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Fiscal Vulnerability and Funding Woes Under Sea Level Rise

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ABSTRACT

Problem, research strategy, and findings: With its densely built coastline and economic and fiscal reliance on development, Florida is an extreme case of how climate change threatens both the built environment and urban land governance. We conducted one of the first statewide assessments of how sea level rise will affect Florida's municipal revenues. We paired this with a statewide survey of coastal planners and managers to assess how they have been funding climate adaptation. We found that more than half of Florida's 410 municipalities will be affected by sea level rise, exposing on average almost 30% of local revenues. Yet, though climate impacts will significantly stress local fiscal health, we found no relationship between cities' prioritization of climate adaptation and their fiscal exposure.

Takeaway for practice: Municipal revenues will become increasingly eroded by climate impacts and market responses. More fiscally affected municipalities are comparatively smaller, Whiter, and wealthier. They may be better able to invest in near-term adaptations, but long-term sea level rise could erode local fiscal capacity to maintain infrastructure and protect local tax bases. These municipalities' fiscal health and decline will affect regionwide housing markets, gentrification, and displacement. These dynamics underscore the need for stronger regional climate assessments and land and tax governance to overcome challenges facing coastal and near-coastal municipalities.

Keywords: climate adaptation, coastal development, municipal finance, property tax, sea level rise

Built on sea, sunshine, and sand, Florida's economy relies on demographic in-migration and coastal development (Carter, 1974; Chapin, 2017; Grunwald, 2006). A pro-growth paradigm permeates the state's land governance system from its tax structure, to zoning and land use regulations, to infrastructure policies. In this context, climate change physically threatens both the built environment and an urban governance framework that depends on the stationarity of land. Although state and local climate adaptation efforts are progressing, disconnects remain between reliance on physical infrastructural resilience on the one hand and contending with fiscal and governance realities of climate impacts on the other.

In this article, we ask: How might sea level rise (SLR) affect municipal fiscal stress in Florida? We conducted a spatial analysis of properties at risk of chronic inundation due to SLR to estimate imperiled municipal property taxes as a percentage of total revenues. To our knowledge, this is the first statewide, municipal-level assessment of fiscal impact for Florida, though other studies have estimated risks to businesses (Risky Business, 2015), infrastructure (Bloetscher et al., 2016; Shen et al., 2016), property values (Bernstein et al., 2019; Fu et al., 2016), and aggregate fiscal risks at county (Union of Concerned Scientists [UCS], 2018) and state levels (Florida TaxWatch, 2020). We complemented this spatial analysis with a statewide survey of local coastal planners and managers to assess how they are attempting to fund SLR adaptation responses and what barriers they face. Here we discuss the context and drivers behind Florida's fiscal vulnerability, present the findings from each data set followed by their cross-cutting implications, and conclude with implications for state and local policy. We see a need for a) a national public data set of municipal fiscal and tax information, b) alternatives to land-based municipal revenue, c) policies that help cities pool land and other resources, and d)

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institutional support for cooperative land and housing strategies.

Literature Review: The Fiscal Risks of Climate Change

The impacts of climate change are widespread, varied, and costly. Climate mitigation will require a nearly complete overhaul of the global energy sector in the next few decades to avoid significant increases in global average temperatures and associated climate change. However, climate adaptation investments will need to address intensifying changes over a longer period given the lag between temperature increases and climate impacts. Both mitigation and adaptation will be costly and require public financing (Ekins & Speck, 2014; Jones et al. 2013; Martín, 2021). Martín (2021) has noted that cities will need public finance for coastal climate adaptation because the costs will reach hundreds of billions of dollars annually in the United States by the 2030s. Public finance is a proven way to pay for infrastructure projects and offers a way to invest in adaptation that focuses on public benefits rather than private gain. Given the importance of public finance to coastal climate adaptation, local governments will face enormous cost burdens and need to draw on municipal, state, and federal funds to finance adaptation projects across infrastructure, services to reduce social vulnerability, and risk management instruments (Cleveland et al., 2019).

Since 2013, the federal government has recognized that climate change poses a major threat to government fiscal health and accountability (Elis, 2018; U.S. Government Accounting Office, 2017, 2019). Yet, fiscal risks of climate impacts and fiscal constraints on local government adaptation have been neglected by research and practice, with scholarship emerging only recently (Chung, 2019; Ekins & Speck, 2014; Gilmore et al., 2022; Levy, 2018; Liao & Kousky, 2022; Martín, 2021; Mullin et al., 2019; Parrado et al., 2020; Shi & Varuzzo, 2020). Though anticipatory adaptation is often cited as offering a benefit–cost ratio of up to 6:1 (National Institute of Building Sciences, 2020), the federal government often bears most of the future post-disaster costs, which disincentivizes prioritizing proactive local adaptations that expend current revenues. Moreover, this calculation of benefits only accounts for hazard mitigation without accounting for climate change, which likely pushes this ratio higher because climate change amplifies many hazard losses.[1] As a result, local governments often do not adapt, nor do they know their fiscal exposure to climate change.

For instance, many cities assess climate impacts on infrastructure, businesses, and household wellbeing through vulnerability assessments, but few consider the potentially severe effects on local budgets. Whereas decarbonization creates opportunities for savings through energy efficiency or revenues through energy generation (Jones et al., 2013), climate adaptation increases development costs in vulnerable areas and expenditures on disaster preparedness or recovery while reducing revenues from affected properties and foregone development (Chung, 2019; Parrado et al., 2020; Shi & Varuzzo, 2020). A recent study conducted for the City of Boston (MA) suggested that even with state and federal resources, the city would need $1 billion to $2 billion in private capital and raise new local revenues through district taxing instruments to meet the targets for infrastructure improvements in the city's resilience plan (Levy, 2018). Studies in other cities similarly have found that climate change will widen budgetary gaps and require using new public financing mechanisms (Cleveland et al., 2019).

There are signs that fiscal risks are unsustainable, escalating, and upscaling. As the magnitude of climate impacts become clearer and larger, some of the public agencies and private markets that have enabled risky development are indicating that they are no longer willing to accept (or capable of accepting) this growing risk (Keenan & Bradt, 2020; Taylor, 2020; Taylor & Weinkle, 2020). Property value assessments are slowly starting to account for climate risks and insurance costs. Studies have found anywhere from slower price value increases for lower-elevation homes to 7% decreases in property value of at-risk properties (Bernstein et al., 2019; Indaco et al., 2019; Keenan et al., 2018; Tyndall, 2021). Wildfires in California have had a substantial negative impact on municipal budgets, especially for smaller municipalities, but this effect has been moderated by the infusion of state and federal transfers of disaster aid (Liao & Kousky, 2022). Similarly, a broader study of the effect of disasters in 50 states from 1970 to 2013 found that federal disaster aid and other welfare supports buffered the effects of increased expenditures and decreased income and property tax revenues (Miao et al., 2018). In other words, local fiscal stress from disasters rolls upwards to state and federal governments, whose political appetite and fiscal capacity to support local recovery may also become tested as disaster damages increase.

Surveys and studies have long found that funding is a major barrier to municipal climate action (Hamin et al., 2014; Moser & Ekstrom, 2012; Shi et al., 2015). However, the foregoing discussion highlights that scholars and policymakers should not only pay attention to raising funding but question how sources of existing funding affect different levels of governments' capacity to adapt over time. Many resilience financing instruments are predicated on existing, land-based financing instruments like bonds, property tax and insurance surcharges, resilience district surcharges, and increased

utility or developer fees (e.g., Cleveland et al., 2019; National Oceanographic and Atmospheric Administration [NOAA], 2021; Plastrik et al., 2019). These instruments are becoming less affordable and inaccessible and are jeopardized by coastal property inundation because municipal credit ratings increasingly account for climate risk (Chung, 2019; Taylor, 2020). Moreover, such land-based financing presents a conundrum for coastal municipalities that are simultaneously losing land and local tax bases.

Case Context: Florida's Development Paradigm at a Crossroads

Nowhere are these questions of climate risk more evident than Florida, one of the world's regions most vulnerable to SLR due to its long coastline, low elevations, intensive coastal urbanization, and reliance on development (Hallegatte et al., 2013). According to demographic analysis of coastal population and inundation, more than half of Americans living in areas that may be submerged by SLR in the 21st century currently live in Florida (Hauer et al., 2016). An estimated 80% of Florida's $4 trillion real estate market lies in coastal counties (Doggett, 2015). Florida already leads the nation in total annual disaster damages: $3.4 billion in average annual property damage (between 2014 and 2018) or about 0.3% of gross state product (Timmons, 2020). Climate Central has estimated that just 3 ft of SLR in Florida would affect 300,000 homes worth $145 billion (Strauss et al., 2014). Florida TaxWatch, a think tank and government watchdog, has estimated that residential flooding will remove $350 million from local governments' property tax base by 2045 (Florida TaxWatch, 2020). The Tampa Bay Regional Planning Council (2021) has estimated the region will lose $7.5 billion in taxable property by 2060 with 3.5 ft of SLR, and infrastructure rehabilitation and upgrades will incur at least $7.2 billion in expenditures, creating a net gap of almost $15 billion.

Florida's fiscal exposure stems from an economic paradigm that relies on growth and development. Though U.S. population grew by 7.4% between 2010 and 2020, Florida's population grew by 14.6% (Klas et al., 2021). Around a quarter of Florida's gross domestic product comes from construction, finance, insurance, real estate, and income from rentals and leases (23% in 2020; The Construction Association, 2020; Statista, 2020). A 10th of the economy comes from the 145 million tourists who visit (Rockport Analytics, 2021; Statista, 2022). To date, disaster aid and insurance mechanisms have mitigated the impacts of disasters on Florida's property values, giving state and local governments little incentive to curb development in hazard-prone areas or invest in disaster mitigation. Coastal real estate continues to grow, buoyed by speculative investors and homebuyers who either have short investment time frames or choose to ignore long-term risks (Palm & Bolsen, 2022).

Florida has no income tax, making it more dependent on other sources of revenue, such as sales tax, property tax, and other user charges and fees, all of which benefit from growth and development (Nicholas et al., 2005). In 2018, property taxes on average accounted for 26% of local revenues in Florida, whereas user fees and charges comprised 29% (U.S. Census Bureau, 2017). A 1995 amendment to the state constitution capped owner-occupied property tax assessed value changes to no more than 3% a year, further incentivizing efforts to grow the taxable base, protect high-value real estate, and raise funds from user fees and charges (Florida Government Finance Officers Association, 2021).

In addition, Florida's coastal regions are highly fragmented. Since 1974, Florida has had more stringent requirements for municipal incorporation compared with the rest of the country. However, the Formation of Municipalities Act of 1974 stipulated that a municipality may incorporate if it is separated from others by a body of water, which can serve as an alternative to the required minimum distance of 2 miles between municipalities (Smith, 2018). This has helped Florida sustain a high rate of new incorporations, often of very small municipalities. As an example of the extent of fragmentation, the Southeast Florida Climate Change Compact encompasses 108 municipalities across four counties. Pinellas County in the Tampa Bay region has 24 incorporated municipalities, including eight along 15 miles of barrier islands. Multiplied across the state, local incorporations have helped create a fragmented administrative landscape of land-constrained municipalities (Carruthers, 2003).

Though state policies addressing disasters and climate change abound, Florida has never successfully steered growth away from vulnerable coastlines (Boarnet et al., 2011; Deyle et al., 2008). Florida has some of the strictest hazard mitigation planning requirements in the country, including the 1985 Growth Management Act and 1998 Local Mitigation Strategy Initiative that preceded the federal Disaster Mitigation Act of 2000. Nevertheless, the state has continued to permit shoreline hardening, has few regulations restricting post-disaster reconstruction or utility extension in the coastal zone, and provides minimal enabling legislation for retreating from the coastline or rolling easements (Dyckman et al., 2014). Development in the state's designated coastal high-hazard areas therefore has slowed but not stopped. Residential exposure to hurricanes increased by $80 billion and nearly 1 million people between 1985 and 2002 in most coastal counties and

municipalities, even after localities adopted hazard mitigation plans (Deyle et al., 2008).

State legislation has done little to question this land governance model and its impacts on local adaptation capacity. A 2011 policy enabled localities to establish Adaptation Action Areas prioritizing planning in areas with high SLR risks. Rather than removing areas from development, these Adaptation Action Areas (adopted by at least 17 municipalities) allow development to continue or even intensify (Butler et al., 2019; Frank, 2020). The 2015 Peril of Flood Act spurred municipalities to adopt SLR adaptation policies in their comprehensive plans, but the resulting comprehensive plan language has been highly inconsistent in part due to vague guidance (Butler et al., 2021; Holmes & Butler, 2021). A 2019 law required projects using state funding to develop an SLR impact assessment for up to 50 years into the future but did not require projects to change based on the studies (FDEP, 2022b). Although state laws can enhance local uptake, the specificity of the guidance and enforcement makes a difference as well (Burby & May, 1997; Dyckman et al., 2014). The 2021 Resilient Florida Program provided more than $600 million of competitive grants, by far the largest state investment in resilience in history (FDEP, 2022a). But this is just a fraction of the $2.5 billion requested by the 300-plus submitted proposals.

Risk management industry responses bode even greater changes by raising rates or divesting from Florida, which would crash the real estate market and paralyze property tax rolls (Leefeldt, 2020; O'Connor, 2020, 2021). In 2021, the National Flood Insurance Program Risk Rating 2.0 started assessing premiums based on actuarial risk on a property-by-property basis. More than a third of its 5 million account holders are in Florida (Haughey, 2021), where 12,500 premiums were expected to increase by $1,200 in 2021, with continued increases up to 18% a year (the cap) for 20 years (Flavelle, 2021). The state insurance program, Citizens Property Insurance, which has been adding policies at a historic pace, is not designed to sustain multiyear disasters or subsidize premiums to maintain affordability (Taylor, 2020; Taylor & Weinkle, 2020). Florida's Peril of Flood Act in 2015, requiring municipalities to account for SLR in local comprehensive plans, was driven in part by insurance companies pressuring state legislators to anticipate the impending crisis.

Infrastructural strategies, such as elevating buildings, roads, and utilities and enlarging drainage systems, as well as land use reforms that steer development to higher ground, are essential for climate adaptation.[2] However, infrastructure approaches will be costly, posing a significant financial burden on local governments, and land use redirecting development away from coastal areas toward inland areas could lead to loss of population and tax base as people move across jurisdictional boundaries in Florida's highly fragmented land governance system. Interrogating this model and assessing alternatives can help coastal regions adapt to long-term climate change. In support of this broader policy gap, we ask: How might SLR affect Florida's municipal revenues from property taxes, and therefore fiscal health? What barriers do coastal communities face, and what resources do they draw on to adapt within the current development paradigm? What are the implications of these findings for adaptation finance and long-term fiscal health?

Research Methods

To answer these questions, we brought together two new data sets from coastal Florida. These data sets cover similar geographies and can be overlaid to produce new insights. Figure 1 shows the relationship between these data sets. We studied 211 municipalities affected by the SLR inundation areas in Figure 1. We also surveyed all coastal counties and municipalities, with 96 responding jurisdictions. We combined these data sets to create a joint data set with 65 municipalities for which we had both fiscal and survey data (labeled in Figure 1). To our knowledge, this is the first statewide, municipal-level assessment of fiscal risks to SLR for Florida and the first to unite fiscal data with survey data to assess local responses to fiscal risk.

The first data set assessed the fiscal impact of SLR on the municipal revenues of coastal municipalities. We built on the work of UCS's 2018 report *Underwater*, which was the only national study of the fiscal impacts of SLR when we began our study that same year. We drew on UCS's SLR model for places that will become chronically inundated with 6.6 ft (2.0 m) of SLR, which was projected to take place by 2100 under an intermediate-high scenario for carbon emissions. Their model built on the 2014 National Climate Assessment and national tide gauges to find places that would be underwater at least once every 2 weeks during high tide, if not permanently underwater (Easterling et al., 2018). Though the 2022 projections by NOAA estimated a $< 1\%$ likelihood of SLR exceeding this level (Sweet et al., 2022), the state of Florida uses the intermediate-high curve to assess SLR impacts to its projects. Moreover, NOAA's 2022 intermediate projections still indicate that 7.2 ft (2.2 m) of SLR is possible by 2150. The uncertainty is more about *when* these impacts happen, rather than *whether* these impacts will happen. We also compared the percentage of each municipality that would be inundated with 3, 4, and 6.6 ft of SLR in the box and whiskers plot in Figure 2.[3] There is a tipping point between 4 and 6.6 ft of SLR as rising seas overtop

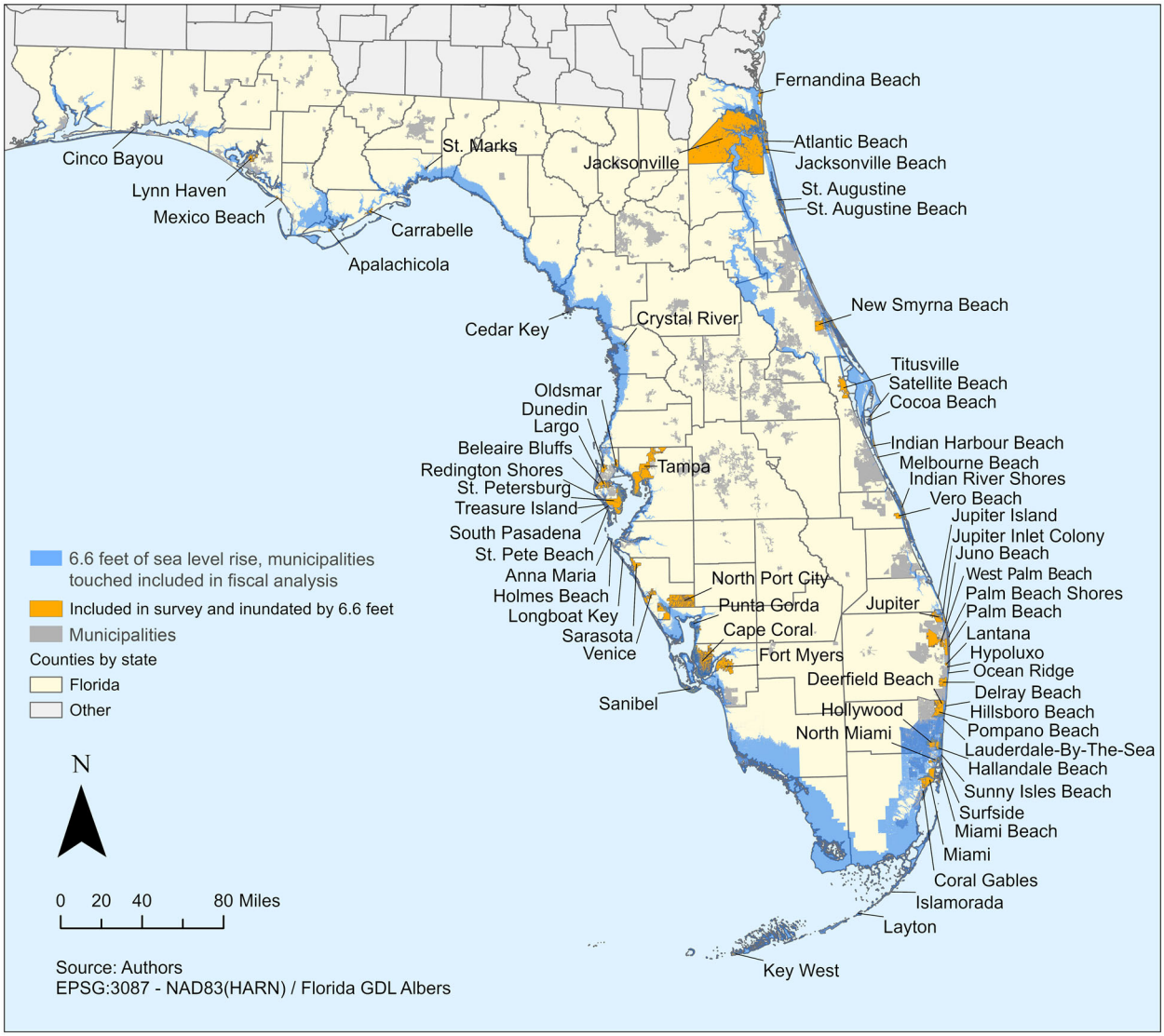

Figure 1. Municipalities in the study.

filled land. Therefore, we used 6.6 ft as a precautionary standard, one that is already exceeded by storm surges.

We then compiled data on the latest available local government tax rates (FDOR, n.d.), 2017 parcel-level assessed property values and tax districts from the Florida Geographic Data Library (2023), municipal revenues and expenditures from the 2012 U.S. Census of Government (U.S. Census Bureau, 2012), and socioeconomic data from the 2010 Decennial Census and 5-year estimates from the 2013–2017 American Community Survey (U.S. Census Bureau, 2010, 2018). We calculated the proportion of property taxes at risk of SLR for each municipality. The centroid of a property parcel counted as at-risk if it intersected with the SLR flood map. We divided affected property tax by the total revenue in each municipality to estimate the overall proportion of municipal revenues that may be affected by SLR if current models of land development, property taxation rates, and property values remain unchanged. Given the trajectory of land development and property values in the state, the fiscal risks we calculated are likely significant underestimates of the future magnitude of the problem.

The UCS report on fiscal impacts found that Florida had just over 2 million people living in 1 million homes valued at $351 billion at risk of chronic inundation under high projection scenarios of climate change by 2100 (UCS, 2018). Though their population and property figures were lower, their estimated tax impacts were nearly double what we found, at almost $5 billion. The discrepancy may be because their tax data were derived from the real estate technology company Zillow, and their assessment used market value rather than assessed values and required re-geocoding many properties

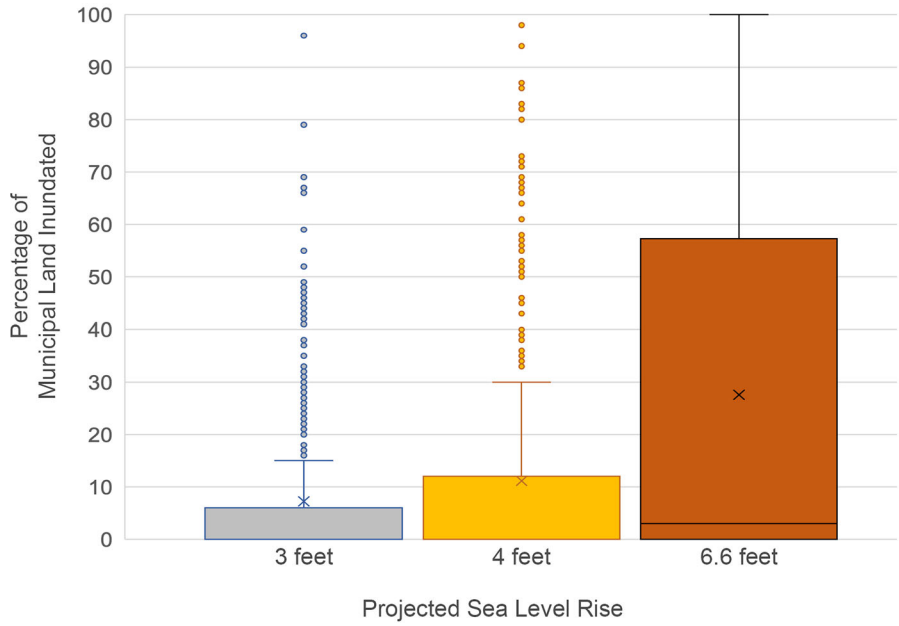

Figure 2. Percentage of municipal land inundated at different projections of sea level rise.

(about a million nationwide). It estimated impacts for census designated districts, which were typically three to four units per county, making them much larger than the typical municipality. Technical Appendix 1 details differences between UCS and our study, choice of SLR projections, and sources of data and gives a link to a public repository of our data (Thomas et al., 2023).

Our sources of fiscal data may have introduced inconsistencies because each locality calculates and reports fiscal information differently. This may have led to inaccuracies and underestimates of fiscal impacts. We also did not include other sources of revenue and expenditures that are likely to be affected by chronic inundation. In reality, population, income, and fiscal conditions will have changed significantly by the time there is 6.6 ft of SLR. As such, the estimates here should be interpreted in the context of an analytical exercise. We did not aim to predict the amount of property tax revenue lost by a given date. Rather, we sought to point out the potential magnitude of loss given the tenuous ability of the fiscal model to withstand substantial physical vulnerability.

The second data set drew on an online survey of planners in all coastal local governments (municipalities and counties) conducted in the summer of 2019. The survey assessed how planners understand, experience, and respond to SLR-related risks. We sent survey links to a list of contacts, usually two for every coastal government in Florida. The list came from the Florida Department of Economic Opportunity, the agency overseeing local planning. We asked contacts to forward the survey to relevant staff members in their municipal government if they were not the appropriate respondent. We asked respondents about SLR priorities in their jurisdiction, direct impacts, barriers to adaptation, availability of information, local plan integration, funding for adaptation planning and projects, participation in and role of regional networks, and state-level support and intervention. Technical Appendix 2 presents the survey instrument. We obtained 178 completed surveys from 96 municipal and county governments, a 45% response rate. To allow for municipal-level comparability, we selected one complete response from each municipality based on a) the completeness of the survey response, b) the level of importance of SLR planning to their job, and c) their job title (selecting for resilience officers and planning directors first). If more than one survey was completed, we selected a respondent who ranked SLR as highest importance in their work. If more than one respondent ranked SLR as equally important in their job roles, we selected planning directors or resilience officers to represent the government.

Finally, we brought these two data sets together to examine whether local prioritization of climate adaptation varied given local municipal revenues, property tax reliance, and fiscal exposure to inundation. The combined data set included 67 municipalities (this excluded coastal counties and few municipalities for which we did not have spatial or survey data). We ran a *t* test to see whether there was a discernable difference between the 211 municipalities with fiscal data and the 67 in the joint data set and found no discernible difference for population size, rate of population growth, density, land area, income, and percentage of population that was White.

Results

Florida's Municipal Fiscal Vulnerability to Sea Level Rise

In response to our first research question, how might SLR affect Florida's municipal revenues from property taxes, we found that the impacts of future chronic inundation with SLR would be substantial and widespread among coastal municipalities. Barring major adaptation investments, the revenue of 211 of Florida's 410 (51%) municipalities would be affected by 6.6 ft of SLR. As of 2018, 5 million people live in a municipality where 10% or more of local revenues is at risk of inundation. Sea level rise would affect $619 billion in assessed property values that currently contribute $2.36 billion in property taxes. For the average municipality, SLR would affect 45% of their property taxes and 29% of total municipal revenues. As Figure 3 shows, 63 municipalities would have lower impact (0%–10% of total revenues exposed), 36 would have moderate impact (11%–25% of revenues exposed), 48 would have moderately high impact (26%–50% exposed), and 64 would have extremely high impact (more than 50% of revenues exposed). Actual fiscal impacts from climate change are likely to be much more severe, after accounting for other sources of lost local revenue, such as user fees and charges, and increases in expenditures, such as repairing or expanding water and sewer infrastructure.

We also found that fiscal vulnerability was concentrated in municipalities that were geographically and demographically smaller, denser, wealthier, and Whiter (see Table 1 for detailed figures comparing socioeconomic, demographic, and fiscal data by the level of fiscal vulnerability). The highest-risk municipalities (more than 50% of revenues exposed) had a median population of 6,875 that was 93% White non-Hispanic, land area of 1.97 square miles, and household median income of $67,885. By contrast, the lower-risk municipalities (less than 50% at risk) tended to be more populous, more diverse, and larger in land area. The value per acre of single-family homes rose from $545,031 in lower-risk municipalities to $1.78 million in extremely affected municipalities, which also relied more on property taxes (32%) compared with lower-impact municipalities (16%).

This uneven vulnerability is reflected in spatial maps of the state and its major coastal metropolitan regions (see Figures 4 and 5). Of the 211 affected municipalities, approximately 30% would face lower impacts (less than 10% revenues affected) and about 30% would be extremely affected (more than 50% of revenues exposed). The latter tended to be on barrier islands or isolated small towns along the coast. Figures 5a and 5b show the reach of 6.6 ft of SLR in the Tampa/St. Petersburg and Miami metro regions. Figures 5c and 5d show the percentage of total municipal revenues imperiled by SLR in these geographies. In the Tampa/St. Petersburg and Cape Coral/Ft. Myers regions, barrier islands face the highest fiscal exposure (Figure 5c). In the Miami metro region, in addition to Miami Beach and other towns on barrier islands, municipalities

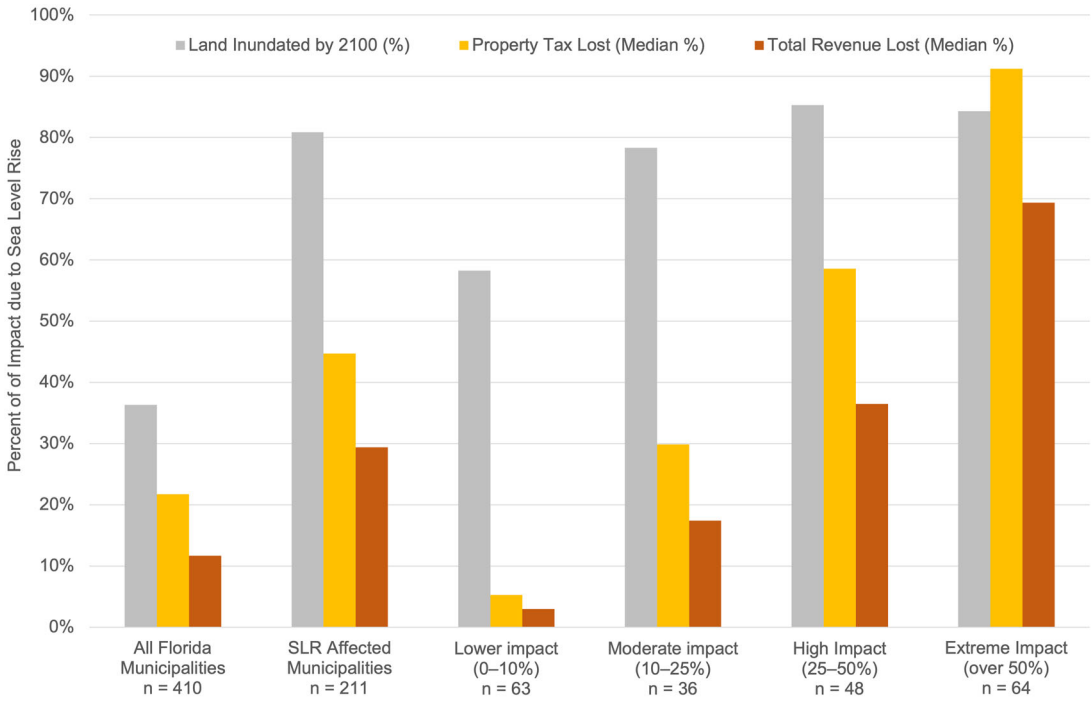

Figure 3. Impact of 6.6 ft of sea level rise on municipal revenues in Florida.

Table 1. Characteristics of Florida's municipalities by proportion of revenue loss from 6.6 ft of sea level rise.

Variable[a]	All Florida municipalities $n = 410$	SLR-affected municipalities $n = 211$	Lower impact (0%–10%) $n = 63$	Moderate impact (11%–25%) $n = 36$	High impact (26%–50%) $n = 48$	Extreme impact (>50%) $n = 64$
Population	6,090	12,062	16,558	19,446	11,041	6,875
Population density (per mi^2)	1,323	2,529	1,704	2,636	2,879	3,017
Population change (2010–2018)	6.5	6.4	7.4	5.7	6.1	6.3
Household median income ($)	49,117	56,532	51,635	53,738	52,682	67,885
Poverty rate (%)	14	12	13	12	12	10
White, non-Hispanic (median %)	81	88	79	85	92	93
Land area (mi^2)	5.2	5.3	9.4	11.7	4.3	2.0
Land inundated by 2100 (%)	47	52	7	31	69	94
Age of single-family homes (years)	45	44	42	45	45	44
Value per acre single family ($)[b]	497,664	988,235	545,031	873,660	1,120,256	1,778,084
Land inundated by 2100 (%)	36	81	58	78	85	84
Residential land use (%)	36	81	58	78	85	84
Commercial land use (%)	4	4	4	4	3	4
Industrial land use (%)	0	0	1	0	0	0
Agricultural land use (%)	3	0	0	0	0	0
Institutional land use (%)	1	0	1	1	0	0
Government land use (%)	15	8	15	9	5	5
Property tax reliance (%)	18	23	16	23	24	32
Property tax and fees reliance (%)	25	32	23	29	33	40
State transfer (%)	7	6	6	6	6	6
Federal transfers (%)	1	1	2	1	1	0
Expenditure per capita ($)	1,427	1,643	1,458	1,772	1,694	1,444
Debt as % of revenue	41	22	37	12	25	28
Property tax affected (avg. %)	22	45	5	30	59	91
Own-source revenue affected (%)	14	32	3	20	40	82
Total revenue affected (%)	12	29	3	17	36	69

Notes: a. All values represent the median for the respective vulnerability classification. b. Includes both land and improvements.

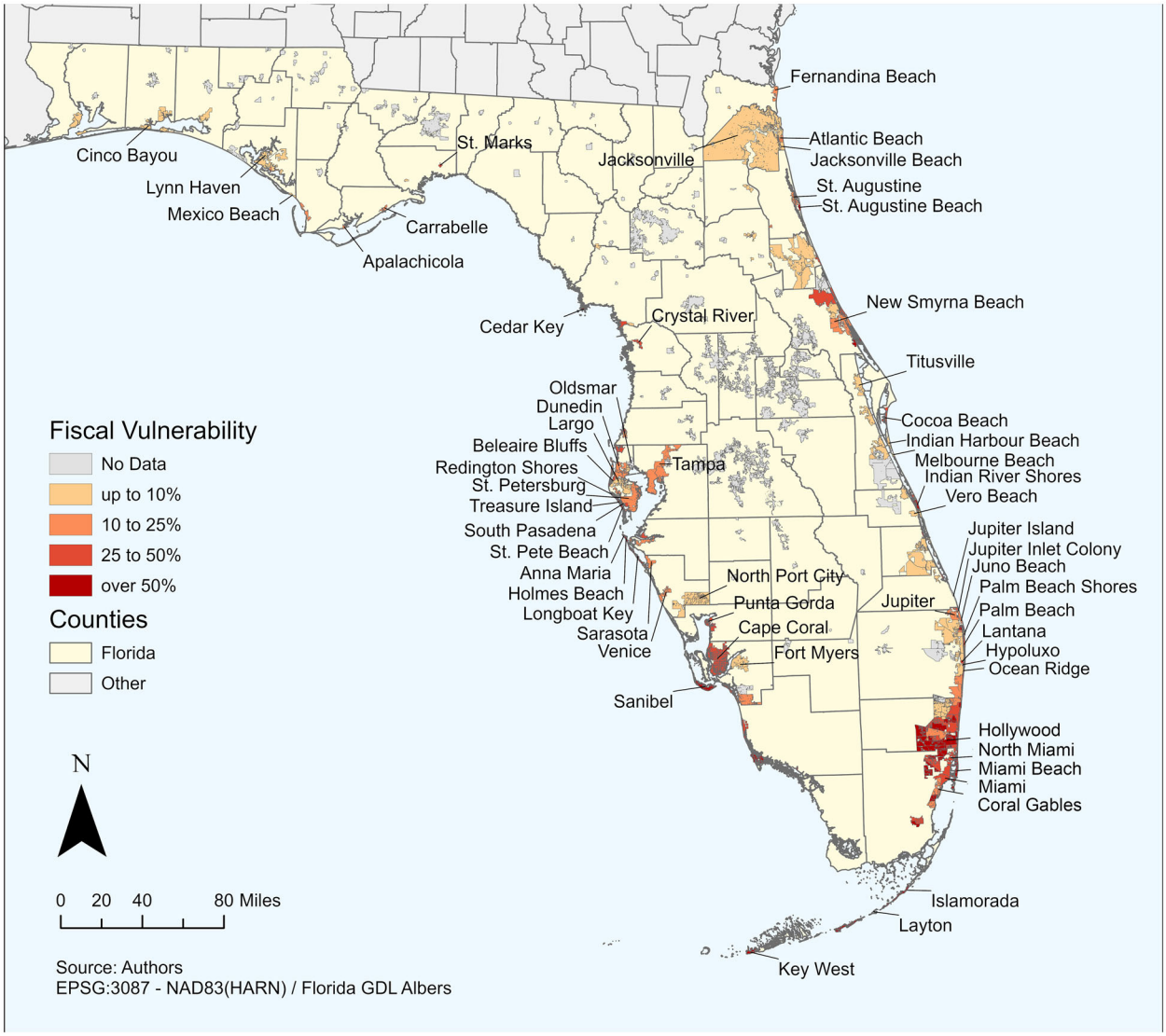

Figure 4. Florida's municipal fiscal vulnerability to 6.6 ft of sea level rise.

bordering the Everglades and interspersed among higher-elevation communities face high fiscal impacts (Figure 5d).

Fiscal Limitations for Adaptation in Florida

In response to our second research question, our survey of coastal planners and managers revealed the primary challenges they face and the resources they have or want to adapt to SLR. The challenges respondents indicated as severely limiting or moderately limiting adaptation were all about funding: funding for implementation (68%) and funding for planning (59%) for SLR (Table 2). The next greatest barrier was internal capacity, which 50% of respondents identified as a severe or moderate barrier. These barriers had more than 20% of respondents characterize them as severe limitations on progress, whereas fewer than 9% of respondents identified barriers like uncertainty, coordination, data, and constituency and political support as severe limitations. Reflecting these constraints, local governments have been funding adaptation primarily through existing local revenues (Table 3). Two-thirds of respondents (66%) cited existing staff time as a source of funding SLR adaptation work and about a fifth (22%) said their local budgets had specific line items funding adaptation projects. State funding (27%) and federal funding (15%) filled in some of the gap, and foundations (9%) and nongovernmental partners (7%) contributed minimally.

The survey also asked respondents to reflect on how the state might support local-level SLR planning and action. The top three ways they identified were allocating state funding for project implementation (73%),

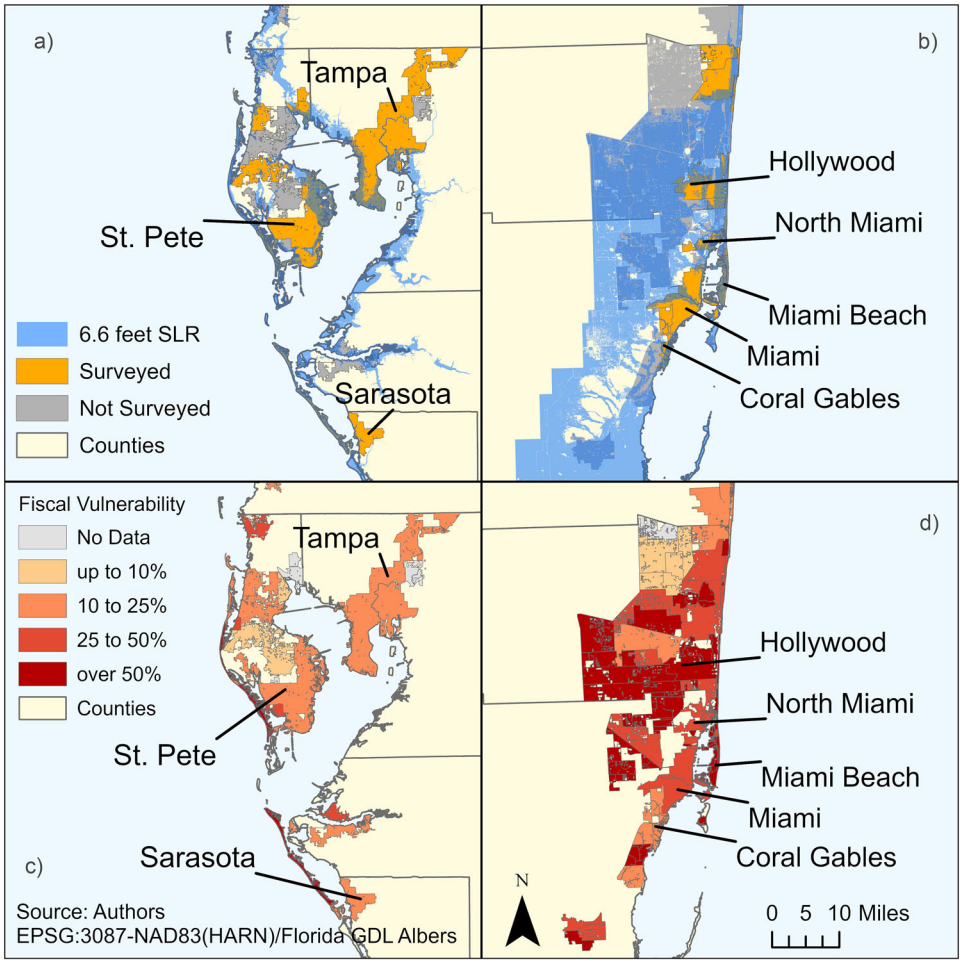

Figure 5. Impact of 6.6 ft of sea level rise on municipal revenues in the Tampa Bay region (a, c) and Miami–Dade County (b, d).

state funding for adaptation planning (43%), and state funding for programs such as education and outreach (39%). A smaller percentage (less than 25%) of our respondents saw value in "state mandates limiting coastal development in areas at risk of sea level rise impacts" or "state mandates for enhanced sea level rise adaptation planning." Around 15% selected "state-level agency coordination" and "state-level assessments and project information" as top priorities for state government assistance.

Awareness of Fiscal Impacts in Adaptation Planning

Bringing together these two data sets, we saw that the cost burden of SLR planning and implementation was already the biggest barrier to adaptation, and local governments were dependent on local revenues and staff time for the adaptation they are currently doing. Meanwhile, the very resources that local governments have been using to fund adaptation—property taxes—are uniquely vulnerable to climate impacts. This creates a vicious cycle in which adaptation planning and implementation lag due to insufficient revenue, and climate impacts continue to erode primary sources of revenue for adaptation.

The juxtaposition of the spatial analysis of fiscal risk and the survey responses for 67 municipalities suggested that planners are not aware of or redressing this tension. When asked, "How high a priority is planning for SLR for your municipality?" respondents reported that, on average, it was moderately important (6.1 out of 10, range of 0–10, with 10 being most important). Among these municipalities, the average fiscal impact of 6.6 ft of SLR was 15.4% of total municipal revenues ($SD = 13.4$). When we correlated these two variables, we found no correlation between how much cities prioritize SLR planning and their level of fiscal vulnerability ($r = -0.027$, $p = .83$). At least for these cities, whose fiscal risk is lower than our overall pool of 211 municipalities, the level of fiscal exposure did not appear to have any bearing on how motivated elected officials or constituents are to act on climate change.

Table 2. Barriers limiting jurisdictions' ability to adapt to sea level rise.

Barriers to progress	Severely limits (%)	Moderately limits (%)	Minimally limits (%)	Does not at all limit (%)	I don't know (%)	No response (%)
We lack funds to plan for SLR	26	33	21	10	3	6
We lack funds to implement SLR projects	33	35	15	6	4	6
We lack internal capacity (staff time or knowhow) to plan for SLR	21	29	19	20	2	9
It is difficult to know how far ahead to plan for SLR	6	31	21	33	1	7
It is difficult to choose which projection curve to use	8	24	20	35	5	7
It is difficult to coordinate with actors in jurisdiction	8	27	21	30	5	8
It is difficult to coordinate with nearby jurisdictions	6	14	23	44	6	7
My elected officials don't think SLR is a high priority	9	19	14	44	6	8
My constituency does not think SLR is a high priority	2	24	24	30	11	8

Discussion: Implications for Regional Governance and Equity

Connecting these data sets painted a disturbing picture of coastal adaptation. Local and state governments have been engaging in fiscally unsustainable practices by building their way out of climate risks through infrastructure upgrades financed through municipal debt and expanded taxation. Miami Beach invested $500 million in stormwater upgrades through municipal bonds and raised stormwater utility fees by 84% (Georgetown Climate Center, 2016). Monroe County estimated it needs $700 million by 2025 and $1.8 billion by 2045 to elevate county roads in the Florida Keys (Harris, 2021). Coastal planners have been approaching SLR from a business-as-usual growth and development mindset while asking the state to pay for protective infrastructure. These investments redress near-term but not long-term SLR, suggesting that, at some point, SLR will overtop them. For its part, by providing significant but still insufficient state support for infrastructure, the state does not appear aware that local fiscal risks from SLR will eventually become a state fiscal liability. As a result, chronic and disaster-based flooding is and will increasingly erode some part of local tax bases. Concomitantly, shifts in reinsurance, bond markets, credit ratings, infrastructure maintenance, and property devaluation can negatively affect revenues (Flavelle & Mazzei, 2019). This can tip fiscally healthy municipalities toward fiscal stress or even insolvency.

It remains unclear how emerging funding will affect local long-term fiscal health under climate change. The 2022 Inflation Reduction Act created landmark federal funding for adaptation,[4] and Resilient Florida did the same for Florida. Neither assesses which localities are fiscally stressed by climate change, most fiscally in need of investments, and are likely to repay or default on loans given projected climate change. Neither are they likely to assess the effects of implementation on future fiscal health. Will these projects enable additional development within floodplains, thereby increasing overall fiscal exposure to future, bigger floods? How do the long-term maintenance costs of new flood risk reduction infrastructure affect municipal budgets? What are the implications for state fiscal stress?

The uneven spatial distribution of fiscal stress and capacity across regions weakens the resiliency and redundancy of transportation, labor, and health systems and further intensifies concerns about regional inequality. Coastal flood risk in Florida reflects a historic pattern of middle-class or higher-end developments on the coast that subsequently incorporated into exclusive and enclaved municipalities (McKenzie, 2011; Rice et al., 2014). Though wealthier coastal municipalities may be better positioned to invest in adaptation, wealthier residents

Table 3. Funding sources for local sea level rise adaptation.

Funding source	No. of local governments using source	% of respondents using source
Local government, existing staff time	63	66
State government	26	27
Local government, specific budget line item(s)	21	22
Federal government	14	15
Foundation grants	9	9
Nongovernmental organization	7	7
Private sector	5	5
Other	7	7
Not planning for SLR yet	12	13

also have greater mobility to move inland to relatively safer places. The spatial proximity of more fiscally affected municipalities to large metropolitan regions also elevates the potential for developers and residents to move toward nearby housing markets in larger cities that are more affordable, less built out, and on higher ground. Growing fiscal stress in these communities may intensify gentrification pressures in larger, higher-elevation municipalities with lower fiscal climate exposure. Though market internalization of climate risks and household-level mobility are desirable, these responses are likely to create fiscal winners and losers that directly affect local governments' ability to fund physical and social infrastructure, including for adaptation (Shi & Moser, 2021).

Evidence of this trend is emerging, particularly in South Florida (Butler et al., 2021; Keenan et al., 2018; Li & Grant, 2022) and Tampa Bay, where upland neighborhoods are disproportionately lower-income and more racially diverse (Butler et al., 2021; Tedesco et al., 2022). Developments in Little Haiti, Overtown, Liberty City, Allapattah, and other neighborhoods in greater Miami suggest that climate adaptation will accelerate displacement in long-marginalized groups, exacerbating the racialized system of land development, property ownership, and real estate markets (Aune et al., 2020; Taylor & Aalbers, 2022). These neighborhoods have already experienced property consolidation under shell companies with names like Higher Ground, LLC. The City of Miami's double-density bonus incentivizes construction of owner-occupied affordable housing in transit-oriented development on higher elevation. This is a promising and atypical strategy but insufficient to meet the demand for affordable housing units and future spatial inequality among cities (Butler et al., 2021).

Implications for Planning Practice: Strategies to Mitigate Fiscal Risk

As Florida's conundrum suggests, local governments' fiscal and physical vulnerabilities are linked and require new approaches to managing land development and municipal finance that complement infrastructural and social strategies. Though Florida's risks are extreme, other states will likely experience high levels of municipal fiscal stress from flooding, heat, wildfires, and drought. State governments have a significant role to play in helping localities adapt in equitable and sustainable ways, including by reimagining land governance. To that end, we suggest strategies to a) assess fiscal risks; b) reduce pressure to develop vulnerable areas by creating alternative revenue sources; c) strengthen regional planning, including supralocal pooling of land, taxes, and services; and d) strengthen low-income communities' control over land and housing to avoid displacement.

Assess Fiscal Risks and Create a National Data Set

Our findings show the importance of assessing how climate impacts and adaptation affect fiscal health at local, state, and federal levels. Credit rating agencies like S&P and Moody's are already incorporating fiscal risks from climate impacts into their products. Such data could be transparently included in other public and private national data sets, such as www.Clear.gov. Data sets can also incorporate models of how real estate disclosures may affect property values, where risks are growing or declining, how these relate to zoning (see www.ZoningAtlas.org), and how these impacts influence other drivers of fiscal stress. Such data could help motivate local and state governments to prioritize more funding for adaptation and more critically assess the sources and uses of this funding.

Establish Alternative Revenue Sources and Incentives

Coastal local governments need access to sources of revenue that either does not come from property tax

and land/growth-based fees or captures these fees from larger, supralocal districts. Metropolitan revenue raising and redistribution can help assemble necessary land and tax revenues to support integrated development while reducing pressure for every municipality to intensify development within its own borders (Freemark et al., 2020; Orfield & Dawes, 2016). States can help enable or encourage the adoption of innovations in climate finance that are emerging to pay for climate resilient projects. New sources of public revenue include climate-informed budgeting techniques, resilience bonds or fees, targeted policy and financing districts, differential taxation based on project benefits, and climate-sensitive development or stormwater impact fees (Cleveland et al., 2019; Keenan et al., 2018; Levy, 2018; Mullin et al., 2019). Hybrid financing of municipal bonds linked to special district taxing or blending public financing and private investment can help bridge some of the gap (Levy, 2018). Incentives in the private sector include aligning flood insurance pricing to better account for risk, supporting integration of future projection data into risk assessment, new types of insurance products, and incorporating resilience or clean energy investments into property assessment calculations (Keenan et al., 2018; Levy, 2018). Scholars should assess how these strategies affect reliance on property taxes and racial disparities and how to design or scale them to avoid doubling down on development in vulnerable places (Bigger & Millington, 2020).

Strengthen Regional Planning and Resources

Higher-risk and smaller municipalities will struggle unless they find ways to pool their resources and coordinate local responses. If places with low and high elevations are treated as an integral fiscal whole, tax and service sharing becomes more feasible to allow regions to get ahead of the housing market, share benefits of investments in elevated areas, help people transition from the coast before all wealth is lost, and transform barrier islands and back bays into ecologically repaired places. Strategies like rolling easements, ecological restoration, and zoning reforms coupled with revenue equalization or transition models can help municipalities retreat. Broward County and New York State have enabled intermunicipal transfers of development rights and land banks so that coastal municipalities can sell development rights to inland jurisdictions (Abramson, 2013; Hummel, 2015). In 2019, New Hampshire passed Senate Bill 285, "Establishing a coastal resilience and economic development program" that "[a]llows municipalities to unify as a result of a climate change emergency" and "declare certain lands as no longer inhabitable or served by municipal resources, and the abandonment of public roadways" in the process (SB 285, 2019, §1.I). Funding the creation of regional climate collaboratives (NOAA, 2023; Shi, 2019; Vella et al., 2016) also can strengthen interjurisdictional planning. Developing regional entities with more teeth either as accountable, multipurpose governments or into special districts with bonding powers or limited land use authority (Orfield & Dawes, 2016) can turn regional planning into action. Examples include the existing Bay Conservation and Development Commission and San Francisco Bay Restoration Authority in California or Regional Plan Association of New York and New Jersey's proposal for a Regional Coastal Commission and Adaptation Trust Fund.

Enable Cooperative Land Trust Strategies

States can also enable communities to form cooperatives and community land trusts with development authority. Research has shown consistently that community land trusts and cooperatives help communities sustain access to affordable housing and resist displacement (Angotti & Jagu, 2007; Choi et al., 2018). These entities can help guide growth toward higher ground and reward dense growth with a fair share of affordable housing inland to help curb the vicious cycle of intensive coastal development, increased exposure, and devastating losses. The experiences of ENLACE and the Fideicomiso de la Tierra de Martín Peña in San Juan (Puerto Rico) and Dudley Square Neighborhood Initiative in Boston (a community organization with eminent domain power) show how communities with control over land can engage in relocation and rehousing, environmental upgrading, and housing creation (Algoed & Hernández Torrales, 2019; Anguelovski, 2014). Cooperatively owned manufactured housing communities have also effectively adapted to climate impacts while resisting eviction and displacement (Lamb et al., 2023).

The reality facing coastal municipalities in Florida and other states is that shrinking requires a paradigm shift from a model of perpetual competitive growth and development to a more strategic, cooperative, and fiscally resilient model that is more fluid and adaptative. For now, that shift remains elusive as exemplified by continued funding for conventional hard infrastructure projects in higher-income coastal municipalities to protect existing structures and double down on coastal development. The strategies we call for here are a first step toward assessing the problem, evaluating alternative responses, and opening the conversation toward more transformative and integrative solutions to fiscal and physical risks of climate change.

ABOUT THE AUTHORS

LINDA SHI *(lindashi@cornell.edu) is an assistant professor in the Department of City and Regional Planning at Cornell University.* ***WILLIAM BUTLER*** *(wbutler@fsu.edu) is an*

associate professor in the Department of Urban and Regional Planning at Florida State University. ***TISHA HOLMES*** *(tthol-mes@fsu.edu) is an assistant professor in the Department of Urban and Regional Planning at Florida State University.* ***RYAN THOMAS*** *(rmt235@cornell.edu) received his doctorate from the Department of City and Regional Planning at Cornell University.* ***ANTHONY MILORDIS*** *(amilordis@fsu.edu) is a doctoral candidate in the Department of Urban and Regional Planning at Florida State University.* ***JONATHAN IGNATOWSKI*** *(jonathanignatowski@gmail.com) is a grant advocate and coordinator at the Adirondack North Country Association.* ***YOUSUF MAHID*** *(ym527@cornell.edu) is a doctoral candidate in the Department of City and Regional Planning at Cornell University.* ***AUSTIN M. ALDAG*** *(ama296@-cornell.edu) is a doctoral candidate in the Department of City and Regional Planning at Cornell University.*

ORCID

Austin M. Aldag *http://orcid.org/0000-0003-2542-9252*

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NOTES

1. We are grateful to an anonymous reviewer for clarifying this point.

2. A diverse set of adaptation strategies for Florida's environment can be found at the Southeast Florida Regional Climate Change Compact's Regional Climate Action Plan 3.0 (Compact, 2022). Rising seas are pushing groundwater up through limestone under much of Florida, causing pervasive flooding and water supply challenges (Strauss et al., 2014). In the long term, relocation and demolition of existing settlements is likely inevitable.

3. There is a 5% probability that SLR will exceed 3 ft by 2050 (Sweet et al., 2022), and 4 ft was a common elevation of landfilling above mean higher high water for much of the coast.

4. Federal investments are also on the rise. The Inflation Reduction Act (2022) budgeted $2.6 billion over 5 years for coastal county resilience project grants (IRA, 2022), and the Infrastructure Investment and Jobs Act (2021) included $3 billion for habitat restoration and climate resilience, representing significant new federal investments in green and nature-based infrastructure projects (IIJA, 2021).

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