A model to identify communities at risk to coastal flooding and optimal rehousing locations

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Agenda

- Executive Summary and Plan
- Methodology
- Analysis and Conclusions
- Applying Results
- Concerns & Next Steps
- Appendix & Sources Cited

Executive Summary

Background

The Antarctic and Arctic polar ice caps are melting. As sea levels rise, American communities on the coasts are **increasingly at risk of coastal flooding**. In fact, according to a study by Wing et al., (2022) the United States **$32 billion annually to flooding** and their projections suggest a **26% increase** in the cost of flooding by 2050. While it is commonly recognized that reducing disaster is the r**esponsibility of the state**, it also presents a **huge opportunity for the private sector**.

Problem

How can Public-Private Partnerships (P3s) best use **data-driven insights to identify high-risk areas and potential rehousing target areas**? The solution must address all **stakeholder interests** in order to ensure an **equitable and profitable solution** for all parties.

Our Plan

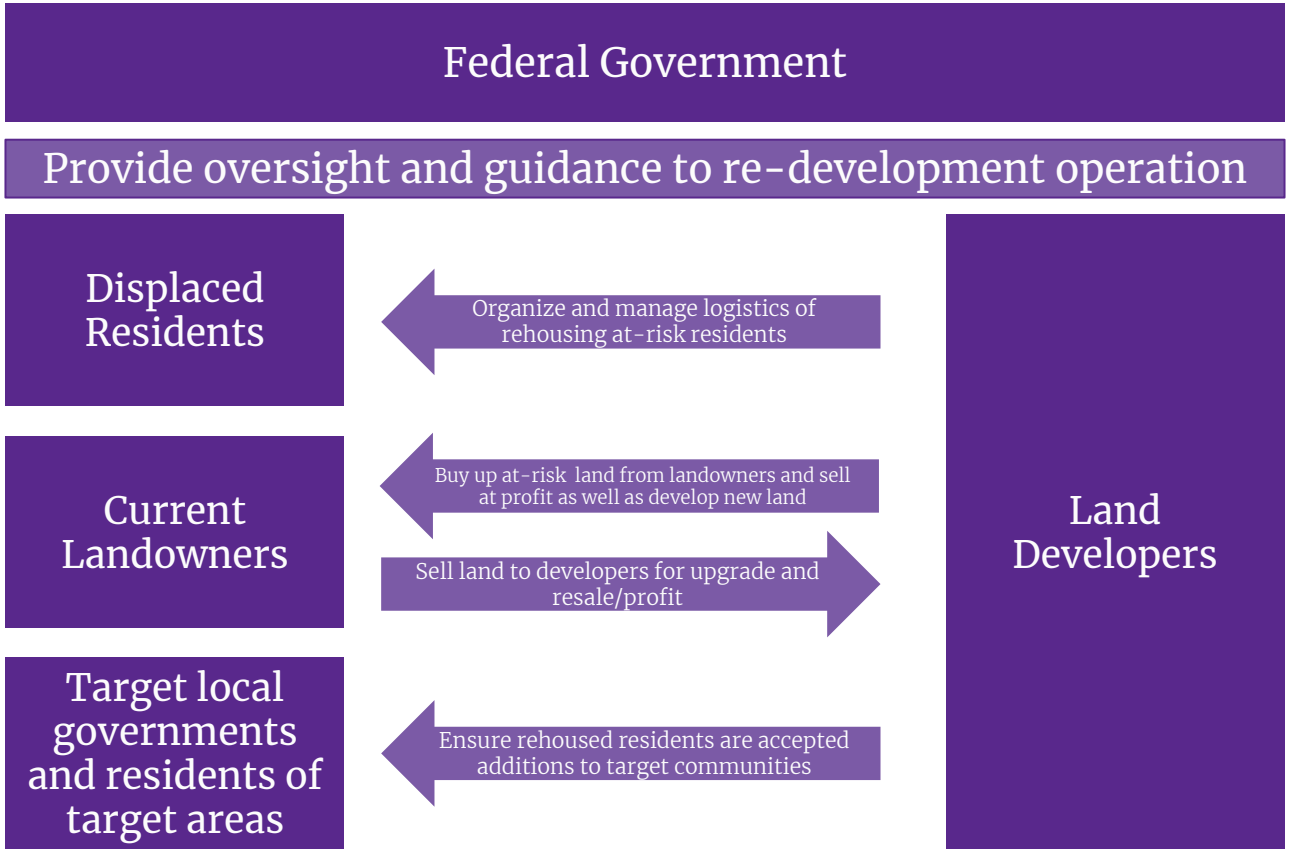
Develop plan for resident displacement and land-redevelopment

Identify main stakeholders and stakeholder priorities

Choose and analyze data to quantify stakeholder interests and build desirability score of redevelopment sites

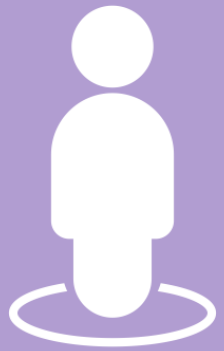
Apply model to identify at-risk and target locations

Public-Private Partnership



Key Stakeholder Interests

Key Stakeholders



- Stable rent and cost-of-living
- Distance moved
- Loss of community

- Return on investment
- Public perception

- Public support
- Ensure services don't become overburdened

- Maintain/Ameliorate current land value and income level
- Maintaining access to current amenities
- Ensure rehoused residents are positive additions to community

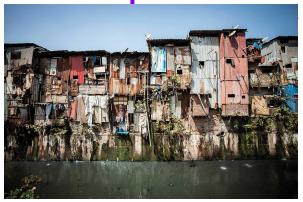
Past Precedent

Mumbai Slum Redevelopment Initiatives

The Maharashtra government partners with local developers and utility companies to rehouse and redevelop Dharavi, the largest urban slum in the world.

Developers build and maintain housing developments for rehoused residents

- Developers are given permits to buy up slum land and redevelop it into modern properties

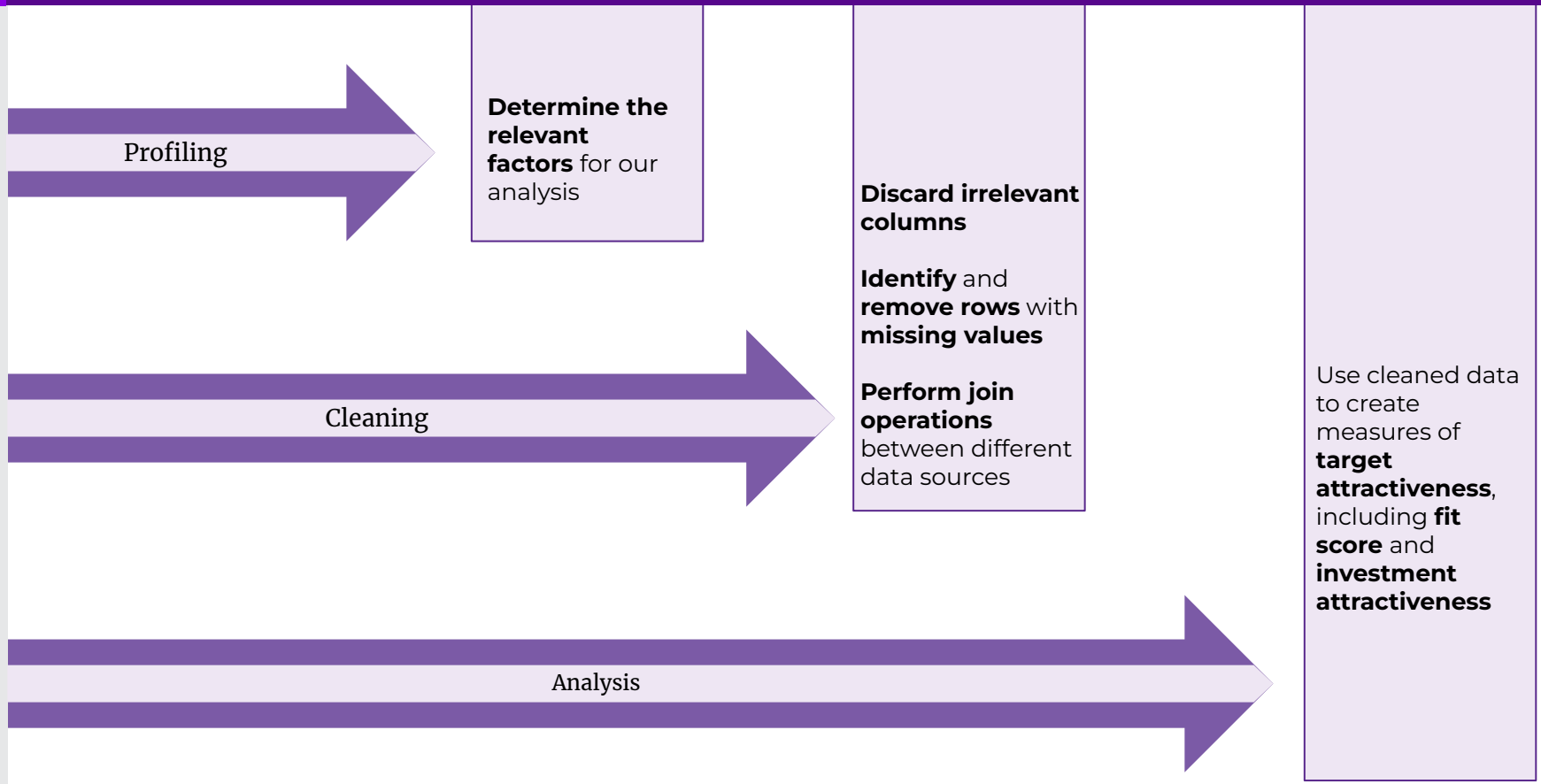


- Developers build needed infrastructure such as electricity lines, water pipes, and proper sewage.

1:https://hunterurbanreview.commons.gc.cuny.edu/wp-content/blogs.dir/12663/files/2021/07/Dharavi-1.png
2:https://images.adsttc.com/media/images/626e/25ce/abf0/7979/9609/9bce/large_jpg/sanjaynagar-slum-rehabilitation-project-community-design-agency_3.jpg?1653482977
3: https://global.luskin.ucla.edu/wp-content/uploads/sites/20/2014/10/vinit-_blog_pic1.jpeg
4: https://geographical.co.uk/wp-content/uploads/resized1-20.jpg

Methodology

Data Processing Framework



Methodology

Fit Score

How viable is it to rehouse at-risk residents in different census tracts

Distance

- **Rehoused residents would not like** to **move far away** from their established communities
- **Target locations** that are **closer** to the **at-risk tracts** are considered more suitable

Cultural Fit

- **Quantify cultural similarity** and community using **DataForGood's Social Connectedness Index**
- **Rehoused residents** are **more likely to be accepted** in target locations where they **fit in culturally**
- **Target locations that are more socially connected** to at-risk tracts are considered more suitable

Similar Economics

- In order to **maintain economic status-quo**, reduce NIMBY concerns, and provide comfortable communities for rehoused residents, economics must be taken into account
- **Target locations with similar median incomes and costs of living a**s the at-risk tract are considered more suitable

Composite Fit Score

Methodology

Computing the Composite Fit Score

1. **Normalize** Relevant Data Columns*
   (Median Income, Building Value, Cost of Living, Social Connectedness Index, Geographic Distances)

2. **Calculate Euclidean Distances** for each Input Variable

3. **Compute a Composite Fit Score**

Note: The relevant data columns were normalized to a range of [0, 1] using MinMax Scaler except for Geographic Distances. Instead, geographic distances were normalized to the same range by calculating the euclidean distance between two points and then divided by the maximum geographic distance that exists between two points throughout the dataset.

Methodology

Final Composite Fit Score Formula

1*(Median Income Distance)+1*(Building Value Distance)+1*(Cost of Living Distance)+2*(Social Connectedness)+5*(Physical Distance)

=

Composite Fit Score

"Distance" as in "Median Income Distance" is a measure of difference between the at-risk tract and the target tract in a specified factor

Methodology

What about property developers?

The key actors in this initiative, our P3s must be made attractive in order for developers to participate

$$\frac{\text{Building Price}}{\text{Rent}}$$

Look for census tracts with high price/rent ratios. Signals ability to generate long-term returns from developed properties as people are more likely to rent than buy

Methodology

FEMA Coastal Flood Risk Ratings

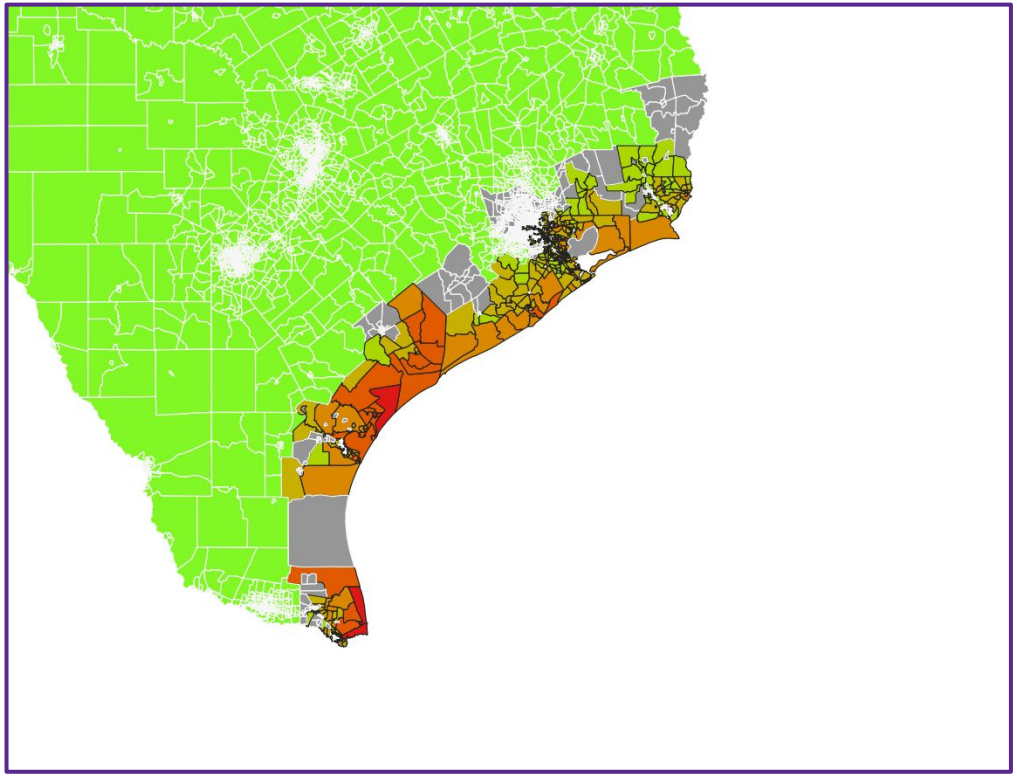
- **Very High Risk <- Regions we'd like to rehouse and upgrade**
- **Relatively High Risk**
- **Relatively Moderate Risk**
- **Relatively Low Risk**
- **Very Low Risk**
- **Not Applicable**

Constant update of FEMA data **ensures scalability** of model to future changes in sea levels

Note on No Rating and Not Applicable:
No Rating is for areas for which a rating could not be calculated while Not Applicable is for inland areas where coastal flood risk ratings do not apply. Not Applicable is treated as a risk rating of 0 while No Rating is omitted.

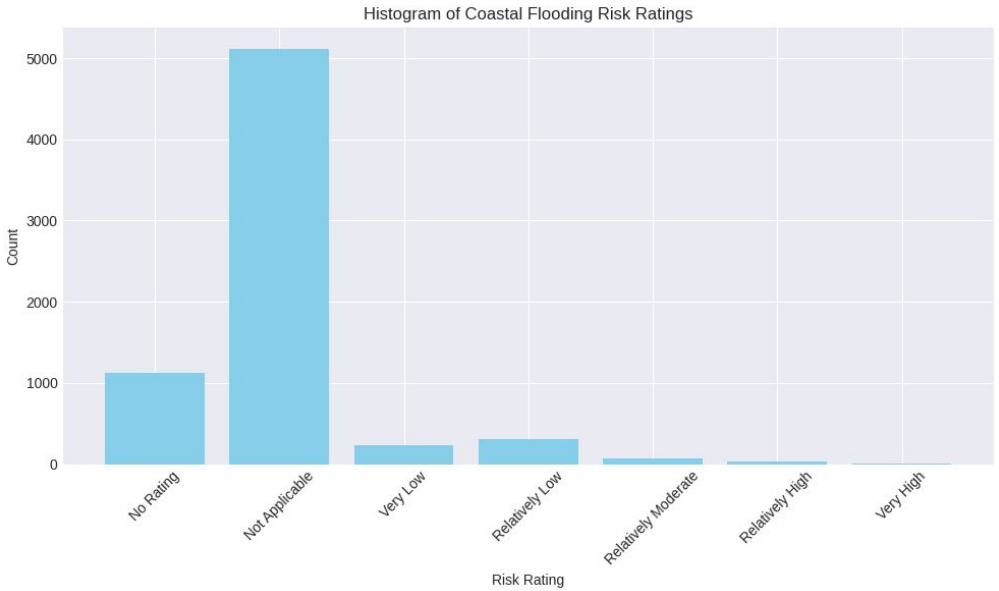
Identifying At-Risk Areas

Risk Levels of Tracts in Texas



While our Geospatial analysis is localized to census tracts in Texas, the model is scalable to other regions with robust census data

Identifying At-Risk Areas



Census Tracts considered "Very High" Risk

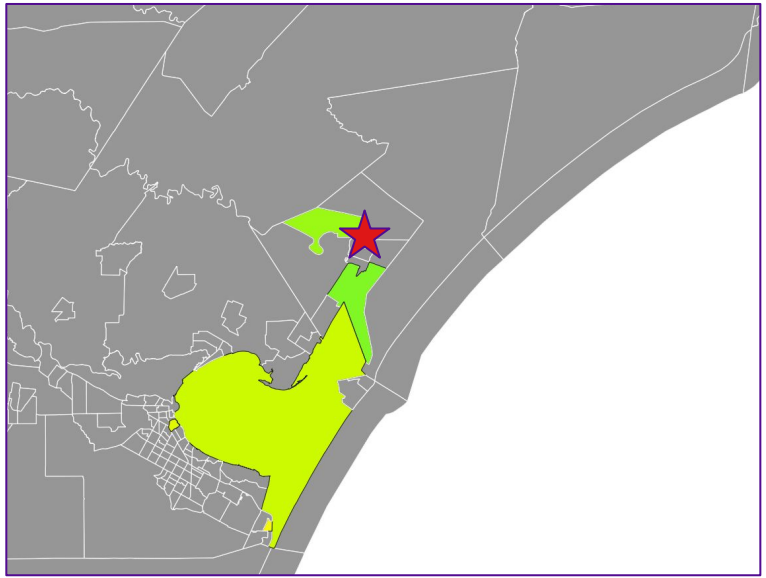
TRACTFIPS	COUNTY	POPULATION	AREA	CFLD_RISKS	CFLD_RISKR
48061012305	Cameron	2847	136.677374	99.983618	Very High
48061012304	Cameron	3886	4.698746	99.858024	Very High
48007950400	Aransas	3340	2.355895	99.789767	Very High
48007950200	Aransas	997	7.913900	99.694206	Very High
48061012700	Cameron	5382	76.974089	99.664173	Very High
48007950101	Aransas	1295	308.138892	99.658712	Very High

Insight: Concentrated within two counties.

Application

Suitable Relocation Tracts for Aransas County Tracts

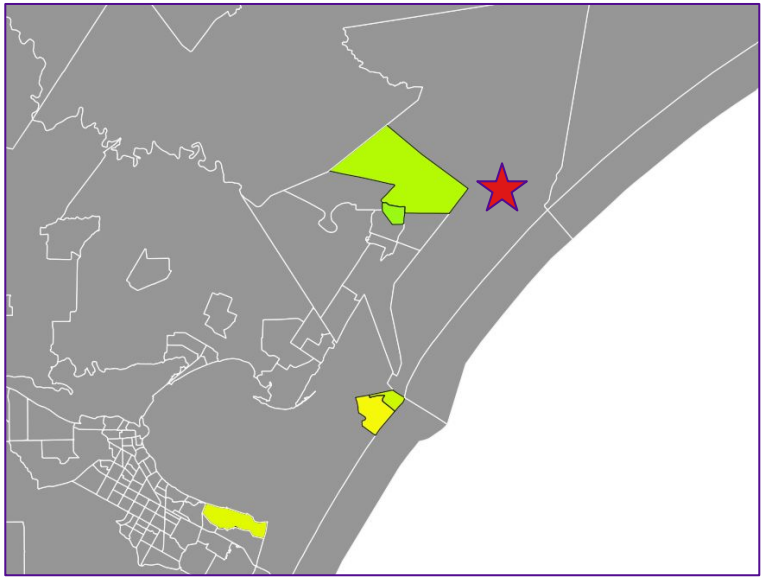
Tract 48007950400



Identified Tracts, Fit Score, and Price to Rent Ratio:

- 48007950503: 99, No Data
- 48007950103: 98.16785369, No Data
- 48355006205: 97.0513877, 395936.1548
- 48355001400: 95.6826591, 500157.9775
- 48355006203: 94.99468876, 171124.5713

Tract 48007950101



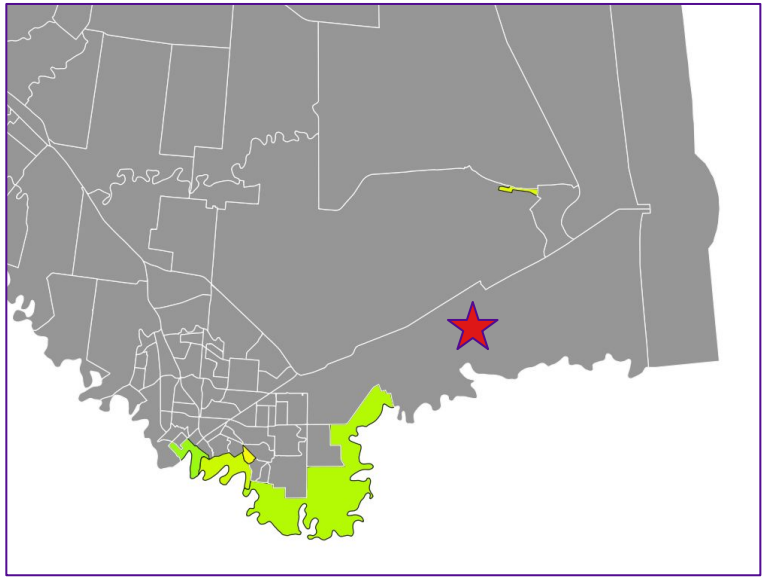
Identified Tracts, Fit Score, and Price to Rent Ratio:

- 48007950302: 94.53058175, No Data
- 48007950102: 93.90508552, 618190.816
- 48355005104: 93.76426318, 166899.0952
- 48355002900: 93.2559446, 565952.2502
- 48355005103: 93.11310074, 566640.0573

Application

Suitable Relocation Tracts for Cameron County Tracts

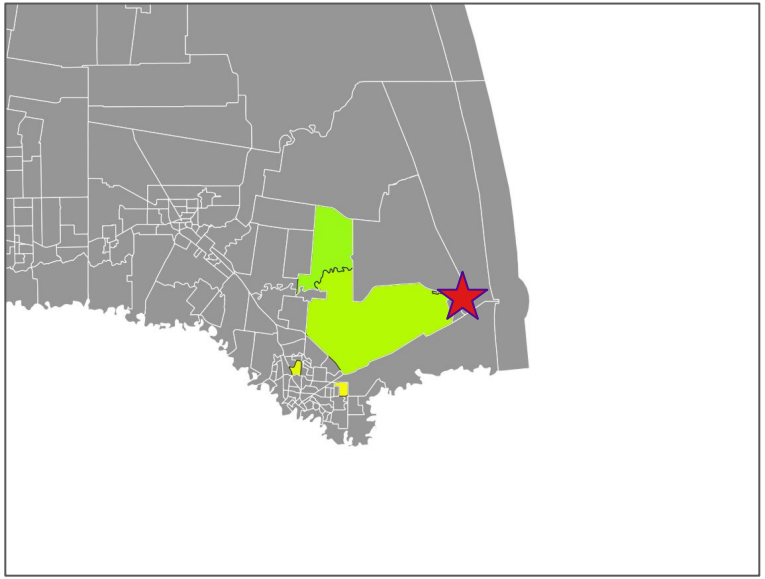
Tract 48061012700



Identified Tracts, Fit Score, and Price to Rent Ratio:

- 48061014001: 93.80782414, 2307199.971
- 48061014103: 93.76291477, Missing Data
- 48061013307: 93.68514747, 1069662.151
- 48061014201: 93.62141377, 166899.0952
- 48061013306: 93.39501424, 175565.2785

Tract 48061012304



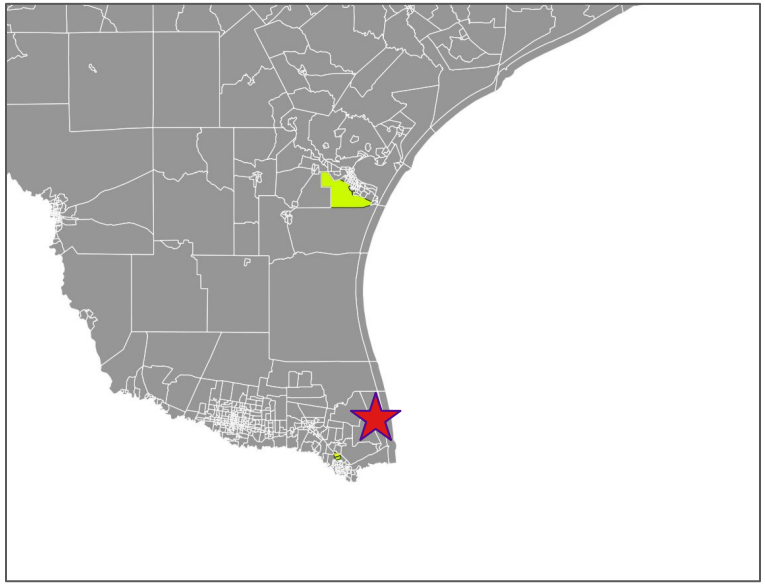
Identified Tracts, Fit Score, and Price to Rent Ratio:

- 48061012202: 96.36380855, No Data
- 48061014202: 95.98824415, 618190.816
- 48061014201: 95.85114591, 166899.0952
- 48061012613: 95.44023386, 565952.2502
- 48061013207: 95.34198229, 566640.0573

Application

Suitable Relocation Tracts for Cameron County Tracts

Tract 48061012305



Identified Tracts, Fit Score, Price to Rent Ratio:

- 48355005416: 71.06473278, 276133.2581
- 48061014402: 70.41310785, 398158.8692
- 48355005406: 70.10587652, 1281100.801
- 48061014401: 69.84000348, 288882.4927
- 48061014502: 69.61969904, 306123.7118

Concerns and Next Steps

Concern 1: Lack of Detail Regarding Stakeholder Interests

Specific preferences of rehoused residents aren't known (e.x: whether they prefer closer distance locations or more culturally similar ones)

Next Step: Resident Interviews

Conduct in-depth at-risk resident interviews to determine which factors are most important to them when determining target locations and then create sensitivity tables to understand how fit score is impacted by changes in factor weighting

Concern 2: Target Locale Amenity Overburdening

Lack of accurate measure regarding the use of target locale amenity and utility utilization means that rehousing initiatives could lead to overburdening

Next Step: Add Amenity Capacity to Fit Score

Find datasets to understand utilization rates of amenities and utility networks to understand which target localities have space for rehoused residents

Concern 3: Other Feasibility Concerns

Model doesn't take into account political and geographic factors which could affect feasibility of identified target locations

Next Step: Feasibility Score

Find datasets to act as proxies for said factors to develop an aggregate feasibility score for each recommended point

License

Thank you!

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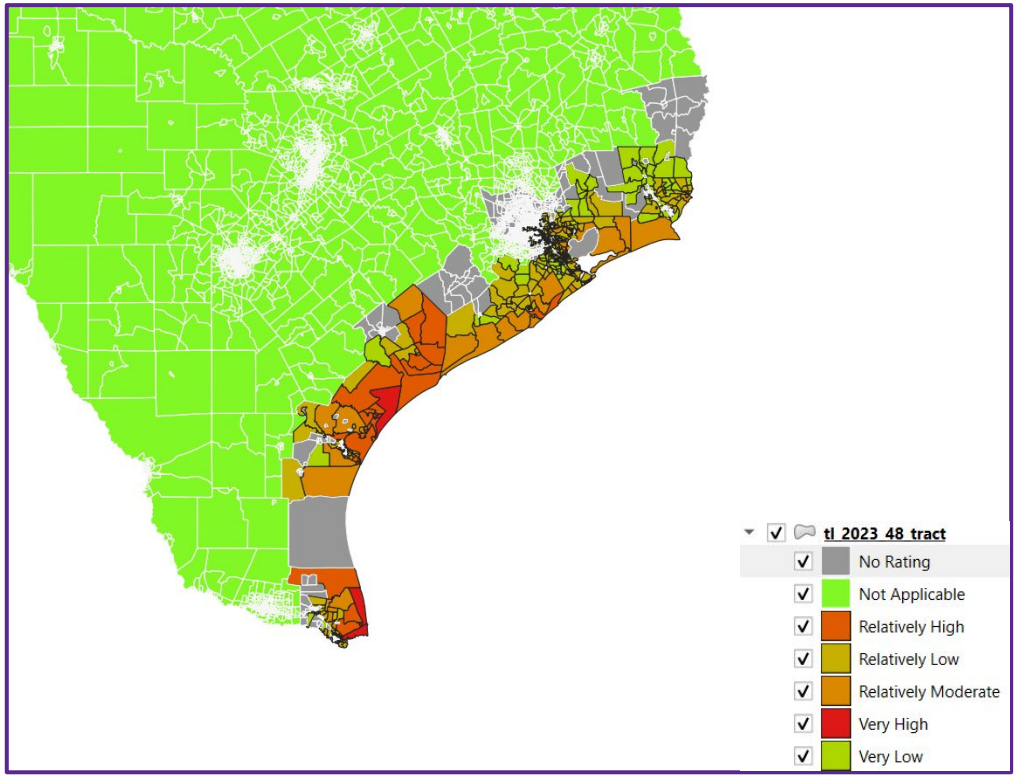
Appendix A

Risk Levels of Tracts in Texas



Appendix B

How FEMA Risk Index Scores are Calculated

What are the National Risk Index scores and ratings? How are they calculated?

The National Risk Index provides relative Risk Index scores and ratings based on data for **Expected Annual Loss** due to natural hazards, **Social Vulnerability**, and **Community Resilience**. Separate percentiles and ratings are also provided for each component: Expected Annual Loss, Social Vulnerability, and Community Resilience. For the Risk Index and Expected Annual Loss, percentiles and ratings can be viewed as a composite score for all hazards or individually for each of the 18 hazard types.

Risk Index and Expected Annual Loss scores are calculated using values from the following equations:

$$\text{Risk Index} = \text{Expected Annual Loss} \times \text{Social Vulnerability} \div \text{Community Resilience}$$

$$\text{Expected Annual Loss} = \text{Exposure} \times \text{Annualized Frequency} \times \text{Historical Loss Ratio}$$

Appendix C

More Information about Not Applicable and No Rating

Why are some data missing for my county or Census tract?

All data supporting National Risk Index risk components were required to be nationwide in scope and able to be measured at the Census tract level. Hazard type data sources were also required to have location and time information. For some counties and Census tracts, data that met these requirements were simply not available.

The National Risk Index uses specific ratings to communicate if a community is missing data:

- **Not Applicable** indicates there is no historical record in the National Risk Index source data for a hazard type and the hazard type is not geographically possible (*i.e.*, Coastal Flooding in inland areas). Therefore, there is no perceived probability of the hazard impacting a community.
- **Insufficient Data** indicates that one or more required components for a calculation are not available.
- **Data Unavailable** indicates source data are not available for an National Risk Index component. This is specific to Social Vulnerability and Community Resilience only.
- **No Rating** indicates there is an National Risk Index component with a score of 0, and the Risk Index score cannot be calculated for that hazard or community.
- **No Expected Annual Losses** indicates one of the Expected Annual Loss factors has a value of 0 and Expected Annual Loss cannot be calculated for a hazard type. If a community has No Expected Annual Loss for a hazard type, then the hazard type does not contribute to the composite Expected Annual Loss score for all 18 hazard types.

Sources Cited

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- https://www.thehindu.com/news/cities/mumbai/dharavi-residents-to-get-350-sq-ft-flats-after-redevelopment-adani-group/article67743065.ece
- https://www.oicrf.org/-/urban-renewal-a-case-study-in-hong-kong
- https://hazards.fema.gov/nri/frequently-asked-questions