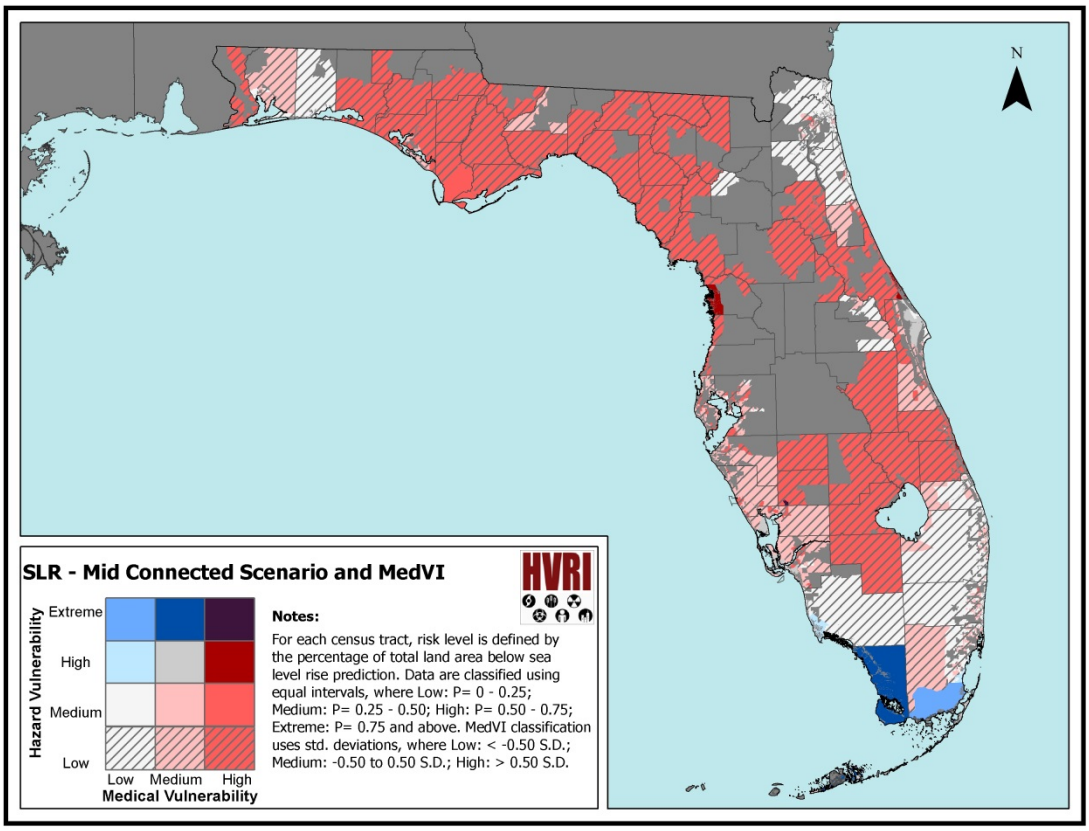

Figure 39: Bivariate representation of MedVI and mid connected SLR risk in Florida.

Table 54: Tract and population summary for counties with high MedVI and medium or greater moderate SLR estimate risk.

County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts
Extreme Risk from Moderate SLR Estimate								
DeSoto	1	1,218		-	-		-	-
State Total	**1**	**1,218**		-	-		-	-
High Risk from Moderate SLR Estimate								
Citrus	2	9,092	St. Lucie	2	5,841	Volusia	2	4,381
State Total	**6**	**19,314**		-	-		-	-
Medium Risk from Moderate SLR Estimate								
Flagler	1	3,217	Franklin	2	4,494	Gulf	1	4,450
Hernando	1	3,027	Hillsborough	1	1,304	Indian River	4	10,857
Pasco	4	8,184	Putnam	2	9,421	St. Lucie	2	5,429
Volusia	7	31,230		-	-		-	-
State Total	**25**	**81,613**		-	-		-	-

Integrating High Projected Sea Level Rise with SoVI and MedVI

High predicated SLR (126.3 cm) stands to heavily impact much of coastal Florida. Broward, Citrus, Miami-Date, and Okeechobee Counties are highlighted in the depiction of social vulnerability and high SLR risk presented in Figure 40. Ten counties contain 48 tracts and nearly 330,000 residents characterized by high social vulnerability and a medium to high level of SLR risk in this scenario (Table 55). Furthermore, many inland portions of Miami-Dade exhibit extreme levels of SLR risk coupled with various levels of social vulnerability. An additional 32 counties including 417 tracts and nearly 2 million people have at least a low level of SLR risk and high social vulnerability.

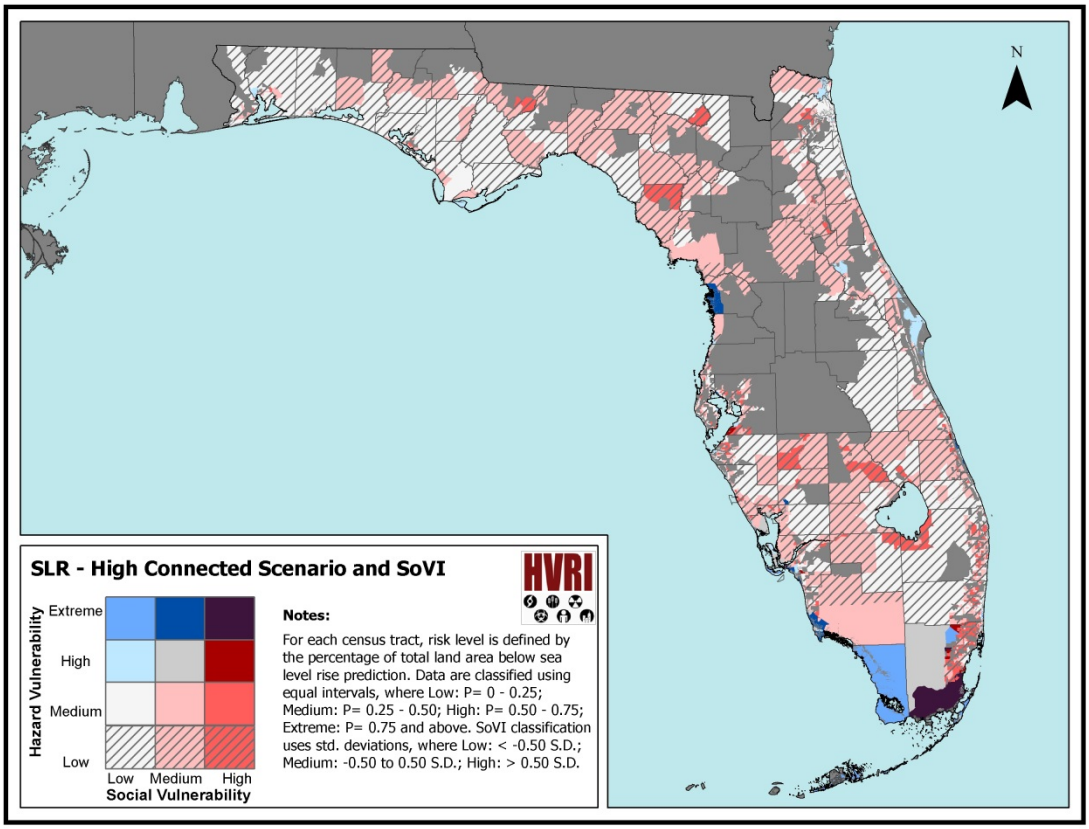

Figure 40: Bivariate representation of SoVI and high connected SLR risk in Florida.

Table 55: Tract and population summary for counties with high SoVI and medium or greater high SLR estimate risk.

County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts
Extreme Risk from High SLR Estimate								
Broward	1	3,098	Lee	1	3,057	Miami-Dade	7	51,608
Pasco	1	1,487		-	-		-	-
State Total	**10**	**59,250**		-	-		-	-
High Risk from High SLR Estimate								
Hillsborough	1	1,304	Indian River	2	3,212	Lee	1	2,768
Miami-Dade	10	59,006		-	-		-	-
State Total	**14**	**66,290**		-	-		-	-
Medium Risk from High SLR Estimate								
Collier	2	3,409	Indian River	1	2,354	Manatee	2	9,457
Miami-Dade	17	83,610	Putnam	1	3,107	St. Lucie	1	1,743
State Total	**24**	**103,680**		-	-		-	-

Areas mentioned above as having higher levels of SoVI tend to have lower levels of MedVI (Figure 41). However, portions of inland and coastal Volusia County as well as coastal Citrus County begin to stand out with higher MedVI and high to extreme SLR risk. Sixty-two tracts within 19 counties exhibit both high medical vulnerability and medium to high SLR risk in this scenario (Table 56). Unlike with SoVI, the greatest risk of SLR coupled with MedVI does not occur in southeast or southwest Florida but rather in Citrus County where 9,000 people live in extreme threat and high MedVI areas and in St. Lucie County where nearly 6,000 people meet these criteria.

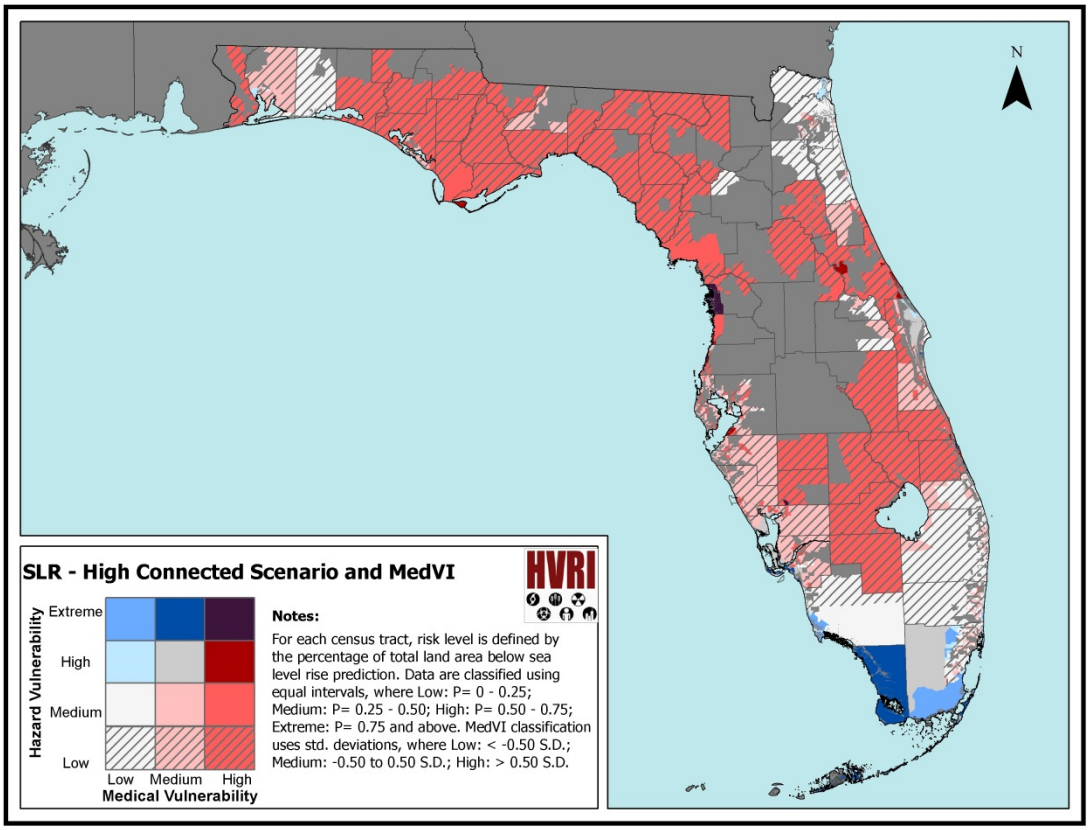

Figure 41: Bivariate representation of MedVI and high connected SLR risk in Florida.

Table 56: Tract and population summary for counties with high MedVI and medium or greater high SLR estimate risk.

County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts	County Name	Number of Tracts	Total Population of Tracts
Extreme Risk from High SLR Estimate								
Citrus	2	9,092	DeSoto	1	1,218	Pasco	1	1,487
St. Lucie	2	5,841		-	-		-	-
State Total	**6**	**17,638**		-	-		-	-
High Risk from High SLR Estimate								
Flagler	1	3,217	Franklin	1	1,690	Hernando	1	3,027
Hillsborough	1	1,304	Indian River	2	3,212	Pasco	3	5,754
St. Lucie	1	3,686	Volusia	4	15,470		-	-
State Total	**14**	**37,360**		-	-		-	-
Medium Risk from High SLR Estimate								
Bay	1	2,190	Charlotte	1	4,425	Escambia	1	3,978
Franklin	1	2,804	Gulf	1	4,450	Hernando	1	5,516
Hillsborough	2	6,474	Indian River	5	19,765	Lake	1	1,634
Lee	3	16,593	Levy	1	3,289	Pasco	6	16,134
Putnam	2	9,421	St. Lucie	2	4,520	Volusia	14	53,573
State Total	**42**	**154,766**		-	-		-	-

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