MarXiv Summary

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How Venice and Miami are adapting to sea-level rise

The authors describe governance approaches to sea-level rise (SLR) adopted by the large, coastal cities of Venice, Italy, and Miami, Florida, USA – offering advice on how each city could learn from the other. The authors, who work in these cities on the issue of SLR, were able to bring their own observations into this analysis alongside archival research and interviews with government officials, NGOs, and scientists.

Current ecological and management status

Venice's neighboring Venice Lagoon and the North Adriatic Sea are the most vulnerable areas to SLR, with land areas at or below sea level. Beaches and wetlands along the Adriatic are particularly vulnerable to coastal flooding. Subsidence of the land areas, combined with rising seas, have already raised waters 30cm since the end of the 19th century. "[C]urrently, around 10% of the city is flooded 15-20 times a year." Man-made changes to over 50% of the Lagoon for development purposes, like the construction of the Venice Airport, have exacerbated flood surges. As a result of these and other modifications, the Lagoon now behaves more like a bay. Unprecedented flooding in 1966 causing US\$400 million in damages led to the passage of the "Special Law" which set out to minimize the city's vulnerability to future flooding events. To combat flooding, mobile flood gates have been installed at three entrances to the Lagoon from the Adriatic as part of an experimental solution.

In Miami, sea levels have risen 30cm as well, but only since the 1930s. Streets along Miami Beach's west side flood during "king tides" roughly six times a year. Flooding in the region is expected to happen more than once a day by 2045. While Venice has been working to combat flooding due to SLR, Miami is just getting started. Miami sits on a limestone substrate made of fossilized corals, making it highly porous and permeable. To Miami's east is the Biscayne Bay and barrier islands like Virginia Key. The bay is shallow at only 2-4 meters below the mean low water line. The northern part of the bay has been heavily changed by humans, adding bulkheads for residential development, opening two inlets to the Atlantic, and removing most of the region's mangrove forests. In 1948, a series of canals and levees were installed in the bay to reduce flooding, which restricted freshwater flow. Now, the bay is less estuarine and more saline.

Prior research in Venice suggested a lack of coordination between levels of government has impaired planning and management. In addition, the Special Law makes it difficult to change policy and tackle problems at the large scale that is necessary for adaptation. Recently, corruption issues and the creation of a new administrative body have further complicated the issue. Miami's governance structure is easier to navigate than Venice's, but the change in administration between the Obama and Trump presidencies have caused much climate-related work to cease. The US Army Corps of Engineers recently updated flood maps for the city, but the maps were based on historical data and did not take SLR into account. At the state-level, Miami's SLR issues are largely being ignored. Florida's governor even prohibits his agencies from using the terms "climate change" and "global warming" in official documents. However, at the county-level, the Office of Resilience has developed the county's first Climate Action Plan to address SLR adaptation, among other issues.

This is a summary of:
Adaptations to Sea Level Rise: A Tale of Two Cities – Venice and Miami

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Impacts of SLR

The damages from future sea-level rise vary widely by industry for Venice: lost clam aquaculture productivity could cost between €10-17 million in 2030; losses from tourism could amount to €35-40 million. Flooding alone in Venice may result in €100 million of lost economic activity. Recent flooding events have caused 90% of the city's pedestrian areas to be inundated, thanks to a combination of high-tides and a strong southern wind.

With 25% of Miami-Dade county's land at only one meter or less above sea level, Miami is the most vulnerable US city, and ranked 6th most vulnerable in the world. Just half a meter of SLR by 2070 would impact \$3.5 trillion in assets in the county and displace 300,000 people. NOAA predicts \$25 billion in annual flood-related losses each year under an intermediate climate-change scenario. "Assuming population growth, moderate SLR rates, and implemented adaptation measures, losses from flooding in Miami may still increase to \$2.55 billion by 2050." Hurricanes are also expected to increase in frequency and intensity with climate change, resulting in increased storm surge.

Responses to SLR

In Venice, a raised walkway has helped lessen impacts on pedestrians during flooding events. Residents are notified about flooding by alarms and web alerts. Seawalls in some low-lying areas have been raised, and other low-lying areas are planned to be raised to at least 110 cm. Venice has been educating its citizenry about SLR, urging them to protect assets, especially cultural artifacts. Electrical systems have been modified to prevent water damage, and some buildings have installed steel barriers at entrances. The Special Law forbade drilling new artesian wells, while promoting beach nourishment and dredging of internal canals. In addition, the Special Law set forth the creation of the Experimental Electromechanical Module (in Italian, the acronym is MoSE) which should be completed by 2022. MoSE is a mobile tidal barrier, composed of 78 mobile gates installed on the seabed at three inlets to the Venice Lagoon from the Adriatic Sea. Each gate weighs 300 tons and is capable of withstanding SLR of 0.6 meters and tidal fluctuations of three meters. The majority of funding has gone to this project, with beach nourishment and wetland creation efforts stopped due to lack of funds. Impacts on shipping due to the gates are estimated at around €10 million/year. There are still unresolved questions as to how the gates will impact the ecosystem, industry aside from shipping, and the long-term vulnerability of the city.

While Venice has started their SLR response, Miami is just getting started. Miami's SLR efforts have thus far focused on planning by municipalities. The aforementioned Climate Action Plan has 110 "Action Items" which focus on everything from greenhouse gas emissions to sustainable communities. The plan recommends the creation of additional plans by relevant agencies to address saltwater intrusion into drinking-water aquifers. Local governments are encouraged to create "Adaptation Action Areas" to identify the areas most vulnerable, and thus, most in need of funding. Future development is encouraged to take place in less vulnerable areas. Emergency planning efforts have created the Comprehensive Emergency Management Plan to help prepare the area for future hurricane events which could result in the evacuation of 2.4 million people, basically the entire metro population. Beach nourishment plans are expected to decrease storm surge by 80% during 100-year storm events, should the task which began in 1966 be completed.

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The City of Miami Beach, itself a barrier island, has developed new building standards that account for SLR during a 30-50 year horizon. The design standards account for roads, stormwater outlets, seawalls, and ground-floor elevations for new construction. The city has installed 70 pumps in streets most vulnerable to flooding, while other roads are being raised entirely.

Future responses

“Coastal managers should learn a lesson from wise investors – diversification. Coastal cities should not rely on one intervention, but must adopt numerous measures that to a certain extent may be redundant. Nature-based adaptation measures, such as coastal wetland creation and enhancement, must be important components of the package.” While massive engineering solutions may solve problems temporarily, unknown impacts to the ecosystem and stakeholders could cause heavy costs. Decision-making processes should be transparent to prevent issues of corruption. Furthermore, planning should integrate all levels of government.

Responses are needed quickly. Insurers and banks are unlikely to offer services to fund development of areas that are, or soon will be, underwater. Tax revenue will decrease if coastal developments are abandoned and real estate values fall, making it even more difficult to fund adaptation strategies.

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