Sea-level rise adaptation mechanisms in San Francisco Bay, CA, USA highlight need for multi-level cooperation and new governance structures

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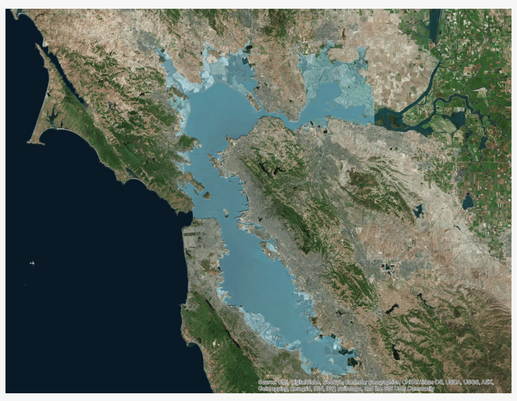
Introduction



Our study region is San Francisco Bay, CA, USA. This region comprises over 60 community jurisdictions, is a hub of California water supply, and a major US and global economic engine.

This image shows the flooding extent (in blue) due to tides, river flows, storms, and 1m sea-level rise (SLR).

Coastal regions are increasingly vulnerable to flooding from increased storm intensity and rising sea-levels through climate change. Economic losses may be mitigated through collaborative adaptation across communities. Such efforts are, however, stymied by the desire for communities to follow their own individual incentives.

What types of flooding risk and adaptation mechanisms require or may even benefit from a collective response?

We present approaches that provide mechanisms to group communities by similar risks, and highlight the costs and benefits of local action and inaction by one community on others.

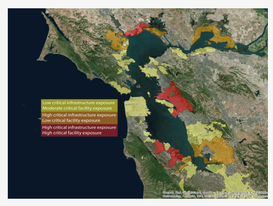
Approaches & Methods

We apply a process-based hydrodynamic model to project flooding under SLR for community-specific shoreline infrastructures[1,2]. Projections are used in a demand-based traffic model to determine regional traffic delays due to community-specific flood events.

Communities are connected or grouped by:

1. **"Shared experience":** Which communities share similar flooding vulnerabilities?
2. **"Vulnerability interdependence":** How does one community's lack of adaptation action affect other community's flooding risk?
3. **"Adaptation interdependence":** How does one community's adaptation action affect another community's flooding vulnerability?

1. "Shared experience"

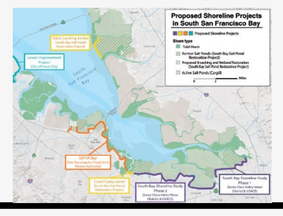


Projected community clustering for 1.5m of SLR using existing shorelines, based on similarities in vulnerable infrastructure.

2. "Vulnerability interdependence"

Embarcadero, San Francisco, January 10, 2017.

3. "Adaptation interdependence"

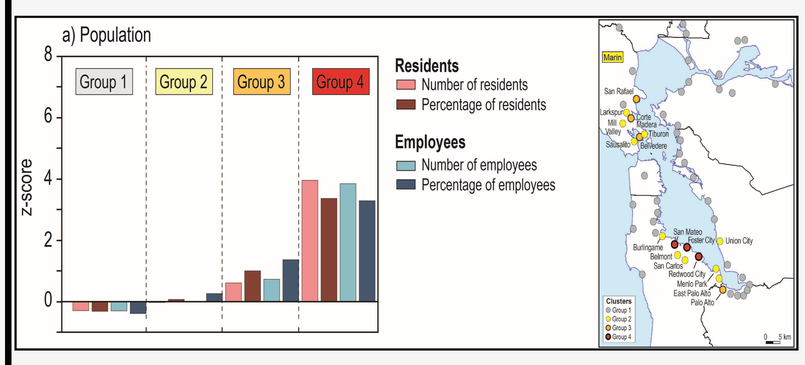


Map depicting proposed shoreline projects in South San Francisco Bay for addressing sea level rise in the South Bay.[3]

Results

Shared Experience

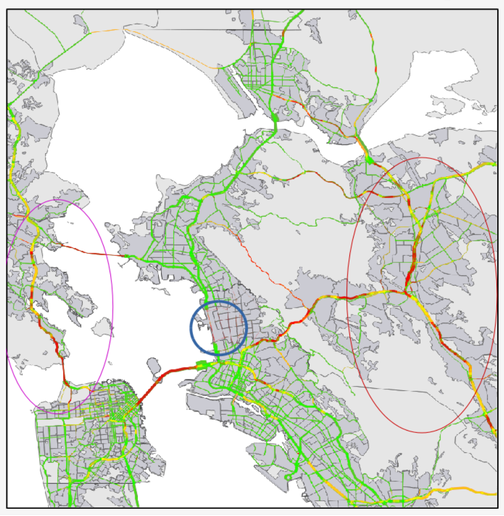
This experience creates opportunities for communities with similar flooding vulnerabilities to learn from each other, and share strategies that have been analyzed by a particular community. Here, a network among Group 3 communities in Northern San Francisco Bay (San Rafael, Corte Madera, and Belvedere) could be strengthened by Palo Alto in South San Francisco Bay.



Community clusters of population exposure to coastal-flood hazards with 50cm of SLR, and 100-yr storm influence. Increasing group numbers denote increasing population exposure.

Vulnerability Interdependence

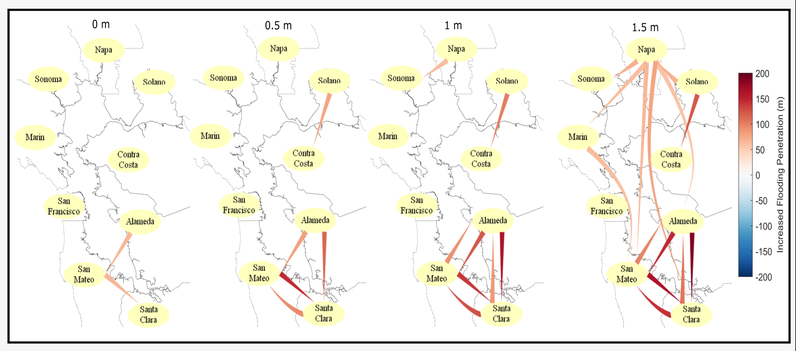
This usually occurs geographically when a lack of action by one local jurisdiction creates a "weak link" where flood waters can spread to other jurisdictions, even if other jurisdictions have invested in adaptation strategies.



Projected changes in traffic flow where shorelines of all jurisdictions except the City of Berkeley (inundated region highlighted by blue circle) are protected. This case considers 1m of SLR. Travel times increase by 0-50% (yellow segments), and more than 50% (red segments).

Adaptation Interdependence

In this interdependence, when adaptation actions in one local area have regional benefits, it makes sense to jointly invest in that particular area. Adaptation actions with local benefit that increase vulnerabilities regionally should be avoided.



Projections of direct influence of action in one jurisdiction (county) on other jurisdictions in the region. Shoreline scenarios assume that each county acts individually to construct a sea wall to provide complete protection against SLR. Colors show change in volume of water that enters other counties due to one county's action. The arrows are pointing in the direction of influence.

New Governance Structures

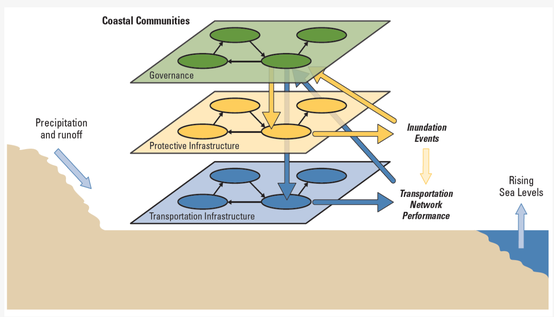
While most stakeholders recognize the risk of sea-level rise and other climate impacts, and have good ideas about potential on-the-ground solutions, realizing these solutions requires overcoming a series of governance challenges[3].

SF Bay Area SLR Governance Challenges	Proposed Solution Concepts
Institutions for Multi-Level Cooperation	Climate Adaptation Vision or Commission
Climate adaptation Planning	Vision Plan and next step recommendations
Funding Portfolio	Regional/local: parcel taxes, increase in fares, special taxation districts
Integrated Permitting	Create new integrated permitting strategy for green infrastructure
Climate Science Enterprise	Climate science services center (data and assistance/ guidance) hosted at agency, university, consortium
Civic Engagement	Community-based adaptation meetings
Political Leadership	Create state and federal legislative caucus groups focused on climate adaptation

The table provides governance challenges and solution concepts. These challenges were identified directly from the stakeholders, and most of the solutions are also part of the overall policy dialog. The solutions provided in the table are the "preferred alternatives" and can be viewed as initial recommendations. Many more solutions concepts are provided in M. Lubell, 2017.

Summary

Coastal regions are increasingly vulnerable to flooding due to changes in hydrology, precipitation, and sea-level rise from climate change. In this work, we analyze the interactions among governance, protective infrastructure, and transportation structure in the context of sea-level rise adaptation.



Collaborative adaptation can help to mitigate economic losses across communities. These approaches are, however, not pursued due to the desire of communities to follow their own individual strategies.

We have identified 3 main types of interdependence which may require, or benefit from, a collective response.

There exist several governance challenges to achieve multi-level cooperation. New institutions must therefore be designed by policy stakeholders to facilitate multi-level cooperation that balance the perceived need for more centralized authority with acceptance of local decision-making. We propose several solution concepts to "push the ball forward" towards regional cooperation.

References

[1] R-Q Wang, and others, 2017. "Interactions of Estuarine Shoreline Infrastructure with Multiscale Sea-Level Variability", *Journal of Geophysical Research: Oceans,* 2169-9291, DOI: 10.1002/2017JC012730

[2] R.C. Martyr-Koller, and others, 2017. "Application of an unstructured 3D finite volume numerical model to flows and salinity dynamics in the San Francisco Bay-Delta", *Estuarine , Coastal and Shelf Science*, Vol 192, 86-107

[3] M. Lubell, 2017. "The Governance Gap: climate adaptation and sea-level rise in the San Francisco Bay Area". Center for Environmental Policy and Behavior, University of California Davis, Davis, CA, USA.

About RISER SF Bay

RISER SF-Bay is an NSF-funded initiative which analyzes the interaction of sea-level rise, coastal storms, and shoreline infrastructure with the transportation network. The initiative then investigates how these networks influence the governance that makes infrastructure planning decisions.

For more information, visit: http://riser.berkeley.edu