Building Urban Resilience to Climate Change with Nature-, Community- and Infrastructure-based Solutions: A Mixed Methods Study in the Gulf of Mexico. Ciudad del Carmen, Mexico as Case Study

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Introduction

The Gulf of Mexico (GoM) is a semi-closed sea shared by Cuba, Mexico, and the USA. These countries have managed the GoM individually while implementing cross-border efforts to manage it jointly. **However, no project focuses on building resilience to climate change (CC) from a transboundary perspective.**

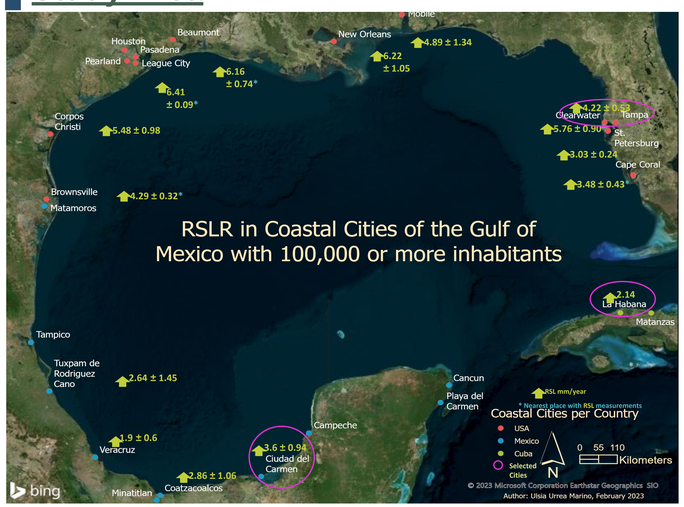
Cities can face the effects of CC by adopting actions that allow them to strengthen their resilience. Among the existing actions, nature- (NbS), community- (CbS), and infrastructure-based solutions (IbS) have been incorporated into urban agendas with encouraging results.

Objective

Evaluate urban resilience in the context of CC in coastal cities in the GoM with direct attention to the Mexican case study in Ciudad del Carmen.

To carry it out, it has proceeded through analyzing Urban Ordinances (content analysis, CA), semi-structure interviews, and observation notes (thematic analysis, ThA) that focus on NbS, CbS, and IbS

Study Area



Map 1: Twenty-five preselected cities through criteria (1) Population (≥100,000 inhabitants), (2) Water or Riverine marine-influenced location

Acknowledgements

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Mixed Methods Methodology

Assess potential study sites → Coastal Cities in the Gulf of Mexico

Select case studies based on criteria → Stratified purposive sampling

Collect quantitative/qualitative data → QUAN: a) Urban Ordinances; b) SLR & flooding trends (2030, 2050 & 2100) QUAL: a) Interview; b) Field Notes

Analyze data → QUAN: a) Keywords frequencies (Content Analysis); b) Landscape Change Analysis QUAL: a) Perceptions (Thematic Analysis)

Conclusion → Approach → Interpretation each case study → Local Comparison among study cases → Regional

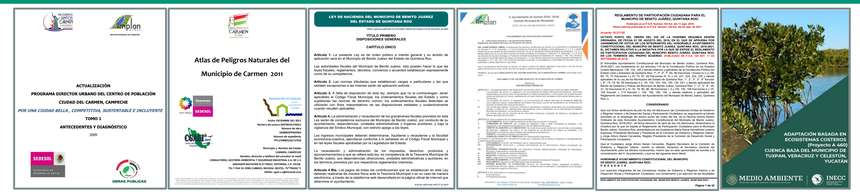

Fig 1 to 6: (from left to right) Examples of Urban Ordinances: i) Planning and Ordination, ii) Management, iii) Tax, iv) Democratic Participation, v) Monitoring and Evaluation, & x) Technical Reports. Photo credit: Municipal Governments of Carmen & Benito Juárez, and AbE Technical Report, SEMARNAT, México. Publicly available

Stratified purposive sampling

Coastal cities' universe in the Gulf of Mexico (+200)	(a) ≥100,000 inhabitants (b) Water or Riverfront with marine influence **R= 25 cities in 3 countries**	Urban Ordinances (CA) → Purposefully select 3 cities (one per country) with highest keywords frequency: **flooding, SLR, NbS, CbS & IbS**

Figure 7: Content Analysis (CA). Photo credit: https://delvetool.com/guide

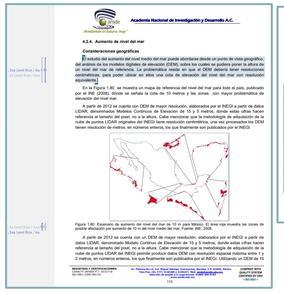

Figure 8: Example CA on MAXQDA. Photo credit: Ulsía Urrea Mariño

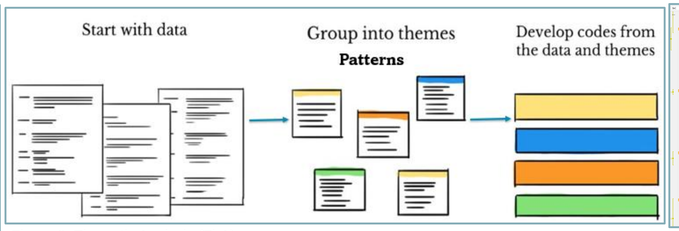

Figure 9: Thematic Analysis (ThA). Photo credit: https://delvetool.com/guide

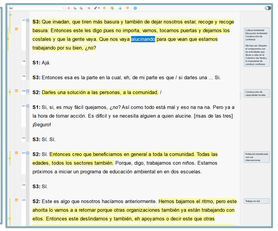

Figure 10: Example ThA on MAXQDA. Photo credit: Ulsía Urrea Mariño

Results

SLR, Flooding, NbS, CbS & IbS (Main sub-themes and frequencies)

Content Analysis Mexico 10 cities

167 urban ordinances

SLR: 77 — **Flooding:** 2116 — **NbS:** Mangrove restoration (top-down): 50 — **CbS:** Mangrove restoration (bottom-up): 18 — **IbS:** Breakwater & Roads Protection: 15

Photo credit: https://redrural.org.py/

Photo credit: https://www.poresto.net/campeche/2022/10/19/

Photo credit: Santiago Rejón

Photo credit: Santiago Rejón

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Thematic Anaylsis Ciudad del Carmen

17 interviews

SLR: Erosion: 24 — **Flooding:** Storm surge; High tide + Rain: 44 — **NbS:** Mangrove conservation: 38 — **CbS:** Local Leadership & Co-creation: 99 — **IbS:** Elevated roads (piles): 5

Photo credit: Ulsía Urrea Mariño

Photo credit: https://www.youtube.com/watch?v=4_QMoB3UQ48

Photo credit: Santiago Rejón

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Photo credit: https://www.expedia.com/es/Puente-El-Zacatal-Ciudad-del-Carmen

Conclusions

1) Successful methodology to select & analyze study cases

From the CA and ThA:

2.1) *Mangrove restoration* financed by the federal government and implemented by various local actors has been the most used **NbS** over time;

2.2.) *Mangrove conservation* by local actors, NGOs and local government, is another **NbS** that has been applied for several decades.

From the ThA:

3) Since there is a significant economic disparity in the city's population, the **CbS** have a *large area of opportunity to be applied to reduce climate-associated risks, strengthen climate outreach, and reduce poverty traps*;

4) The **IbS** implemented until now have caused a greater risk exposure because they have accelerated the coastal erosion of the Island, which is why the *redesign of the piloted road infrastructure and coastal protection structures is imperative*