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Building adaptive capacity to address coastal flooding: The case of a small Texas City

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ABSTRACT

Coastal flooding is a severe and recurring problem, as evidenced by recent disasters that have caused significant damage for coastal communities. A community's ability to mitigate the effects of coastal flooding depends on the local context and its adaptive capacity. Although past research has highlighted the important role that non-governmental organizations play in building adaptive capacity to support effective adaptation, few studies have focused specifically on rural, community-based nonprofits. To fill this gap, we employ a mixed-methods approach to evaluate the role of the Ingleside on the Bay Coastal Watch Association (IOBCWA), a resident-led, community-based nonprofit, in building adaptive capacity to coastal flooding in the City of Ingleside on the Bay (IOB; pop. 800), located in the Coastal Bend Region of Texas. By applying a grounded theory framework, we show that IOBCWA has improved the adaptive capacity of IOB through five primary activities: engaging in community organizing, boosting advocacy and outreach, implementing evidence-based data collection, building capacity among residents, and developing regional communication networks. Our findings are further examined using the Regional Fingerprint tool (Hirschfeld et al., 2020) to assess progress toward building regional adaptive capacity. We identify a need for more formalized policies, enhanced regional partnerships, and broader inclusion of socially vulnerable groups to address environmental challenges. Overall, this work highlights the important role that small, community-based nonprofits like IOBCWA play in building community adaptive capacity and suggests the need for a more comprehensive regional approach with participation from multiple stakeholders to address challenges related to coastal flooding.

1. Introduction

Coastal flooding due to high tides, storm surges, and waves threatens lives and property in shoreline communities (Cigler, 2017; Consoer and Milman, 2017; Kick et al., 2011; Sadiq, 2017; Tyler et al., 2019), and its frequency and severity is increasing due to ongoing development along the coastline and changes in sea level and weather patterns (Wong-Parodi et al., 2017). To address concerns related to flooding and mitigate future impacts, coastal communities may initiate adaptive measures. These may include structural measures that leverage technology and engineering approaches such as seawalls and levees or non-structural measures of legal, institutional, and organizational approaches such as public policies, planning measures, and initiatives to increase public awareness of flood hazards and impacts (Bezboruah et al., 2021; Dawson et al., 2011; Idllalène and Van Cauwenbergh, 2016; Lee, 2014). Because coastal flood exposure is a function of the physical, built, social, and political environments (Brody et al., 2011), the extent and severity of impacts and the types of adaptation measures chosen to address these impacts vary substantially from one community to the next, motivating the need for local-level identification and understanding of flood drivers, vulnerabilities, and responses.

This study employs a participatory mixed-methods approach that

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leverages both deductive, indicator-based frameworks and inductive, grounded theory methodology to evaluate the role of community-based organizations (CBOs) in building adaptive capacity in communities impacted by climate change and industrial development. Our case study is the city of Ingleside on the Bay (IOB), located in San Patricio County, one of the eleven counties in the Coastal Bend Region of Texas, USA. In 2018, residents of IOB established a grassroots CBO, the Ingleside on the Bay Coastal Watch Association (IOBCWA), in response to growing concerns about the environmental and societal impacts of climate change and expanding industry. The goals of this research are to (1) identify the environmental impacts of coastal flooding in IOB, (2), examine the extent of engagement by community members, and (3) assess the adaptive strategies adopted by the community. The findings fill critical gaps in the literature by uncovering how local conditions shape planning and policy actions related to adaptation and by identifying strategies and tools that are being used to build adaptive capacity in smaller coastal communities that are on the front lines of climate impacts but lack political and economic power at the regional scale (Arnold et al., 2021; USGCRP, 2018). To assess how IOB is addressing the challenges from coastal flooding, this paper asks the following question - What is the adaptive capacity of the community of IOB in response to flooding issues?

Findings from this work can provide policymakers and researchers with knowledge and tools to apply the Regional Fingerprint tool to similar smaller coastal communities that are facing severe climate impact but may be economically and politically vulnerable at the regional scale.

2. Literature review

Adaptive capacity is an important concept in climate change adaptation and is broadly defined as the "ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC, 2007, p.72). Many past studies have evaluated adaptive capacity at the household (e.g., Dafiesta and Rapera, 2014), community (e.g., Paton et al., 2008), or institutional (e.g., Gupta et al., 2010) level using pre-defined indices based on the literature or expert input (Siders, 2019). While these approaches can provide insight into the factors that contribute to adaptive capacity, the chosen indices vary substantially across studies and there is not yet consensus on which subset of indicators is most appropriate or valid (Eriksen and Kelly, 2007; Hinkel, 2011; Siders, 2019). In addition, top-down, deductive approaches that apply index-based frameworks do not account for the local conditions and histories that shape the built, social, and political environments and contribute to adaptive capacity (Sehrsweeney and Fischer, 2022). Inductive approaches that identify salient themes and build theory through analysis of empirical data and observations (e.g., surveys, stakeholder interviews, community workshops, or organizational plans and documents) can provide an important complement to index-based approaches by highlighting the underlying conditions and structures that influence adaptive capacity (Vásquez-León et al., 2003; Antwi-Agyei et al., 2015; Sehrsweeney and Fischer, 2022).

In climate hazard response, institutions can play an important role in building community adaptive capacity by "empower[ing] actors to design and plan for responses to short and long-term impacts of climate change" (Hirschfeld et al., 2020, p. 36). In particular, local environmental stewardship groups such as CBOs have been critical in representing citizens and communicating and advocating for adaptive strategies through participatory planning for management, restoration, preservation, and conservation of ecosystems (Connolly et al., 2013; Fisher et al., 2012; Rudge, 2021). Strategies include developing engagement plans, communicating gaps in plans, building trust, enhancing awareness about pressing issues, and providing a forum for discussing solutions (Bergstrom et al., 2012; Cilliers and Timmermans, 2014; Jenewein and Hummel, 2022). Scholars tout the importance of the management of the adaptive capacities of communities to reduce their vulnerability to climate hazards (Douglas et al., 2012). They suggest a variety of management techniques, including creating awareness about adaptation measures through visual depictions, understanding the existing knowledge and cultural values regarding climate change and the financial capacity to sustain the measures before implementation, and including the community from the beginning of the planning process (Douglas et al., 2012). In the implementation of these management techniques, CBOs can effectively act as a bridge between citizens, planners, and public administrators to promote community-generated solutions, spread knowledge and best practices, foster inclusive and equitable planning, build grassroots coalitions with other similar agencies, and engage in adaptive practices that contribute to community resilience (Connolly et al., 2013; Reid and Huq, 2014; Moser and Pike, 2015; Warrick et al., 2017).

Despite the important role that CBOs serve in providing resources to help residents address climate challenges through collective action, there is still limited research that focuses specifically on how rural, community-based nonprofits develop planning and policy-making structures and build adaptive capacity in response to environmental threats (Arnold et al., 2021; Cutter et al., 2016; USGCRP, 2018). Small towns often utilize CBOs to make their needs and voices more evident to larger neighboring communities and other state and regional entities. Also, smaller towns have different strengths and needs compared to larger urban areas in post disaster recovery and in the adoption of hazard mitigation strategies (Kapucu et al., 2013; Ross, 2013). Often, the administration of emergency management in non-urban or rural communities is based on the community capacity in terms of availability of funds post-disaster for reconstruction and strengthening of structural measures as well as community participation in hazard mitigation and adaptive strategies (Fannin et al., 2012; Kapucu, 2016; Ross and Clay, 2018). Some small coastal communities of Texas that were devastated by hurricanes (especially Hurricane Harvey in 2017) and are regularly prone to coastal flooding from industrial developments, rising sea levels, and ship traffic are addressing these challenges by engaging in both structural and non-structural measures. Thus, these communities serve as strong research case studies to examine and understand their adaptive capacities (Arnold et al., 2021).

3. Methods

This study is conducted in two phases. First, we apply an inductive, grounded theory approach to analyze the case study of IOB. Second, we examine our findings from the first phase using the Regional Fingerprint tool introduced by Hirschfeld et al. (2020) to assess the adaptive capacity of IOB. While the grounded theory analysis provides insights into how a small rural town is addressing environmental impacts by engaging in adaptive capacity building practices, the assessment of these initiatives using the Regional Fingerprint tool sheds light on the efficacy of these activities and provides a roadmap for taking necessary measures to mitigate disasters, build community networks at a regional scale, and effectively adapt to environmental threats (Cutter, 2016). The Regional Fingerprint tool is a framework that applies multiple criteria for assessing the adaptive capacities of regions (Hirschfeld et al., 2020). This five criteria framework assists with tracking progress of adaptive capacity initatives and with identifying gaps between regions and opportunities for intervention.

We apply the case study research design because it is a “systematic inquiry into an event or a set of related events which aims to describe and explain the phenomenon of interest” (Bromley, 1990, p. 302). This case study design (see the study’s research framework in Fig. 1) explores how the small, rural community of IOB is addressing coastal flooding through adaptive strategies spearheaded by IOBCWA and how it fits into the larger regional adaptive capacity framework. The unit of analysis for this case is the city of IOB and the research questions are specific to the case (Stake, 1995). The analysis is conducted from empirical data

Fig. 1. Research framework.

collected by the researchers (Yin, 2009). Content analysis is employed to analyze the data generated from policy documents (i.e., meeting minutes, government documents, and flood zone and land use policies) and qualitative data collected from a stakeholder workshop.

3.1. Case study

IOB, located along the shores of Corpus Christi Bay on the Texas Coast, was selected as a case due to its geographic location and strong citizen engagement. The strong citizen engagement signals the gathering of local knowledge for relevant grassroots solutions and capacity building to address the environmental issues (Beierle and Konisky, 2001; Rentschler and Williams, 2022). Corpus Christi Bay is part of the Coastal Bend Bays and Estuaries system, designated in 1994 by the Environmental Protection Agency (EPA) as one of twenty-eight estuaries of national significance. Founded in 1958 and incorporated as a Texas General Law city in 1991 with its own mayor and city council, IOB has a population of about 787 residents (U.S. Census Bureau, 2021), of which 71. 3 % are White followed by Hispanic (26.7 %). The median household income of IOB households was $84,115 in 2021, with a median age of 51.2 years, and about 92 % have a high school degree or higher, suggesting a well-off and educated rural community. Yet, 4.1 % of the people are below the poverty line. IOB is also located at the intersection of the La Quinta and Corpus Christi Ship Channels, slated to become the deepest and widest ship channel on the U.S. Gulf Coast by 2024 at 54 feet deep (Jenewein and Hummel, 2022). This location exposes the community and its infrastructure to significant impacts from coastal forces, including storm surge, waves, and ship wakes as well as conflicts between advocates for environmental preservation and industrial development.

The closing of a navy base in 2010 and lifting of a 40-year oil export ban in 2015 led to construction of petrochemical export facilities along the San Patricio County coast, led by the Port of Corpus Christi, which has become the largest port in the United States in total revenue tonnage (Jenewein, 2022). The Enbridge Ingleside Energy Center, located on the former Naval Station property adjacent to IOB to the east, is now the largest crude oil export terminal in North America (Krishna and Nickel, 2021). Flint Hills Resources and Buckeye Partners oil export terminals, located next to Enbridge, are also expanding to accommodate larger vessels that benefit from the Port of Corpus Christi's deepening of the Corpus Christi Ship Channel. To the north of IOB, Cheniere's Corpus Christi Liquefaction facility is the largest exporter of liquefied natural gas (LNG) in the U.S.(Lepic, 2022). The increasing flow of LNG tankers on the Corpus Christi and La Quinta Ship Channels that pass within 150 feet of IOB causes additional environmental impacts on air and water quality as well as flooding due to ship wakes (Jenewein and Hummel, 2021). Ship wake flooding occurs when large ships move at speeds that generate waves, which can then propagate to the shoreline and overtop

bulkheads. The region is extremely prone to recurring coastal flooding and has a heightened risk of over 50 % of the properties being destroyed in the next 30 years (Floodfactor.com).

About a third of the city is in the floodplain (Fig. 2), including some High-Risk Coastal Areas with over a 1 % chance of annual flooding. A series of bulkheads, installed about 50 years ago and maintained by the property owners, protect the waterfront properties (Jenewein and Hummel, 2022). Maintenance of these bulkheads is inconsistent and dependent on the owners, and consequently, some properties experience severe flood impacts along IOB's waterfront (Dunning, 2020). IOB also

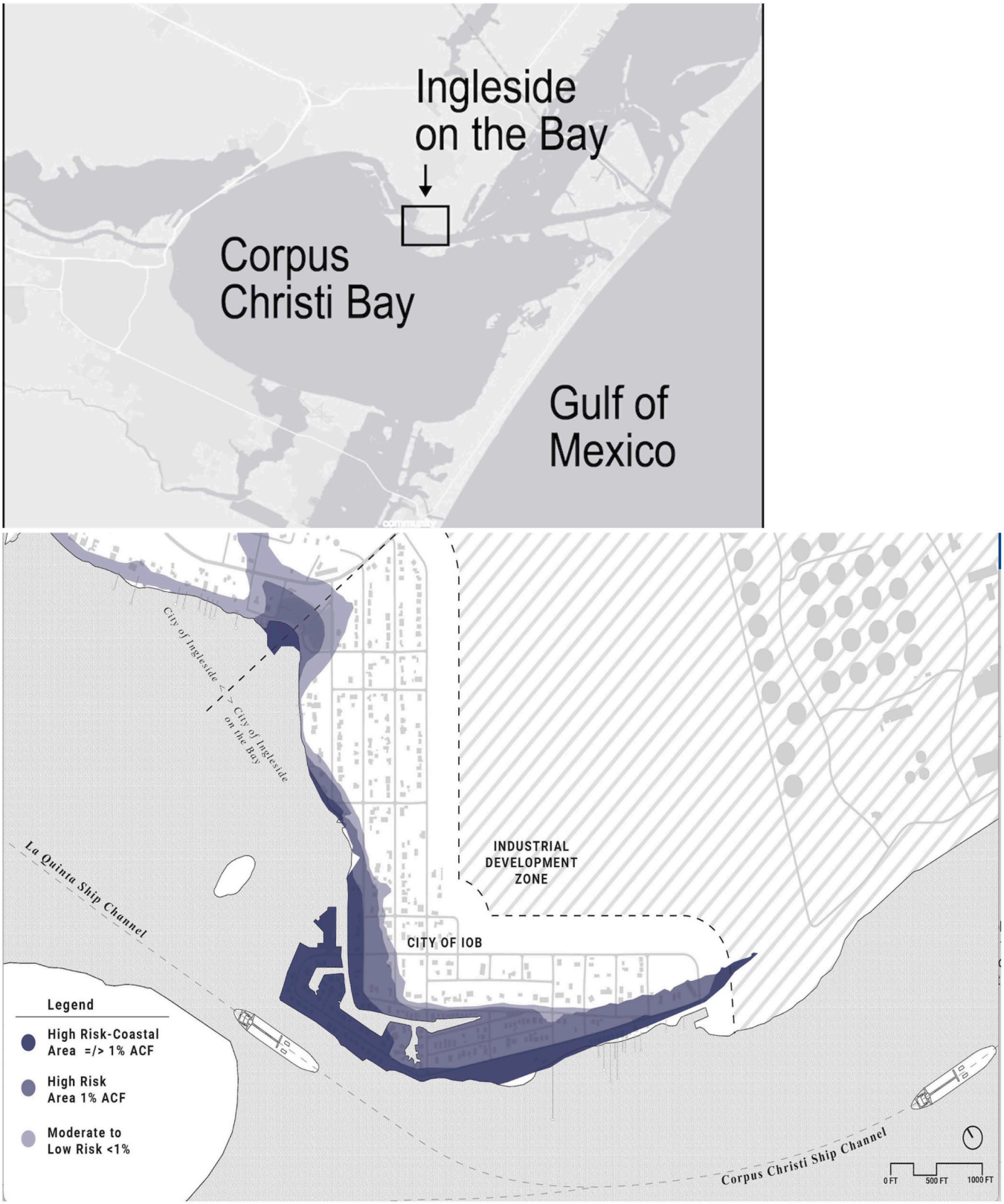

Fig. 2. FEMA flood zone map of Ingleside on the bay. *ACF = Annual Chance of Flooding.*

lacks a city-wide drainage system that causes properties, yards, and major roads to flood. While IOB has grown accustomed to seasonal tidal flooding exacerbated due to relative sea-level rise, during the 2020 hurricane season from July to November, IOB experienced effects from eight tropical cyclones that hit the Gulf of Mexico, bringing storm surges of up to 4 feet and inundating as much as a quarter of the city for days (Beven, 2021). This makes the case for adaptive strategies even more critical to protect and preserve the city and its shoreline.

Additionally, there is a strong grassroots movement of citizens through IOBCWA who are engaged in adaptive flood mitigation strategies to address the environmental and health impacts of sea-level rise, ship traffic, and industrial growth. IOBCWA is composed of residents of IOB actively engaged in fostering collaborations to mitigate the impacts of environmental changes and industrial developments on the community. Its mission is to study the impact of climate and industrial changes through scientific, engineering, and research-based approaches (IOBCWA, 2019a) and to safeguard their community. This citizen movement collaborates with other organizations in this region to generate awareness and inform people through environmental advocacy and evidenced-based information. In 2020, IOBCWA joined the Coastal Alliance to Protect Our Environment (CAPE), a network of over 20 CBOs advocating against industrial expansion that adversely affects the health and living conditions of communities in the Coastal Bend Region. CAPE works as a network alliance for organizations focusing on issues within the Coastal Bend Region with their own goals and missions, but all members share the common concern that the current trend of industrial activity in Corpus Christi Bay and along its shoreline is drastically contributing to the negative impacts of climate change (CAPE, 2020).

3.2. Data collection

We collected primary data from (1) a stakeholder engagement workshop held in IOB in November 2021, (2) key stakeholder discussions, and (3) onsite observation of the conditions of IOB (see Table 1 Data Sources). The stakeholder workshop included 20 participants from IOB and focused on outlining community assets and challenges related to air quality, water quality, and flooding and discussing strategies to overcome these challenges. We collecetd secondary data from city planning reports, permit applications, responses to public comment requests, and meeting agendas and minutes from local, state, and federal agencies and organizations (e.g., IOBCWA, IOB City Council, San Patricio County Commissioners, Port of Corpus Christi, and Texas Council on Environmental Quality) involved with environmental/industrial issues and policymaking in the region. We applied open coding to these documents to identify and organize the major stakeholders and initiatives as well as their topical foci and linkages. We also categorized the advocacy activities (e.g., legal, education and mobilization, capacity development, government relations, etc.) engaged by IOBCWA. Information derived from this analysis informs the development of a theoretical framework characterizing the structure of communication, information-sharing, policymaking networks, and citizen engagement activities in IOB. This framework identifies connections or advocacy efforts that are working well and new strategic partnerships that should be pursued.

3.3. Grounded theory analysis

First, we apply a grounded theory approach to assess the current state of structural and non-structural policies, environmental conditions, and flood mitigation mechanisms in IOB. As an inductive research methodology, grounded theory helps to uncover theoretical explanations and interpretations from social science data using a bottom-up, inclusive approach (Dunn and Swierczek, 1977; Glaser et al., 1968). This contrasts with more traditional logico-deductive research methods that use data collection and analysis to verify existing theories through a top-down approach (Dunn and Swierczek, 1977). The grounded theory methodology is appropriate to develop theories and concepts regarding smaller communities' adaptive capacities, engagement, and communication in the public policy process. IOB is an exploratory case study that describes the experience of building a grassroots movement and the process of change (Randall, 2009) to address climate change through improved policies.

We analyze the primary data (workshop, stakeholder inputs, participant observations, and field notes) collected from the residents of IOB and secondary data from meeting minutes and published reports of vatrious organizations working in this area, to ensure that the data is as comprehensive as possible. Using the grounded theory method, we code the data through three phases - open, axial, and selective coding (Corbin and Strauss, 2015; Creswell and Poth, 2016). The flow diagram in Fig. 3 maps the grounded theory technique of data analysis and shows the five themes that emerge in this process. Starting with open coding the information, we develop categories for the data collected from the publicly available meeting minutes of the IOBCWA, San Patricio County, Port of Corpus Christi, City of IOB, CAPE, and primary data from the community workshop, discussions with key stakeholders, and onsite observations (inner most circle in Fig. 3). The open coding of the data reveals the central phenomena relating to coastal flooding in IOB (the black boxes at the center of Fig. 3). Indicated by the dotted circles in Fig. 3, the dataset was then axial coded to further understand the impact and drivers of coastal flooding, the community adaptive capacity to address them, and the policy implications on the community. The axial coding reexamines the data to form the categories as discussed in Fig. 4. Finally, we apply selective coding to extract the main themes of the findings, which are used to build theory at the local scale.

Table 1
Data sources.

	Data Sources	Data Type
Primary Data	Workshop with IOB residents	1. Assets of the city 2. Environmental challenges 3. Strategies to address the flooding
	Discussions with key stakeholders	1. Assets of the community 2. Challenges faced by homeowners 3. Industrialization 4. Initiatives to address challenges
	Onsite Observations	1. Assets of the city 2. Flooding challenges in the shoreline and inland areas 3. Industries
Secondary Data	Government - Meeting agenda and minutes of IOB City Council	1. Assets of the city 2. Community Participation 3. Budget/ Fiscal state 4. Community Initiatives/ Programs
	Government - Meeting Minutes of San Patricio County	1. Assets of the county 2. County Level Programs/ Initiatives 3. Budget/ Fiscal state
	Government - Meeting minutes of Port of Corpus Christi Commission	1. Assets of the Coastal Bend region 2. Economic development opportunities
	Government - Texas General Land Office – Community Development Block Grant Mitigation (CDBG -MIT) grant public hearings	1. Community Participation 2. Budget/ Fiscal state 3. Strategies to address challenges
	Nonprofit - IOBCWA Meeting Minutes	1. Legal 2. Education & Awareness 3. Capacity Building
	Nonprofit - CAPE Website & Climate Summit Recordings	1. Regional Capacity Building 2. Educational and Awareness 3. Strategies to address regional challenges

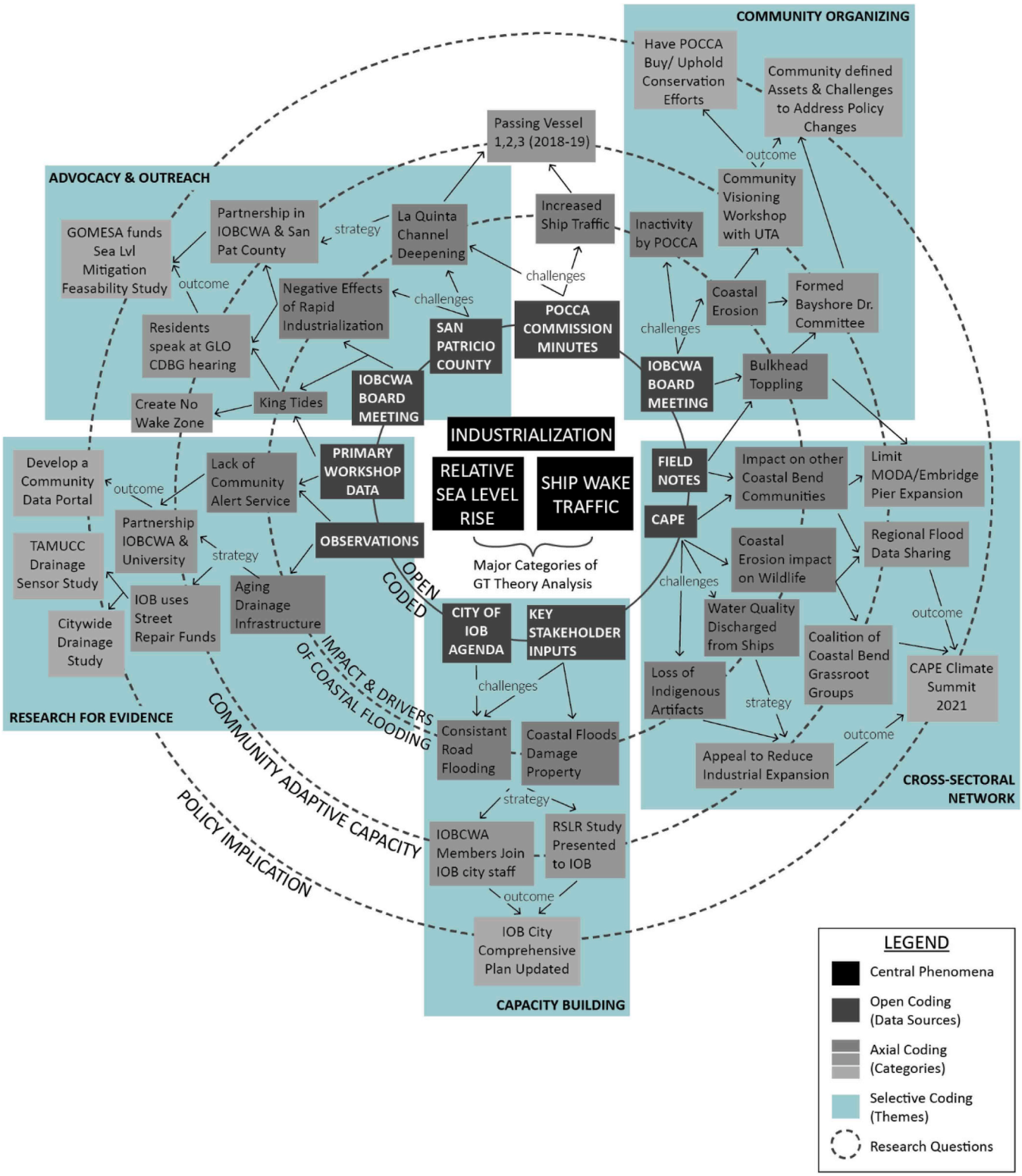

Fig. 3. Flow diagram mapping the grounded theory methodology.

3.4. Regional adaptive capacity analysis

The findings from the grounded theory methodology are then evaluated by applying the Regional Fingerprint tool proposed by Hirschfeld et al. (2020) to assess how the adaptive capacity of smaller communities fits into the regional adaptive capacity. Hirschfeld et al. (2020) proposes five criteria for evaluating regional adaptive capacity – 1. Adopted Actions (AA), 2. Institutional Capacity (IC), 3. Research Quality (RQ), 4. Planning Processes (PP), and 5. Regional Collaboration (RC). These criteria are based on multiple studies conducted over more than a decade. This tool provides the ability to assess adaptive capacity of communities at a regional level by using financial and non-financial lenses. We assessed the regional capacity of IOB by recategorizing our data and results from the grounded theory approach into the five criteria

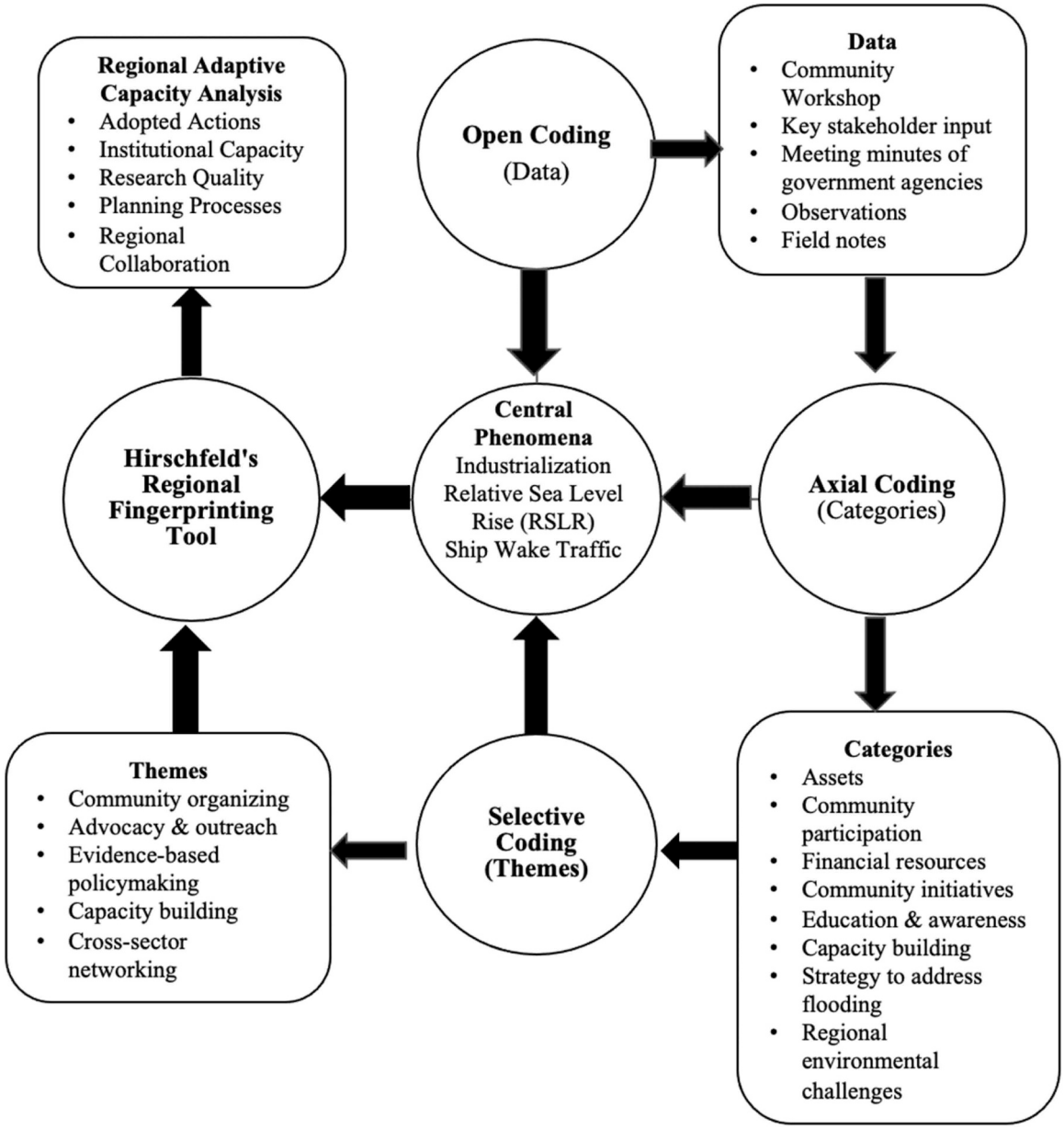

Fig. 4. Theory building for community adaptive capacity with grounded theory analysis.

of regional adpative capacity. Through content analysis, we evaluated each of the five categories of the Regional Fingerprint tool. We use this tool to primarily to evaluate the presence or absence of each criterion. Our study is focused on the small town of IOB, which limits our dataset and allows the use of a simplified version of the regional footprint tool that only captures the presence or absence of the evaluation criteria rather than assigning scores.

By applying grounded theory methodology and the Regional Fingerprint tool together, we evaluate IOB's adaptive capacity as a small coastal town faced with threats from industrial development, relative sea level rise, and ship wakes, and its capacity at a regional scale. Thus, this research meets the three criteria proposed by Garson (2002), first, fitness of application to the context, second, generalizability to similar settings, and third, the possible emergence of confounding variables during analysis. Thus, this case study is instrumental to gain a broader understanding of the issue of flooding in the Coastal Bend Region (Stake, 1995).

4. Results

The findings from the content analysis of the data are presented below. First, we discuss the outcomes of the stakeholder workshop. We then evaluate the local adaptive capacity of IOB based on the grounded theory analysis. Finally, we discuss the regional adaptive capacity of the city by applying Hirschfeld et al.'s (2020) Regional Fingerprint tool.

4.1. Stakeholder workshop

The workshop data points to the community assets, flood-related challenges, and strategies to address them. Some of the community assets that make IOB a vibrant city are the opportunities for water recreation activities, wildlife sanctuary (e.g., for birds, fish, pelicans, and endangered species such as sea turtles), water quality supplied by the municipality, and location of the city. This community thrives from the natural assets and resources found in the area.

The challenges identified in the community workshop include relative sea level rise, increased ship traffic, heightened industrialization,

shoreline erosion, proposed desalination plants, aging water infrastructure, polluted groundwater, dysfunctional drainage systems, and the dumping of trash and dredged material by ships near the shore (See Appendix A). Many of these challenges are anthropogenic, resulting from impacts of climate change, improper planning, and industrial and commercial developments. It appears that the impacts of flooding are geographically distinct between coastal and inland areas within the city, resulting in differing degrees of community involvement and advocacy activities to address flooding. Inland residents experience more flooding due to rainfall during large tropical cyclone events, while coastal residents also face inundation due to both storm surges and ship wakes. For those most affected by coastal flooding, the inaction of the Port of Corpus Christi to address the impacts of ship wake beyond a few technical studies has added to the losses caused by relative sea level rise. This has resulted in outreach, organizing of residents, drafting of mitigation plan proposals for grant funding, partnering with academic institutions to build data-driven advocacy, and building capacity by developing a regional network of those addressing environmental issues across the Coastal Bend.

4.2. Local adaptive capacity

Our study finds that relative sea level rise, the impact of waves generated by large ship traffic, and the rapid industrialization of the city's surrounding and its shorelines are the main causes of flooding in IOB. The grounded theory methodology highlights the causal conditions, strategies, and outcomes as indicated with the arrows in Fig. 3. The axial coding reveals that relative sea level rise is impacting the frequency and severity of the problems that IOB is facing, such as, king tides, hurricanes, coastal erosion, bulkhead overtopping, stormwater drainage problems, increasing damage to coastal properties, and consistent road flooding. Additionally, the La Quinta Ship Channel deepening and increased ship traffic not only drive larger ship wakes but also cause loss of indigenous artifacts, destruction of coastal wildlife, and increased flooding impacts on neighboring coastal communities. The larger ship wakes further affect coastal erosion, bulkhead overtopping, road flooding, and wildlife.

As described in Fig. 3, the analysis also highlights the various types of adaptive capacity building efforts currently practiced in IOB, including research studies, grants, capacity building workshops for residents and local CBOs, educational outreach, development of government relations, and network building with regional organizations with similar missions. The outermost circle in Fig. 3 describes the various policy implications captured in the grounded theory analysis. These include the city of IOB updating their Comprehensive Plan to include strategies that address coastal flooding, IOB residents partnering with academic institutions to develop a community data portal which alerts residents of coastal risks, and San Patricio County approving the use of Gulf of Mexico Energy Security Act funds for a relative sea level rise study. Finally, the grounded theory analysis generated five primary themes as depicted with the light blue boxes in Fig. 3. These include community organizing, advocacy and outreach, research for evidence-based policymaking, capacity building, and cross-sectoral networking. These themes are discussed in more detail below.

4.2.1. Community organizing

The critical work of organizing the community for addressing the environmental challenges in IOB was driven by IOBCWA. This CBO is pivotal to keeping IOB residents informed about environmental issues through sponsored research projects and presentations by experts on climate or industry-related topics. A key initiative, as a response to the limited actions by the Port of Corpus Christi and local government toward rapid industrialization in the area, is the organization of advocacy activities (IOBCWA, 2020a, 2020b). IOBCWA members met with the residents along the shoreline in IOB who were most affected by ship traffic to gauge the risks, issues, and damages caused by flooding (IOBCWA, 2020a). IOBCWA also held educational meetings about the increased ship traffic due to heightened commercial activities in the region. IOBCWA summarized the Port of Corpus Christi studies since 2018 and presented a separate but related commissioned study of relative sea level rise (IOBCWA, 2020b). Feedback generated from the audience was utilized for seeking funds from the Port of Corpus Christi to execute mitigation projects. Additionally, these meetings discussed the urgency for all IOB residents to act together and come to a consensus on preferred solutions to communicate to the Port of Corpus Christi.

IOBCWA assisted IOB residents with voicing their needs and concerns to regional and state agencies (IOBCWA, 2019b) and organized trainings for public hearings (Texas General Land Office, 2019a, 2019b). As a result, several IOB residents, including city council members, business owners, and IOBCWA board members, spoke at state-organized budget hearings about funding needs to address hurricanes and coastal erosion damages caused by ship traffic. In February 2020, researchers from a state university conducted a community visioning workshop with IOB residents and stakeholders to help define assets and challenges related to the environmental impacts of climate change and industrial growth (Jenewein and Hummel, 2021). That workshop focused on the four types of infrastructure (green, gray, brown, blue) and identifying the assets, challenges, and strategies related to each. The second workshop in 2021 focused specifically on air quality, water quality, and flooding, also discussing assets, challenges, and strategies.These efforts not only increased the organizing capacity of the IOB community but also heightened their advocacy efforts to governments and institutions for better policy solutions.

4.2.2. Advocacy and outreach

IOBCWA initiated advocacy efforts to spread awareness about flooding issues affecting IOB by informing residents of the increasing traffic from ships, trash dumping, and relative sea level rise and by meeting with government officials, other CBOs and environmental activists in the region, and researchers from universities to assist with flood mitigation solutions. In 2019, IOB residents participated in public hearings for the Texas General Land Office's Community Development Block Grant Mitigation program offered by the US Department of Housing and Urban Development to help communities recovering from Hurricane Harvey and other flooding events and (Texas General Land Office, 2019a). These requests included the inclusion of IOB in the state's new mitigation plan; and funds to develop resiliency plans, mitigate the loss of boulder protection due to coastal storms,and address the open ditch-based drainage located throughout the city. While IOB did not meet the low-to-moderate income guidelines required to apply for this large grant, IOBCWA did obtain a $20,000 grant from the Gulf of Mexico Energy Security Act fund from San Patricio County to support a relative sea level rise study (San Patricio County, 2019).

4.2.3. Research for evidence-based policymaking

Several studies have been conducted by San Patricio County, the City of IOB, and IOBCWA over the years to assess the impacts of climate change and industrial development on the coastal community. These include ship wake studies by the Port of Corpus Christi (MacDonald, 2019a, 2020a; POCCA, 2020); a relative sea level rise study by IOBCWA, funded by San Patricio County (MacDonald, 2020b); a drainage study by the City of IOB, funded by the San Patricio County (City of IOB, 2021); and flooding studies conducted through Texas A&M Corpus Christi (NSF, 2021). The relative sea level rise study recommended that a comprehensive drainage study be conducted, proposed several mitigation alternatives and an assessment of their cost-effectiveness, and recommended that neighboring communities collaborate to apply for additional funding (San Patricio County, 2019). This resulted in IOB utilizing their Drainage District and street repair funds to perform a city-wide drainage study (City of IOB, 2021). The study included hydraulic analysis, a comprehensive Drainage Master Plan, and a Capital Improvement Plan. In parallel, IOBCWA partnered with Texas A&M

Corpus Christi researchers to examine air and water quality impacts due to industrial expansion and assess the drainage problem by placing drainage sensors across IOB (NSF, 2021). All these efforts have been made to gather and present evidence of the flooding issues the community is facing to bring about policy change.

4.2.4. Capacity building

The community of IOB initiated several initiatives to address flooding issues by establishing IOBCWA and recruiting dedicated members, seeking funding for projects from regional institutions, partnering with other nonprofits to find solutions, and engaging the community to advocate for public policies that address flooding issues due to storms and rapid industrialization. Members of IOBCWA are actively engaged in the city administration by participating in the Planning and Zoning Commission, through which they initiate measures to address coastal flooding issues as part of the commission agenda (City of IOB, 2020). This has assisted with developing community organizing skills, increasing advocacy capacity at local and regional levels through participation in governance and policy decisions, enhancing grant proposal writing activities resulting in attracting resources in the form of research support from area universities, identifying and leveraging funds for small projects, and bringing greater visibility to the environmental issues affecting the region.

4.2.5. Cross-sectoral networking

In 2021, IOBCWA joined five other organizational members of CAPE to form a communications collaborative. CAPE organized its first climate summit in November 2021 that provided the members an opportunity to learn about the climate issues relevant to different communities within the Coastal Bend (CAPE, 2021). The organization's representatives spoke about the ways industrialization and relative sea level rise have adversely affected their communities (Citizens Alliance for Fairness and Progress, 2021; Coastal Bend Chapter - Surfrider Foundation, n.d.; Douglas, 2021), which include dealing with constant anxiety and fear of living near oil and gas industries and large ship vessels (Port Aransas Conservancy, n.d.; IOBCWA, 2019a). Members discussed future steps to address environmental concerns within the Coastal Bend. We also found that IOBCWA established partnerships with regional nonprofit organizations, educational and research institutions, governmental agencies, and for-profit corporations for sharing of resources and information to address coastal flooding. Between 2019 and 2021, there were 12 reports (see Appendix B) drafted by ten different agencies through partnerships. Although these reports suggest that increased ship traffic and/or relative sea level rise are the main causes of coastal flooding in the region, there exist very few flood-mitigation plans or programs to address these issues.

4.3. Regional adaptive capacity

Building upon the findings of the grounded theory analysis, which provides insight into the capacities that are developing at the local scale, we next discuss the findings of the regional adaptive capacity analysis. The results are presented in the following sections based on the categories presented by Hirschfeld et al. (2020) in their Regional Fingerprint framework, including Adopted Actions (AA), Institutional Capacity (IC), Research Quality (RQ), Planning Processes (PP), and Regional Collaboration (RC). Table 2 lists these categories and their associated elements that contribute to regional adaptive capacity and presents the results of our evaluation of IOB's progress toward these elements. Our results indicate that some of the elements of the criterion of the tool were present while others were absent. We depict this in Table 2 by highlighting the present elements and striking the absent ones.

4.3.1. Adopted actions (AA)

In the Sea Level Mitigation Project feasibility study funded by the Gulf of Mexico Energy Security Act funds received from San Patricio County (2019), IOBCWA discussed relative sea level rise and industrialization as drivers of coastal flooding. This resulted in discussions of these topics in the IOB City Council meetings and their inclusion in the city's general plans (AA1), such as the comprehensive plan. However, the San Patricio County hazard mitigation plan (AA2) does not discuss relative sea level rise nor suggest any limitations to industrial development (AA3) to reduce coastal flooding. Further, there has been no action to adopt a formal regional plan with multi-jurisdictional partnerships to address practices that are accelerating the number of flood events in the Coastal Bend region (AA4).

Table 2
Adaptive capacity evaluation of IOB using Hirschfeld et al.'s (2020) Regional Fingerprint tool.

Categories	Elements of Categories	Evaluation Criteria for IOB				
Adopted Actions	AA1: General Plan AA2: Hazard Mitigation Plan AA3: Local Coastal Program AA4: Regional Plan	**AA1**	~~AA2~~	~~AA3~~	~~AA4~~	
Institutional Capacity	IC1: Grant Funding IC2: Internal Staffing IC3: Development of New Funding IC4: Localized Cost Analysis IC5: Champions	**IC1**	**IC2**	**IC3**	**IC4**	~~IC5~~
Research Quality	RQ1: Vulnerability Assessments RQ2: Model & Mapping Tools Used RQ3: Secondary Impacts RQ4: Development of Baseline Data	~~RQ1~~	**RQ2**	**RQ3**	**RQ4**	
Planning Processes	PP1: Public Engagement Strategies PP2: Use of Polling PP3: Vulnerable Communities Identified PP4: Voice for Vulnerable Communities PP5: Inclusive Citizen Science	**PP1**	~~PP2~~	**PP3**	~~PP4~~	~~PP5~~
Regional Collaboration	RC1: Collaborative Structures RC2: Formal Agreements RC3: Permit Procedures	**RC1**	~~RC2~~	~~RC3~~		

Note: The table notes the presence or absence of the elements of the criterion.

4.3.2. Institutional capacity (IC)

Through IOBCWA and other local efforts, the community has been successful in acquiring grant funds (IC1) to help plan for coastal flooding, for example by partnering with Texas A&M Corpus Christi researchers to conduct the drainage study (NSF, 2021). IOBCWA has increased their capacity by contracting its own air monitor technician and engaging volunteers (IC2) who focus on coastal flooding and environmental issues, engaging in legal processes to block industrial permits, establishing outreach for new funding sources (IC3), and developing a localized cost analysis for infrastructure that can protect against coastal flooding (IC4). An example is the cost-benefit analysis conducted for each alternative proposed in the Passing Vessel Hydrodynamic Study by the Port of Corpus Christi (MacDonald, 2019b). However, there is an absence of a local champion among the region's elected officials that could advocate for the implementation of mitigation strategies (IC5).

4.3.3. Research quality (RQ)

IOBCWA has significantly strengthened their research quality through partnerships with researchers to conduct the Sea Level Mitigation Feasibility, Air Quality, and Drainage studies (RQ2). They have identified the key impacts of coastal floods (RQ3) through scientific evidence (IOBCWA, 2020), and continue to collect and analyze relevant data (RQ4) on water quality, air quality, and flooding. However, they are yet to develop a comprehensive vulnerability assessment (RQ1) of all the barriers for developing regional adaptive capacity.

4.3.4. Planning processes (PP)

IOBCWA places substantial effort on planning for the city by employing a range of public engagement strategies from community workshops and education events to preparing community members to speak at public hearings (PP1). Though IOBCWA has presented the relative sea level rise study at city meetings to increase public knowledge on the topic, the polling to gauge public knowledge and beliefs on sea level rise has not been utlized for IOB residents (PP2). Though vulnerable communities are successfully identified (PP3) in some of the studies, a clear vision to include their inputs in the decision-making process (PP4) and their inclusion in citizen science research (PP5) are missing.

4.3.5. Regional collaboration (RC)

At the grassroots level, IOBCWA has established partnerships with CAPE to bring together stakeholders to address sea level rise (RC1). However, there is a lack of formal agreements for collaborative coastal flood mitigation work across jurisdictions (RC2) at the regional level. IOBCWA and other grassroot organizations that work across jurisdictions lack the structure and processes that facilitate collaboration among multiple agencies for permit approvals which can help with strategic planning and adaptive measures for climate change at the regional scale (RC3). More formal, multi-agency agreements and permits will strengthen the adaptive capacity of all grassroots groups in the Coastal Bend Region.

5. Discussion

Findings from the grounded theory analysis suggest that there is a growing need to address coastal flooding due to environmental and industrial drivers, not only in the City of IOB but also in the Coastal Bend Region at large. The pressures of economic development through oil and gas export have led to larger and more frequent ship traffic, which impacts erosion and flooding along the shoreline. The region is also prone to major storms and hurricanes that severely affect the community (Dunning, 2020). We find presence of both structural and non-structural measures to address the impacts of flooding, although these are not consistently applied (Dunning, 2020). As flooding poses multiple challenges, the impact is experienced differently by each resident. While the waterfront and shoreline residents of IOB are more vocal about the issues and engaged in advocacy for policy change, the same engagement is not seen in inland residents that face flooding mostly during storm events. This has made communication of the differing impacts through empirical evidence even more important for the community.

The establishment of IOBCWA has improved the adaptive capacity of IOB by engaging in community organizing, boosting advocacy and outreach to highlight coastal flooding issues, implementing evidence-based data collection and analysis approaches to inform policymaking, building capacity among members and residents, and developing communication network with other regional entities. These are some of the key criteria of adaptive capacity of communities (Whitney et al., 2017) at the local scale and can contribute to increased community resilience to climate change (Adger, 2003; Cutter et al., 2014; Sehrsweeney and Fischer, 2022).

While the content analysis of the empirical study highlighted the growing adaptive capacity of IOB in the local context, its examination in the regional context suggests mixed results. IOBCWA has made substantial progress toward building institutional capacity, supporting quality research activities for policymaking, and engaging in planning processes. This is consistent with communities that are educated and are aware of environmental threats (Dunning, 2020; Peacock et al., 2010). However, our analysis suggests that IOB lacks in three main areas that are important for building regional capacity. First, systems must be developed to improve formalization of assessments, plans, and policies practiced or desired at the local scale. Local planning efforts that consider how land-use planning and hazard mitigation policies can mitigate impacts due to coastal flooding and relative sea level rise could help reduce damages to people and property (Burby et al., 2000). Second, regional partnerships must be established that can help create plans, place community champions in governing institutions, and forge formal inter-agency agreements to address coastal flooding. Regional approaches can help ensure consistency in coastal land-use planning, project permitting, and policy implementation across jurisdictions, leading to more coordinated management of the coastal zone (Lubell et al., 2021). Finally, socially vulnerable communities that are currently lacking representation in the local and regional plans should be included in future mitigation efforts. Efforts to include frontline communities who are disproportionately impacted by environmental hazards can improve mitigation planning efforts by contributing new, local knowledge of environmental threats; enhancing procedural democracy; identifying cost-effective and locally relevant solutions; and increasing distributive justice (Corburn, 2003).

The adaptive capacity evaluation of IOB highlights the need to build strategic interventions at the regional scale which leverage local knowledge. However, there is a common pattern to the flooding challenges for most communities in the Coastal Bend region. The lack of regional data on flooding and the impact of industrial buildout are challenges experienced by communities across the region. Lessons from this study is applicable to other similar coastal towns that are experiencing regional pressures of industrial and economic changes and want to organize to manage the change. An example is the two small coastal communities in the Canadian Pacific Northwest region that have struggled to develop a collective vision to address economic and industrial changes in their community, while maintaining their character, identity, and conserving their coastal greenspaces (Hanna, 2005). Other comparable areas include the coastal areas in Texas and Louisiana experiencing effects from climate change and petrochemical buildout. Since 2015, many coastal communities across the world are adapting to the multiple environmental stressess on their communities after the Paris Agreement emphasized that adaptiation is not a local issue but a global challenge (Cheung et al., 2010). However, little evidence exists about their successes (Cinner, et el, 2018) and our approach of utlizing grounded theory and applying the Regional Fongerprint tool could provide some insights into adaptive processes and their outcomes.

The adaptive capacity evaluation of IOB highlights the need to build strategic interventions at the regional scale which leverage local knowledge. This finding is consistent with other studies that highlight the importance of cross-scale (e.g., local and regional) and cross-sectoral (e.g., governmental and non-governmental) linkages in addressing socio-ecological challenges like coastal flood adaptation (Eakin et al., 2010; Hamilton et al., 2018; Vantaggiato et al., 2023). Given the common challenges of flooding and industrial buildout faced by many communities in the Coastal Bend Region, enhanced regional structures and partnerships can facilitate better alignment between the scale of the coastal flood hazard and the scale at which coordination and planning occurs to promote adaptive capacity and reduce scale mismatch (Cumming et al., 2006). In order for this to be accomplished, it is important to develop a well-planned strategy that includes a strong champion to advocate for context-based environmentally friendly policies and to involve active participation from a wide array of individuals and organizations to create a collaborative effort at protecting the Coastal Bend Region.

6. Conclusions

In this study, we examined the adaptive capacity of Ingleside on the Bay (IOB), a small, rural community in the Coastal Bend Region of Texas facing impacts from coastal flooding. First, we collected empirical data from community residents, local government, and a resident-led community-based nonprofit, the Ingleside on the Bay Coastal Watch Association (IOBCWA), to assess the community initiatives to address flooding and its impacts. Second, the results of the empirical data analysis were examined with Hirschfeld et al.'s (2020) Regional Fingerprint framework to assess IOB's role in regional adaptive capacity.

Our findings provide empirical evidence demonstrating the critical role that community-based organizations play in building adaptive capacity to environmental hazards in small, rural communities. Since its establishment in 2018, IOBCWA has improved the adaptive capacity of IOB by implementing efforts related to community organizing, advocacy and outreach, research for evidence-based policymaking, capacity building, and cross-sectoral networking. These efforts have increased awareness of coastal flooding threats and impacts and have led to the formation of several important partnerships with researchers and other community-based organizations to address the community's challenges.

Despite these advancements, we highlight three primary areas of improvement for IOB that could further enhance regional capacity building. These include (1) developing formalized assessments, plans, and policies that specifically address coastal flooding at the local scale, (2) establishing additional regional partnerships to facilitate cross-jurisdictional planning, permitting, and policy implementation, and (3) including vulnerable and frontline communities in future mitigation efforts. These measures are needed to promote consistent and coordinated management of flood hazards across the local and regional scales and to ensure that adopted plans and policies are responsive to local needs.

Author statement

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dr. Michelle Hummel reports financial support was provided by National Science Foundation. Kathryn Masten reports a relationship with Ingleside on the Bay Coastal Watch Association that includes: board membership.

Data availability

Data is in the Appendix.

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Appendix A. IOB Community Workshop data

Assets	• Water Recreation • Aquatic and other wildlife • Good water quality and water pressure from city water • Locations - Ingleside Cove, Bahia Marina, Berry Island and Spoil Island • Ship traffic keeps circulation in bay
Challenges	• Sea Level Rise (3 mm/year) • Presence of a desalination plant • Quality of water being discharged from ships (Ballast water) • Outdated and aging potable water infrastructure at IOB • Issues with well water (methane/rotting egg smell) • Lack of proper drainage system • Mosquitos from standing water • Erosion • Increase in large ship traffic at the deep end of shoreline • Silting in canals (installed by private owners and not actively dredged) • Livelihoods/ property values (those living on waterfront are affected most) • Bay water not clean enough to swim safely • Area subject to freshwater drought • Community doesn't get alerts about industrial pollution in the area • Collusion between port authority and Corpus Christi to promote industrialization • Nurdles (plastic beads) being discharged • Dredging to prepare for new harbor bridge (murky/cloudy water) and dredge materials being dumped on local islands • Dumping/Trash from ships going through channel • Impacts wildlife
Strategies	• Drainage study of the city • Recycling water especially in industrial settings • Update and replace piping in problematic areas • Have POCCA buy/uphold conservation efforts • Reduce ship traffic to improve turbidity issues • Have U.S. coast guard create a no wake zone between breakwater and shoreline • Have industrial facilities fund the Desalination plant • Have desalination plant water intake and outlet 10 miles off of the coast • Have access to water quality readings and have a benchmark to know if water quality is safe • Proactive approach to set a standard for water quality • Industry provides warnings of pollutants through an alert system (must have ability to sign up for these alerts) • Use community channels such as Facebook to spread important information • Using groundwater (brackish) source for Desal (cheaper) and can supply water for 10 yrs.

(*continued on next page*)

(*continued*)

• Limit MOBA/Enbridge pier from expanding • Solar Plant on MODA land could be beneficial

Appendix B. List of studies conducted since 2019 that document the flooding issues in IOB

Agencies Involved	Agencies	Date	Name of Report/Presentation/ Recording	Purpose
County + Consultants	POCCA + Mott MacDonald	6/18/2019	Passing Vessel Hydrodynamic Study 1	Ship Traffic
State + Residents + Nonprofit	GLO + IOB residents + IOBCWA	10/2/2019	CDBG Mitigation Funding Public Hearing - Corpus Christi	RSLR (Tropical Storms) + Ship Traffic
Nonprofit + Members + Academic Institution	IOBCWA + IOB Residents + TAMU-CC	11/15/2019	Nuisance Flooding & RSLR	RSLR
State + Residents + Nonprofit	GLO + IOB residents + IOBCWA	12/2/2019	CDBG Mitigation Funding Public Hearing - Rockport	RSLR (Tropical Storms) + Ship Traffic
Nonprofit + County	IOBCWA + San Patricio County	12/30/2019	Sea Level Mitigation Project Feasibility Study	RSLR + Ship Traffic
County + Consultants	POCCA + Mott MacDonald	1/21/2020	Passing Vessel Hydrodynamic Study 2	Ship Traffic
City + Consultants	City of IOB + Hanson Engineering	1/21/2020	Drainage Study Masterplan	RSLR (Tropical Storms)
Nonprofit + City	City of IOB + IOBCWA	6/1/2020	RSLR Study presented at the City Council	RSLR + Ship Traffic
Nonprofit + Academic Institution	IOBCWA + TAMU-CC	1/22/2021	Where the runoff begins: rethinking the role of impervious area in urban stormwater management	RSLR (Tropical Storms)
Nonprofit + Academic Institution+ City Residents	IOBCWA + UTA + IOB residents	6/3/2021	Developing Climate Adaptation Pathways with Communities Impacted by Sea-Level Rise and Industrial Development	RSLR + Ship Traffic
Nonprofit + Academic Institution + Residents	IOBCWA + UTA + IOB residents	11/15/2021	Implementing an integrated, wireless monitoring network to enhance decision making in communities impacted by environmental and industrial change	RSLR + Ship Traffic
Nonprofit (local)+ Nonprofit (regional)	IOBCWA + CAPE	11/19/2021	CAPE Climate Summit 2021	RSLR + Ship Traffic

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