Vulnerability to Rapidly Intensifying Hurricanes in Mexico: A Social Perspective

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1. Inspiration



October 25, 2023. **Hurricane Otis** makes landfall in the Acapulco, Guerrero, Mexico metro area, home to over **1 million people**, with catastrophic sustained winds of **160 mph**. 24 hours prior, **it wasn't even forecasted to become a hurricane** (74+ mph).
- $15+ billion in damage, 52+ deaths, 250k+ families homeless

- **Rapid Intensification (RI): 30+ knot wind speed increase in 24 hours**
- 80% of major cyclones worldwide undergo RI
- **Puts communities at risk:** little time to prepare for widespread damaging wind/flooding
- Mexico has extensive coastlines to tropical Atlantic and Pacific hurricane basins: **extremely vulnerable**
- Many households in Mexico lack communication technologies, reliable infrastructure, or vehicles
- **<u>Which communities are most at risk to another Hurricane Otis scenario?</u>**

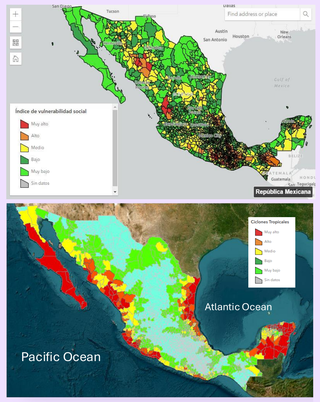


Figure 1 (top right). Index of Social Vulnerability. Existing map.

Figure 2. Risk to Tropical Cyclones. Existing map.

2. Social Vulnerability Index

Data
- National Insitute of Statistics, Geography, and Computing (INEGI): Population and Housing Census 2020, Occupation and Employment Survey 2020
- National Commission of Housing (CONAVI): Housing Underdevelopment
- Atlas Nacional de Riesgos

- **Risk evaluated by municipality**: second-level administrative division of Mexico, similar in function to US counties
- Counties more than 200 km from coastline are not considered at risk and thus omitted here

- **<u>Selected 25 variables that represent vulnerability, particularly to RI hurricanes</u>**

- Applied a **principal component analysis** (PCA) to remove variable redundancy and highlight underlying correlations
  - Statistical technique that creates handful of factors that best explain the variance of a large data matrix, performed with IBM SPSS
- **Six principal components** (PCs) were generated that explain **67.493% of the total variance.** *See Figure 3.*

PC1: Lack of Economic Prosperity (32.415%)
PC2: Poor Housing Quality (10.503%)
PC3: Age/Disability (9.369%)
PC4: Healthcare Dependency (6.661%)
PC5: Exposure/Population (4.408%)
PC6: Female Prominence (4.117%)

- Applied individual factor scores to a weighted **additive model** based on the percentage of total dataset variance they explain for final score. *See Figure 4.*
- **Mapped with ArcGIS Pro** and classified according to natural breaks
  - Maximizes difference between categories and minimizes difference within categories

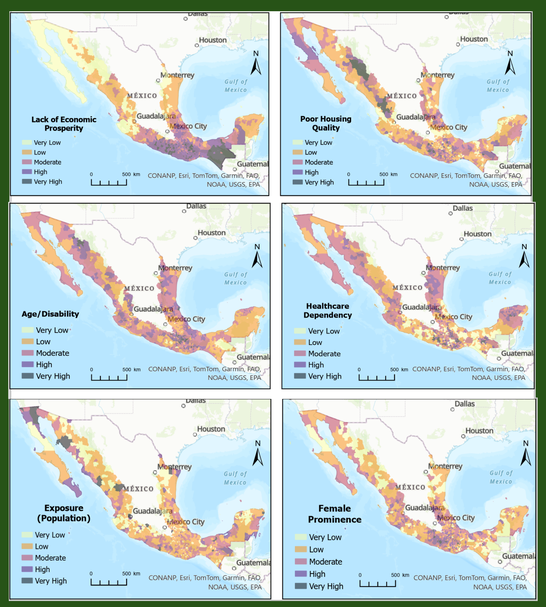


Figure 3. Vulnerability Map of Each PC Factor.

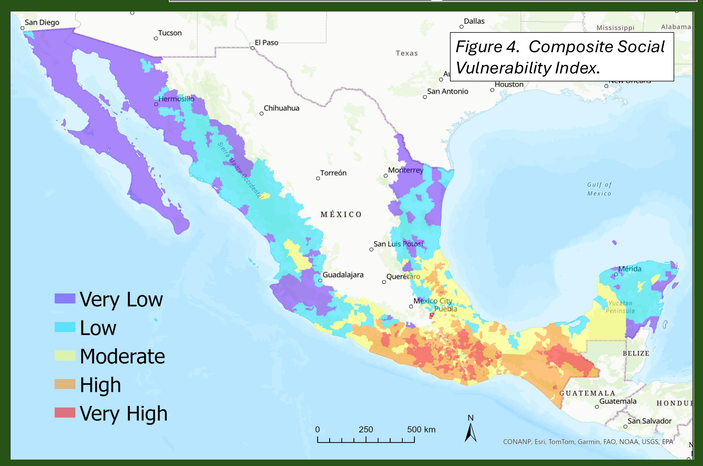


Figure 4. Composite Social Vulnerability Index.

3. Physical Vulnerability Index

Data
Simulated Mexico-landfalling hurricane tracks generated by eight future climate models following the RCP8.5 (worst-case global warming scenario) 2026-2055.

- Generated MATLAB scripts to extract all points from hurricanes that had undergone RI following a landfall in Mexico
- Plotted in ArcGIS
- Applied kernel density analysis (weighted by wind speed at point)
- Combined with municipality map
- Classified according to natural breaks
- *See Figure 5.*

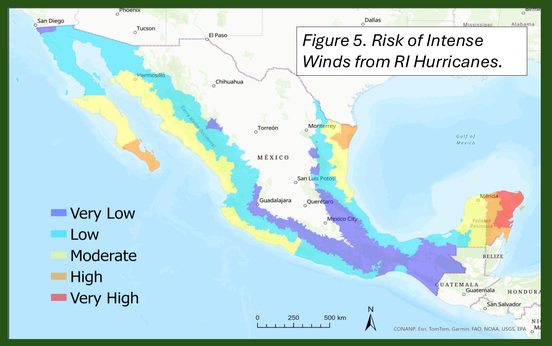


Figure 5. Risk of Intense Winds from RI Hurricanes.

4. Final Vulnerability Index (SoVI RIM)/Conclusions

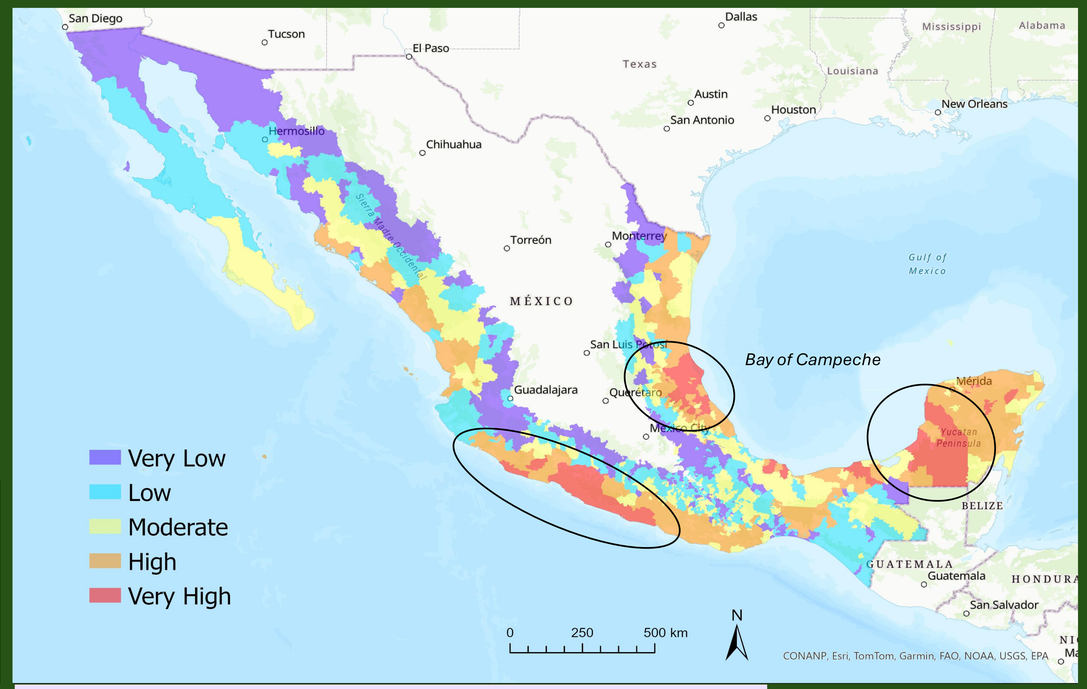


Figure 6. A social and physical vulnerability index to RI hurricanes.

- Physical index combined with **climatological RI hurricane analysis** (see Sara Michaelson's poster)
- Municipality classification on scale 1-5 for **both social and physical index multiplied** to yield final index score
  - Natural breaks used once more
- **<u>Southern Pacific coast, Yucatan, and Western Bay of Campeche coast most vulnerable overall</u>**
- **No area is extremely vulnerable**: the "Very High" category is relative and only encompasses scores 11-16/25
- Government of Mexico must take precautions to make sure these areas are equipped with resources, can access information, and able to quickly obtain assistance

5. Future Work

- Apply a 3-D risk matrix to give appropriate weight to exposure/population
- Consult Servicio Meteorologia Nacional and Gobierno de Mexico to implement this into practice
- Consult social vulnerability experts to assess our selection of social demographic factors
- Continue to analyze simulated hurricane data to draw conclusions about RI cycles (duration, location, frequency, intensity, etc.)

6. Acknowledgements/References

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https://www.nhc.noaa.gov/data/tcr/EP182023_Otis.pdf
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