Multidisciplinary research of mangrove conservation and reforestation

Executed for the Mekong Delta's Living Lab

E.M. Van Bemmelen
J.J.B. Buysschaert
G.D.C Van Eeuwijk
S.S. Maingay
T. Pennock
N.A.M. Ter Avest

Delft University of Technology

TU Delft

Multidisciplinary research of mangrove conservation and reforestation

Executed for the Mekong Delta's Living Lab

by

E.M. Van Bemmelen
J.J.B. Buysschaert
C.D.C Van Eeuwijk
S.S. Maingay
T. Pennock
N.A.M. Ter Avest

Project duration: September 5, 2024 – November 5, 2024
MDP committee: Dr. Ir. J. Ninan, TU Delft, CME-supervisor
Dr. Ir. D. S. van Maren, TU Delft, HE-supervisor
Dr. Ir. E. Minkman, TU Delft, EPA-supervisor

TU Delft

Preface

This research project was carried out as part of our Master of Science studies at Delft University of Technology. Through this project, we aimed to deepen our understanding of the complex environmental issues surrounding mangrove conservation and coastal erosion in the Mekong Delta. We are grateful to have had the opportunity to explore these urgent topics, which allowed us to gain valuable insights into the socio-technical systems at play in this unique region while simultaneously obtaining hands-on fieldwork experience.

We would like to express our gratitude to our supervisors, Dr. Ir. E. Minkman, Dr. Ir. J. Ninan, and Dr. Ir. D. S. van Maren from the TU Delft, for their expert guidance and constructive feedback throughout this project. Their support has been essential to our work, helping us approach our research from both technical and stakeholder perspectives.

We are thankful to Lindsey Schwidder for facilitating our connections and providing us with the opportunity to travel to Vietnam. Without Lindsey's help, this project would not have been possible.

We are also deeply thankful to Ms. Dr. Phan Khanh Linh from Thuyloi University in Hanoi and Mr. Dr. Phan Manh Hung, Director - Center for Marine and Coastal Resources Research, Institute of Coastal and Offshore Engineering (ICOE) and his team in Ho Chi Minh, who welcomed us warmly and helped us with our research as well as with showing us around. We are thankful for the opportunity to experience the beautiful culture Vietnam has to offer.

Lastly, we would like to thank the Partners for Water program, for funding this report as part of the Living Lab project.

E.M. Van Bemmelen
J.J.B. Buysschaert
C.D.C Van Eeuwijk
S.S. Maingay
T. Pennock
N.A.M. Ter Avest
Hanoi, November 2024

Abstract

The Mekong Delta in Vietnam, one of the world's most fertile and ecologically rich deltas, faces environmental challenges that threaten its biodiversity and local communities. Historically, the delta's extensive mangrove forests provided natural coastal protection, but in recent decades, agricultural expansion, aquaculture, and infrastructure developments have degraded these ecosystems.

This research focuses on Bạc Liêu, a region acutely affected by these changes. With diminishing mangrove buffers, local vulnerabilities to environmental hazards have increased, putting pressure on sea defenses. In response, the Dutch government and Vietnamese partners have introduced the "Mekong Living Lab," an initiative for in-field research that promotes mangrove restoration and sustainable coastal management.

Conducted by TU Delft students, this study contributes to the Living Lab's goals by exploring the causes of mangrove decline in Bạc Liêu. Combining interviews with local residents and field data on coastal profiles, this multidisciplinary approach seeks to safeguard the ecological and economic future of the Mekong Delta.

The study suggests an integrated approach within the Living Lab framework, emphasizing research, showcasing, and education to bridge hydraulic, ecological, and socio-economic perspectives. Priority recommendations include continuous cross-sectional measurements, sediment retention analysis, stakeholder engagement strategies, and further interdisciplinary studies on mangrove viability. These initiatives aim to align technical insights with stakeholder needs, advancing observation-driven solutions for Bạc Liêu's mangrove ecosystems.

Contents

1

Introduction

The Mekong Delta, located at the southernmost tip of Vietnam, is the world's third-largest delta. It features a complex network of rivers and canals that have historically fostered the region's agricultural richness. This vast ecosystem supports both aquaculture and agriculture, making the delta a critical resource for the livelihoods of local communities. The Mekong River is home to the world's largest inland fishery and supplies approximately 70% of Vietnam's rice and fruit production (L. Phan et al., 2015).

Bordered by the South China Sea to the east and the Gulf of Thailand to the west, the delta naturally expanded until the 1980s, when sediment deposits from the Mekong River facilitated its growth. Coastal mangrove forests provide natural protection against storms and coastal erosion. However, due to the overexploitation of mangroves for timber, aquaculture, and agriculture, this natural protection has dramatically declined. A sea dike system was then introduced to protect the land from flooding. (L. Phan et al., 2015).

Since the 90s, human interventions like the sea dike have significantly disrupted these natural processes further. The construction of upstream dams, extensive sand mining, and excessive groundwater extraction caused land subsidence, reversed the delta's natural accretion, and led to further severe degradation of the mangrove forests (Marchesiello et al., 2019). The rapid expansion of aquaculture, agriculture and population growth along the coast has added more pressure on these natural defences. Local communities, heavily reliant on mangroves for both income and protection, continue to exploit them, which in turn threatens the long-term sustainability of the ecosystems.

Mangrove belts, once crucial to both the environment and local economies, have been reduced to mere protective strips, some just over 100 meters wide, or entirely replaced by man-made revetments. The coastal retreat is no longer viable due to almost complete aqua- and agriculture encroaching behind the dike and intense shrimp farming at the seaside along the eastern coast. In many cases, this drastic decline has diminished the mangroves' role, relegating them primarily to functioning as buffers against environmental threats. In certain coastal stretches, the remaining mangroves are insufficiently dense to sustain themselves, thus losing their protective and socio-economic functions (L. Phan et al., 2015).

The phenomenon of mangrove belt decline is notably observable in Bạc Liêu, one of the seven provinces in the Mekong Delta, situated between the provinces of Cà Mau and Sóc Trăng (Figure 1.1). The 56-kilometre stretch of coastline in Bạc Liêu has experienced significant erosion, with some protective mangrove belts disappearing entirely. This has placed stress on the sea dikes and jeopardized the agricultural lands situated behind them (Quang Chien et al., 2018). Bạc Liêu has a population of approximately 900.000 people, with a significant portion engaged in agriculture and aquaculture (Quyen, 2019). Despite ongoing efforts to diversify economically, including investments in tourism and renewable energy, income levels remain relatively low, with the average annual income per capita estimated to be about $2,200 USD (Quyen, 2019). With high poverty rates and limited access to essential resources, the local population is particularly susceptible to environmental challenges. Any disruption in agriculture or aquaculture can lead to severe economic and social repercussions for the region. Unsustainable farming practices, such as the overuse of fertilizers and pesticides, poor waste management in shrimp farms, and the destruction of mangroves, exacerbate these environmental issues (Van Bay et al., 2009).

Figure 1.1: Bạc Liêu province and city

In 2023, the Dutch Government, the Netherlands Embassy in Hanoi, and the Netherlands Enterprise Agency (RVO) collaborated on a study to support the Management Board for Forestry Projects (MBFB) at the Ministry of Agriculture and Rural Development (MARD) in improving mangrove reforestation and restoration along the MKD coast (Stive et al., 2023). Part of this initiative included the proposal for an open-air laboratory called The Mekong Living Lab. The Living Lab addresses the complex socio-ecological challenges of the Mekong Delta, with a specific focus on coastal protection and nature-based solutions like mangrove restoration. The lab's main goals are:

- Knowledge generation: The lab conducts long-term in-field measurements and research experiments to better understand mangrove ecosystems and inform sustainable coastal protection.
- Demonstration: It serves as a platform to showcase coastal management solutions to key stakeholders, including government bodies, NGOs, and local communities.

The lab promotes interdisciplinary collaboration, involving engineers, ecologists, sociologists, and economists, and emphasizes community engagement to ensure the success of mangrove restoration efforts. By integrating theory and practice, the Living Lab aims to shape policy decisions and encourage the adoption of sustainable coastal protection measures.

This initiative is a result of a long-standing partnership between Vietnam's Thuy Loi University and the Netherlands' TU Delft, inspired by TU Delft's Green Village. The research conducted in this report is also part of this partnership. The team consists of six TU Delft students who work on a 'Multi-Disciplinary Project', which is a project containing students of different master studies. The research was conducted by two Hydraulic engineering, three Engineering and Policy Analysis, and one Construction and Management Engineering student. Together these different specializations aim to provide a well-rounded analysis that supports one of the Living Labs projects.

Previous studies have focused on the conservation of mangrove belts and aggradation, accompanied by various coastal intervention strategies (Stive et al., 2023). However, the amount of fieldwork-based studies is very limited. This project will look at the effects and causes of the worsening situation in Bạc Liêu by interviewing local citizens and measuring profiles by hand to obtain accurate data on the situation.

2

Problem demarcation

This chapter outlines the scope and objectives of the research. The report is written from two distinct perspectives, reflecting the multidisciplinary nature of the project. The relationship between the main goal and these perspectives is depicted in a conceptual model, as can be seen in Figure 2.1.

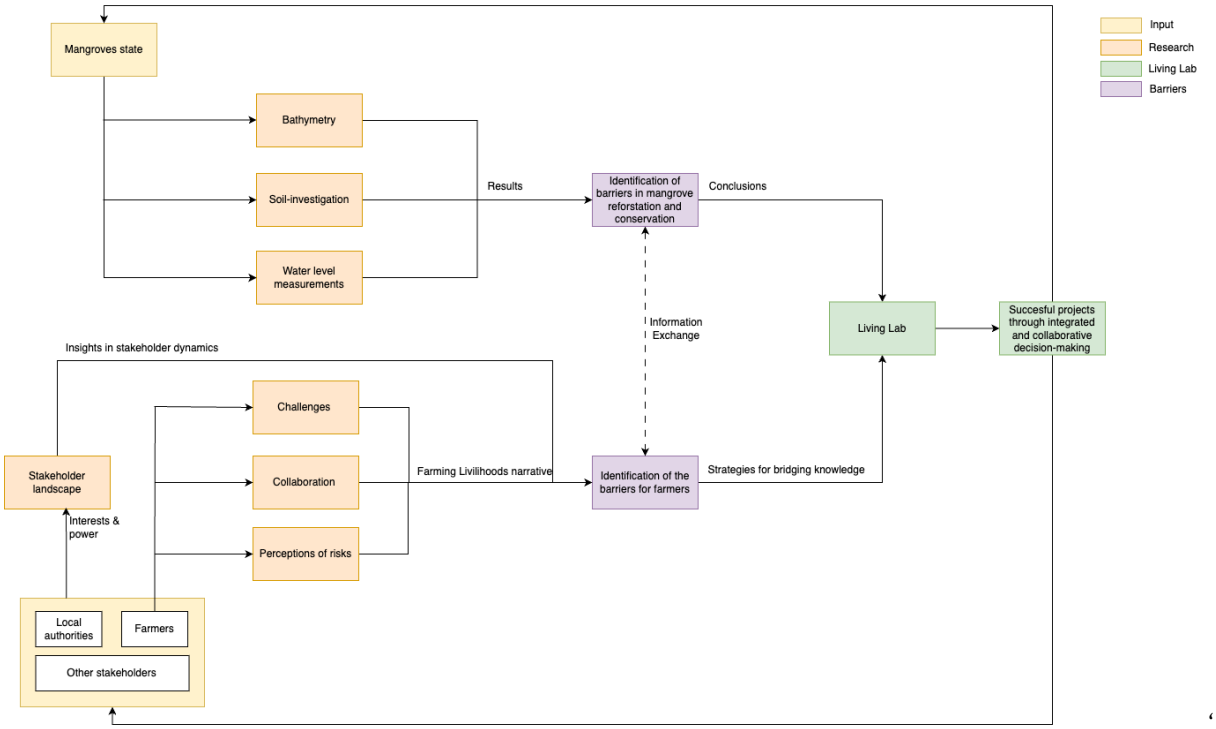

Figure 2.1: Conceptual Model

The model presents a collaborative framework where various stakeholders engage through a Living Lab. As described in Chapter 1, this lab acts as a central hub for information exchange and decision-making, aiming to improve both stakeholder engagement and hydraulic research within the complex socio-technical system of mangrove ecosystems.

The conceptual model illustrates two main research perspectives:

The **hydraulic research** is focused on the failure of mangrove conservation and reforestation in the Bạc Liêu province. For this, three aspects are studied, which are not investigated locally in earlier papers, collected from the coast of Bạc Liêu:

- Bathymetry: Different bathymetries of mangrove sections in different conditional states are collected from the field to analyze the bed height, the foreshore length, and the profile of the tidal flats and their correlation with the conditional state of the investigated mangroves.
- Soil-investigation: Soil samples are collected in the field and analyzed to see if the soil poses a limiting factor for mangrove reforestation.
- Water level measurements: Checking whether the inundation period is not as desired for mangrove conservation and thus an indicator for failure, combined with eliminating possible rehabilitation sites.

The combination of these three collected measurements will be used to assess whether the conditions at the chosen location are favourable for healthy mangroves, to evaluate the limitations of reforestation efforts, and to contribute to additional knowledge for mangrove conservation in a challenging environment.

The **stakeholder dimension** includes four main areas of focus which were performed iteratively:

- Stakeholder landscape: A comprehensive literature study and a stakeholder-analysis is conducted in order to gain an understanding of the dynamics of stakeholders.
- Challenges: This involves gathering insights from farmers regarding their perceptions and knowledge of local environmental issues, particularly in the mangroves.
- Collaboration: Understanding the possible partnerships between farmers, experts, institutions, and other stakeholders to address shared environmental concerns.
- Perceptions of risks: Assessing how local farmers perceive the viability of mangrove systems and their engagement in related projects.

The findings from these areas are used to identify barriers to stakeholder participation and inform strategies for promoting collaboration and sustainable practices.

The conceptual model investigates the integration of stakeholder engagement and hydraulic research, assuming that improved collaboration and knowledge-sharing among stakeholders can lead to more effective conservation practices. The Living Lab might serve as the connecting platform for these fields, promoting sustainable mangrove management through a comprehensive approach that recognizes the need for technical insights and active stakeholder participation.

This conceptual model lays the foundation for the **main research question**:

"How can the Living Lab facilitate integrated hydraulic and stakeholder analyses to develop sustainable, observation-driven solutions for mangrove restoration and conservation in Bạc Liêu?"

The Living Lab's role is structured around three core functions that collectively support the project's objectives (Delft University of Technology, 2024), as can be seen in Figure 2.2. In order to answer the main research question, multiple sub-questions have been formulated. These sub-questions can be directly linked to the Living Lab's core functions, research, showcasing, and education, highlighting how the lab's resources and activities support each aspect of the investigation. This integration allows the Living Lab to address the multi-dimensional challenges of mangrove conservation and restoration in Bạc Liêu.

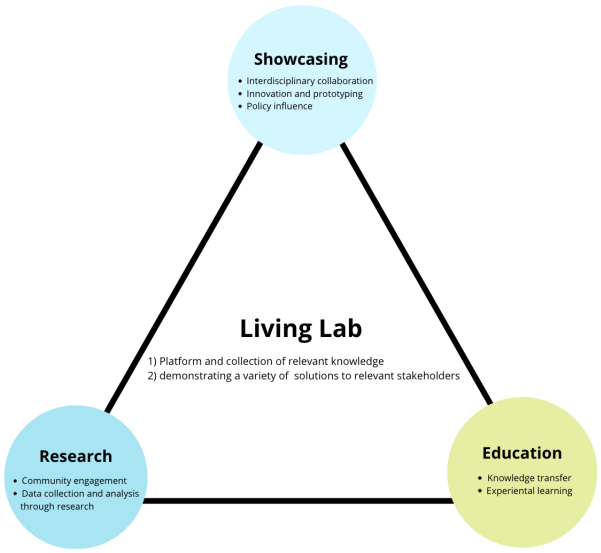

Figure 2.2: Core functions Living Lab

The **hydraulic research sub-questions** are supported by the Living Lab's research and showcasing functions, which facilitate data collection, real-world experimentation, and the testing of innovative solutions:

- *Which conditions are important for mangrove viability?*
- *What are the conditions of the mangroves in Bạc Liêu?*
- *How do the results contribute to existing mangrove reforestation and conservation knowledge?*

The **stakeholder research sub-questions** are supported by the Living Lab's showcasing and education functions, which enhance collaboration and facilitate the sharing of knowledge:

- *What are the most pressing challenges perceived by farmers, and what is their perspective on collaboration in addressing these issues?*
- *What are farmers' perceptions of risks related to aquacultural practices?*
- *How do diverse interests and power dynamics among stakeholders in Bạc Liêu influence implementation and mangrove conservation efforts?*

The combination of these approaches highlights the Living Lab's comprehensive strategy for addressing mangrove conservation challenges. By linking hydraulic research to stakeholder engagement, the Living Lab not only gathers empirical data to inform restoration efforts but also ensures that these efforts are socially acceptable and practically implementable. This holistic approach ensures that the solutions developed are both scientifically sound and aligned with the needs and priorities of the local community.

3

Literature Exploration

This chapter provides a literature review of the shoreline dynamics and erosion trends along the Vietnamese Mekong coastline, with a focus on the Bạc Liêu coast, combined with the requirements for mangroves in this coastal region to survive and rehabilitate. Furthermore, it will focus on the strategies that have tried to enhance this coastline, manage the water resources, and support sustainable development. To finalize, the literature dives into the stakeholder theory, and a stakeholder analysis is conducted.

3.1. Shoreline Dynamics

For successful mangrove reforestation, it is essential to understand the hydraulic conditions and limitations that the mangroves along the Bạc Liêu coast face. Without this knowledge, any proposed rehabilitation measures would be ineffective (Thomas Dunlop and Felder, 2023).

3.1.1. Seasonal Variations

The Vietnamese Mekong Delta experiences two distinct seasons annually: the wet (flood) season and the dry season (L. Phan et al., 2015, Stive et al., 2023). The wet season spans from May to October, driven by the southwest summer monsoon (Marchesiello et al., 2019). During this period, cold winds from the ocean are drawn towards the low-pressure area above the warm Asian landmass (Bosboom and Stive, 2021), resulting in heavy rainfall, humid air, and high temperatures (Stive et al., 2023). This leads to increased river discharge, particularly in September and October, marking the peak of the wet season (L. Phan et al., 2015). The extensive discharge generates a density-driven current towards the Bạc Liêu coast, though this current is weakened by tidal mixing, as discussed in the Subsection 3.1.2. The monsoon winds create a weak southwest-to-northeast current as stated by H. Phan (2020), though it is not dominant (Marchesiello et al., 2019). The winds generate dominant offshore wave propagation in the northeast direction, which drives the potential longshore sediment transport in the same direction. This process is believed to result in sediment being moved away from the Bạc Liêu coastline (H. Phan, 2020). From November to April, the dry season occurs (Stive et al., 2023). During this time, the winds reverse direction and come from the northeast due to the low-pressure zone created by warm ocean waters (Bosboom and Stive, 2021). Rainfall is minimal, and temperatures are milder. The coastal current along Bạc Liêu flows from the northeast, in line with the monsoon winds, and is stronger than the summer monsoon-driven currents (Marchesiello et al., 2019). Severe storms are infrequent in the Mekong Delta, but when they do occur during the wet season, they cause large surges, high winds, and increased wave activity (Tran Thanh et al., 2019).

3.1.2. Tidal Environment

The tidal regime along the Bạc Liêu coastline can be described as irregular and semi-diurnal. On most days, two high and two low tides occur. However, the presence of numerous tidal constituents often results in only one high and one low tide per day, with more diurnal days observed further south (L. Phan et al., 2015). The four main tidal constituents influencing the region are O1, K1, M2, and S2, originating from the Pacific Ocean (Marchesiello et al., 2019). However, the actual tidal environment is more complex, with over sixty constituents acting simultaneously ("Institute of Marine Engineering (ICOE)", n.d.). Due to resonance within the Mekong Basin, semi-diurnal tides are stronger than the global average (Marchesiello et al., 2019). The average tidal range is 2.6 meters, while during spring tides, this can increase to 3.8 meters (Stive et al., 2023). Other studies have reported peak ranges of up to 4.0 meters (L. Phan et al., 2015). The tidal current predominantly flows

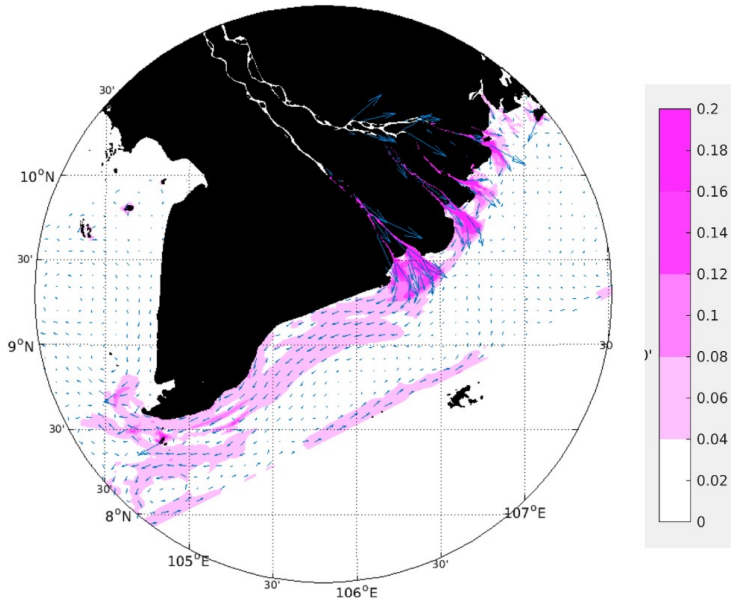

Figure 3.1: 2014 Annual mean currents in the Mekong Delta (Marchesiello et al., 2019).

from the northeast to the southwest, but it is found that a complex radial tidal current occurs in front of the Bạc Liêu coast (H. Phan, 2020). The overall tidal current is in the same direction as the stronger northeastward flow driven by the winter monsoon (Subsection 3.1.1). In the dry season, tidal forces dominate the coastal current (L. Phan et al., 2015). The tidal currents also weaken the density-driven flow from the Mekong River by mixing fresh and saline waters, thereby reducing the salinity gradient (Marchesiello et al., 2019). The tides partly dictate the overall annual current direction, as shown in Figure 3.1, but this tidal current is more complex in front of the Bạc Liêu coast due to the radial point (H. Phan, 2020).

3.1.3. Waves Facing Bạc Liêu Coast

The wave patterns along the Bạc Liêu coast align with the seasonal monsoon changes. During the summer monsoon, waves approach from the southwest, but the Ca Mau Peninsula offers some protection from westerly waves (Marchesiello et al., 2019). Winds from the southwest generate weak alongshore currents, pushing sediment northeastward from the Mekong River mouth (Anthony et al., 2015) and away from the Bạc Liêu coast (H. Phan, 2020). The mean significant wave height in this period is approximately 0.5 meters (Figure 3.2, L. Phan et al., 2015). During the dry season, waves are more intense, originating from the northeast in the South China Sea. These waves generate strong longshore sediment transport along the Bạc Liêu coast, moving sediment westward from the Mekong River mouth (Marchesiello et al., 2019). The mean significant wave height during this period ranges from 0.8 to 1.0 meters, with the highest waves occurring in December and January (L. Phan et al., 2015). Phan found that for both monsoon seasons, the Bạc Liêu coast experienced the least height waves of the eastern coast (2020). Figure 3.3 shows the mean and significant wave height, along with the wave period for each month, measured at the Ho Bach station, 150 kilometres from Bạc Liêu (L. Phan et al., 2015). Extreme storm events can generate much larger waves. For example, during Typhoon Linda in 1997, wave heights of up to 7.2 meters were recorded (Tran Thanh et al., 2019).

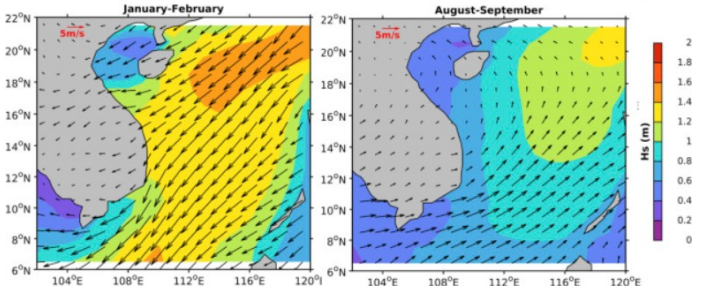

Figure 3.2: Mean significant wave height and direction per season. From Marchesiello et al., 2019

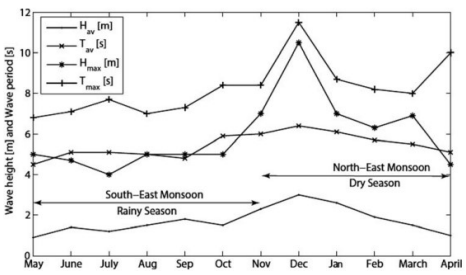

Figure 3.3: Hs, Hmean, Ts, Tmean per month. From L. Phan et al., 2015

3.2. Competing causes mangrove degradation

As discussed in Chapter 1, the Mekong Delta is undergoing significant erosion. This phenomenon was well-documented by Anthony et al. (2015), whose findings remain widely accepted. Historically, sediment dynamics in the Mekong Delta featured accretion along some coastal areas, with sand accumulating near the river mouths and mud dominating further southwest (Anthony et al., 2015). However, recent studies have demonstrated that this sediment accretion has sharply reversed to widespread erosion (Anthony et al., 2015, Stive et al., 2023, Besset et al., 2019).

While Marchesiello et al. (2019) observed that the rate of erosion has not accelerated since 2005, Besset et al. (2019) emphasises the ongoing critical sediment deficit. Coastal erosion creates favourable conditions for mangrove degradation, though the primary cause remains debated. L. Phan et al. (2015) argued that a healthy mangrove belt can promote sedimentation by attenuating short-wave energy. However, the construction of sea dykes and coastal farms has interfered with natural retreat management strategies, resulting in excessive reflection of long-wave energy and tidal currents, which prevent effective sedimentation (L. Phan et al., 2015; Bosboom and Stive, 2021). This is further supported by Stive et al. (2023), who point out that such coastal modifications diminish mangroves' absorption and dissipation capabilities, leading to their thinning and compromised recovery.

Although the concept of 'mangrove squeeze'—where human activities restrict mangrove space—is widely accepted, there is ongoing debate about whether mangrove degradation is a cause or consequence of coastal erosion. Besset et al. (2019) argues that mangrove growth is impossible in areas with a significant sediment deficit, regardless of the width of the mangrove belt, contrasting with L. Phan et al. (2015). While mangroves can trap sediment, they cannot generate it. Therefore, when sediment supply is inadequate, mangrove degradation is a direct consequence of the sediment crisis (Besset et al., 2019). Mangroves may slow down shoreline erosion but cannot prevent it under such conditions.

At the Bạc Liêu coastline, despite hydrodynamics that might theoretically promote sedimentation, this is not observed (Marchesiello et al., 2019). The area is subject to resuspension and re-deposition due to conflicting tidal and monsoon currents, preventing significant sediment accumulation, as mentioned in Section 3.1. H. Phan (2020) put force behind this by stating that due to the contradicting processes in front of the Bạc Liêu coastline, the annual longshore sediment transport potential is almost zero. This aligns with findings by Anthony et al. (2015), who reported that sediment, particularly sand, settles near the river mouths, while less than 2% of mud reaches the eroding eastern coast. The eastern coast is also exposed to the higher wave energy of the winter monsoon, which exacerbates erosion.

Besides the Bạc Liêu coast not receiving much sediment from the river, the sediment supply coming from the Mekong has been rapidly declining. Anthony et al. (2015) was among the first to highlight the effect of sediment trapping behind dams in the Mekong River, while Binh et al. (2020) later modelled the sediment supply time series for the entire Mekong River Basin. Studies found a reduction of approximately 74% of the sediment load due to extensive damming, compared to the pre-dam period when sediment discharge was around 160 Mt/yr. The current sediment load is estimated to be between 40 and 75 Mt/yr. This reduction was not caused by reduced river discharge, but primarily by sediment being trapped behind dams, particularly six mainstream dams in the Lancang cascade in China. Binh et al. (2020) also noted that, although precise figures are difficult to obtain, sand mining likely contributed to about a maximum of 15% of the sediment reduction.

As discussed in Chapter 1, Bạc Liêu province is experiencing significant land subsidence, approximately 2 cm/year (Marchesiello et al., 2019). Without adequate sediment supply, this subsidence leads to shoreline retreat, as described by Bruun's Rule (Bosboom and Stive, 2021). This observation is consistent with Anthony et al. (2015), who found a correlation between subsidence and coastal erosion in Bạc Liêu. If the sediment supply is sufficient, mangroves are able to lift the shore height by approximately 8 mm per year, which will not be sufficient to tackle the land subsidence rates (Besset et al., 2019).
Both Anthony and Besset therefore agree that mangrove degradation is primarily a result of a sediment deficit, combined with human-induced effects. Besset et al. (2019) further argues that if the sediment crisis reaches a tipping point, especially in terms of mud deficiency, the stability of mangrove forests will become impossible to maintain, no matter the length of the mangrove belt.

To counteract coastal erosion, Bạc Liêu has seen a range of coastal interventions, including green, hybrid, and grey structures positioned parallel and perpendicular to the coastline. These structures are designed to reduce wave energy, addressing the issue of mangrove squeeze, while simultaneously promoting sediment de-

position. For instance, a bamboo fence constructed in 2015 initially facilitated sediment accumulation. However, its effectiveness was short-lived, lasting only one monsoon season, as the accumulated sediments were easily flushed away. Similarly, other interventions, such as hollow pile breakwaters and rock pile breakwaters, have yet to demonstrate measurable success in stabilizing the coastline. Given the complex dynamics of the Mekong coast and past evidence showing that an intervention's success in one location does not guarantee its effectiveness elsewhere, it is emphasized that 'No one solution fits all' (Stive et al., 2023).

3.2.1. Implications of mangrove degradation

The socio-economic environment in Bạc Liêu is heavily shaped by environmental factors, such as coastal erosion, tidal inundation, and the degradation of mangrove systems, as will be further discussed in Section 3.3. Because mangroves play an important role in coastal defence and in supporting aquaculture, any decrease in their health can directly impact the stability of local livelihoods. Mangroves help attenuate wave energy and trap sediment through their dense root structures, which contribute to natural flood protection and support local biodiversity. This benefits both aquaculture and agriculture in the region (Thao et al., 2023). Studies indicate that around 73% of the households in Bạc Liêu receive their income through these practices, making the health of these ecosystems an important factor for economic stability (Honga et al., 2022).

The shift from rice farming to shrimp aquaculture in Bạc Liêu is a relatively recent trend, which was mostly driven by economic reasoning. This shift to aquaculture has proven to be profitable, but it comes with environmental challenges in Bạc Liêu's coastal and agroecological systems. Converting rice paddies into shrimp farms brings saltwater to previously freshwater areas, which raises soil and water salinity over time (Vu et al., 2015). The saltwater intrusion associated with shrimp aquaculture does not only affect soil quality but also the quality of the groundwater that farmers rely on (Dung, 2008). When saltwater enters freshwater zones the salinity levels in these water sources gradually rise, a process known as salinization, which limits the use of groundwater for crops or livestock that require low-salinity water (Dung, 2008; Vu et al., 2015). As more areas become brackish for shrimp farming, freshwater zones decrease, which impacts the ecosystem balance and forces many farmers to either abandon traditional farming methods or invest in expensive adaptations to handle the increased salinity (Huynh, 2020).

The seasonal shifts in salinity and water flow patterns, driven by the wet and dry seasons, as mentioned in the Subsection 3.1.1, play an important role in reinforcing these challenges. Mangrove rehabilitation depends on stable water levels, yet Bạc Liêu's wet and dry seasons bring natural fluctuations that complicate this stability. Managing these changes could require expensive water regulation infrastructure, such as water gates. For Bạc Liêu communities, this investment can put tension on their limited budget, which is often needed for essential resources like clean water supply or flood prevention (L. T. Nguyen et al., n.d.). Farmers also may need to change their aquaculture practices because of increased salinity in mangrove areas, which adds tension on their limited budget.

The shift towards shrimp aquaculture in Bạc Liêu has contributed to the loss of mangrove forests, impacting biodiversity, the flood protection functionality, and the essential ecosystem services of the mangroves that local communities depend on (Stive et al., 2023). Huynh (2020) has noted that while this shift to shrimp farming offers short-term economic benefits, it also accelerates environmental degradation, as explained by the mangrove squeeze phenomenon in Section 3.2. The conversion of mangrove areas to aquaculture ponds has not only reduced biodiversity but has also exposed coastal communities to greater risks of flooding and erosion as mentioned earlier in this chapter.

3.3. Mangrove rehabilitation stages and requirements

Mangrove reforestation efforts are being made across the Mekong Delta, including Bạc Liêu, where replanting attempts in front of Nhà Mát have been mostly unsuccessful. Local scepticism is understandable, given that only about 20% of rehabilitation efforts succeed when site conditions are not optimal (Stive et al., 2023). Understanding the specific physical requirements for successful mangrove rehabilitation and conservation in the later life stages is therefore crucial, as emphasized by the Nature-Based Solutions framework proposed by Thomas Dunlop and Felder (2023).

The lifespan of a mangrove forest can be divided into three stages: the pioneer stage, the transitional stage, and the final stage (L. Phan et al., 2015). According to Thomas Dunlop and Felder (2023), the pioneer stage encompasses both the establishment and growth phases, with the establishment phase being most important for successful reforestation.

Mangrove seedlings require an inundation-free period to anchor properly, as without this, seedlings may float and become detached from the shore. Research by Balke et al. (2011) identified this as a "Window of Opportunity" (WoO), critical for early-stage establishment. This study by Balke focused on Avicennia alba, a common pioneer species and also used in Bạc Liêu reforestation efforts (L. Phan et al., 2015; Stive et al., 2023). He found that seedlings need at least 2 centimeters of root growth to resist dislodgement. After reaching 4 centimeters in root length, seedlings could withstand bottom shear stress up to 0.52 N/m^2, a level typically achieved within 8 days of growth, suggesting a minimum inundation-free period of about a week. However, the exact time required for seedlings to achieve this root length can vary depending on local conditions like sediment type and hydrodynamics. Cohesive, fine sediments may provide more stability and reduce the time needed for adequate root growth, whereas coarser sediments might delay root development and prolong vulnerability to uprooting (Balke et al., 2011).

Building on this work, Kibler et al. (2022) highlighted that the main vulnerability of newly planted seedlings lies in insufficient root development. Although Kibler's study focused on *Avicennia Germinans*, the findings were stated to be applicable to A. alba as well. Kibler's research extended the understanding of early-stage mangrove vulnerability, noting that after one month of growth, the failure mechanism shifts to root tensile strength and the complexity of the root system. Sediment size also plays a significant role; finer, cohesive sediments offer greater resistance to uprooting, enhancing the anchorage of young mangroves. Kibler found that in coarse sediments, seedling establishment is significantly less successful. It was also found that young mangroves competing for light allocate more resources to above-ground growth, resulting in a less developed root system. Therefore, providing adequate space between seedlings is crucial to encourage root development and enhance resistance to hydrodynamic forces. The critical current velocity for uprooting mangrove seedlings was identified as 1.50 m/s, consistent with Balke et al. (2011)'s findings that the second critical phase for seedling survival involves outgrowing the hydrodynamic disturbances during early establishment.

Additionally, Hu et al. (2015)'s later research introduced the concept of a second Window of Opportunity (WoO2), which focuses on the role of bathymetry in seedling survival. Convex tidal flats provide better conditions for seedling establishment compared to concave profiles, as they promote wave attenuation, reducing erosion. Convex profiles have gentler upper slopes and a larger horizontal area at higher elevations, leading to longer inundation-free periods, which are critical for seedling rooting (Hu et al., 2015). In contrast, concave profiles, dominated by wave action, are more prone to erosion and have steeper slopes, offering less favourable conditions for seedling establishment.

The initiation of cliff formation proves even more disastrous for seedling survival, as noted by Willemsen (2021) in his research on salt marshes. This process occurs when the seaward edge of a salt marsh is not adequately shielded from high wave forces, leading to the formation of a cliff. Once formed, the cliff accelerates erosion of the adjacent tidal flat and diminishes its wave attenuation capacity. As a result, the environment becomes inhospitable for young seedlings due to the increased hydrodynamic stress. Under normal wave conditions, seaward expansion of the salt marsh is unlikely. Nevertheless, if sediment supply is abundant, the tidal flat may accrete, allowing for wave attenuation and potentially facilitating reforestation efforts. Moreover, elevation gains behind the cliff are possible when low bed-level dynamics and minimal inundation prevail, as these conditions promote sedimentation and reduce hydrodynamic forces, fostering gradual elevation increases in the marsh interior (Willemsen, 2021).

Hanssen et al. (2024) extends upon existing research by indicating that convex tidal flat profiles are more beneficial to tidal flat growth than concave profiles. Convex profiles promote sediment accumulation, which is crucial for the development of suitable conditions for mangrove seedling establishment. Furthermore, Hanssen et al. (2024) demonstrated a relationship between tidal flat length and its elevation relative to the Mean High Water (MHW) level. When hydrodynamic conditions are favourable, longer tidal flats can support higher elevations and gentler slopes, which, in turn, promote seedling growth. Tidal flats shorter than 100 meters, however, are unlikely to rise above the MHW level and thus may be excluded as potential reforestation sites. On top of that, Hanssen et al. (2024) highlighted that coastal interventions, such as breakwaters placed parallel to the shore, may hinder the natural expansion of tidal flats. On the Bạc Liêu coast, shore-parallel breakwaters placed no further than approximately 200 meters offshore significantly limit the potential for tidal flat enlargement, which may diminish reforestation success. Substantial sediment supply is also critical for tidal flat growth. As discussed in Section 3.2, Bạc Liêu's coast is currently experiencing sediment erosion rather than accretion, which further complicates reforestation efforts. Favourable tidal flats for mangrove

class -	*elevation* *[cm + MSL]*	duration of inundation [min per day]	duration of inundation [min per inundation]	species -
1	*<0*	>800	>600	none
2	*0–50*	400–800	450–600	*A. alba* Blume, *Sonneratia sp.*
2*	*50–100*	250–400	200–450	*Avicennia sp.*, *Rhizophora sp.*, *Bruguiera sp.*
3	*100–150*	150–250	100–200	*Rhizophora sp.*, *Ceriops sp.*, *Bruguiera sp.*
4	*150–210*	10–150	50–100	*Lumnitzera sp.*, *Bruguiera sp.*, *Acrosticum aureum* L.
5	*>210*	<10	<50	*Ceriops sp.*, *Phoenix paludosa* Roxb.

Figure 3.4: Required inundation times for different mangrove species by Loon et al. (2016)

seedling growth may thus be in a transitional phase, with their long-term potential for reforestation at risk due to ongoing sediment deficits.

Hu et al. (2015) echoes this and notes that sediment deficits can result in more concave profiles, further reducing the potential for successful mangrove reforestation. In such scenarios, erosion around the root systems, rather than hydrodynamic forces alone, becomes a critical failure mechanism for mangrove seedlings. Complete erosion of the sediment surrounding the roots can dislodge seedlings, making reforestation attempts unsuccessful. Kibler et al. (2022) also emphasizes that after the first month of seedling growth, the primary cause of failure is sediment erosion, not insufficient root strength. This underscores that the sediment deficit along the Bạc Liêu coast is not only responsible for coastal erosion and mangrove degradation but is also a key reason why reforestation efforts continue to fail.

The tidal flat elevation height and the potential to grow under harsh sediment conditions can be decisive factors for the success of reforestation attempts. As stated by Loon et al. (2016) mangrove reforestation attempts mainly fail, because 'hydrological conditions are disregarded'. Very critical hydrological factors are the inundation time and frequency, which are directly influenced by the (convex/concave/cliff) shape and elevation height of the tidal flat. In the pioneer stage, mangrove seedlings need an inundation-free period for roots to settle. However, after this establishment period, mangroves require a certain inundation time and frequency in every life stage, which is different for every species. These inundation times for every species were quantified by Watson J. G. in 1928 and in later research adapted and confirmed by Loon et al. (2016) and shown in Figure 3.4.

Failure to meet the required inundation frequencies often leads to species degradation. As Loon et al. (2016) suggests, a species' survival is closely tied to its elevation. However, the elevation ranges shown in Figure 3.4 apply only to areas with regular semi-diurnal tides. In irregular semi-diurnal tidal environments, such as the Mekong Delta coast, total inundation duration is a more suitable indicator of mangrove survival (Loon et al., 2016).

While Loon et al. (2016) focuses on inundation patterns driven by tidal fluctuations, Erftemeijer et al. (2021) highlights that inundation periods can also be influenced by water ponding and entrapment behind mangrove roots. If only tidal effects are considered in relation to elevation, the actual inundation levels may exceed expectations, potentially leading to the failure of mangrove restoration efforts (Erftemeijer et al., 2021).

When the reforestation process succeeds and the growth phase is established, the transitional stage is reached. In this stage, the pioneer species, having stabilized the area, effectively attenuate wave energy and capture sediment, creating favourable conditions for late-successional species to thrive. Over the course of four to five years, the pioneer species are gradually replaced by these newer species (L. Phan et al., 2015). However, during the transitional stage, it is critical to ensure that the boundary conditions supporting the pioneer species are not exceeded, i.e. the inundation period, as their collapse before the late-successional species can fully establish would result in the failure of both species (Thomas Dunlop and Felder, 2023).

Mangroves are typically found between the mean sea level (MSL) and the highest spring tide (HAT), with the final stage of mangrove development occurring in areas inundated only during high tide, because of extensive sediment accretion. These less harsh conditions allow for a greater diversity of mangrove species to grow (L. Phan et al., 2015). At this stage, the survival of the mangroves is no longer primarily determined by hydrodynamic forces but by broader ecosystem needs. Rather than chronic tidal forces, it is extreme events, such as storms or flooding, that pose the greatest risk to the mature mangroves. Furthermore, as noted by Besset et al. (2019), a lack of sufficient sediment support can also undermine the stability of mangroves during the final stage, making sediment supply a key factor throughout all phases of mangrove development. The resilience of mangrove ecosystems to extreme disturbances relies heavily on effective management practices and resource

availability, both of which are essential for their long-term survival, especially in the face of climate change (Thomas Dunlop and Felder, 2023). A vital component of this resilience is the continuous monitoring and potential restoration of rehabilitation efforts, which necessitates active involvement from local stakeholders who are equipped with "physical and ecological principles" (Loon et al., 2016). As noted by Thomas Dunlop and Felder (2023), projects focused solely on collaboration with engineers and stakeholders involved in flood risk mitigation may fail to leverage the full spectrum of ecosystem services. Likewise, Stive et al. (2023) underscores the critical role of engaging local communities in the ongoing maintenance and conservation of mangrove ecosystems, emphasizing that their participation is essential to the sustainability of rehabilitation efforts. The concept of 'no one solution fits all' therefore also applies to policy interventions and social dimensions (Stive et al., 2023).

3.3.1. Socio-economic challenges regarding hydraulic mangrove requirements

Meeting the hydraulic requirements for mangrove reforestation in Bạc Liêu involves ecological, technical, and socio-economic challenges. As discussed in Sections 3.2 and 3.3, factors like sediment deficit, tidal inundation, and root stability are important for successful reforestation but require large financial investments. Local communities are put under tension as these investments divert funds from basic needs, such as water management to sediment interventions, like hollow pie breakwaters, important for reducing erosion (Tran et al., 2023). The uneven sediment distribution due to complex currents, as discussed in Section 3.1), complicates restoration, impacting fisheries and shrimp farms that rely on natural sediment patterns (Huynh, 2020). The loss of mangroves increases coastal vulnerability to storms, flooding, and erosion, further disrupting agriculture and aquaculture, the primary livelihoods in Bạc Liêu (Tran et al., 2023). These findings call for balanced investment in sustainable aquaculture and reforestation to promote long-term stability (Thao et al., 2023).

Another crucial hydraulic need is controlled tidal inundation. Mangroves thrive within their species-dependent inundation range, as mentioned in Section 3.3. Too much inundation can hinder growth and reduce mangrove density, thus weakening the coastal defence function, while too little reduces essential nutrient exchange (L. T. Nguyen et al., n.d.). The tidal inundation further impacts the region's socio-economic stability as L. T. Nguyen et al. (n.d.) highlights that improper tidal inundation effects result in increased coastal erosion and flooding, which affects agricultural and aquaculture productivity.

These socio-economic challenges show the need for a holistic approach that considers the needs of mangrove reforestation. To explore possible solutions and enhance collaborative efforts, a stakeholder analysis is conducted in Section 3.4.2. This analysis will further examine the roles, interactions, and contributions of various stakeholders in supporting sustainable mangrove conservation and rehabilitation.

3.4. Stakeholders' roles in meeting mangrove conservation benchmarks

For mangrove conservation in Bạc Liêu, it is important to understand the roles of the stakeholders in meeting the benchmarks necessary for the conservation of healthy mangroves. The research mentioned in Section 3.3 highlights hydrological benchmarks that are important for mangrove survival, but it also suggests that due to the complex interaction of hydrological forces and site characteristics, these benchmarks may be difficult to achieve. Reforestation and conservation require the local community to have access to this knowledge and to want to be engaged (Loon et al., 2016). However, little is known about the extent to which the local community, particularly farmers who work directly next to or within the mangroves, is willing to participate in these efforts.

Firstly, assessing farmers' awareness of conservation benchmarks and the broader environmental issues impacting mangroves is essential for fostering informed local decision-making. This awareness forms the foundation for understanding the ecological role of mangroves and their importance to aquaculture and can increase farmers' willingness to engage in sustainable practices (Ngo et al., 2019; Van der Linden, 2015). Farmers' recognition and understanding of the importance of these benchmarks for mangrove conservation may enhance their motivation to adjust farming methods in ways that support conservation, aligning their practices with broader conservation goals. Furthermore, combining science-driven insights with observation-based knowledge can provide a broader perspective, offering predictive data to inform decisions both for immediate needs and long-term sustainability (H. Q. Nguyen, Korbee, et al., 2019, Bradley et al., 2020). Understanding the role of inundation duration in mangrove survival can deliver "quick wins" that help farmers adjust to changing environmental conditions and reduce dependence on reactive, experience-based responses.

Another important aspect is the farmers' openness to new knowledge and practices. Integrating new knowledge on sustainable farming techniques could improve their contribution to mangrove conservation. Assessing their openness to collaboration with local authorities, other farmers, and research institutions can also provide insights into possible improvements in the decision-making of mangrove conservation.

While farmers play an important role in achieving the benchmarks for mangrove conservation, it is equally important to consider the roles of other stakeholders, such as local authorities and research institutions. The climate change risk perception model (CCRPM), MOTA-framework, and stakeholder analysis provide theories and frameworks that can help to understand and clarify these roles (elaborated in section 4.2.1). Using these theories and frameworks helps clarify how different stakeholders have different perceptions and subsequently different approaches to conservation efforts.

3.4.1. Stakeholder theory

Stakeholder theory focuses on the connections of several stakeholders and the importance of addressing their interests and influences to achieve better outcomes (Freeman, 2010). In the context of the system, stakeholders include all stakeholders that interact with or are impacted by the system, such as government institutions, local communities, or international organizations. Stakeholder theory suggests that a system will work more effectively if it engages all stakeholders in the decision-making. This approach is very relevant in complex systems, such as environmental management, because the actions of one stakeholder can affect the broader ecosystem (Reed, 2008). Important principles within stakeholder theory:

- *Inclusivity:* All relevant stakeholders should be included, even those who are often overlooked. By ensuring that every stakeholder feels represented, the system can be more in line with the needs of the entire community (Reed, 2008).
- *Collaboration in decision-making:* decision-making should be shared between all stakeholders. A collaborative approach often leads to more balanced and effective solutions, because of the different knowledge and perspectives of all the stakeholders (Reed et al., 2009).
- *Balancing interests:* Stakeholders can have conflicting goals in many systems. Stakeholder theory tries to find a middle ground in these conflicting interests and aims to find solutions that are acceptable for all parties (Reed et al., 2009).
- *Adaptation:* Many systems are dynamic and change over time. The continuous engagement of stakeholders will make sure that the system adapts to new information and changes in the environment, which can make the system more resilient (Reed et al., 2009).

Besides all the benefits that the stakeholder theory presents, it is important to stay critical. Stakeholder theory has also challenges, some are listed below.

- *Conflicting interests and priorities* can exist among various farmers. Different farmers may have divergent views on project goals, resource allocation, and implementation strategies.
- Engaging a wide range of current farmers from the early stages of a process can significantly *extend timelines and increase initial costs*. The process of gathering input, facilitating discussions, and reaching consensus among diverse groups is often time-consuming.
- It can *lead to scope creep*, where the project's boundaries expand beyond its original objectives to accommodate various resident requests. This can result in project complexity, budget overruns, and diluted focus (Leijten, 2024).

It is important to be aware of these challenges and realize that they can occur. With the right strategies, these challenges can be minimized or even prevented. Different strategies exist but will not be elaborated in order to be concise.

Connecting stakeholder theory to our research in Bạc Liêu will help include the interests and perceptions of all different groups that are affected by the interventions and the mangroves in Bạc Liêu. Stakeholder theory puts an emphasis on involving everyone in the process of decision-making. The research tries to highly consider the interests of the farmers and fishermen, which can make our findings more practical and fair for all stakeholders in Bạc Liêu.

3.4.2. Stakeholder of Bạc Liêu

The stakeholder analysis of Bạc Liêu begins by identifying the key stakeholders involved in the region's environmental and socio-economic landscape. This analysis will be followed by a Power/Interest grid to map their influence and power, furthermore, potential conflicts are drawn from the literature.

Government stakeholders

- National level
  On the national level, there are the higher authorities with decision-making power for policies, subsidies, and regulations. For aquaculture practices and mangroves conservation strategies, the following ministries are respectively key stakeholders:

  - Ministry of Agriculture and Rural Development (MARD)
    MARD oversees state management in agriculture, forestry, fishery, water resources, salt production, and rural development in Vietnam. Its key roles include developing national strategies, policies, and regulations, as well as coordinating public services in these sectors. MARD is responsible for promoting sustainable agricultural development, managing natural resources, implementing rural development programs, and ensuring food security. It also plays a vital role in disaster prevention, disease control for crops and livestock, and protecting ecosystems and biodiversity (Ministry of Agriculture and Rural Development, n.d.).
  - Ministry of Natural Resources and Environment (MoNRE)
    MoNRE is responsible for managing land use, natural resources, and environmental protection in Vietnam. It oversees the implementation of national land use plans, ensures compliance with the Land Code, and raises awareness of land policies and legislation, especially among ethnic minorities. MoNRE also coordinates land use planning at both national and local levels, monitors its implementation, and provides support to provincial and district authorities. Its mission includes promoting sustainable development and environmental conservation through education and regulation (Ministry of Natural Resources and Environment, n.d.).

- Regional level

  - People's Committee of Bạc Liêu Province
    The People's Committee of Bạc Liêu Province develops proposals for the Provincial People's Council and implements its resolutions. It manages provincial budget execution, socio-economic and industrial development, agriculture, infrastructure, and natural resources. The committee focuses on defence, security, disaster prevention, and environmental protection, and implements programs. It also oversees local governance, education, healthcare, and social policies (Committee, n.d.).
  - Department of Agriculture and Rural Development Bạc Liêu (DARD)
    DARD is a specialized agency under the People's Committee of Bạc Liêu Province which is assigned by MARD. It advises and supports the committee in managing agriculture, forestry, seafood, the salt industry, irrigation, and rural development. DARD also handles disaster prevention, food safety in agricultural products, and public services in these areas, as assigned by the People's Committee of Bạc Liêu Province and its Chairman (Department of Agriculture and Rural Development of Bac Lieu Province, 2024).

Research and scientific institutions

Research and scientific institutions play a pivotal role in advancing coastal and marine environmental management in Vietnam. Institutions like the Institute of Coastal and Offshore Engineering and Delft University of Technology are just examples of many organizations contributing to research, innovation, and technology transfer. These institutions focus on areas such as marine dynamics, climate change adaptation, and sustainable development, while also engaging in international cooperation to address pressing environmental challenges.

- Institute of Coastal and Offshore Engineering (ICOE)
  ICOE focuses on scientific research, technology transfer, and consulting in marine engineering and coastal environmental management. Its key areas include research and development of marine dynamics, flood prevention, water management, and climate change adaptation in coastal and island regions.

The institute also provides consulting services for construction projects, environmental impact assessments, and project management related to coastal and marine infrastructure. It engages in international cooperation, human resource training, and the promotion of sustainable development in coastal areas through applied research and technological innovation ("Institute of Marine Engineering (ICOE)", n.d.).

- Delft University of Technology (TU Delft)
  TU Delft is a public institution focused on providing scientific education, conducting research, and transferring knowledge to society. It promotes social responsibility and innovation while contributing to societal development. As a designated public benefit institution, TU Delft is committed to advancing technology and addressing global challenges through its research and educational programs (TU Delft, n.d.).

Private sector stakeholders

- National Investors
  - Wind farm investors
    Invest in renewable energy wind farms, which support local economic development and sustainability. These companies invest in these projects that also integrate with other sectors like aquaculture and tourism. An important investor in Bạc Liêu is Cong Ly Construction-Trade-Tourism (Vo et al., 2019). Wind farms can potentially influence the growth of mangroves. This influence could be due to changes in water flow or sediment positions. The precise effects are still uncertain and may vary based on the specific conditions of a site (Ashley, 2014). Windfarm investors can impact local ecosystems and community interests, which is why they are a stakeholder in this system.

- Aquaculture Companies
  These businesses can be affected by changes in water management and can be important economic stakeholders. Aquaculture companies typically operate on a much larger scale than individual farmers and often use more advanced technology and infrastructure (T. K. L. Nguyen et al., 2023).
- Civil Engineering Companies
  These companies are responsible for the construction and implementation of the hydraulic interventions. Their expertise is essential for the infrastructure projects in Bạc Liêu. For example, Coteccons, a prominent construction company in Vietnam, is involved in many large-scale infrastructure projects across the country (Coteccons, n.d.).

Local community stakeholders

- Local Fishermen
  Can be directly affected by changes in water management and coastal interventions. They highly rely on coastal ecosystems and water management in Bạc Liêu. Changes in the water quality and the sediments can affect fish populations and fishing activities, which can be a threat to their productivity and income (Mcllveen and Hung, 2019).
- Local Farmers
  Shrimp farmers are key stakeholders that are affected by the interventions, especially those farming near mangroves. Different types of (shrimp) farmers have other interests. Ecological farmers, who work in mangroves, focus on producing high-quality shrimp in a sustainable way. Intensive farmers, on the other hand, farm further inland and try to produce a higher quantity of shrimp. Other types of farmers exist in Bạc Liêu, but they are located further from the coast and are not included in this research. The focus is on understanding the different interests of shrimp farmers near the coast (Lan, 2013).

International stakeholders

- International Environmental Organisations and NGOs (IEO & NGOs)
  Advocate for sustainable practices by raising awareness. These organizations often collaborate with local governments, research institutions, and community groups to implement projects that protect the environment, such as mangrove reforestation. They often also advocate for policy changes. International NGOs can provide funding and technical expertise for local projects and they are often experienced in dealing with certain issues in several countries. Examples of these organizations are the International

Union for Conservation of Nature, the Coca-Cola Foundation (International Union for Conservation of Nature, 2024), and the World Bank (Bank, 2024).

- International Investors
  International investors are often involved in the funding of large-scale projects in Bạc Liêu, including renewable energy and water management interventions in Bạc Liêu. These investors provide essential financial support and drive projects for climate protection and economic growth in Bạc Liêu. An example of an organization like this is Delta Offshore Energy (NSEnergy2019).

  – Ministry of Foreign Affairs of the Netherlands The Ministry of Foreign Affairs of the Netherlands is an example of an international investor in the mangrove restoration efforts in Vietnam, specifically through its support of the Mangrove Living Lab. This initiative, part of a broader collaboration between Vietnam and the Netherlands, focuses on combining Dutch expertise in coastal defence and ecosystem restoration with Vietnam's local knowledge. By investing in the lab, the ministry helps fund long-term research, field experiments, and monitoring activities that aim to restore mangroves, an essential natural defence against coastal erosion and flooding, while also enhancing local livelihoods. The ministry's involvement reflects its commitment to promoting sustainable development and international cooperation in climate resilience (Ministerie van Buitenlandse Zaken, 2024).

Tourism-related stakeholders

- Resorts and Recreational Parks (Tourism)
  The development of hotels can influence the land use in Bạc Liêu and the economic activities. Some stakeholders prefer tourism over the conservation of the mangroves because they perceive that tourism will lead to more economic benefits. This highlights the conflict between mangrove restoration and commercial interests in the region (Honga et al., 2022).

3.4.3. Power-interest grid

In the power-interest grid, seen in Figure 3.5, stakeholders are placed according to their levels of power and interest in Bạc Liêu's coastal protection efforts.

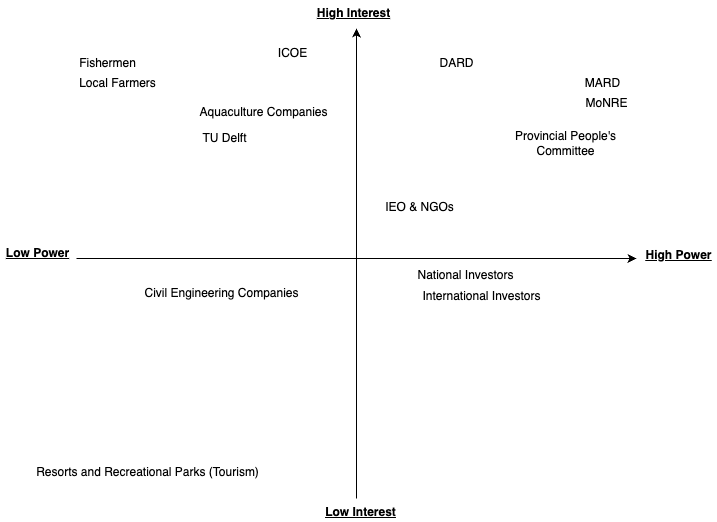

Figure 3.5: Power-Interest Grid for Stakeholders in Bạc Liêu Coastal Protection

High power and high interest (players)
The *DARD* fits within this category because it plays a crucial role in overseeing agricultural policies. Its significant power stems from its control over policymaking and funding, while its high interest comes from the need to ensure that projects protect agri- and aquacultural areas from coastal erosion and flooding, directly impacting Bạc Liêu's agricultural economy. Similarly, the *People's Committee of Bạc Liêu Province* has high power because it coordinates the actions of local governments and manages regional resources. Its high interest stems from the fact that these interventions will directly affect the economy, infrastructure, and environment of the province. The *MARD* and the *MoNRE* also fit here, as both have national oversight over agricultural sustainability and environmental protection, respectively, with strong influence on project outcomes and a vested interest in ensuring their success.

High power but low interest (context setters)
In the high-power but low-interest category, there are the *International investors* and *National Investors*. *National Investors* hold power due to their financial investments in renewable energy projects, which may overlap with coastal areas. However, their primary focus remains on the financial returns from energy production rather than coastal protection measures, placing them in the low-interest zone. Similarly, *International Investors* have significant power because they provide the financial backing for large-scale projects, but their interest tends to be lower as they are more concerned with the profitability and success of their investments rather than the specific impacts on Bạc Liêu's coastal protection.

Low power but high interest (subjects)
Within this category, stakeholders like *Local farmers*, *local fishermen*, *aquaculture companies*, *research institutions* such as *TU Delft* and *ICOE*, and *international NGOs* fit well. Local farmers and fishermen have a high interest in the success of these coastal interventions because their livelihoods rely on the health of mangroves and coastal waters, which are essential for their sustainable practices. However, they have limited influence over policy decisions. Similarly, aquaculture companies are highly dependent on good water management and ecosystem health but have relatively low power compared to governmental agencies or financial stakeholders. Research institutions and NGOs provide essential data, expertise, and global experience, but they lack decision-making authority and control over implementation, leaving them with limited power but a high interest in the environmental success of these projects.

Low power and low interest (crowd)
Finally, the crowd involves stakeholders such as *civil engineering companies*, *tourists*, and *the tourism sector*. Civil engineering companies have a role in designing and implementing projects, but their influence is relatively limited once projects are contracted out, and they primarily focus on fulfilling their contractual obligations rather than engaging in the long-term impacts of these interventions. Stakeholders from the tourism sector have limited power because they are not involved in the decision-making processes related to coastal protection. Their interest remains low unless tourism infrastructure is directly threatened by the interventions or coastal erosion, in which case their engagement might increase.

3.4.4. Competing Interests

Land Use Conflicts: Tourism Development vs. Mangrove Restoration
Both tourism development and mangrove restoration efforts compete for the same coastal land, creating a significant tension between economic growth and the conservation of ecosystems.

- *Tourism Developers* seek to expand coastal resorts and hotels to attract visitors and boost local businesses. However, this leads to the destruction of mangrove ecosystems and other critical habitats, prioritizing financial returns.
- *Mangrove Restoration Supporters*, including IEO & NGOs, and MoNRE focus on preserving coastal ecosystems that provide long-term benefits like erosion control and biodiversity support. Ecotourism has emerged as a potential compromise, blending economic and environmental interests.

Economic Growth vs. Environmental Protection
Bạc Liêu's rapid economic growth, driven by sectors like energy and aquaculture, often comes at the expense of environmental sustainability.

- *Energy Sector and Wind Farm Investors* prioritize renewable energy projects that create jobs and boost

the local economy, but these initiatives frequently neglect the environmental costs, such as the disruption of coastal ecosystems.

- *Aquaculture Companies* contribute significantly to the local economy through shrimp farming but engage in unsustainable practices like overexploitation of water resources and deforestation of mangroves. This short-term focus undermines long-term ecosystem health.
- *Tourism Developers* prioritize the construction of resorts and hotels to drive rapid economic growth, often resulting in conflicts over land use for mangrove restoration. This preference for beach resorts leads to habitat destruction.
- *Local Government* often prioritizes immediate economic gains through infrastructure projects that create jobs, despite recognizing the need for environmental conservation. Economic pressures often take precedence over sustainable planning.
- *IEO & NGOs* advocate for the protection of mangroves, sustainable water management, and long-term ecological health. They frequently oppose projects that prioritize short-term profits over environmental sustainability.
- *Research Institutions* provide evidence-based insights on the benefits of protecting mangroves and promoting sustainable development, emphasizing the long-term ecological and economic value of healthy ecosystems.
- *Local Farmers and Fishermen* depend on healthy ecosystems for shrimp farming and breeding stocks. While they support conservation measures for long-term benefits, they are also motivated by the need for immediate financial returns. This dual focus drives their support for both short-term solutions and long-term sustainability.

Short-Term Profits vs. Long-Term Sustainability
Many sectors prioritize short-term financial gains, creating a significant challenge for long-term sustainability efforts.

- *Civil Engineering Contractors* focus on delivering infrastructure quickly and efficiently, with little attention to the long-term environmental impacts of their projects.
- *Tourism Developers* favour rapid expansion for immediate economic benefits, but this approach results in habitat loss and compromises future sustainability, especially for ecosystems like mangroves.
- *Wind Farm Investors* drive renewable energy initiatives that benefit the economy in the short term, but the long-term environmental consequences, such as coastal ecosystem damage, are often overlooked.

National vs. Local Government
A tension exists between national and local governmental priorities, complicating the implementation of sustainable practices.

- *National Government*, particularly through MARD, often focuses on large-scale infrastructure projects to stimulate growth. These projects, such as coastal defences, may not always align with local environmental needs.
- *Local Government* understands the immediate impacts of development on communities dependent on ecosystems, such as farmers and fishermen. However, they face resource limitations and often must prioritize short-term economic growth over longer-term sustainability efforts.

The competing interests between economic development and environmental protection in Bạc Liêu reflect a broader struggle for sustainable growth. Short-term economic projects in tourism, energy, and aquaculture frequently clash with long-term sustainability efforts supported by IEO & NGOs, research institutions, and local communities. This conflict is further complicated by the misalignment of priorities between national and local governments, intensifying the challenge of balancing economic development with environmental conservation.

3.5. Identification of knowledge gaps

Existing literature emphasizes the ecological and technical challenges of mangrove conservation and reforestation but lacks an in-depth understanding of stakeholder perspectives, collaboration dynamics, and practical implementation challenges in the region. This section knowledge highlights areas where this research will contribute new insights.

Farmers play an important role in the long-term sustainability of mangrove ecosystems, as their practices and attitudes toward conservation directly affect mangrove health (Thomas Dunlop and Felder, 2023). Despite this, limited research explores the specific challenges these farmers face, such as salinity fluctuations and erosion. This research aims to provide a better understanding of the challenges that shape the daily lives of the farmers. Clarifying the roles and responsibilities of diverse stakeholders, including government agencies, local communities, and research institutions, is also vital to effective mangrove management in Bạc Liêu. Enhanced role definition could improve coordination to address hydraulic requirements for mangrove reforestation, such as tidal windows (Section 3.3) and economic requirements by the farmers.

In the hydraulic field, there is a notable lack of research based on fieldwork. When studies utilize locally acquired data, they often focus on a single specific environment. This research aims to analyze cross-sections from various environments to identify relationships and differences among them. The analysis will be conducted from three perspectives: bathymetry, inundation, and soil characteristics. By gathering this data, we hope to uncover and confirm key factors that are critical for mangrove conservation and reforestation efforts.

4

Methodology

This chapter discusses how data is collected to answer the research question. Technical data is acquired through in-field measurements at selected shore cross-sections. For the Stakeholder dimension, information is gathered through interviews with local farmers and authorities.

4.1. Cross-shore Analysis

To assess the failure of mangrove conservation and reforestation, specific cross-shore attributes were selected for study. These included height profiles, sediment composition, and the duration of inundation periods experienced by the mangroves.

Comparative analysis was conducted on cross-shore sections representing various mangrove conditions, categorized as healthy, unhealthy, undergoing reforestation, successfully reforested, and unsuccessfully reforested. Given the overall erosion trend along the Bạc Liêu coastline, as discussed in Section 3.2, all mangrove belts were considered unhealthy. For this study, further distinctions were made between healthy and unhealthy mangroves based on sediment stability and erosion severity, following consultations with the ICOE (personal communication, September 2024). "Somewhat healthy" mangroves were defined as those growing on stable sediment beds with minimal erosion, while "unhealthy" mangroves were found on heavily eroded cliffs or exhibited clear signs of degradation, such as fallen trees.

The success of reforestation efforts is determined by whether mangrove seedlings have survived for at least one year. In addition to collecting cross-shore topographic profiles, sediment samples were taken from both successful and unsuccessful reforestation sites. These data, combined with tidal records which are checked with field measurements, provide the basis for a thorough cross-shore analysis aimed at addressing the research questions in Chapter 2. The resulting dataset, which includes bathymetry, sediment composition, and inundation periods, will show insights that have not been previously explored.

4.1.1. Bathymetry Profile

Study Area

Field reconnaissance was conducted along a 16-kilometre stretch of the Bạc Liêu coastline. Five shore sites were selected based on their accessibility for field measurements and their suitability for comparison between different mangrove stages, as described above, and reforestation efforts, as outlined in Section 3.3.

- **Cross-section 1**: Located at the Bạc Liêu border near Soc Trang, this site was undergoing reforestation with newly planted mangroves observed. The planting date was not known, but the mangroves were estimated to be less than a year old, while they were very short. This section is therefore in the pioneer stage. Only half of the tidal flat was accessible for measurement.
  Coordinates: 9.244933, 105.826776.
- **Cross-section 2**: This site, situated 1.5 kilometres east of Nhà Mát pier, consisted of a mature mangrove belt and a gently sloping but extensive tidal flat. The mangroves were mature, but only a few species were observed, namely mangroves of the Avicennia species, as stated by the Forester of Bạc Liêu seen in Appendix G. Therefore, this cross-section was deemed to be in the transitional stage. The belt was unhealthy, with clear signs of erosion observed. However, the erosion was not as extreme to form cliffs at the front between mangroves and tidal flats.
  Coordinates: 9.209505, 105.756407.

Figure 4.1: Bạc Liêu province

- **Cross-section 3**: Located approximately 800 meters east of Nhà Mát pier, this site contained a section with younger mangroves that could have remained from the last failed reforestation attempt at Nhà Mát in 2019, see Appendix G. Based on their height, the seedlings were estimated to be more than a year old. However, they were quite small for six years' worth of growth, thus the seedlings could also be planted naturally. Measurements were taken within the neighbouring mangrove belt, as this was the only accessible area. Efforts were made to measure as close to the younger mangroves as possible. This cross-section will be used to analyze why mangrove seedlings from the reforestation attempt only survived in this area.
  Coordinates: 9.206860, 105.752086.
- **Cross-section 4**: At the Nhà Mát pier, reforestation attempts have been unsuccessful, with the last failed attempt in 2019, see Appendix G. Therefore, this site will be used as a comparison for unsuitable reforestation conditions. The tidal flat showed no signs of irregularities in topography.
  Coordinates: 9.203716, 105.744780.
- **Cross-section 5**: At the Hoa Binh 1 Windmill Park pier, the site featured a mature mangrove forest consisting of multiple species, which was assessed as representing the final stage. Directly adjacent was a successfully reforested area, planted in August 2023 as stated by the Forester of Bạc Liêu in Appendix G. The presence of hard cliffs, reinforced by a bamboo fence, indicated significant erosion, leading to the site being classified as unhealthy. Coordinates: 9.186046, 105.696873.

For more detailed findings from the field reconnaissance, refer to Appendix A.1.

Survey equipment
The Trimble R8s RTK GNSS device was used to measure topographic profiles, also referred to as bathymetries. RTK GNSS, which stands for Real-Time Kinematic Global Navigation Satellite System, comprises a fixed base station, a portable rover (receiver) with controller, and satellite connectivity. Multiple GNSS satellites determine the position of the base station with many different frequency bands to ensure accuracy. Subsequently, the base station transmits these signals to the rover, and via triangulation calculation between the base station, rover, and the satellites, the rover's precise location can be determined with an accuracy of approximately 1 centimetre in both vertical and horizontal dimensions. In this paper, the CORS (Continuously Operation Reference Station) was used as the base station, which can quickly provide a location and upload its data via the internet to form a network (ICOE personal communication, 2024). The rover's controller enabled data point collection as required (Company, 2023; Limited, 2015). At locations where accessing the tidal slope on foot was not possible, measurements were conducted from the pier. In these instances, a rope was used to lower the RTK device onto the tidal bed for data collection, resulting in a higher error margin compared to direct foot-based measurements due to the increased distance and potential movement of the device during placement.

Bathymetry data collection approach
To obtain accurate bathymetry measurements for comparison, the survey focused on several key areas. Where feasible, the entire mangrove belt in front of the shoreline was measured, but additional care was taken to capture at least the final section of the mangrove belt before the tidal flats. This transition between the mangrove zone and tidal flat was used as a reference point to align all the bathymetries. The length of the tidal flat was measured to the fullest extent possible, as its importance was discussed in Section 3.3. Measurements were taken at a horizontal resolution of five meters, although deviations occurred due to accessibility challenges. Survey lines were oriented perpendicular and straight to the coastline as allowed by the cross-sectional conditions. The execution of the bathymetry data collection can be found in Appendix A.2.

Calibration to reference level
Additional measurement points were taken at the water level to align the measured bathymetries with the local Vietnamese vertical datum. By recording the time and vertical height of each measurement, the water level data were compared with tide predictions from Gành Hào Station, approximately 40 kilometres east of Nhà Mát. This allowed for the conversion of all vertical bathymetry measurements to the Vietnamese vertical datum. Although this distance may have introduced tidal fluctuations, Gành Hào Station was the closest available tide measurement location, making it the best option for calibration. Furthermore, because it is a 'regular astronomical phenomenon, its predictability is quite accurate, if extreme events are not considered (Bosboom and Stive, 2021), and therefore this data set is deemed sufficient.

Data collection
RTK GPS positional data and depth measurements from the echosounder were logged simultaneously on a dedicated onboard computer. RTK corrections were received in real-time, ensuring high precision for depth soundings, which were stored in VN-2000 / TM-3 zone horizontal and vertical datum systems. The resulting data file was a '.txt' file containing the longitude, latitude, height, and notes of the bathymetry. The collected dataset underwent post-processing using Python. Initial steps involved identifying and removing outliers from depth readings, as well as excluding erroneous soundings to ensure data integrity. Once the dataset was cleaned, it was divided into six distinct files corresponding to the individual cross-sections of the study area. The distance between each consecutive point in the dataset was computed using the Pythagorean theorem, ensuring accurate spatial measurements. Finally, an additional column was appended to each dataset, capturing the cumulative distance across the points, thereby providing a continuous measure of the total distance traversed. The final output was plotted using Python and QGIS.

4.1.2. Inundation period
To analyze the effect of inundation periods on different stages of mangrove development, the study combined tidal data with field measurements of inundation duration. Predicted tidal data were obtained from the ICOE MarineMekong website, which provides annual tidal forecasts incorporating all relevant tidal constituents, as discussed in Subsection 3.1.2 (personal communication, September 2024). For the Bạc Liêu coastline, the tidal data from Gành Hào Station were used to calibrate the bathymetry, as detailed in Subsection 4.1.1.

Field measurements supplemented the predicted tidal data. A ruler was placed vertically at two bathymetry locations with approximately known heights, which would later be extracted from the bathymetry data. These measurements took place at cross-section 4 and cross-section 5, corresponding to a failed and a successful reforestation attempt, respectively. The ruler was positioned during low tide, and the experiment began when the rising tide first reached the underside of the ruler. The high water mark was noted based on the tidal predictions once no significant water level changes were observed. The retreating tide was recorded when the water fell below the ruler. Residual puddles in the tidal flat were not considered part of the inundation period.

The ruler measurements were then compared to the predicted tidal data and bathymetry levels, providing independent validation of the inundation periods beyond reliance on predictions alone.

The predicted tidal data underwent post-processing to extract key metrics, including Mean Sea Level (MSL), Mean High Water (MHW), Mean Higher High Water (MHHW), Mean Lower High Water (MLHW), Mean High Water Spring (MHWS), and Mean Low Water (MLW). Additionally, hourly predicted tide levels for the entire year were compiled into a cumulative probability distribution function (PDF) to assess the total percentage of inundation time for each bed level height relative to the Vietnamese reference datum.

These predicted values, together with field measurements, were used to compare inundation characteristics across different shore bathymetries and mangrove condition states, as described in the Subsections 4.1.1 and 4.1.1. Additional findings and occurrences during the field measurement are shown in Appendix A.3.

4.1.3. Soil analysis

Soil samples from cross-section 4 and cross-section 5 were analyzed for sediment content and moisture levels. At cross-section 4, the ICOE collected three soil samples from the tidal flat, which will be used to assess the failed reforestation attempt. At cross-section 5, a total of four samples were collected: two from the heavily eroding cliff and two from the successful reforestation area. Two samples were taken at each location to minimize the impact of irregularities on the overall soil content assessment. A detailed description of soil sample acquisition is provided in Appendix A.4.

4.2. Socio-technical research approach

Two frameworks along with the stakeholder analysis, as conducted in Section 3.4.1, provide the foundation for framing the interview questions. These frameworks guide the analysis of farmers' awareness, experiences, and challenges, offering insights critical to developing management plans that reflect farmers' realities.

The initial research plan involved conducting interviews with farmers in two phases: an initial phase with exploratory questions, followed by a Q-methodology assessment to delve deeper into farmers' perceptions and preferences. Additionally, interviews with local authorities are designed to uncover their decision-making processes, resource allocation strategies, and views on the role of farmers in mangrove management. Subsections 4.2.1 and 4.2.2 will shortly explain the frameworks that are used. A deeper explanation of these theories is provided in Appendix B. Subsequently, Subsection 4.2.3, will elaborate on the reviewed research approach, as some adjustments were made.

4.2.1. Introduction to theoretical frameworks

The first model, a combination of theories, that is used, is called the **Climate Change Risk Perception Model** (CCRPM). The CCRPM, which is based on four theories, is designed to understand how people perceive and react to environmental risks. Its four dimensions are cognitive factors, experiential processing, socio-cultural influences, and socio-demographic control variables. CCRPM enables researchers to identify factors that shape how communities perceive risks, such as coastal erosion, and how they respond to conservation or reforestation efforts. While this research is not mainly focused on climate change, this model gives a useful framework for understanding attitudes and perceptions. By applying this model, insights can be gained about whether factors influence the stakeholders' support or resistance to some projects, regardless of their link to climate change (Van der Linden, 2015).

The second framework used is called the **Motivation and Ability Framework** (MOTA). This is a practical framework for assessing the motivation and ability of individuals and/or communities to adopt new behaviours. It examines two main components: motivation (the reasons or incentives that drive the behaviour) and ability (resources, skills, and knowledge that are necessary to act). In the context of mangrove rehabilitation, MOTA helps determine whether stakeholders are able and willing to participate in conservation and reforestation initiatives and what factors are lacking to incentive motivation and ability (H. Q. Nguyen, Patiño Guerra, et al., 2019).

Farmers were chosen as the primary focus for applying these frameworks because their interactions with mangrove systems are more frequent and direct compared to other stakeholders. This direct engagement makes farmers' perspectives crucial in assessing the practical challenges and opportunities for mangrove reforestation and conservation in Bạc Liêu. Moreover, local communities face multiple socio-economic challenges regarding the degradation of mangroves due to their dependence on mangrove ecosystems for fishing and farming. The loss of mangroves affects their livelihoods by increasing exposure to coastal erosion and storm surges, which threatens income stability and food security (Tran et al., 2023).

4.2.2. Application of the CCRPM and MOTA-framework

By systematically applying CCRPM and MOTA to this research, this study captures the perceptions of risks and the motivation and ability regarding reforestation and conservation efforts in Bạc Liêu. Below is an outline of how each component of these frameworks can be directly applied in research to gain the necessary insights. More information on the CCRPM and the MOTA-framework can be found in Appendix B.

1. **Cognitive factors and knowledge awareness (CCRPM):** This dimension assesses the farmers' knowledge and understanding of hydraulic challenges, ecological challenges, and social challenges. By analyzing

how well farmers understand the challenges faced and how they have gained their knowledge, an evaluation can be made of their overall awareness and identify potential knowledge gaps (Van der Linden, 2015).

2. **Experiential processing (CCRPM):** Experiential processing evaluates whether farmers have personally encountered certain challenges, such as flooding, erosion, pollution, or increased salinity in their water resources. Direct exposure to these issues among farmers can reveal how lived experiences shape their perceptions and concerns about mangrove degradation (Van der Linden, 2015). Insights from this dimension address the knowledge gap regarding the challenges farmers face in their daily lives.
3. **Socio-cultural influences and community values (CCRPM):** Socio-cultural influences assess how community values and beliefs shape farmers' perceptions of mangrove reforestation and conservation efforts. This component analyses how farmers' socio-cultural contexts affect their priorities and willingness to support or oppose policies for mangrove conservation, addressing the knowledge gap in understanding farmers' socio-economic and cultural perspectives (Van der Linden, 2015).
4. **Socio-demographic control variables (CCRPM):** Socio-demographic factors, such as age, education, and income levels, may affect farmers' perceptions and their motivation or ability to participate in mangrove reforestation. This dimension provides essential context for interpreting differences in motivation, ability, and responses to environmental risks (Van der Linden, 2015). This could address a knowledge gap in the influence of socio-demographic control variables on the other dimensions as well as on the risk perspective on reforestation and conservation.
5. **Motivation to engage in reforestation or conservation efforts (MOTA):** The motivation component of MOTA explores the reasons or incentives that encourage farmers to participate in rehabilitation initiatives. This dimension is important for understanding whether farmers want to support conservation measures and, if so, why (H. Q. Nguyen, Patiño Guerra, et al., 2019). By analyzing farmers' motivation to engage in mangrove protection, this research addresses the knowledge gap concerning how specific socio-economic realities impact their commitment to conservation. Knowledge from the CCRPM model can also help assess the level of motivation within the MOTA analysis.
6. **Ability for reforestation or conservation efforts (MOTA):** The ability dimension assesses whether farmers have the resources, skills, and knowledge necessary to participate in rehabilitation efforts. Understanding their capacity to manage challenges is important for assessing their practical capability to support mangrove conservation (H. Q. Nguyen, Patiño Guerra, et al., 2019). This dimension addresses the knowledge gap around issues that farmers face, as it identifies limitations. As with motivation, insights from the CCRPM model can highlight strengths or inadequacies in their abilities.

4.2.3. Reviewed approach

The original approach for interviewing farmers and local authorities was adjusted to address practical limitations. Factors such as dependency on local authorities, coordination with a translator, and limited control over logistics necessitated a flexible, iterative process for the interviews. Consequently, interviews were conducted in three sequential rounds, with each round containing a refined set of questions. Further details on the limitations encountered are provided in Chapter 7.

Interview Farmers I: Understanding the context

The primary goal of the first interview round was to understand the perspectives and challenges faced by both ecological and intensive shrimp farmers in Bạc Liêu. These interviews focused on identifying the unique motivations and challenges of different farming practices, with questions adjusted based on feedback from the translator. The questions can be found in Appendix C.1

For ecological farmers, the focus was on understanding their approach to shrimp farming within the mangroves, as well as the perceived benefits and challenges associated with their farming methods. For intensive shrimp farmers, the questions centred on land use and aquaculture practices outside mangrove areas, exploring their views on productivity and any conflicts with other stakeholders. This framing of the first interview round allowed for the establishment of baseline perceptions and concerns among ecological and intensive shrimp farmers.

Interview Farmers II: Collaboration and primary problems

During the first round of interviews, many responses were observed to be similar, indicating a need for further refinement of questions to obtain more specific insights. Given these initial findings, along with time

constraints and logistical limitations in the interview process (Chapter 7), the Q-methodology was considered unsuitable at this stage.

The second round of questioning focused on farmers' experiences with collaboration, both with local authorities and other farmers, as well as identifying their primary challenges. Key concerns, such as pollution, were explored in greater depth to uncover the most pressing issues. A semi-structured interview format was adopted, as can be seen in Appendix C.2, allowing room for follow-up questions based on the farmers' responses. This approach aimed to capture more detailed and precise information without restricting participants' answers.

Interview Farmers III : Perceptions
The third round of interviews shifted focus to understanding farmers' awareness and perceptions of environmental issues in the region. This approach provided an opportunity to analyze their attitudes toward environmental conservation and their understanding of long-term impacts on their livelihoods. Additionally, questions assessed farmers' perspectives on community collaboration and external support.

In previous interviews, farmers had expressed concerns regarding pollution and erosion, yet there was limited information on their views regarding possible causes, such as climate change or advanced aquaculture practices. This final round, which can be found in Appendix C.3, tried to deepen understanding of farmers' attitudes toward mangrove protection and potential collaborations.

DARD Bạc Liêu
In the interview with representatives of the DARD in Bạc Liêu, the objective was to understand their role and perspective on managing erosion, flooding, and mangrove restoration in the region. Interview questions focused on the tasks of DARD, their decision-making processes, and the challenges encountered in implementing interventions, as well as their interactions with local farmers.

To gain insight into the broader relationship between DARD and local farmers, questions were included on DARD's awareness of socio-economic issues faced by farmers and how these issues are perceived in relation to DARD's objectives. This provided an understanding of whether DARD integrates socio-economic considerations into their environmental strategies and their willingness to cooperate with local farmers. Additionally, questions addressed the types of support or resources that DARD considers necessary to enhance their efforts in mangrove restoration and protection, potentially revealing resource needs and areas for further governmental or external support. The questions for this interview can be found in Appendix C.4

Mangrove Management Board
Upon arrival in Bạc Liêu, the existence of the Mangrove Management Board was initially unknown. However, during fieldwork, the Board's involvement in local mangrove efforts was recognized, and their presence during all farmer interviews allowed for questions about their roles and responsibilities. Interviews with the Mangrove Management Board aimed to clarify their specific duties and contributions to DARD policies. Questions, as can be found in Appendix C.5 focused on practical measures they implement, coordination efforts, and challenges encountered in sustaining the mangroves.

Initial questions provided insights into the Board's responsibilities within Bạc Liêu's broader environmental strategies, exploring the types of interventions the Board has implemented to prevent erosion and flooding and how these efforts are coordinated with local authorities and other stakeholders. Additionally, practical and logistical challenges faced by the Board were identified, including issues with resource acquisition, technical difficulties, or potential conflicts of interest.

Further questions addressed the Board's interactions with local farmers, specifically their methods of engaging farmers in planning and decision-making processes. The Board's views on farmer participation highlighted both the importance and limitations of community engagement. Lastly, the interviews covered the resources and support required from the government to improve the Board's effectiveness. This information helps reveal potential gaps that could be addressed through external support or policy adjustments.

5
Results

This chapter presents the results obtained from the field research, providing a detailed overview of the findings. First, the results, and their interpretation, of the hydraulic research are presented, followed by the results of the stakeholder analysis.

5.1. Hydraulic findings

An overview of the fieldwork is shown in Figure 5.1. These results will be discussed in the following subsections.

5.1.1. Bathymetry profile

The bathymetry was split up in the following cross-sections:

- **Cross-section 1** is the short span of 15 data points that were taken walking across the new cross-shore breakwater. This location was characterized by a revetment on the dike with a mudflat going to the rock pile wall. The first point is taken on top of the dike at 3.8 meters high. After one more point on the side of the revetment, the points were taken on the mudflat. After 15 points the path became untraversable.
- **Cross-section 2** is the longest cross-section containing 41 data points taken through diverse terrain. The first 23 data points were acquired by measuring at the edge of the forest as depicted. The remaining points were taken by walking through the mudflat.
- **Cross-section 3** is the shortest section of only 5 points due to poor accessibility. Points are taken on the mudflat beside the reinforced ground by mangrove roots.
- **Cross-section 4** also started with the first measurement on the top of the revetment and the second halfway down the revetment. After this, 2 separate lines are visible on the GIS image. This is due to the first attempt of 7 points being obtained through the mudflat by foot, which failed, and the continuation of the measurement from the pier.
- **Cross-section 5** was taken from the windmill farm pier. After 9 points the measurements were switched to the other side of the pier to obtain a better connection. Visible here in the graph is the steep cliff at the cross-over point from mangroves to mudflat

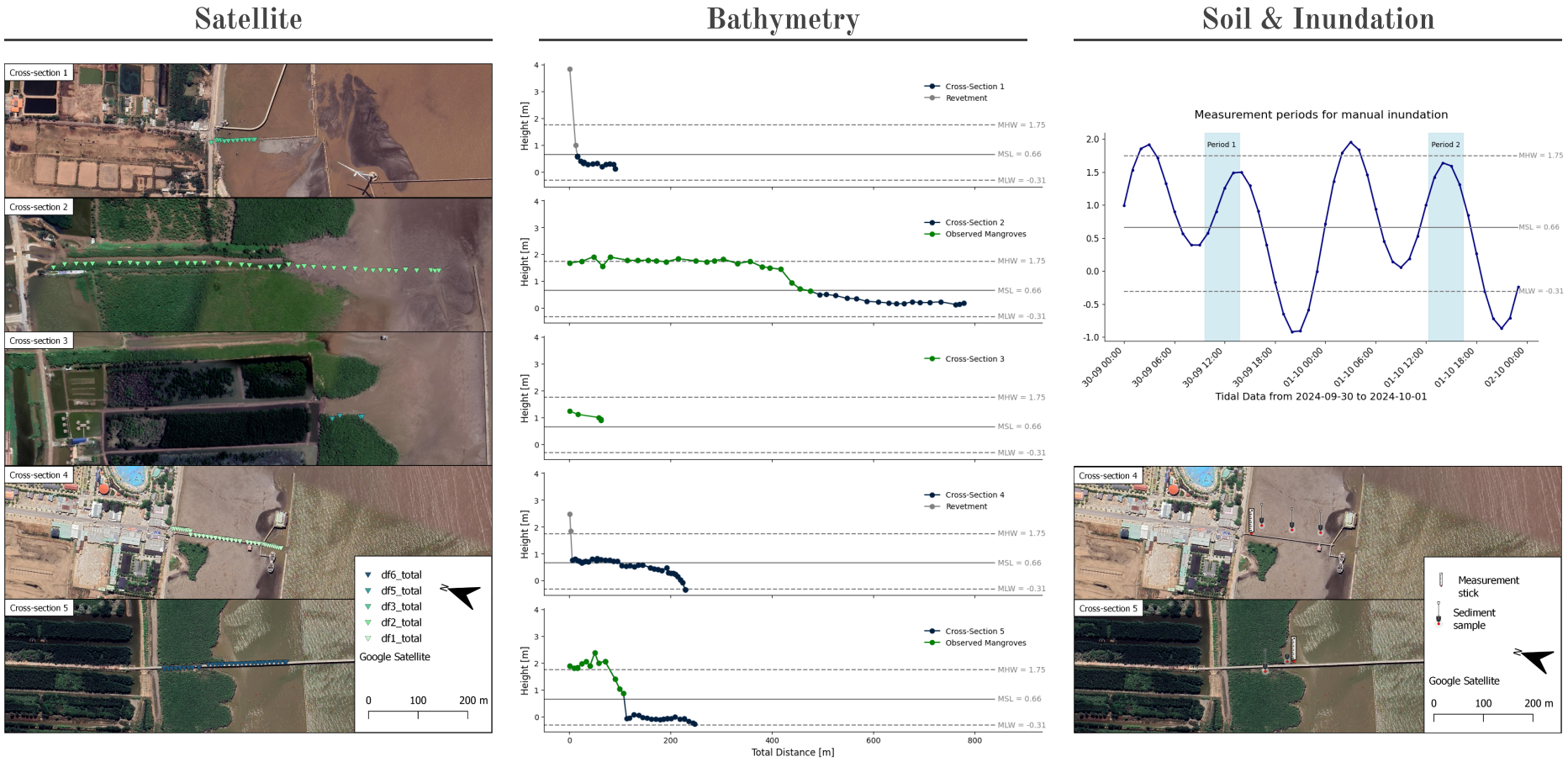

Figure 5.1: Overview of all results obtained from the fieldwork. From left to right: the first column shows the RTK data points measured on a satellite map, highlighting the surroundings and context of the measurements. The second column presents the resulting height profile from the RTK data, including the revetment (in grey) and observed mangroves (in green). The last column displays the periods during which the inundation analysis was performed, followed by the specific cross-sections (4 and 5) where inundation and soil investigations were conducted.

5.1.2. Inundation period

The tidal data was collected using a measurement station in the vicinity and a measurement stick deployed in the field. The results from both methods will be discussed in the sections below.

Tidal data method

The predicted tidal data for 2024 by the ICOE is analyzed to acquire significant tidal levels by the Vietnamese Reference Datum (VRD). The complete yearly prediction for every hour of the year is shown in the histogram visible in Figure 5.2. From the dataset, the following tidal levels are found for the year 2024:

- The mean sea level (MSL) is +66.4 cm VRD
- The mean high water (MHW) is +175.1 cm VRD
- The mean low water (MLW) is -31.1 cm VRD

Due to the irregular semi-diurnal tidal character, most days show multiple high waters during a day but some days the tide is diurnal. These values are added to both the higher high water and the lower higher water, to not generate too high or low values than. That gives the following tidal levels:

- The mean higher high water (MHHW) is +190.2 cm VRD
- The mean lower high water (MLHW) is +158.9 cm VRD

The probability density (PDF) and cumulative density (CDF) functions of the tide are shown in Figure 5.2. In the left figure, the pdf shows the irregularity of the tidal cycle by the asymmetric peak at the higher water levels. This higher peak indicates that the coast experiences higher water levels more often than lower water levels.

The 1-CDF was created to formulate this probability into a yearly percentage. This shows that the MWL is 57 % of the time inundated. The rest of the critical water levels are shown in Table 5.1.

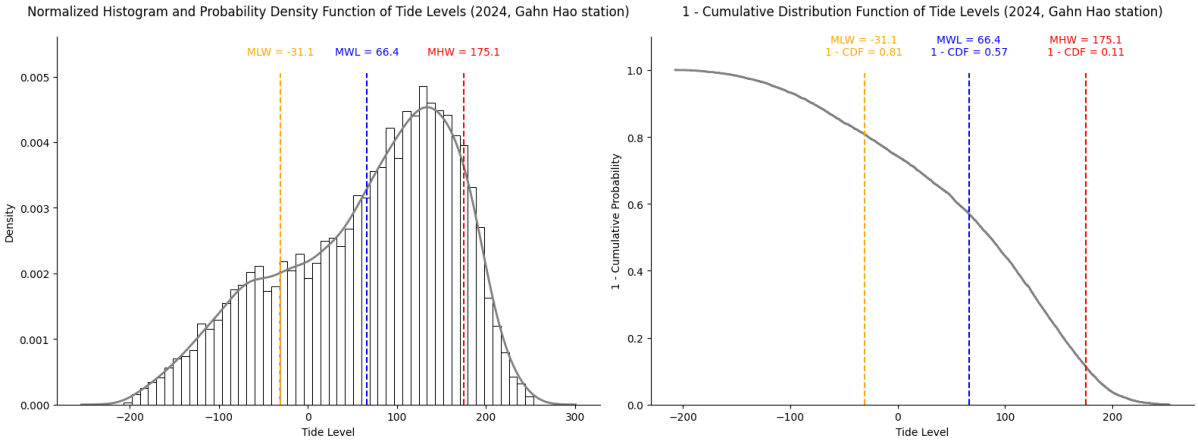

Figure 5.2: Probability Density Function (PDF) and Cumulative Distribution Function (CDF) of Tide Levels at Ganh Hao Station, 2024

Table 5.1: Table of Tidal Heights and Daily Inundation Times calculated with the cdf

Level	**Height** $[cm]$		**Daily Inundation time** $[min/d]$	
	Max	**Min**	**Min**	**Max**
Mean Higher High Water	190.2		89	
Mean Lower High Water	158.9		261	
Mean High Water (MHW)	175.1		164	
Mean Sea Level (MSL)	66.4		822	
Mean Low Water (MLW)	-31.1		1164	
Cross-section 1 mudflat	58.5	11.9	855	1031
Cross-section 2 mudflat	63.7	13.2	834	1028
Cross-section 3 mudflat	-	-	-	-
Cross-section 4 mudflat	82.6	-33.9	738	1172
Cross-section 5 mudflat	87.4	-26.4	713	1149
Cross-section 1 mangroves	-	-	-	-
Cross-section 2 mangroves	191.5	63.7	84*	834
Cross-section 3 mangroves	123.4	90.5	497*	696
Cross-section 4 mangroves	-	-	-	-
Cross-section 5 mangroves	237.9	87.4	5*	713

* Not accurate due to puddling and SOURCE.

Measurement stick method

The measurement stick method provided critical data points: the time when the waterline first reached the stick, the maximum water level, and the time when the water receded past the stick (Table 5.2). These observation periods are also shown in the right column of Figure 5.1. In the Nhà Mát experiment, this method recorded a maximum water level of 0.67 meters. Another notable observation was that as the waterline receded, the water level remained higher than the initial level, forming a small puddle around the stick.

In contrast, during the experiment at Hoa Binh, the waterline never reached the measurement stick, prompting the experiment's end at the recorded maximum water level. This finding suggests that only one tidal cycle that day reached the measurement point.

Table 5.2: Table of the inundation experiment results

Location	**Variable**	**Value**
Cross-Section 4	$t_{1,start}$	11:47
Nhà Mát	$h_{1,max}$	0.67 m
	$t_{1,finish}$	15:54
Cross-Section 5	$t_{1,start}$	09:35
Hoa Binh	$h_{1,max}$	0.00 m
	$t_{1,finish}$	13:45

5.1.3. Soil analysis

Soil samples were collected from five different locations, as shown in Table 5.3. Samples NM1, NM2, and NM3 were taken from Nhà Mát, corresponding to cross-section 4. Samples M1 through M4 were obtained from the HOA Binh wind farm, corresponding to cross-section 5. These samples were analyzed for particle size distribution and classified into three categories: sand (particles larger than 0.05 mm), silt (particles with diameters between 0.05 and 0.005 mm), and clay (particles smaller than 0.005 mm).

Table 5.3: Table of the soil properties of the 7 investigated locations

Location	Sample	Sand [%]	Silt [%]	Clay [%]	D_{50} [mm]
Cross-Section 4	NM1	17.8	60.3	21.9	0.0252
Nhà Mát	NM2	14.3	62.2	23.5	0.0232
	NM3	23.8	54.3	22.0	0.0273
Cross-Section 5	M1	3.5	52.6	43.8	0.0070
Hoa Binh	M2	2.0	53.5	44.4	0.0070
	M3	21.9	69.7	8.3	0.0345
	M4	98.1	1.4	0.5	0.1750

The soil samples from Nhà Mát exhibited similar characteristics across the cross-section, with a notably higher sand content at the seaward location. This observation aligns with the field report, which indicated that the soil in this area is more stable and easier to traverse.

Samples M1 and M2 were taken in close proximity, a few meters apart, to assess soil homogeneity. As expected, these samples showed very similar properties, including the same median particle size (D_{50}). Both contained the highest proportion of fine particles compared to the other samples, with almost no sand present. In contrast, samples M3 and M4 collected higher up the shoreface, showed considerable variation. Sample M4 consisted predominantly of sand, with a markedly different composition compared to M3.

5.2. Interpretation of hydraulic findings

In this section, the bathymetries found in Subsection 5.1.1 will be analyzed in depth for the relation that could be drawn between bathymetry length, height, profile, inundation time, and soil characteristics on the effect of their witnessed state as described in Subsection 4.1.1. First assumptions and conclusions are drawn for each different cross-section.

The bathymetry data is visible in Figure 5.1 in Subsection 5.1.1. Average daily inundation times are extracted from Table 5.1 in Subsection 5.1.2. Soil characteristics are shown in Table 5.3.

- **Cross section 1** illustrates a portion of a mud flat where mangrove reforestation has shown initial signs of success so far, as stated in Appendix A.1. The bed elevation lies below the Mean Sea Level (MSL), and it shown that this results in an average daily inundation duration exceeding the survivability threshold for mangrove species. Specifically, the current bathymetry suggests an inundation period ranging from 855 to 1,031 minutes per day, which typically falls outside the tolerance range for any pioneer mangrove species. This makes the observed survival of the seedlings at this site somewhat unexpected.

  The profile of the cross-section could be observed as concave, implying limited potential for natural sediment accretion as discussed in Section 3.3, which is crucial for reducing inundation time to levels suitable for mangrove establishment (WoO2). Based on these factors, it is unlikely that this reforestation effort will succeed in the long term unless additional interventions are implemented to support sediment accumulation. As noted in Appendix A.1, a newly constructed breakwater adjacent to the site may have been intended to promote this sediment deposition, potentially influencing future outcomes. This situation presents a valuable opportunity for ongoing monitoring to further assess the rehabilitation requirements for the bathymetry shape and elevation, particularly if this reforestation attempt proves successful in the future.

- **Cross section 2** indicates that the bed elevation of the mangrove belt remains at a plateau around Mean High Water (MHW), before the mangrove front adjacent to the mud flat exhibits a concave profile, with the bed level of the mud flat eventually dropping below the Mean Sea Level (MSL), suggesting ongoing erosion as stated by Hu et al. (2015). Although the mangrove belt itself is situated at an appropriate

elevation for survival, the tidal flat appears to be experiencing erosion or subsidence. The tidal prediction shows that the front of the mangrove belt experiences inundation periods ranging from 84 to 834 minutes. However, the actual minimum inundation duration is likely to be longer due to ponding effects (Erftemeijer et al., 2021), as also observed at the Nhà Mát pier water level measurement (Appendix A.3). This ponding effect may also apply to the rest of the mangrove belt, indicating that the current equilibrium is maintained by sedimentation around MHW, as to be expected according to Section 3.3.

Notably, the first line of mangroves is under stress, as stated in the site investigation (Appendix A.2). This stress could be attributed to a combination of factors, including prolonged inundation over the required limit of the Avicennia species or too extreme wave action at the mangrove front caused by a lower-than-optimal bed level around MSL, as discussed in Section 3.3. The large opening between breakwaters in front of this section, as mentioned in Appendix A.2 might promote additional wave action that complicates the matter. Additional research for the specific wave actions at this site combined with an inundation test at the front might clarify the real cause of this front degradation.

The resilience of the mangrove belt, despite visual indications of erosion or subsidence on the mud flat, suggests that the mangroves may be effectively trapping sediment during inundation. The process of ponding, where water remains stagnant during certain periods, may facilitate sediment deposition by reducing current velocities and allowing particles to settle, as suggested by Willemsen (2021). A smaller inundation height, due to the high elevation of the mangrove belt, could further enhance sediment settling. This would help counteract land subsidence and mitigate the sediment deficit, supporting the findings of L. Phan et al. (2015) and in contrast to those of Besset et al. (2019). If the mangrove belt can sustain its elevation through sediment trapping, then sediment deficit may not be the primary cause of degradation. Instead, wave action destabilizing the mangrove front or excessive inundation could be more significant contributors, as observed in this cross-section. Further elevation research is needed to investigate the bed level of mangroves located directly behind the sea dyke, where access to sediment is restricted, to compare this effect of sediment settlement.

The concave profile and excessive inundation at the mangrove front confirm the unhealthy state of this cross-section, as discussed in Subsection 4.1.1. The shoreline currently exhibits characteristics of retreat, although the slope of the tidal flat is gentle rather than cliff-like, and its length is approximately 300 meters. These conditions suggest that natural sedimentation may still be feasible under favourable circumstances, particularly if the mud flat level rises above the MSL.

- **Cross section 3** demonstrates that mangrove pioneer species of Avicennia can survive under optimal inundation conditions, with inundation periods ranging from 497 to 696 minutes, even when accounting for ponding. This finding suggests that a tidal flat with an elevation above Mean Sea Level (MSL) is a suitable location for reforestation efforts, following the concept of the 'First Window of Opportunity (WoO1). However, due to the small set of data points of this dataset, no further conclusions can be drawn.
- **Cross section 4** at the Nhà Mát pier reveals a tidal flat with the initial section slightly above Mean Sea Level (MSL) and the remaining section below MSL. This elevation results in excessive inundation times, exceeding 822 minutes, which could explain the failure of the reforestation attempt in 2019 due to unsuitable site conditions.

  However, despite the short length of the mudflat, the convex profile suggests the potential for sediment accretion, as elaborated in Section 3.3, which could eventually raise the entire cross section above MSL. This accretion may be facilitated by the hollow pile breakwater as mentioned in Appendix A.1, which might trap sediment entering from the breakwater opening at cross-section 2 and following the annually dominant southwestward current, which then promotes the accumulation at this location. Consequently, the site could meet the conditions necessary for successful rehabilitation in the future by elevating higher than MSL, making it a valuable location for ongoing monitoring as stated by the 'Second Window of Opportunity'(WoO2).
- **Cross section 5** at the Hoa Binh 1 windmill pier reveals a continuous plateau around Mean High Water (MHW), followed by a steep cliff where the tidal flat drops significantly below Mean Sea Level (MSL).

  The mangrove belt exhibits an equilibrium height around MHW, with recorded inundation periods ranging from 5 to 713 minutes. The minimum value is likely influenced by a single, elevated bathymetry measurement, and it is assumed that actual inundation durations across the plateau are longer due to the generally lower elevation and the effects of ponding. Otherwise, the mangroves at this site would not display such vitality. The effects of ponding, where water remains in place for extended periods, could facilitate sediment deposition by reducing the movement of water, allowing particles to settle.

The relatively high elevation of the mangrove belt around MHW may also contribute to easier sediment deposition, thereby countering land subsidence, as previously discussed in Cross Section 2.

The successful reforestation at this site indicates that suitable reforestation locations are not limited to mud flats. The required inundation-free period (WoO1) and inundation duration criteria appear to apply effectively to higher bed levels, which may reduce exposure to extreme currents and erosion, thus enhancing reforestation success. The elevation height of cross-section 5 suggests that, as long as the inundation period is within an acceptable range, higher bed elevations may improve the outcomes of reforestation efforts, as lower bed elevations did not show any reforestation successes, as for example the mentioned failed attempt before Nhà Mát in

At the mangrove front, the presence of a steep cliff indicates ongoing erosion, while the rest of the tidal flat shows no signs of significant change. Given the considerable depth of the tidal flat, wave action may be too intense for sedimentation to occur, which aligns with the observation that this site is in a poor state of health, as mentioned in Appendix A.1.

5.3. Stakeholder findings

In total 29 interviews were conducted with 29 farmers, including 24 ecological farmers and 5 intensive farmers. The average age of the respondents was 61 years, with most farmers having over two decades of experience. Additionally, members of the Mangrove Management Board and DARD provided insights into the administrative and protective measures concerning mangrove conservation and aquacultural management.

It is important to note that a representative from the Mangrove Management Board was present during all farmer interviews. Additionally, our logistics relied on local authorities and the interpreter conducting the interviews, which may have influenced the results. These limitations are further discussed in Chapter 7.

5.3.1. Reassessing stakeholder dynamics

This section focuses on the new insights that were gathered in comparison to the stakeholder analysis within the literature review. Additionally, a link with the CCRPM model can be established. This is only possible for perceptions of the farmers, but not for the authorities due to insufficient information.

Ecological Farmers

Ecological farmers generally maintain a high interest in mangrove restoration due to their dependence on healthy mangroves for shrimp farming. The farmers, mostly in their senior years with extensive experience, have reported a variety of changes impacting their operations, such as erosion and pollution, which align with their concerns about dense mangrove canopies. A dense canopy can negatively impact shrimp production by limiting sunlight and leaves in the water (reducing the oxygen levels). Farmers feel that their local knowledge and experiences are often overlooked in decision-making processes. This limits their influence, despite their direct stake in mangrove conservation. These farmers also indicate a lack of immediate results from embankments and other protective measures, although some improvements in coastal stability were noted. All interviews for rounds one and two for the ecological farmers can be found in Appendix D.1 and Appendix E.

Table 5.4: Table of common problems reported by ecological farmers

Problem	Frequency (out of 19 ecological farmers)
Water pollution	15
Mangrove density (thick canopy)	12
Erosion	10
Flooding	8
Lack of oxygen	9
Lack of seed stock	7
Salinity	5

Table 5.4 presents the common problems reported by the ecological farmers, with their respective frequencies. It is important to note that three rounds of different interview questions were held, which were created iteratively upon each other based on the results of the previous interviewing round (Section 4.2.3). This slight change in questions per round may have influenced how frequently certain issues were mentioned. The frequencies reflect the prevalence of the different problems during the interviews.

Intensive Farmers
Intensive farmers tend to prioritize immediate economic returns and are less involved with mangrove restoration efforts. Their interactions with local authorities seem to be limited, and they mostly focus on economic aspects rather than environmental considerations. They are primarily concerned with issues like pollution and sedimentation (blockage of the water stream in the canals) that directly affect their farming operations, often blaming high-tech farms for the pollution. The farmers believe that these organizations are dumping waste and chemicals into the waterways. While recognizing the protective role of mangroves against erosion, their engagement in conservation is minimal, driven by economic priorities. Table 5.5 presents the common problems reported by the intensive farmers, with their respective frequencies. All the interviews conducted with the intensive farmers, only for the first round, can be found in Appendix D.2.

Table 5.5: Table of common problems reported by intensive farmers

Problem	Frequency (out of 5 Intensive farmers)
Water pollution	5
Canal blockages	4
Poor quality breeds	3
High mortality rates	3
Flooding	2
Salinity issues	2

DARD
DARD has a big role in setting farming policies in Bạc Liêu, but they often get slowed down by needing too many approvals from the People's Committee of Bạc Liêu Province. Even though they interact often with local farmers, who really know the challenges they face, DARD is seen as focusing more on following rules than on solving real problems quickly. This need for so many approvals delays and weakens their efforts, making it hard for DARD to effectively handle local issues with mangroves and farming. The answers from the interview can be found in Appendix H

Mangrove Management Board
The Mangrove Management Board has become a critical stakeholder as it plays an important role in the maintenance and restoration of mangrove ecosystems. They face logistical and resource constraints that impede their ability to act independently. Their effectiveness is also dependent on approvals from both DARD and the People's Committee of Bạc Liêu Province, which can delay or dilute their conservation efforts. Although they frequently interact with farmers, their constrained capacity limits their impact, making it challenging to address the broader needs of mangrove conservation comprehensively. The answers from the interview that we received via mail can be found in Appendix G.

NGOs and Research Institutions
NGOs and research institutions are crucial advocates for environmental sustainability and play a significant role in raising awareness and driving conservation initiatives. However, the perception among farmers is mixed; while some are unaware of their involvement, others feel that these organizations fail to deliver lasting results. This scepticism comes from experiences where projects are initiated but not seen through to completion, leading to dissatisfaction and a lack of trust in such interventions. People often judge these organizations on how well they connect with local communities and deliver real benefits.

5.3.2. Understanding farmers' risk perceptions through CCRPM and MOTA-framework
Table 5.6 presents an overview of ecological and intensive farmers' responses concerning their aquacultural practices, structured according to the four dimensions of the CCRPM and the MOTA framework (Van der Linden, 2015). The table examines how farmers' answers align with the CCRPM dimensions—cognitive factors, experiential processing, socio-cultural influences, and socio-demographic factors—and the MOTA framework's focus on motivation and ability. This table is used to explain how the four dimensions and the MOTA-framework shape the risk perceptions of farmers regarding their aquacultural practices.

Table 5.6: CCRPM Dimensions and MOTA Framework Analysis for Ecological and Intensive Farmers

	Ecological Farmers	**Intensive Farmers**
CCRPM Dimension		
Cognitive factors	Ecological farmers understand environmental risks through direct experience and community knowledge, focusing on how mangrove conditions impact shrimp health. Limited access to scientific resources restricts their formal knowledge.	Intensive farmers share similar experiential knowledge but focus more on economic aspects, prioritizing profitability and production over mangrove conservation.
Experiential processing	Farmers' experiences with pollution, flooding, and thick canopies drive concern for productivity. These issues lead to a focus on practical solutions that balance conservation with output.	Experiences with pollution, flooding, and salinity changes evoke frustration, emphasizing immediate economic risks and leading to a preference for rapid, profit-driven solutions.
Socio-cultural influences	Value conservation, but seek balance with productivity. Limited collaboration occurs due to a perceived lack of support from authorities.	Value economic success over conservation. Collaboration is valued only if it directly improves profitability.
Socio-demographic factors	Older experienced farmers have limited resources and are cautious in adopting new practices.	Older, profit-focused farmers lack resources, education, and infrastructure for sustainable practices.
MOTA Framework		
Motivation	Intrinsically motivated toward conservation but limited by frustrations with canopy density and support from authorities.	Primarily motivated by economic gain, with little interest in conservation unless it directly benefits profitability.
Ability	Limited financial and technical resources constrain conservation and productivity efforts.	Similar resource limitations and lack of sustainable practice knowledge.

The perceptions of risks associated with aquacultural practices are primarily shaped by the four dimensions of the CCRPM.

Farmers' understanding of the risks involved in their aquacultural practices—such as water pollution, erosion, flooding, and mangrove canopy thickness—primarily stems from direct experience and community knowledge rather than scientific data as mentioned in Table 5.6 (Paek and Hove, 2017). This practical knowledge shapes their perceptions and approaches to managing risks but may result in a more narrow, short-term perception of risks compared to scientifically informed understanding, potentially limiting adaptive strategies and awareness (Van der Linden, 2015). Direct experiences with environmental challenges as mentioned in Table (5.6) evoke emotional responses, increasing the feeling of vulnerability and making these risks feel more immediate and pressing. These experiences lead to a focus on immediate risks that threaten aquacultural productivity and thus farmers' whole livelihood, shaping a preference for practical and short-term responses over longer-term adaptive strategies (Ngo et al., 2019). Norms and values within farming communities shape risk perception by influencing what individuals and communities consider important and/or worth protecting and thus what acceptable and non-acceptable risks are (Slimak and Dietz, 2006). Ecological farmers, operating in a farming sub-community that values mangrove conservation, view mangrove health as important and worth protecting. In contrast, intensive farmers view profitability as important and worth protecting, placing profitability above conservation (Tiet et al., 2022). Socio-demographic factors as mentioned in Table 5.6 empathize with how access to age, resources, and education shapes individuals' knowledge and vulnerability levels. These factors affect how people understand risks, their ability to respond to them, and the importance they place on them (Van der Linden, 2015). The mainly older, experienced farmers demonstrated a cautious, practical approach to aquacultural risks, relying on experimental knowledge of local conditions. Limited education and financial resources restrict their knowledge and budget which impacts their aquacultural risk perception and hinders them from implementing adaptive, sustainable practices, leading them to rely on established traditional methods (Ngo et al., 2019). Intensive farmers, under economic pressure to maximize output, often lack the resources to engage with conservation efforts, while ecological farmers are constrained by limited support, despite their interest in balancing conservation with productivity.

The MOTA framework enhances the understanding of farmers' risk perceptions by examining the broader context of motivation and ability as they relate to behavioural change. Motivation within the MOTA-framework includes intrinsic values, perceived benefits, and community norms, which drive ecological farmers toward conservation despite barriers like canopy thickness and perceived insufficient support from authorities (H. Q. Nguyen, Patiño Guerra, et al., 2019). Intensive farmers are not intrinsically motivated toward conservation and largely by economic returns. They are only motivated by conservation when it aligns directly with their profitability goals (Bradley et al., 2020).

Ability in the MOTA framework extends beyond access to resources, encompassing technical knowledge, skills, and perceived efficacy in adapting to new practices. While both ecological and intensive farmers indeed face limited resources, their ability to implement adaptive practices is also shaped by the relevance of available skills and knowledge to sustainable practices, as well as institutional support structures (H. Q. Nguyen, Korbee, et al., 2019). The farmers' perception of vulnerability plays an important role in motivation to pursue behavioural change. When farmers feel highly vulnerable to risks but lack the necessary resources to cope with their consequences, this can reduce their motivation to make risky changes. These farmers feel more inclined to stick with existing, familiar methods rather than embrace new, potentially risky practices (Bradley et al., 2020; Tiet et al., 2022).

5.3.3. Key themes

In addition to categorizing stakeholders, the research results can be organized around three critical themes: problems, collaboration, and decision-making. Each of the following three subsections focuses on one of these themes, highlighting areas where conflicts arise as well as opportunities for common ground or shared interests among the stakeholders involved.

Problems

- *Mangrove Expansion and Farming Conflicts:* Ecological farmers face practical issues like thick mangrove canopies affecting shrimp production, while DARD pushes for mangrove conservation. The conflict arises when ecological farmers want modifications like thinning mangroves to improve shrimp farming conditions, but DARD emphasizes conservation and long-term sustainability.
- *Erosion and Flooding:* Both groups recognize erosion and flooding as serious problems, but ecologi-

cal farmers believe DARD's interventions, such as embankments, have not provided immediate relief. There's a gap between DARD's long-term projects and the farmers' need for immediate solutions.

- *Policy Restrictions on Land Use*: DARD's conservation-focused policies may limit what ecological farmers can do on their land, leading to tensions between the desire for productive farming and compliance with environmental rules.
- *Water Quality Issues:* Intensive farmers face water quality degradation, with pollution and seasonal changes in salinity impacting their shrimp production. DARD's mandate includes managing water resources, but intensive farmers often feel that their immediate needs for water quality improvements are not being adequately addressed. There is frustration over the perceived ineffectiveness of pollution control measures, which intensifies the complexity.
- *Shrimp Health and Economic Pressures:* Intensive farmers often prioritize high shrimp yields to maximize profits, but environmental conditions, such as unpredictable salinity, hinder their efforts. DARD's broader goal of promoting sustainable practices sometimes conflicts with the intensive farmers' demand for quick fixes to immediate problems.
- *Land Allocation Conflicts:* The Mangrove Management Board allocates land with specific conditions for conservation and farming, often requiring 70% of the land for conservation and 30% for aquaculture. Farmers may find these restrictions too strict, limiting their ability to optimize land use for both farming and conservation.
- *Competing Priorities:* Ecological farmers face difficulties with dense mangrove canopies, which hinder shrimp farming, while the Mangrove Management Board and DARD focus on full conservation and restoration of the forests. The complexity here lies in balancing ecological farming needs with strict conservation measures, causing tension between land use for farming and conservation.
- *Pollution and Seed Stock Availability*: Farmers express concern over pollution from high-tech farms and a declining natural seed stock, while the Board's conservation efforts focus more on overall forest health than addressing pollution. The farmers feel that the Board is not addressing the ecological farming needs directly.

Ecological farmers value mangrove conservation for its ecological benefits but face practical issues like dense canopies that hinder shrimp farming. They advocate for a balance between conservation and aquacultural productivity and express the need for more targeted support that aligns with their specific needs. In contrast, intensive farmers prioritize the profitability of their practices and feel frustrated with the lack of consistent, proactive support from local authorities. They find government interventions often reactive and insufficient for addressing long-term challenges like water management and infrastructure maintenance, which increases their scepticism toward conservation efforts.

Collaboration

While ecological farmers are open to collaboration, they often feel frustrated by the lack of meaningful engagement from local authorities and research institutions. These farmers feel that their tacit knowledge is undervalued in decision-making processes. Despite collaboration in the past, currently, collaboration among farmers is minimal, and many do not see its potential unless it brings direct economic benefits. Several farmers mentioned that they cannot envision what collaboration with other farmers would look like. One farmer noted that if such a concept were implemented, he would not want to be responsible for it, seeing it as the government's role rather than something farmers should be expected to undertake.

The ecological farmers see a need for more impactful partnerships to address pressing challenges, such as pollution control and sustainable aquaculture practices.

Intensive farmers, meanwhile, tend to focus collaboration efforts on immediate, practical issues such as water treatment, canal dredging, and market access. Due to inconsistent support from authorities, they often rely on individual action. Intensive farmers show limited enthusiasm for broader environmental initiatives, seeing little relevance to their economic realities. For them, collaboration with other farmers is generally not perceived as beneficial unless it addresses direct operational needs.

Both ecological and intensive farmers desire more consistent and impactful support from authorities, particularly in areas such as infrastructure improvements and water pollution management. Some farmers participate in local knowledge-sharing networks, but they would welcome more engagement with aquacultural experts to tackle specific challenges like water treatment and shrimp health.

Overall, ecological farmers demonstrate a strong willingness to collaborate on conservation efforts, though they remain sceptical of higher authorities' effectiveness. Intensive farmers, in contrast, are hesitant to engage in conservation unless there is a clear benefit to their operations. Many farmers would be open to more collaboration with the government, recognizing that the authorities possess the resources to facilitate meaningful change. However, some believe that the responsibility for organizing collaborative efforts lies with the government, rather than individual farmers.

Decision-making
The governance structure in Bạc Liêu operates in a top-down manner, with national bodies like MoNRE and the MARD holding primary decision-making authority. These institutions establish policy directives that lower-level authorities must follow. The People's Committee of Bạc Liêu Province holds decision-making power within the province, provided it aligns with national interests and guidelines. The DARD is a specialized agency under the People's Committee of Bạc Liêu Province, responsible for advising and assisting in state management across a wide range of areas, including aquaculture, forestry, irrigation, rural development, and more. The Mangrove Management Board operates under DARD.

As previously mentioned, mangrove forest density poses a significant challenge for farmers. Farmers are required to submit an official request to local authorities to thin the mangroves. During interviews, farmers shared that approval for such requests often faces lengthy delays. In a conversation with a member of the Mangrove Management Board, as referenced in Appendix G, it became evident that a request to thin the canopy must be submitted to the Mangrove Management Board. Which directs this to DARD, after which DARD then seeks final approval from the People's Committee of Bạc Liêu Province. If the request is approved, the Mangrove Management Board can execute the thinning of the canopy (the farmers are not allowed to do this themselves). This is one of many examples of the hierarchical decision-making process, which results in prolonged waiting periods for farmers and contributes to a sense of being unheard (especially when the organizations in charge, who have to forward the application, have a different interest).

5.3.4. Deeper insights into stakeholder complexities

The key difference revolves around the conflict between the immediate economic needs linked to aquacultural practices and the broader, long-term goals of environmental sustainability. At a deeper level, this tension is caused by different perspectives on what makes up the 'value' of land use. For those depending on aquaculture, immediate productivity, and income generation are essential to their livelihoods, often leading to practices that prioritize high yields and adaptability to changing environmental conditions. On the other hand, conservation goals emphasize maintaining ecosystem integrity, which requires sacrificing some short-term gains for future environmental resilience.

This difference also reflects a different perception of risk: farmers are very concerned with risks that threaten their annual income, such as water quality and salinity fluctuations, whereas conservation efforts address broader ecological risks, such as biodiversity loss and erosion, which have less immediate but far-reaching impacts. There is also the structural challenge of aligning immediate action ("quick-wins") with long-term resilience, where practical action can often lag behind due to resource allocation, political processes, or coordination constraints. Without bridging these views and addressing both immediate and longer-term needs in a balanced way, this disconnect will continue to hinder coherent progress toward sustainable land and water use.

6

Conclusion and recommendations

This chapter presents the conclusions of this report, beginning with separate summaries of the hydraulic research and the stakeholder analysis. In Section 6.2, findings from both fields are integrated, highlighting the interdisciplinary aspects of mangrove ecosystems in Bạc Liêu. This integrated conclusion is complemented by recommendations for the Living Lab project and proposals for future research directions.

6.1. Summary of findings

This section gives an answer to the subquestions that are formulated in Chapter 2 based on the findings from the fieldwork.

6.1.1. Hydraulic subquestion answers

Drawing on insights from literature and fieldwork results, the research findings offer valuable data for future Living Lab initiatives. These findings assess the suitability of selected sites in Bạc Liêu for mangrove health, reveal limitations affecting reforestation efforts, and contribute knowledge toward preserving mangroves.

- *"Which conditions are important for mangrove viability?"*

  The literature review highlights key conditions for mangrove viability across different life stages. During the establishment phase, seedlings require sufficient time to anchor with roots of at least 2 cm, as well as cohesive, fine-particle soils and adequate seed spacing to promote rapid establishment. Mangroves cannot survive below Mean Sea Level (MSL), and viability increases at higher elevations. Established mangroves thrive best in areas where flow velocity does not exceed 1.50 m/s and proper inundation periods are maintained, following the First and Second Window of Opportunity principles. Every mangrove species requires a specific inundation period. For the pioneer Avicennia species in Bạc Liêu, the required inundation period is between 250 and 800 minutes a day, influenced by tidal patterns, elevation, and morphology. Convex tidal flat profiles are beneficial as they support sedimentation, ideal inundation, and low inundation heights, while concave and cliff profiles tend to cause erosion and degrade mangroves. Lastly, active community engagement for monitoring and ecosystem service is critical for mangrove conservation, but this community engagement depends on local knowledge and understanding of ecological principles.

- *"What are the conditions of the mangroves in Bạc Liêu?"*

  Multiple cross-sections along the Bạc Liêu coast were measured with an RTK rover, analyzing bathymetries in relation to inundation periods based on tidal predictions and direct water level measurements. Findings indicate that none of the measured cross-sections exhibit healthy conditions; all profiles display signs of erosion, characterized by concave and cliff formations. Observations confirm that mangroves do not establish below Mean Sea Level (MSL), with main mangrove belts predominantly observed to be situated at Mean High Water. These belts could indicate that they appear unaffected by land subsidence or sediment deficits. Within seaward interventions, small particle retention was noted at the mudflat and mangrove front, suggesting an effective sediment diameter limit in these areas of around

0.023 and 0.007 mm respectively. The smaller diameter was found within the mangrove belt, hinting at their effective trapping capability. Additionally, at Nhà Mát, where a breakwater interrupts the longshore current, the only convex profile, suggestive of sedimentation, was recorded.

- *"How do the results contribute to existing mangrove reforestation and conservation knowledge?"*

Field research underscores the challenges in collecting data at the Bạc Liêu coast, particularly due to the highly saturated mudflats, with inundation and bathymetry measurements proving both time-intensive, physically demanding, and complex. Results show considerable variability among cross-sections, even across short distances, indicating site-specific dynamics and the need for localized measurements. This finding aligns with the Stive et al. (2023) assertion that "no one solution fits all." Results indicate that inundation periods combined with elevation strongly correlate with mangrove forest health and suitability for reforestation, in line with the First and Second Windows of Opportunity. The results also showcase the vast amount of mudflat in Bạc Liêu that is not suitable for reforestation attempts. Additionally, the inundation period, potentially prolonged by ponding and sediment entrapment, may exceed predictions based solely on tidal patterns. Despite a documented sediment deficit, the main mangrove belt remains at a Mean High Water level, suggesting mangroves' inherent ability to capture sediment even under deficit conditions, likely due to ponding and entrapment, an aspect not yet explored in mangrove literature.

6.1.2. Stakeholder subquestion answers

Based on the acquired information from the interviews, insights are gathered on the perspective of farmers.

- *"How do diverse interests and power dynamics among stakeholders in Bạc Liêu influence implementation and mangrove conservation efforts?"*

One of the biggest challenges is the opposing interests between stakeholders higher in the food chain and the farmers. It is a constant battle between the short-term economic needs of farmers versus the long-term national and local policy goals for coastal protection and mangrove conservation. Furthermore, the organizational structure has a strong top-down approach, where the top, in this case, the People's Committee of Bạc Liêu Province preserves all the power for decision-making. This different perspective on the 'value' of land can cause frustrations among the farmers and make public support for new initiatives difficult.

- *"What are the most pressing challenges perceived by farmers, and what is their perspective on collaboration in addressing these issues?"*

Farmers face various challenges that affect their aquacultural practices and profitability. Ecological farmers are caught between mangrove conservation and shrimp farming needs; thick mangrove canopies hinder production, yet DARD's conservation policies limit their ability to modify the environment for better yields. They feel DARD's focus on long-term sustainability overlooks their immediate concerns, like breeding stocks, and water quality issues. Intensive farmers, prioritizing high shrimp yields, are similarly impacted by unpredictable salinity and poor water quality and feel frustrated by DARD's reactive, rather than proactive, measures to support them. Land use policies and competing priorities between conservation and farming further intensify tensions, making farmers sceptical of the effectiveness of current interventions.

Although there has been collaboration in the past, farmers currently do not engage in cooperative efforts. Without direct economic benefits, they seem to lack motivation to explore potential collaborations with other farmers and do not understand how such partnerships might function. Taking responsibility for initiating such efforts is viewed as a governmental role rather than something farmers are willing to undertake themselves. However, farmers are open to increased collaboration with the government, as they believe the authorities possess the necessary resources and expertise to drive meaningful change.

- *"What are farmers' perceptions of risks related to aquacultural practices?"*

The perceptions of the farmers related to aquacultural practices are shaped by immediate, practical concerns and influenced by their farming community, direct experiences, and resource limitations. Ecolog-

ical farmers focus on environmental risks, such as the thickness of the mangrove canopy, water quality, and erosion, which they see as essential to sustaining shrimp farming. Intensive farmers, however, are driven by economic factors, viewing profitability as the primary goal and seeing conservation as secondary unless it directly benefits yield. Both groups tend to prioritize short-term solutions, largely due to limited financial and technical resources, making them focus on risks that threaten immediate productivity. Additionally, experiences with flooding, pollution, and salinity changes increase farmers' sense of vulnerability and make these risks feel more pressing, reinforcing a focus on immediate, practical responses over longer-term adaptation.

Motivation and ability further shape their risk perception. Ecological farmers are motivated by conservation but feel constrained by limited support, while intensive farmers prioritize profit and show low motivation for sustainable practices unless they yield economic benefits. If farmers lack the ability to manage potential outcomes, due to limited financial resources, education, or technical support, they tend to become more cautious, avoiding risks that might threaten their livelihood. With little financial flexibility, they are cautious to try new or adaptive practices, preferring established methods that feel safer within their constrained capacity.

6.2. Integration of the disciplines

The previously drawn conclusions from the two disciplines, as mentioned in Section 6.1, combined with the experience gained through integrating the two disciplines while writing this paper, form the foundation to answer the main research question:

"How can the Living Lab facilitate integrated hydraulic and stakeholder analyses to develop sustainable, observation-driven solutions for mangrove reforestation and conservation in Bạc Liêu?"

To facilitate the integration of the hydraulic and stakeholder analyses, the Living Lab must commit to the three core functions of the Living Lab; Research, Showcasing, and Education, as displayed in Figure 2.2. For each pillar, recommendations are made for the direction the Living Lab could take and for further research on the topic of mangrove reforestation and conservation.

6.2.1. Research

This combination of both disciplines and the conclusions drawn in Section 6.1 prove the constant need for expanding research, while ongoing research opens the door for new insights. The findings from the bathymetric and inundation analyses in this paper suggest new hypotheses, creating a valuable foundation for more targeted studies that contribute to a better understanding of the degradation problem that Bạc Liêu is facing. These insights offer essential guidance not only for advancing technical research but also for informing local stakeholders and helping to shape sustainable solutions and effective management strategies. However, in order to capitalize on this potential, it is vital to maintain a streamlined collection of hard-to-achieve data to avoid the loss of important findings, while this could prove invaluable for later research.

Mangrove implementation and conservation efforts in Bạc Liêu are significantly influenced by conflicting priorities between policymakers and farmers. Farmers prioritize short-term economic security, whereas policy goals focus on long-term coastal protection and mangrove conservation. This tension is heightened by a top-down governance structure, with decision-making concentrated in the People's Committee of Bạc Liêu Province, causing frustration among farmers and hindering public support for new initiatives.

Farmers view collaboration with the government as essential due to lacking resources and expertise, but without direct economic benefits, they lack the motivation to cooperate with each other. Their aquacultural practices are constrained by conservation requirements, such as limits on mangrove management, which affect productivity and increase scepticism about the effectiveness of current interventions.

This research explored how mangrove conditions, along with the varied interests and power dynamics among stakeholders in Bạc Liêu, impact the effectiveness of mangrove implementation and conservation efforts. Incorporating ecological insights could better bridge these two essential disciplines for a more integrated approach and therefore improved outcomes. A lot of the challenges that the farmers perceived as most pressing, were related to the ecological field.

Therefore, to develop sustainable, observation-driven solutions for mangrove restoration, the ecology aspect must be included, to create a better bridge between disciplines, solutions, and communications.

In addition to integrating the ecological field, the research indicates several other research directions that should be prioritized:

Integrating hydraulic and socio-economic research:
Future research should further connect hydraulic and socio-economic factors to strengthen mangrove resilience. This paper identified key requirements for mangrove health and clarified the roles of different stakeholders. Building on this, researchers could explore how local communities, government agencies, and private sectors can support these requirements within the existing system, considering each group's (perhaps limited) resources and motivations. Including more hydraulic topics in the questionnaires could be valuable, such as analyzing farmers' understanding of technical aspects such as erosion and inundation periods. Findings from this research indicate that farmers are aware of certain hydraulic issues affecting their lands, which allows more detailed questions on these topics.

Further integrated multi-disciplinary research on mangrove viability:
Mangrove viability is closely tied to ecological factors, which were not the primary focus of this study. Future research integrating social, hydraulic, and ecological disciplines could provide a more comprehensive framework, helping to streamline solutions to complex viability issues. To enhance the efficiency of the Living Lab project and maintain the streamlining of found data, each discipline group can provide one-pagers summarizing their main findings, recommendations, limitations, and suggestions for further research for new (student) projects. Vietnamese researchers can also contribute to these summaries, adding valuable cultural and local background information, which is often missing in the literature.

Statistical analysis through structured interviews:
To expand understanding of mangrove viability, future research could incorporate structured interviews aimed at statistical analysis. By conducting a larger set of interviews with carefully selected groups, a quantitative approach can provide insights into trends, perceptions, and patterns that complement the available qualitative findings. This approach allows for the collection of data on specific topics, such as the levels of knowledge on erosion control techniques, or differences in practices between ecological and intensive farmers. Statistical analysis could reveal correlations between factors like farm type, location, and access to resources, offering a clearer picture of the broader patterns influencing mangrove resilience.

Perspective of local authorities:
It is important to learn more about the long-term perspective of local authorities, such as DARD and the People's Committee of Bạc Liêu Province, on farming in Bạc Liêu. Investigating whether they envision a future for ecological farming within mangrove areas is crucial. If ecological farming does not align with their policies and they plan to phase it out over time, investing in it may not be worthwhile. Understanding the stance on high-tech shrimp farming is also essential; if it is prioritized for its revenue potential, this should guide future policies. Research into its environmental and social impacts will clarify how it affects local communities, mangroves, and the balance between conservation and economic growth.

Market analysis:
A market analysis for intensive, ecological and super intensive shrimps could better paint a picture of each farmers positioning in the market. This would include a supply-chain investigation for the different origins of the shrimps. This research could give a comprehensive understanding of the competition and how to protect the smaller farmers from the high-tech zones.

Time-series analyses to obtain concrete solutions on the measured cross-sections:
To draw more concrete conclusions on the effectiveness of Bạc Liêu breakwaters in sediment retention, additional cross-sectional measurements should be conducted after at least one year at the same locations. If reforestation efforts at the Soc Trang border remain successful and the convex profile at Nhà Mát shows continued accretion, a more robust evaluation will be possible, providing significant insights for future Living Lab recommendations.

Research on Ponding, Entrapment, and Elevation Maintenance:
To investigate the impact of ponding and sediment entrapment on mangrove elevation stability near Mean High Water, further research should focus on the total inundation time in mangrove forests and the mangrove elevation compared to bathymetries without sediment access. Using moisture sensors and monitoring elevations behind the sea dyke, one could yield new insights into mangrove resilience against land subsidence and sediment capture.

6.2.2. Showcasing

"Showcasing" is not only about demonstrating research progress but also establishing the Living Lab's presence within the stakeholder landscape, which is an essential step for engaging stakeholders. Stakeholders need to understand what the Living Lab offers, in order to encourage their participation. To activate and keep them engaged over time, it is crucial that they feel heard and see their interests addressed.

The strong top-down approach within the Vietnamese government frequently emerged in the research, presenting challenges for open dialogue and influencing policy. As mentioned above, gaining more insight into the agendas of authorities would enable better alignment with them. Currently, it remains unclear where the barriers lie within the hierarchical decision-making process and why progress may be hindered.

If the Living Lab can establish itself as a credible and influential player within the system, providing reliable information, government bodies may be more inclined to consider its recommendations and adopt policy decisions grounded in scientific evidence. By combining the hydraulic expertise, which is the core strength of the Living Lab, with a role as a strong connector between stakeholders, the Living Lab could become the trusted link that bridges interests and gains the confidence of government authorities.

Effective positioning requires thorough knowledge of the interests of all stakeholders. As the Living Lab is still in its initial stages, with a primary focus on hydraulic research, there should also be an early focus on engaging stakeholders. For this, a dedicated individual or organization should be responsible for representing the interests of the local community. Farmers see the responsibility for initiating collaborative efforts as a governmental role rather than one they would assume themselves. Additionally, farmers mentioned seeing researchers but have yet to see tangible results. The Living Lab must thus be visible, not only to private and public organizations but also to the farmers to gain their support. Informing them about relevant technical developments, such as the current mangrove conditions in Bạc Liêu or reasons for unsuccessful reforestation attempts, can help bring them on board.

With transparent communication and scientifically backed data, the Living Lab can earn the trust of diverse stakeholders, helping to align varied perspectives on land use and support policy decisions that reflect shared interests. Examples of policy making which could be investigated by the Living lab, based on the findings of this project are:

Canopy trimming policy:
It is essentially mangrove roots and ponding within a mangrove belt that promotes sedimentation and keeps the mangroves as observed at a Mean High Water level. Leaves do not play a significant role in the purpose of trapping sediment but do pose challenges for farmers. Implementing a policy allowing leaf trimming could potentially alleviate these issues, with the knowledge that it is not a hydraulic constraint. Further investigation by the Living Lab on this matter would be valuable.

Revised reforestation policy:
This paper showed limitations to mangrove reforestation. Reforestation attempts should be focussed on higher elevation levels that meet the required inundation period. Conversely, reforestation on mudflats around Mean Sea Level should be avoided, especially in areas showing erosive indicators, such as concave or cliff profiles. It is important that this information is communicated to local authorities and stakeholders, so fewer reforestation attempts will be in vain and the trust between the local stakeholders and science-driven instances increase. It is unknown what the current reforestation policy is, but findings from this paper suggest that these reforestation limits are not upheld. Since there were limited sites observed that comply with the specific elevation and inundation criteria in Bạc Liêu, mudflat nourishment where the tidal profile shows no critical signs of erosion should be considered if reforestation on these mudflats remains the intended approach.

6.2.3. Education

The last core function of the Living Lab, education, has proven challenging in practice. As discussed in this Chapter, hydraulic insights, such as knowledge of inundation patterns, the current condition of Bạc Liêu's mangroves, and limitations on reforestation, are essential for local stakeholders to understand and integrate into their practices. However, farmers in the region often rely more on direct experience and community knowledge than on scientific information to address challenges. As highlighted in Sections 3.3 and 3.4, combining science-driven insights with observation-based knowledge can provide farmers with a broader perspective, offering predictive data to inform decisions both for immediate needs and long-term sustainability. For example, understanding the role of inundation duration in mangrove survival can deliver "quick wins" that help farmers adjust to changing environmental conditions and reduce dependence on reactive, experience-based responses.

It is essential to recognize that this educational exchange must be mutual. The local stakeholders' tacit knowledge proved extremely valuable during the hydraulic field campaign conducted in this research, offering practical insights directly applicable to the unique environment of Bạc Liêu, which could not be assumed or found beforehand. Companies, organizations, and institutions investing in hydraulic projects in Bạc Liêu should incorporate the expertise of local farmers, who possess invaluable knowledge that might otherwise be overlooked. In fact, farmers have expressed feeling unheard in past initiatives, reinforcing the need for a platform that ensures their voices are integrated.

This aligns closely with the "Showcasing" function discussed in Section 6.2.2, where the Living Lab is not only a source of reliable scientific data but also a trusted connector among stakeholders. By fostering an open exchange of knowledge, the Living Lab can bridge the gap between technical research and local practices. To support this transfer, a dedicated role within the Living Lab is essential. Engaging stakeholders in a two-way educational exchange will strengthen the integration of hydraulic and community insights, driving sustainable, observation-based solutions for mangrove restoration in Bạc Liêu. Based on this project, the Living Lab could pursue the following educational transfers:

Guidance on optimal inundation and elevation for farmers:
Providing farmers with knowledge about the best inundation periods and elevation levels, as found in this paper, can support mangrove health and resilience. This information will empower farmers to respond more effectively to changes like erosion and flooding, equipping them with "quick-win" strategies that reduce dependency on reactive measures.

Active involvement of local stakeholders in field research campaigns:
Involving local stakeholders, such as authorities and farmers, in field research has proven invaluable, as their knowledge helped guide the team to sites that might have otherwise been overlooked. Farmers and local leaders have expressed strong interest in participating in such research to better understand scientific methods and findings directly relevant to their region. Institutions and research groups conducting fieldwork are encouraged to engage these stakeholders early, recognizing the practical knowledge they offer and fostering a collaborative research approach that leverages local expertise.

Openness to disciplinary approaches in ecological and economic practices:
Farmers in Bạc Liêu have shown a strong willingness to learn from disciplinary research groups, particularly in areas such as ecological and economic approaches to enhance their farming methods. This openness suggests an opportunity for specialized research teams to share knowledge on sustainable practices and diversification methods that can improve resilience and economic outcomes. Engaging farmers in these areas can further support the integration of diverse approaches into local farming, making future mangrove conservation efforts both more effective and more widely adopted.

7

Discussion

In this Chapter, the limitations of this project are discussed, some of which are also incorporated in the recommendations made in Chapter 6.2.

Cultural and language differences

- Due to language barriers, reliance on an interpreter was necessary, whose level of English competence was unknown beforehand. Without direct communication with interviewees, some relevant information may have been lost. This constraint also reduced the opportunity to ask follow-up questions on interesting responses, and the notes received afterwards were only brief summaries. While translation and transcription tools (such as recording apps) were employed, these were limited in scope, likely resulting in some loss of meaning during translation, potentially adding an additional layer of interpretation.
- The term "local authorities" was frequently used in interview questions, which in retrospect proved to be overly vague. Limited prior knowledge of the various governmental agencies involved in the system contributed to this issue. Furthermore, clarifications from farmers regarding whether references to "local authorities" indicated the Mangrove Management Board, DARD, or other agencies were not obtained.
- Certain questions remained unanswered or were avoided, particularly those directly related to government involvement. To respect the sensitivity around these topics, questions with explicit references to government entities were carefully phrased or occasionally omitted. This may have impacted the completeness of responses on specific themes.

Fieldwork logistics

- Interview questions were prepared for DARD; however, one day prior to the scheduled interview, it was cancelled without explanation. As a result, the ICOE conducted the interview, sending a digital list of the prepared questions and subsequently forwarding the responses. This indirect approach limited the ability to follow up or clarify responses during the interview.
- The interviews with farmers were conducted in group settings, raising concerns about the potential influence of group dynamics on individual responses. Some farmers may have echoed or repeated responses they heard from others, which could affect the authenticity of the responses.
- Many farmers became quite emotional during the interviews when asked about specific challenges they face. This emotional response is essential to consider in interpreting their answers, as it may influence the focus of the responses.

Limitations in initial research design

- The initial plan was to conduct a statistical analysis using a Q-methodology approach. However, due to uncertainties surrounding the interview process, a statistical framework was not prepared. Key aspects required for Q-methodology, such as the exact number of farmers, types of farmers, their locations, and other sampling details, were unknown beforehand. Without this information, a structured statistical approach was not possible, so qualitative analysis was used instead.
- The accessibility and the condition state of mangroves at the coast were unknown, with online Google maps and Google Earth to base assumptions on. Therefore, locating and choosing cross-section sites for clear comparison was impossible beforehand.

Time constraints

- Only a small part of the involved stakeholders were interviewed due to time constraints. As a result, the attitude of all key stakeholders within the landscape cannot be fully assessed.
- Measurements within hydraulic research are highly time-dependent due to the rising and falling of the tides. Although additional measurements would undoubtedly have strengthened the results and conclusions, there was simply not enough time to conduct them.
- Besides the tide introducing time-dependency, the measurements conducted in this paper were also time-consuming. Therefore, it was only possible to conduct a few (maximum of three) measurements a day.
- Because collecting enough data was a hasty manner, there was not enough time to assess whether the collected data would be sufficient to eliminate the need for assumptions.

Influence and dependence on the Mangrove Management Board

- The Mangrove Management Board was present throughout all farmer interviews. While their presence facilitated coordination and farmer accessibility, it also raised concerns regarding potential influence over the process. The translators stated that the involvement of the Mangrove Management Board was mainly to foster trust between the interviewers and the farmers. On the other hand, it was mentioned that it was also to have control or show the hierarchy of the state (the metaphor of the "Backstabbing handshake").
- Dependence on the Board for interview organization and process guidance limited interviewer autonomy. For instance, an expectation emerged to provide an envelope at the conclusion, indicating a degree of influence that impacted the intended interview structure.
- The Board's involvement became evident only upon arrival in the field, necessitating last-minute question preparation directed to them. These questions were posed through the interpreter, Mrs. Trang, as direct attendance at the meeting with the Board was not permitted.

In field measurement constraints

- It was not always possible to measure complete cross-sections from sea dike to seaward intervention. The mudflats proved to be too inaccessible due to too much moisture not supporting human weight and measurements within the mangrove belt were not possible due to a lack of signal. This was not anticipated during the fieldwork preparation.
- Due to the inaccessibility of the mudflat, measurements were conducted from the pier, requiring the RTK rover to be lowered to the mudflat using a long rope. This method introduced some inaccuracies, as it was not always possible to maintain the rover in a perpendicular position, which may explain the anomalous point observed in cross-section 5 at the MHW plateau.

Equipment availability

- To make concrete conclusions about whether the wave forces, currents, or land-subsiding is the main reason for the witnessed erosion in the cross-section, additional equipment is required that can measure these variables. This equipment was not available and there was no budget to purchase these. Therefore, these measurements were too expensive to conduct.
- Because of the lack of equipment and thus only knowing global currents and wave forces at the Bạc Liêu coast, the precise eroding cause at the mangrove's front could not be decided.

Data collection limitations

- The exact profile of the reforestation attempt close to cross-section 1 could not be measured because the permit did not allow tests beyond the provincial border (despite it being only 30 meters further). Therefore, the profile of this 'reforestation attempt' is an estimate based on the nearest permitted cross-section.
- To demonstrate that mangroves retain enough sediment to remain at Mean High Water (MHW) and counter land subsidence, comparisons with soil elevation behind the sea dike are necessary. This measurement was not conducted, as its relevance was not yet known during fieldwork.
- To strengthen the capacity of mangroves to retain sediment at low inundation heights, precise flow velocities and durations of ponding within the mangrove forest are needed. These measurements were not taken, as the need for them only became apparent after analysing the initial data.
- To calculate the optimal inundation duration of the profiles through tidal movement, a tidal gauge station close to Bạc Liêu is needed for extensive tidal prediction modelling. This was unavailable, so the nearest station was used. However, at a distance of 40 kilometres, it was not accurate enough to demonstrate the exact 'inundation time,' which would have clarified the effects of ponding and sediment entrapment.
- To confirm with certainty that a cross-section is 'unhealthy' and experiencing erosion, at least two time-step measurements are required, showing either the retreat of the mangrove front or a decrease in the elevation where the mangroves are rooted. These precise time-step measurements were not available.
- This is also relevant for cross-section 4, where time is needed to verify that sedimentation is indeed occurring due to adjacent interventions and that the convex profile is an indicator of sedimentation.
- Cross-section 1 also requires validation to determine whether the reforestation attempt is declining under current conditions or whether conditions are improving. This validation could also potentially reveal another factor (such as an ecological effect) if reforestation succeeds despite insufficient hydraulic conditions. Without this validation, the hypotheses remain untested.
- To assess whether mangroves can grow with coarser sediment, more soil samples were needed. Only two samples were taken, and they were too far apart to support any reliable assumptions.

AI Acknowledgement
We acknowledge the use of artificial intelligence tools, such as ChatGPT, DeepL and Grammarly, which assisted in refining, visualising with Python and structuring parts of our report. These tools provided support in the clarity of our research, while all ideas and insights remained our own.

Bibliography

Anthony, E. J., Brunier, G., Besset, M., Goichot, M., Dussouillez, P., & Nguyen, V. L. (2015). *Linking rapid erosion of the mekong river delta to human activities* (tech. rep.). Nature, Scientific Reports. https://doi.org/10.1038/srep14745

Ashley, M. (2014). The implications of co-locating marine protected areas around offshore wind farms. *School of Biological and Marine Sciences*. https://researchportal.plymouth.ac.uk/en/studentTheses/the-implications-of-co-locating-marine-protected-areas-around-off

Balke, T., Bouma, T., Horstman, E., Webb, E., Erftemeijer, P., & Herman, P. (2011). Windows of opportunity: Thresholds to mangrove seedling establishment on tidal flats. *Marine Ecology Progress Series*, *440*. https://doi.org/10.3354/meps09364

Bank, W. (2024). Development projects: Mekong delta integrated climate resilience and sustainable livelihoods project - p153544.

Besset, M., Gratiot, N., Anthony, E. J., Bouchette, F., Goichot, M., & Marchesiello, P. (2019). Mangroves and shoreline erosion in the mekong river delta, viet nam. *Estuarine, Coastal and Shelf Science*, *226*, 106263. https://doi.org/https://doi.org/10.1016/j.ecss.2019.106263

Binh, D. V., Kantoush, S., & Sumi, T. (2020). Changes to long-term discharge and sediment loads in the vietnamese mekong delta caused by upstream dams. *Geomorphology*, *353*, 107011. https://doi.org/https://doi.org/10.1016/j.geomorph.2019.107011

Bosboom, J., & Stive, M. (2021, January). *Coastal dynamics*. https://doi.org/10.5074/T.2021.001

Bradley, G. L., Babutsidze, Z., Chai, A., & Reser, J. P. (2020). The role of climate change risk perception, response efficacy, and psychological adaptation in pro-environmental behavior: A two nation study. *Journal of Environmental Psychology*, *68*, 101410. https://doi.org/10.1016/j.jenvp.2020.101410

Committee, B. L. P. (n.d.). People's committee of bac lieu province [Accessed: 2023-10-23].

Company, E. S. (2023, July). The role of rtk gnss in autonomous vehicles, precision farming, surveying, cartography [(Accessed on 10/18/2024)].

Coteccons. (n.d.). Coteccons construction [Accessed: 2023-10-23].

Delft University of Technology. (2024). Mekong delta living lab - an open air laboratory for coastal protection and nature-based solutions.

Department of Agriculture and Rural Development of Bac Lieu Province. (2024, January). Department of agriculture and rural development of bac lieu province.

Dung, L. C. (2008). *Environmental and socio-economic impacts of rice-shrimp farming: Companion modelling case study in bac lieu province, mekong delta, vietnam* [PhD thesis]. Chulalongkorn University, Thailand.

Erftemeijer, P. L. A., Winterwerp, H., Bosma, R. H., & To, H. H. (2021, December). *Increasing coastal resilience through mangrove afforestation in the mekong delta: International examples and lessons learnt* (Technical Report). Ministry of Economic Affairs and Climate Policy.

Freeman, R. E. (2010). *Stakeholder theory: The state of the art*. Cambridge University Press.

Hanssen, J., Prooijen, B., & Maren, D. (2024). The shape of fringing tidal flats in engineered estuaries. *Frontiers in Marine Science*, *11*. https://doi.org/10.3389/fmars.2024.1354716

Honga, H. T. C., Van Tya, T., & Van Duya, D. (2022). Community perception, use, and economic valuation of mangrove ecosystem services: Case study in soc trang and bac lieu provinces of viet nam. *Tuyn Tp Công Trình Khoa Học Cua Các Ti´n Sĩ Tre*, *55*.

Hu, Z., van Belzen, J., Wal, D., Balke, T., Wang, Z. B., Stive, M., & Bouma, T. (2015). Windows of opportunity for saltmarsh vegetation establishment on bare tidal flats: The importance of temporal and spatial variability in hydrodynamic forcing. *Journal of Geophysical Research: Biogeosciences*, *120*. https://doi.org/10.1002/2014JG002870

Huynh, T. C. H. (2020). *Roles of mangrove ecosystem in the sustainability of communities in the vietnamese mekong delta: A case study in soc trang and bac lieu provinces* [Doctoral dissertation]. Hokkaido University.

Institute of marine engineering (icoe) [(Accessed on 10/10/2024)]. (n.d.).

International Union for Conservation of Nature. (2024, July). Kick-off meeting on mangrove restoration and hybrid nbs in the mekong delta.

Kibler, K., Pilato, C., Walters, L., Donnelly, M., & Taye, J. (2022). Hydrodynamic limitations to mangrove seedling retention in subtropical estuaries. *Sustainability*, *14*, 8605. https://doi.org/10.3390/su14148605

Lan, N. T. P. (2013). Social and ecological challenges of market-oriented shrimp farming in vietnam. *SpringerPlus*, *2*(1), 675. https://doi.org/10.1186/2193-1801-2-675

Leijten, M. (2024). Process management [Accessed: 2024-11-05]. https://brightspace.tudelft.nl/d2l/home/595135

Limited, T. N. (2015, February). *Trimble r8s gnss receiver user guide* (Version 1.0, Revision A) [© 2004-2015, Trimble Navigation Limited]. Trimble Navigation Limited. Dayton, Ohio, USA. http://www.trimble.com

Loon, A. F. V., Brake, B. T., Huijgevoort, M. H. J. V., & Dijksma, R. (2016). Hydrological classification, a practical tool for mangrove restoration. *PLOS ONE*, *11*, e0150302. https://doi.org/10.1371/journal.pone.0150302

Marchesiello, P., Nguyen, N. M., Gratiot, N., Loisel, H., Anthony, E. J., Dinh, C. S., Nguyen, T., Almar, R., & Kestenare, E. (2019). Erosion of the coastal mekong delta: Assessing natural against man induced processes. *Continental Shelf Research*, *181*, 72–89. https://doi.org/https://doi.org/10.1016/j.csr.2019.05.004

Mcllveen, S., & Hung, P. Q. (2019). Improving livelihoods and increasing coastal resilience: A look at integrated mangrove-shrimp aquaculture in vietnam. *Aquaculture*, *23*(4), 11–13.

Ministerie van Buitenlandse Zaken. (2024, April). Mangrove living lab resultaat 'bloeiende samenwerking' vietnam en nederland [Accessed: 2023-10-23].

Ministry of Agriculture and Rural Development. (n.d.). History of establishing and developing ministry of agriculture and rural development [Accessed: 2023-10-23].

Ministry of Natural Resources and Environment. (n.d.). Task and function [Accessed: 2023-10-23].

Ngo, C. C., Poortvliet, P. M., & Feindt, P. H. (2019). Drivers of flood and climate change risk perceptions and intention to adapt: An explorative survey in coastal and delta vietnam. *Journal of Risk Research*, *23*(4), 424–446. https://doi.org/10.1080/13669877.2019.1591484

Nguyen, H. Q., Korbee, D., Ho, H. L., Weger, J., Hoa, P. T. T., Duyen, N. T. T., Luan, P. D. M. H., Luu, T. T., Thao, D. H. P., Trang, N. T. T., Hermans, L., Evers, J., Wyatt, A., Nguyen, X. Q. C., & Phi, H. L. (2019). Farmer adoptability for livelihood transformations in the mekong delta: A case in ben tre province. *Journal of Environmental Planning and Management*, *62*(9), 1603–1618. https://doi.org/10.1080/09640568.2019.1568768

Nguyen, H. Q., Patiño Guerra, J. D., Korbee, D., Hong Luan, P. D. M., Duc Dung, T., Quang Hung, D., Loc, H. H., of Water management, C., Climate Change (WACC), V. N. U. .-. H. C. M. c., of Technology, D. U., for Water Education, I. D. I., & Hermans, L. (2019). Manual for application of the mota framework [Unknown]. https://strategic-delta-planning.un-ihe.org/sites/strategic-delta-planning.un-ihe.org/files/quan_mota_manual_-_version_1.pdf

Nguyen, L. T., Van Pham Dang Tri, L. T., Loi, J. S., & Nobuoka, H. (n.d.). Mangrove structure variation under influences of tidal-inundation in the bac lieu coastal zone [Unpublished manuscript or details not provided on publication year or source.].

Nguyen, T. K. L., Phan, T. C. T., Vo, N. S., & Huynh, T. G. (2023). Phytoplankton composition in intensive shrimp ponds in bac lieu province, vietnam. *Fisheries and Aquatic Sciences*, *26*(8), 470–479. https://www.e-fas.org/archive/view_article?pid=fas-26-8-470

Paek, H., & Hove, T. (2017). Risk perceptions and risk characteristics. *Oxford Research Encyclopedia of Communication*. https://doi.org/10.1093/acrefore/9780190228613.013.283

Phan, H. (2020). *Coastal and seasonal hydrodynamics and morphodynamics of the mekong delta* [Dissertation (TU Delft)]. Delft University of Technology. https://doi.org/10.4233/uuid:2bcb33bf-5b73-4873-9168-08b1e7a2836f

Phan, L., Thiel de Vries, J., & Stive, M. (2015). Coastal mangrove squeeze in the mekong delta. *Journal of Coastal Research*, *31*, 233–243. https://doi.org/10.2112/JCOASTRES-D-14-00049.1

Quang Chien, N., Hien, L., Tran Thanh, T., & Le, H. T. (2018, March). *Coastal erosion and mangrove forest recession along bac lieu coast, vietnam* (tech. rep.).

Quyen, N. H. (2019). Reducing rural poverty in vietnam: Issues, policies, challenges. *Mekong Development Research Institute, Written for the Expert Group Meeting on Eradicating Rural Poverty to Implement the 2030 Agenda, 2030*, 1–7.

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation*, *141*(10), 2417–2431.

Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., & Stringer, L. C. (2009). Who's in and why? a typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management*, *90*(5), 1933–1949.

Slimak, M. W., & Dietz, T. (2006). Personal values, beliefs, and ecological risk perception. *Risk Analysis*, *26*(6), 1689–1705. https://doi.org/10.1111/j.1539-6924.2006.00832.x

Stive, M., Kreijns, M., Schwidder, L., Erftemeijer, P., Trung, H. L., Truong, S., Linh, P., Hung, P. M., Dao, T., Ha, T. T. T., & Nhan, D. T. (2023). *Restoration and sustainable management of coastal forests in the mekong delta to enhance environmental change adaptation capacity* (tech. rep.) ((Accessed on 10/10/2024)).

Thao, N. D., Kiet, N., Huynh, P. T. D., Hiep, L. D., & Trang, D. D. T. (2023). Wave attenuation in coastal mangroves: The case of mekong delta vietnam. *IOP Conference Series: Earth and Environmental Science*, *1226*(1), 012026.

Thomas Dunlop, W. G., & Felder, S. (2023). Restoring estuarine ecosystems using nature-based solutions: Towards an integrated eco-engineering design guideline. *Science of The Total Environment*, *873*, 162362. https://doi.org/https://doi.org/10.1016/j.scitotenv.2023.162362

Tiet, T., To-The, N., & Nguyen-Anh, T. (2022). Farmers' behaviors and attitudes toward climate change adaptation: Evidence from vietnamese smallholder farmers. *Environment, Development and Sustainability*, *24*(12), 14235–14260. https://doi.org/10.1007/s10668-021-02030-7

Tran, D. D., Hoang, L. P., & Tran, T. A. (2023). Farmers' livelihoods and adaptation in the vietnamese mekong delta: Current practices and policy implications. In *The mekong river basin* (pp. 527–558). Elsevier. https://doi.org/10.1016/B978-0-323-90814-6.00007-3

Tran Thanh, T., Quang Chien, N., Le, H. T., & Hai, L. (2019, September). *Modelling storm surge hazard to mekong delta* (tech. rep.). https://doi.org/10.1007/978-981-15-0291-0_1

TU Delft. (n.d.). Organisation [Accessed: 2023-10-23].

Van Bay, D., Lam, P. T., & Luan, T. D. (2009). Assessment of social economic impacts of failed semi-intensive and rice-shrimp farming model on livelihoods of small farmers in soc trang and bac lieu provinces. *Research for Developing Sustainable Agriculture*, 266.

Van der Linden, S. (2015). The social-psychological determinants of climate change risk perceptions: Towards a comprehensive model. *Journal of Environmental Psychology*, *41*, 112–124. https://doi.org/10.1016/j.jenvp.2014.11.012

Vo, H. T., Le, V. T., Phung, L. M., & Cao, T. T. H. (2019). Offshore wind power in vietnam: Lessons learnt from phu quy and bac lieu wind farms. *Proceedings of the 1st Vietnam Symposium on Advances in Offshore Engineering: Energy and Geotechnics*, 276–281.

Vu, P. D. T., Phan, H. V., Pham, T. V., & Nguyen, H. T. (2015). Agro-ecological dynamics in the coastal areas of the vietnamese mekong delta in the context of climate change (a case study in bac lieu province). *CTU Journal of Innovation and Sustainable Development*, (01), 81–88.

Willemsen, P. W. J. M. (2021, January). *Biogeomorphology of salt marshes: Understanding the decadal salt marsh dynamics for flood defense* [Dissertation (University of Twente)].

A

Site investigation

To gain a deeper understanding of the challenges facing the current state of the mangroves, we conducted field measurements in the Bạc Liêu province, located in the Mekong Delta, South Vietnam. This region has been the subject of numerous hydraulic research expeditions by various organizations, including the Institute of Offshore and Coastal Engineering from Ho Chi Minh City, the Living Lab project led by TU Delft, and several NGOs. The substantial amount of data already collected in this area makes it an ideal focus for further investigation. Additional data contributions will further enrich the data in this area of interest.

During our site investigation, we gathered three primary types of data. First, bathymetric surveys were conducted across different coastal cross-sections. Second, water levels at two different cross-sections were measured during the vertical high tide rising and falling period. Lastly, sediment samples were collected from various spots. These datasets are intended to be analyzed collectively to derive new insights and answer the research questions, as mentioned in Chapter 2.

This field investigation was conducted in collaboration with the Institute of Offshore and Coastal Engineering from Ho Chi Minh City. Prior to our fieldwork in Bạc Liêu, the institute assisted us by sharing their expertise on the coastal conditions and addressing our questions and assumptions. During the measurements, they accompanied us into the mangroves and mudflats, providing us with both guidance and equipment. We extend our sincere gratitude once again to Mr. Thó, Mr. Mitikó, and Mr. Hùng for their invaluable support.

A.1. Bạc Liêu coastline reconnaissance

On Monday 23-09-2024, a comprehensive survey of the Bạc Liêu coastline was conducted, to validate initial assumptions and confirm accessibility to the predetermined measurement sites.

The first site visited was the pier at Nhà Mát resort, located in the small town Nhà Mát approximately 10 kilometers south of Bạc Liêu City, facing the coastline directly. The shoreline at the resort was reinforced with a concrete revetment. To the left of the pier, approximately 200 meters offshore, a pile rock breakwater separated the mudflats from the open sea. On the mudflat, the remains of a damaged bamboo fence were visible, and no mangroves were present. This location, where mangroves had failed to establish, was selected as a comparison site against areas of successful mangrove growth, while it was properly accessible. The last failed afforestation attempt in this mudflat dates from August 2019, as stated by the forester director of Bạc Liêu Nguyên Hôi (personal communication, October 2024). On the right side of the pier, a small belt of mangrove trees, protected by a hollow pile breakwater, was observed, though the area was too limited to serve as a viable site for measuring successful mangrove restoration.

Approximately half a kilometre eastward from the resort pier, a belt of young mangroves was identified within the mudflats, with trees extending up to half a meter above the coastline. These trees could be the only remnants of a failed mangrove reforestation project along the Nhà Mát coastline, which were in quite decent shape. However, due to the observed height of the mangroves, this might also be a case of natural seeding. Despite the difficult accessibility, this location was chosen as a site to measure successful reforestation and thus investigate the conditions for young but struggling mangroves.

Figure A.1: Pier at Nhà Mát. Left Mangroves, right mudflat

Figure A.2: Young successful mangroves near Nhà Mát

Eight kilometres further east, a wind farm with a pier extending into the sea was visited, called Bạc Liêu wind farm. While the pier was easily accessible, the mangroves near the shore were not. Furthermore, the mangrove belt in this area appeared to be in poor health, with trees along the shoreface collapsing due to insufficient sediment support and the impact of wave action. As a result, this location was excluded from the list of measurement sites. Between Nhà Mát and the wind farm, organic shrimp farms were observed on the seaward side of the dike. Beyond the wind farm, the mangrove belt had thinned significantly, making it unsuitable for farming activities. The last shrimp farm was located just west of the first line of windmills extending into the sea.

At the provincial border of Bạc Liêu, a new mangrove reforestation project was observed. The young mangroves appeared healthy, although limited information about the project's background was available. However, the older mangroves situated behind the shoreline showed signs of erosion. This new reforestation site, located on the border with Sóc Trăng province, was identified as a potentially valuable site for further study, but measurements were not permitted due to local restrictions that prohibited data collection beyond the Bạc Liêu provincial border. A new rock-pile breakwater, constructed in July 2024, was also observed at this location, which was not known beforehand. On the Bạc Liêu side of the breakwater, no new mangroves had been planted, and the older mangroves were eroding. This site was considered useful for a comparative analysis between areas with young mangroves and those without. Additionally, the construction of a revetment along the dike on the Bạc Liêu side was still in progress.

Figure A.3: Newly planted mangroves in Soc Trang

Figure A.4: Newly build pile rock breakwater at Bạc Liêu border

The site investigation continued westward from Nhà Mát, where a mangrove belt near the river mouth was initially identified as a potential site for measuring healthy mangroves. However, access to this area was restricted, as it was within military territory.

The final site visited was the Hoa Binh 1 windmill farm, a location that was easily accessible due to the pier being a tourist destination. Inland from the sea dike, a section of healthy mangroves was observed. At the seaside of the dike, newly planted mangroves adjacent to the pier were observed and in good health. This reforestation project dates from August 2023, according to the reforest director of Bạc Liêu, Nguyên Hôi (personal communication, October 2024). Great signs of erosion were witnessed where a bamboo fence had been placed at the mangrove front facing the mudflat and a cliff was clearly visible. Beyond the bamboo fence, a long stretch of mudflat extended toward a hollow pile breakwater. Perpendicular to the coastline, additional hollow pile breakwaters had been installed. The wind turbines were positioned 7 to 11 kilometres offshore.

Figure A.5: Succesful reforestation attempt at Hoa Binh 1 windmill pier

Figure A.6: Cliff formation indicating erosion behind bamboo fence

A.2. Bathymetry measurements

Figure A.7 shows the locations chosen for the bathymetry measurements after the coastal reconnaissance.

The bathymetry measurements are done with an RTK GNSS system, which is described in 4.1.1.

On Tuesday 24-09-2024, the first three bathymetric surveys were conducted with the assistance of ICOE staff and under the supervision of a government official, the forester of Bạc Liêu province. The surveys were carried out during low tide, which occurred between approximately 10:00 and 19:00. Favorable weather conditions, including calm winds and clear skies, provided an optimal environment for data collection.

Figure A.7: Chosen cross-sections for bathymetry measurements in Bạc Liêu

Location (4), the Nhà Mát pier, was the first site visited. The bathymetry data collected here will serve as a reference point for comparative analysis, while the coastal conditions were found unsuitable for mangrove reforestation projects at this location.

Initially, the bathymetry data collection was conducted on foot, with the RTK device held by hand. However, the excessively saturated muddy soil quickly proved too penetrable to support human weight, presenting significant safety concerns. This difficulty arose over a 40-meter stretch between RTK points 1 and 11. At this point, the initial attempt was halted. Local residents observing the activity offered assistance by providing a rope, which allowed the RTK device to be safely lowered from the pier—approximately 3 meters high, onto the coastal bed. This solution enabled the continuation of measurements for approximately 150 meters, covering RTK points 12 to 29. The final 20 meters of the stretch, consisting of firmer, sandy terrain, allowed for the resumption of on-foot measurements between RTK points 30 and 38. The entire 200-meter stretch was surveyed within one hour.

The second measurement was taken at location (2). Here, it was possible to conduct a complete bathymetric survey of the mangroves, from the dike to the mudflat. The mangroves at this location were deemed unhealthy, with noticeable erosion at the mangrove front facing the mudflat. To ensure a proper connection between the satellite and the RTK device, measurements were taken along the side of the mangroves for approximately 400 meters. Beyond this distance, the mangrove density decreased, and the trees became shorter. After an additional 50 meters, the mangrove front was reached, where the soil became moist and muddy. Further measurements were completed on foot, facilitated by a walkable clay path used by local fisher farmers, which proved not to be as saturated as other parts of the mudflat. The bathymetry measurements were still taken from the tidal flat and not this clay path. The end of the tidal flat was not reached, while there was a large opening in between the breakwaters, which showed deeper parts and more water. The entire measurement took roughly two hours.

The third and final measurement on Tuesday was taken at location (1), near the border of Sóc Trăng. The mudflat appeared extremely saturated, making on-foot measurements unsafe. The breakwater adjacent to the site exhibited similar conditions but was accessible, so it was selected as the measurement location. Furthermore, it was situated at the Bạc Liêu border, where permission for measurement was granted. This site is considered suitable as a validation point for a reforestation attempt (successful so far). The first newly constructed breakwater was accessible via a log bridge. This breakwater stood approximately 2 meters high, allowing the RTK device to be placed correctly on the seabed. However, the first breakwater lacked stairs on the rear side, and a 10-meter gap to the second breakwater, which also lacked stairs, made it unreachable. Consequently, only part of the bathymetric area between the shore and the parallel offshore breakwater was measured at this

Figure A.8: Saturated mud unable to hold human weight

Figure A.9: Walkable sand coast behind Nhà Mát pier

location.

On Wednesday, 25th September 2024, bathymetric surveys were resumed, with the final two measurements conducted. Low tide occurred between 11:00 and 20:00, providing the necessary window for data collection. The surveys were again carried out with the assistance of two ICOE staff members and under the supervision of the forester from Bạc Liêu province. The weather was hot throughout the day, with a brief period of rain occurring around 14:00, temporarily halting measurements to prevent exposure of the RTK equipment to water.

At first, the water level at Nhà Mát was measured at 08:00, to function as a reference level for the RTK measurements on the 24th of September. This made it possible to couple the measurements to the Vietnamese reference Datum. This was done the next day, while on the 24th the low tide did not reach the shore and during high tide, it was raining.

Next, location (3) was visited, where successful mangrove replanting had occurred along the mangrove frontline. Access to this site required crossing the land of a local farmer, who maintained a long strip of artificial mangroves protected by clay dikes unaffected by tidal movements. Measurements began beyond the furthest clay dike parallel to the shore. Directly behind this dike, there was an area with smaller, but healthy mangroves to the left and denser, older mangroves to the right. Initial measurements were attempted on the left side, assuming it was accessible. However, the soil was too saturated and could not support human weight, necessitating the abandonment of this location for safety reasons. On the right side, it was possible to walk along the mangrove roots, allowing bathymetric measurements in this area. Due to the dense mangrove cover, only a few locations permitted satellite contact with the RTK device, resulting in large gaps between the measurements. There was too much water at the mudflat front to allow safe access to the mudflat. As a result, only bathymetric measurements close to the mangrove bed were conducted. It was tried to place the RTK rover as close to the younger mangroves as possible. The time needed to conduct this measurement was approximately one and a half hours.

Figure A.10: Measurements at edge of mangroves

Figure A.11: Walkable claydyke alongside the mudflat

The final location visited was (5), at the Hoa Binh 1 wind farm. Here, it was possible to measure the entire stretch, extending from the first mangroves to the breakwater. The pier was approximately 8 meters high, so a rope was used to lower the RTK device to the bed from above. However, this made it difficult to position the RTK stick perfectly perpendicular to the bed, introducing a small margin of error. This method was applied across the entire 300-meter stretch. The measurement took approximately one hour.

Figure A.12: Breakwater Bạc Liêu measurement by log bridge

Figure A.13: Measuring inside a healthy mangrove forest

Figure A.14: Rope connected to the RTK

Figure A.15: Lowering the RTK from the pier

A.3. Water level measurements

To perform an inundation analysis, the water level was measured at 2 cross-sections. This was done by placing a height measurement pole, otherwise known as a ruler, in the ground in the measured cross-section and then measuring the following 3 aspects:

- **First contact with the waterline.**
  This was the time that the water line reached the pole during rising tide. This is needed for the total inundation time of the point.
- **Maximum water level.**
  This was useful to understand the maximum inundation level of the point.
- **last contact with the waterline.**
  This was the time the waterline reached the pole during falling tide. Combined with the first time stamp, gives us the full inundation period and therefore also the dry period.

The first water level measurement was conducted on Monday 30-09-2024. This was done at the Hoa Binh 1 windmill farm (location 5). This location was selected to evaluate the inundation duration of fully developed mangroves. Based on tidal predictions from ICOE, the tide was expected to rise around 10:00. The ruler was placed near the cliff edge of the mangroves at 09:35, as shown in Figure A.16. High tide was observed around 13:30; however, the ruler was not submerged at this time, and no inundation height was recorded. It is important to note that this measurement coincided with the lower of the two high tides predicted for the day, as depicted in Figure A.17.

The second water level measurement was done on Tuesday 01-10-2024, at the Nhà Mát pier. The ruler was placed near the start of the pier, as shown in Figure A.18, to assess inundation levels for an area of unsuccessful reforestation. It was secured in the mudflat at 11:47 to prevent displacement. At low tide, the initial reading indicated 17 centimetres above the mudflat. The rising tide first reached the ruler at 12:00, with a peak level of 74 centimetres recorded at 13:52, as seen in Figure A.19. The tide had retreated completely at 15:54, and this final measurement showed 23 centimetres on the rule due to a residual tidal water puddle, which did not experience any currents by the tidal retreat anymore. Therefore, a clear indication of water ponding was observed.

Figure A.16: Ruler placed on developed mangrove site threatened by erosion

Figure A.17: The ruler did not have contact with the tide. No inundation was witnesssed

Figure A.18: Ruler placed on mudflat under Nhà Mát pier

Figure A.19: Water level during High tide at Nhà Mát pier

A.4. sediment samples

Following the coastal reconnaissance, two sites were selected for sediment sampling. The first sampling site was the mudflat in front of Nhà Mát resort. Four weeks prior to this survey, the ICOE had collected three sediment samples from these mudflats. The sediment will be analyzed to assess conditions at a location where previous mangrove reforestation efforts were unsuccessful.

The second sampling site was at location (5) at Hoa Binh 1 Windmill Park and this sampling was collected on 30-09-2024. Successful mangrove reforestation was observed under the pier, although severe erosion was noted behind the mangrove fence. Two sediment samples were collected from areas where newly planted mangroves were thriving, as seen in **??** while two additional samples were taken from the mangrove frontline, as seen in **??** where significant erosion of the trees was observed. In total, four sediment samples were collected to compare conditions in both scenarios. This was done around 10:00 a clock, while the water was not yet inundated. A minimum of 1 kilogram of soil was required per sample.

Figure A.20: Sediment sample collection at successful reforestation site

Figure A.21: Sediment sample collection at mangrove erosion front

B

Explanation of CCRPM and MOTA-framweork

B.1. Climate Change Risk Perception Model

The Climate Change Risk Perception model (CCRPM) is a framework based on four risk theories: (1) the psychometric model, (2) the value-belief-norm theory, (3) the theory of planned behaviour (4) the protection motivation theory. It should be noted that the statistical analysis was not conducted; only the theory of the CCRPM was used to explore and interpret farmers' risk perceptions. In this study alterations of the psychometric model and theory of planned behaviour were used to improve the applicability of the theories on the research. Instead of the psychometric model, the psychometric paradigm was used and instead of the theory of planned behaviour, the theory behind the MOTA-framework was used. Subsequently, the MOTA-framework was executed since this provides valuable insight into the ability and motivation of the stakeholders involved (H. Q. Nguyen, Korbee, et al., 2019).

From the four theories of the CCRPM four dimensions can be derived: cognitive factors, experiential processing, socio-cultural influences and socio-demographic control variables. Each of these four dimensions, as described below, can help explain how people understand and respond to the risks of climate change leading to a multi-dimensional model which can therefore capture more variance in risk perception. Figure B.1 shows a visualisation of the four different dimensions with examples composing the CCPRM (Van der Linden, 2015). Using the CCRPM in this research is beneficial because it can help to understand how different stakeholders perceive risks related to environmental changes. While our research does not focus on climate change, this model gives us a useful framework for analysing attitudes and perceptions. By applying this model, it can gain insights into whether factors influence the stakeholders' support or resistance to some projects, regardless of their link to climate change (Paek and Hove, 2017).

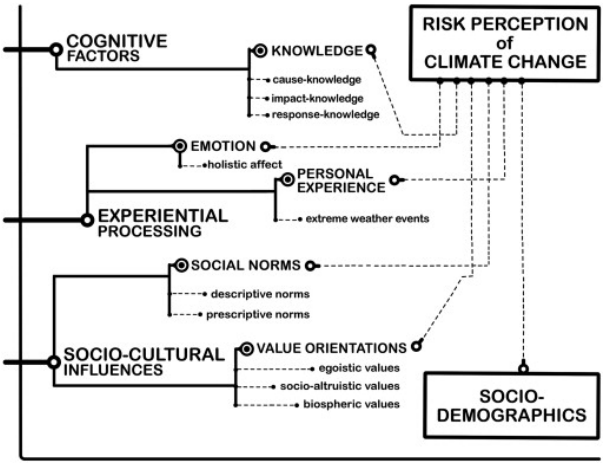

Figure B.1: The four dimensions within the CCPRM

Cognitive Factors
Cognitive factors relate to the knowledge and understanding that individuals have about a certain topic or problem, including the impact and the causes of this topic or problem. The level of knowledge and perceived effectiveness of measures influence how people see the risks and make decisions regarding climate change (Ngo et al., 2019). In the context of our research, it is used to understand the level of knowledge people have about their surroundings and the problems they might face and from what source they obtained this information. It is important to note that cognitive factors refer to information that is derived from legitimate sources like research papers, authorized information centers and scientific reports. While individuals' perceptions may be influenced by their surroundings, including conversations with neighbours, the CCRPM emphasizes scientifically-backed information to form the basis of cognitive factors (Ngo et al., 2019).

The first theory, the psychometric paradigm, explains how perceived knowledge can significantly influence individuals' risk perceptions. Perceived knowledge is the result of how individuals process and organize the information they receive and use this information to make an interrelated network as a mental structure in their minds (Ngo et al., 2019). This interrelated network can shape how they understand hazards. The psychometric paradigm emphasizes factors such as uncertainty and controllability, which can show how people's understanding of risks can influence their responses. For example, if a risk is perceived as catastrophic, it may evoke strong feelings of fear, which can influence their overall perception towards that risk (Paek and Hove, 2017). Regarding the dimension of cognitive factors, this theory highlights the effect that scientifically-backed information can have on individuals' risk perception (Van der Linden, 2015).

The second theory, the value-belief-norm theory, explains how knowledge can play an important role in shaping individuals' beliefs and norms. This theory suggests that when individuals have a deeper understanding of the problems they face, it can influence their values and beliefs, which can contribute to their sense of morality to engage in sustainable practices. Scientifically-backed information can drive the formation of personal values about responsibility, which can influence the perceived ability to undertake effective action against a certain perceived risk (response effectively). This can motivate individuals to take action (Bradley et al., 2020, Tiet et al., 2022).

These two theories are important to create an understanding of how cognitive factors, in this research, meaning the influence of scientifically-backed information, have on individuals. Cognitive factors explain the impact of knowledge and understanding on risk perceptions and how knowledge and understanding can motivate action (Ngo et al., 2019).

Experiential Processing (Emotion and experience)
Experiential processing explains how personal experiences and emotions can influence the perceptions and behaviour of individuals. People who have directly experienced the consequences of an event such as extreme weather events such as flooding may feel more concerned about such risks. These experiences can lead to higher emotional responses, which can shape attitudes and actions towards such events (Van der Linden, 2015).

The fourth theory of the CCRPM, the protection motivation theory, suggests that personal experiences with environmental threats influence perceived vulnerability and can influence emotional responses because of that. When individuals personally experience certain events or face certain problems, they are more likely to recognize the severity of these threats. Higher awareness often leads to a higher motivation to behave more protectively (Ngo et al., 2019).

The already mentioned value-belief-norm theory is also related to experiential processing. Regarding experiential processing, this theory explains how emotional reactions can reinforce beliefs that are based on values. The values identified by this theory are: personal values, general beliefs, a sense of responsibility, and personal norms towards the intended action (Slimak and Dietz, 2006). If someone has witnessed the harsh effects of flooding, they might feel a stronger moral obligation to engage in adaptive behaviour and proactive risk mitigation behaviour. Their emotional connection to the experiences can strengthen their commitment to take action (Slimak and Dietz, 2006, Tiet et al., 2022).

These two theories help to understand how emotional and experiential factors can shape the risk perceptions and subsequently adaptive and proactive risk mitigation behaviours of individuals (Ngo et al., 2019).

Socio-cultural influences (Norms and Values)
Socio-cultural influences, as a dimension of the CCRPM, consider the role of all social norms, values and beliefs that can shape how individuals and communities perceive and respond to certain events and problems. These factors often determine the extent to which people feel morally obligated to engage in certain behaviours to protect the environment (Van der Linden, 2015). The socio-cultural influences within the CCRPM are explained by two theories:

The third theory of the CCRPM, the theory behind the MOTA-framework, connects social norms and values to an individual's motivation to act. If behaviour is socially accepted and valued within a community, individuals are more likely to adopt this type of behaviour (H. Q. Nguyen, Korbee, et al., 2019).

The value-belief-norm theory states that norms and values of an individual as well as those of the community that an individual is in are a critical aspect of the feeling of moral responsibility for individuals. Combining the MOTA-framework and the value-belief-norm theory suggests that people are more likely to act in a certain way if they align with their personal values and if they align with their perceived societal expectations (Ngo et al., 2019).

Considering the social norms and values within a community can either facilitate or hinder the adoption of certain adaptive and proactive risk mitigation behaviours, according to these theories (Slimak and Dietz, 2006).

Socio-Demographic Factors
Socio-demographic factors, such as age, education, occupation, etc. can influence how individuals perceive and respond to certain events and problems. These factors can often be considered as background variables that help explain variations in risk perceptions and behaviours. Socio-demographics have a certain effect on the other three mentioned dimensions but this effect can be inconsistent. Therefore they function as control variables in the CCRPM (Van der Linden, 2015).

The effect that socio-demographic factors have on how people evaluate their ability to cope with and respond to environmental threats can be explained by the fourth theory of the CCRPM, the protection motivation theory. For example, people with lower socio-economic status may feel less capable of responding effectively to climate risks due to limited resources or limited knowledge (Ngo et al., 2019).

B.2. Execution of the MOTA Framework

The next to the theory behind the MOTA-framework, is it also an executable theoretical framework, that is used to understand the possible factors that influence changes in behaviours, practices or technologies within a system. By examining motivation and ability, the MOTA-framework can help identify what drives individuals or groups to change their behaviour or what causes their (dis)ability to change their behaviour. In figure B.2 the components of the MOTA-framework are visualised and their relation to each other (H. Q. Nguyen, Patiño Guerra, et al., 2019, H. Q. Nguyen, Korbee, et al., 2019).

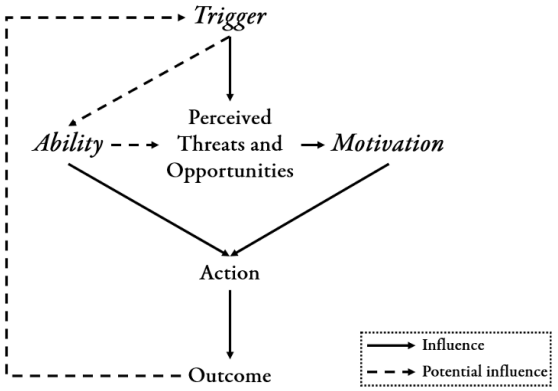

Figure B.2: MOTA-framework

B.2.1. Components of the MOTA-framework

Motivation

The component motivation refers to the reasons, incentives, and internal or external drivers that influence people's willingness to adopt new behaviours such as adaptive and proactive risk mitigation behaviours or practices (H. Q. Nguyen, Patiño Guerra, et al., 2019).
Important factors that can influence motivation:

- Perceived benefits
- Social norms or peer pressure
- Personal values
- External incentives

Ability

The component of ability refers to the capacity, skills, resources and knowledge that is needed to change to new behaviours such as adaptive and proactive risk mitigation behaviours or practices. Even if the motivation is high, the ability is necessary for a behavioural change to occur (H. Q. Nguyen, Patiño Guerra, et al., 2019).
Important factors that can influence ability:

- Access to resources
- Skills or training
- Support
- Infrastructures and technologies

B.2.2. The MOTA-framework applied

In Bạc Liêu the MOTA-framework can be used to analyze if involved stakeholders are motivated and/or able to participate in the different possible solutions to promote mangrove reforestation and conservation, which can make sure that the efforts from the other stakeholders, such as the living lab, align with the needs and capabilities of the community (H. Q. Nguyen, Korbee, et al., 2019).

- **Motivation analysis:** interviews will be used to assess how involved stakeholders perceive the problems they are currently facing and how they would perceive the benefits of different efforts to remedy those problems. For example, if an effort for mangrove restoration and/or conservation is seen as a benefit for the protection from flooding, the motivation to maintain the mangroves will be higher (H. Q. Nguyen, Korbee, et al., 2019).
- **Ability analysis:** The framework will also examine to see if the communities have the necessary skills, resources and support to engage in mangrove restoration and/or conservation. This could for example be financial support or education in ecological farming practices for farmers to transition to a new type of farming involving mangroves (H. Q. Nguyen, Korbee, et al., 2019).

Through identifying potential gaps in motivation and/or ability of involved individual stakeholders or stakeholder groups, the framework can help to enhance the effectiveness of the efforts made to remedy the problems these individual stakeholders or stakeholder groups face. These efforts should not only be designed to achieve technical objectives but should also be implementable by the stakeholders who are most affected by them (H. Q. Nguyen, Patiño Guerra, et al., 2019).

B.2.3. Relation CCRPM and MOTA-framework

The MOTA-framework and the CCRPM can be used as complementary tools to understand how individuals perceive and respond to the risks of the events and problems they face and how their motivations and abilities influence their behavioural changes. The link between the two models can be established in this way:

- **Cognitive factors: motivation & ability:** The knowledge and understanding of the problems involved stakeholders face can directly influence motivation in the MOTA-framework. If individuals have knowledge about the benefits of mangrove restoration and conservation, they are more likely to be motivated to support such measures. Interview questions about knowledge can help identify knowledge gaps that might hinder the motivation of individuals. It also attributes to the ability they feel to change something about their current situation (H. Q. Nguyen, Korbee, et al., 2019).

- **Experiential processing: motivation:** Personal experiences and emotional responses to perceived risks can heighten the perceived vulnerability of individuals. This can lead to a stronger internal motivation to stimulate measures that protect themselves from these perceived risks and is in line with both the MOTA-framework and the CCRPM model. Interview questions about the experiences of individuals can be linked to how these experiences affected their motivations for certain behaviours (H. Q. Nguyen, Korbee, et al., 2019).
- **Socio-cultural influences: motivation & ability:** Social norms and values shape the perceived acceptability and importance of certain behaviours, which influences the motivation to act in the MOTA-framework and these norms and values are also used in the socio-cultural dimension in the CCRPM model (H. Q. Nguyen, Korbee, et al., 2019).
- **Socio-demographic factors& ability:** The resources, skills and support available to individuals can influence their ability in the MOTA-framework. They are also often linked to socio-demographic factors such as education and income level, which are also used in the CCRPM model (H. Q. Nguyen, Korbee, et al., 2019).

By linking the CCRPM and MOTA-framework and by providing information through the interviews, it is possible to create a more nuanced picture of the risk perceptions the involved stakeholders have. It also highlights their needs and capabilities. This integration makes sure that the measures in Bạc Liêu are not only backed by theoretical insights but also align with the local context and the local problems.

C

Interview questions

C.1. Interviews Farmers - I

C.1.1. Ecological Farmers

General Information

- Name:
- Age:
- What kind of farm:
- Location of farm (address):
- Time spent as a farmer (working years):
- Family situation:

Questions

- Can you tell us about your farm?
- How long have you been farming in this area?
- What changes have you seen around your shrimp farm since they started protecting the mangroves?
- How have these mangrove protection actions affected your shrimp farming?
- What problems do you face when farming shrimp in the mangroves?
- How do you feel your ideas are considered in mangrove projects?
- How do you work with other mangrove farmers to solve problems?
- How has your farm changed over the years compared to how it was in the past?
- What do you believe has caused these changes on your farm?
- What kind of problems with flooding or extreme weather have you experienced on your farm?
- What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
- Who would you like to collaborate with more to improve your farming?

C.1.2. Intensive Farmers

General Information

- Name:
- Age:
- What kind of farm:
- Location of farm (address):
- Time spent as a farmer (working years):
- Family situation:

Questions

- Can you tell us about your farm? (What do you farm: shrimp, rice, fish, etc.)
- How long have you been farming in this area?
- What changes have you noticed in the water around your farm over the years?
- What problems do you face in shrimp farming?
- To what extent do you feel your ideas are considered in decisions about water use and farming?
- How have your personal experiences shaped the way you see changes in Bạc Liêu's environment?
- How do you work with other farmers to solve problems when they arise?
- What kind of support have you received from the government or NGOs for your farming?
- Who would you like to work with more to improve your farming?
- What are the benefits of intensive shrimp farming for you?
- What support would help you farm better?

C.2. Interviews Farmers - II

General Information

- Name:
- Age:
- What kind of farm:
- Location of farm (address):
- Time spent as a farmer (working years):
- Family situation:

Collaboration

- How often do you collaborate with local authorities/DARD (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local authorities?
  - What does collaboration look like to you?

- How often do you collaborate with other farmers (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local farmers?
  - What does collaboration look like to you?

- How often do you collaborate with the management Mangrove Management Board (check one circle)?

  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with the management Mangrove Management Board?
  - What does collaboration look like to you?

Existing Facilities

- Do you know where to go when you have a problem related to farming (check one box)?

  - Yes
  - No

  Follow-up questions:

  - Do you feel like something is being done about it and that you are being heard?
    - ◇ Yes
    - ◇ No
  - Would you like to have more opportunities to share your concerns?
    - ◇ Yes
    - ◇ No
      - · Why not?
  - Is it easy and common for you to get access to information about pollution, mangroves, and sustainable aquaculture? (check one box)
    - ◇ Yes
      - · Where is that? And what does it look like (what kind of information can you get there, and from whom)?
    - ◇ No
      - · Would you like to have such a place? And what would it look like?

Ranking Questions

- What is the biggest problem you are currently facing? → Why did you rank it this way?

  1. Pollution
  2. Lack of oxygen

3. Flooding
4. Landslides
5. No wild breeds
6. Salinity

- What solution do you see as most necessary? → Why did you rank it this way?

1. Education
2. Collaboration
3. Equipment
4. Medication for breeds
5. New policy for sustainable farming

Foreign Research

- Have you ever seen research being done on the mangroves?
- Were these researchers local people or from abroad?
- Do you believe that research can contribute to a solution?
- Would you like to collaborate more often with international researchers

C.3. Interviews Farmers - III

Understanding of Climate Change and Protection Measures

- Can you tell me what you understand about climate change and how it affects your farm?
- Have you heard about any measures to protect you from the effects of climate change?
  - Yes
    - ◇ What measures have you heard about?
  - No

Attitudes Toward Mangrove Protection

- Do you think it is important to protect the mangroves?
  - Yes
    - ◇ In your opinion, why is it important to protect the mangroves?
  - No
- Do you try to protect the mangroves, even if they negatively affect your farm?
  - Yes
    - ◇ Can you explain why you still protect the mangroves?
  - No

Community Beliefs and Environmental Protection

- Do you feel that people in your community believe protecting the environment is important?
  - Yes

  - No
  - I'm not sure

- Do you think working together with others can help protect the environment?

Collaboration Between Farmers

- Do you think working together with intensive shrimp farmers and those farming near mangroves can lead to better solutions?

  - Yes

    - What kinds of solutions do you think would be possible through collaboration?

  - No
  - I'm not sure

Technology and Farming Practices

- Have you heard of any new farming methods or technologies that you think could help improve your work?
- Who, in your opinion, has the authority to make decisions regarding policies on mangroves/aquaculture/shrimp and the high-tech zone?
- Do you think that researchers come to investigate problems and then leave without helping?

  - Yes
  - No
  - Sometimes

- What do you think is the most important change in policy that could help make farming more sustainable here?
- Do you think that research or help from outside has been useful or has it caused problems for farming here?

  - Helpful
  - Disruptive
  - Both

  Follow-up question:

  - Can you give an example of how it has been helpful or disruptive?

- Would you be willing to accept larger investments in tourism if it negatively affects the mangroves?

  - Yes
  - No

  Follow-up question:

  - Why?

C.4. Local authorities: DARD

- Please explain your role within your department and the tasks and goals of the department.
- What types of measures have been implemented in Bạc Liêu to address erosion and flooding?

- How was this coordinated and can you take us through the steps of the process (from a problem-statement to finding a solution and the implementation of it, how does it work)?
- What challenges were there in the implementation of the interventions/mangrove reforestation? And how did you manage or tackle them?
- Who is responsible for maintaining the mangroves? In your opinion, do you agree that he/she is responsible and why?
- How do you involve local farmers in the planning and decision-making of mangrove restoration projects?
- What role do the local communities play in maintaining these ecosystems?
- How do you think local authorities can contribute to the long-term success of these interventions?
- What additional support or resources from the government would help you improve the effectiveness of your work in mangrove restoration and protection?
- Do you have a feeling that you are aware of the socio-economic problems of the farmers? How do you know or in which way would you like to be (more) involved?
- How would you describe the relation between DARD and the local farmers?

C.5. Mangrove Management Board

- Please explain your duties and how you contribute to the department's activities in Bạc Liêu.
- What types of measures have been implemented in Bạc Liêu to address erosion and flooding?
- How was this coordinated?
- What challenges were there in the implementation of the interventions/mangrove reforestation?
- Who is responsible for maintaining the mangroves?
- How do you involve local farmers in the planning and decision-making of mangrove restoration projects?
- What role do the local communities play in maintaining these ecosystems?
- How do you think local authorities can contribute to the long-term success of these interventions?
- What additional support or resources from the government would help you improve the effectiveness of your work in mangrove restoration and protection?

D

Interviews Farmers - I

D.1. Ecological farmers

D.1.1. Farmer #1

General Information

Name:	Vu Van Van
Age:	64 years old
Farm type:	ecological
Location of farm:	inside mangroves
Time spent as farmer:	since 1999
Family situation:	family lives close to the farm
Date of interview:	24th of September, 2024

Figure D.1: Photo of Farmer #1

Interview Questions and Responses

Can you tell us about your farm?
He fishes for crab and shrimp. He has about 4 hectares.

How long have you been farming in this area?
Since 1999

What changes have you seen around your shrimp farm since they started protecting the mangroves?
Before the embankment was built, there was severe erosion. After the embankment was built, they hoped to limit the erosion. They have not seen the results yet. The embankment is very new (two years ago) so he doesn't know the effects yet.

How have these mangrove protection actions affected your shrimp farming?
He doesn't know yet, because he has not seen any result.

What problems do you face when farming shrimp in the mangroves?
The forest canopy is too big according to the farmer. Because there is less oxygen because of it, according to the farmer. Pollution by the farms more inside the land affects the shrimp farms in the mangroves. They don't want the whole mangrove to be destroyed, but they just want to thin it out.

How do you feel your ideas are considered in mangrove projects?
Question is not asked.

How do you work with other mangrove farmers to solve problems?
They formed a farmer association to solve the problems.

How has your farm changed over the years compared to how it was in the past?
They say that erosion has destroyed large areas of mangrove forest, which destroys too much. Their farm has also shrunk from what it used to be due to erosion.

What do you believe has caused these changes on your farm?
Because of the erosion and reduction of the mangrove there is a reduced productivity and a lack of breeding stock, so they have to buy breeding stock. Before they didn't have to buy breeding stock.

What kind of problems with flooding or extreme weather have you experienced on your farm?
He has experienced flooding. They built dikes around the farm and their house to protect the house. He built a soil dike himself. He said that he doesn't have enough money to build the full dike around his house.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
The government built the seadike and the revetments. They hope the revetments will help expand the mangrove and their farm.

Who would you like to collaborate with more to improve your farming?
Collaborate with the government to re-planning the farming areas to limit pollution.

D.1.2. Farmer #2

General Information

Name:	Nguyen Van Thuong
Age:	54 years old
Farm type:	ecological
Location of farm:	?
Time spent as farmer:	since 2003
Family situation:	near the farm
Date of interview:	24th of September, 2024

Figure D.2: Photo of Farmer #2

Interview Questions and Responses

Can you tell us about your farm?
He fishes shrimp and crab. He has a farm inside the mangroves. about 6 hectares.

How long have you been farming in this area?
Since 2003

What changes have you seen around your shrimp farm since they started protecting the mangroves?
He also did other work because his farm did not produce enough money. This changed, first he was only farming.

How have these mangrove protection actions affected your shrimp farming?
He said it was the same as what farmer number 1 said because their farms are very close together.

What problems do you face when farming shrimp in the mangroves?
Water pollution is a big problem. He needs to buy breeding stock to raise on the farm.

How do you feel your ideas are considered in mangrove projects?
They have not contributed to any projects → they are the local authorities. The farmers don't communicate with the government.

How do you work with other mangrove farmers to solve problems?
He said the same thing as the first farmer interviewee.

How has your farm changed over the years compared to how it was in the past?
There is no more diversity of species in the mangrove forests. Because of that he would buy the breeding stock. Before there were many species in the mangrove forests: crab, fish, shrimp, but now no more.

What do you believe has caused these changes on your farm?
He says he believes it is because of the pollution. He blames the farmers more inside for the pollution.

What kind of problems with flooding or extreme weather have you experienced on your farm?
Floodings. When there is a high tide, the water level is high and it can flood his farm. There is a new sewer being built and they fear it will increase the risk of flooding.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
The government has built revetments to prevent erosion. He doesn't know about NGOs.

Who would you like to collaborate with more to improve your farming?
The local government. He hopes the government will trim the mangroves.

D.1.3. Farmer #3

General Information

Name:	Ha Vunh
Age:	72 years old
Farm type:	ecological
Location of farm:	inside the mangrove forest
Time spent as farmer:	since 1994
Family situation:	near the farm
Date of interview:	24th of September, 2024

Figure D.3: Photo of Farmer #3

Interview Questions and Responses

Can you tell us about your farm?
He fishes shrimps and crabs as well. He has 6 hectares in his farm.

How long have you been farming in this area?
Since 1994. He was the first person to come to farm in and plant the mangrove forest and protect it

What changes have you seen around your shrimp farm since they started protecting the mangroves?
His farm area has decreased because of erosion and pollution.

How have these mangrove protection actions affected your shrimp farming?
He has not seen the effects of the new embankment.

What problems do you face when farming shrimp in the mangroves?
Erosion and floods and water pollution. 200 meters of mangrove forest was destroyed by erosion.

How do you feel your ideas are considered in mangrove projects?
He said they didn't know anything about the mangrove projects.

How do you work with other mangrove farmers to solve problems?
Same as the other farmers he said.

How has your farm changed over the years compared to how it was in the past?
Our aquaculture production also decreased. Before the production was 40 to 50 kilos per day, but now it is not.

What do you believe has caused these changes on your farm?
Pollution, erosion.

What kind of problems with flooding or extreme weather have you experienced on your farm?
Effects of floodings. He built a dike around his house to protect the house.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
He said the same as the first and second farmer interviewees.

Who would you like to collaborate with more to improve your farming?
The local government.

D.1.4. Farmer #4

General Information

Name:	Ngo Mạnh Hi`n
Age:	Born 1965
Farm type:	Ecological
Location of farm:	Inside mangrove
Time spent as farmer:	Since 1999
Family situation:	
Date of interview:	24th of September, 2024

Figure D.4: Photo of Farmer #4

Interview Questions and Responses

Can you tell us about your farm?
Farmer Ngo Mạnh Hi`n runs an ecological shrimp farm located within the mangroves.

How long have you been farming in this area?
He has been farming in this area since 1999.

What changes have you seen around your shrimp farm since they started protecting the mangroves?
Shrimp and fish resources have significantly decreased. The farm faces issues such as water pollution and the mangrove forest becoming too dense. Annual flooding also remains a problem.

How have these mangrove protection actions affected your shrimp farming?
The dense mangrove forests and water pollution have reduced the farm's productivity, making it harder to farm shrimp successfully.

What problems do you face when farming shrimp in the mangroves?
The main problems are:

- Water pollution, possibly from nearby high-tech farms.
- The forest is too dense, reducing shrimp farm productivity.
- Annual flooding, with low embankments and insufficient funds to build them higher.

How do you feel your ideas are considered in mangrove projects?
He has requested the state's support for thinning mangroves and providing funds to raise land and build embankments to prevent flooding.

How do you work with other mangrove farmers to solve problems?
No specific information was provided about collaboration with other farmers.

How has your farm changed over the years compared to how it was in the past?
In the past, shrimp and fish were in surplus, ensuring stable income. However, currently, aquatic resources are low, leading to insufficient income. As a result, he has had to work outside the farm to support his family.

What do you believe has caused these changes on your farm?
The causes include water pollution, dense mangroves, and annual flooding.

What kind of problems with flooding or extreme weather have you experienced on your farm?
The farm is affected by annual flooding. The embankments are too low to prevent water from rising, but there are not enough funds to raise them.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
No specific help was mentioned, but Farmer Hien has proposed more government support, including flood prevention measures and financial assistance to raise land levels.

Who would you like to collaborate with more to improve your farming?
He would like to collaborate with the government to thin mangroves, prevent flooding, and provide capital to raise land levels to protect against flooding.

D.1.5. Farmer #5

General Information

Name:	Tr` n Văn Khính
Age:	Born 1965
Farm type:	Ecological
Location of farm:	Inside mangrove
Time spent as farmer:	24 years
Family situation:	
Date of interview:	24th of September, 2024

Figure D.5: Photo of Farmer #5

Interview Questions and Responses

Can you tell us about your farm?
Shrimps are farmed on a plot that was purchased. The farm is located near other farms, so they all encounter similar problems.

What problems do you face when farming shrimp in the mangroves?
The main problems are:

- Water pollution from the shore, which affects the shrimp.
- The forest is too dense, leading to a lack of oxygen, which causes shrimp and fish deaths.
- Landslides have destroyed three farming plots.

What kind of help do you need for your farm?
Support from the state in zoning shrimp farming areas to reduce pollution would be beneficial. Assistance with thinning the mangroves to improve shrimp farming conditions is also appreciated.

How has your farm changed over the years?
The farm has faced increasing environmental challenges, particularly with water quality and natural disasters. The encroachment of dense forest has made it more difficult to manage the farm effectively.

Have you received any assistance from the government or other organizations?
There has been little support so far, but future projects should consider farmers' needs, especially in managing mangrove density and addressing pollution issues.

What do you believe has caused these changes on your farm?
The water pollution from nearby farms and the increasing density of the mangrove forest have both contributed to the decline in productivity and environmental stability.

What kind of problems with flooding or extreme weather have you experienced on your farm?
Flooding is an annual issue, and with insufficient funds to build higher embankments, the damage to the farm is significant every year.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
Very little assistance has been provided. There is a strong need for state support in planning and managing the shrimp farming areas and ensuring the mangrove ecosystem is managed sustainably.

Who would you like to collaborate with more to improve your farming?
Closer collaboration with government agencies and environmental organizations is desired to address pollution and improve shrimp farming techniques.

D.1.6. Farmer #11

General information

Name:	Nguy˜n Văn Hi´u
Age:	58
Farm type:	Ecological
Location of farm:	Inside mangrove
Time spent as farmer:	Since 1996
Family situation:	3 people
Date of interview:	25th of September, 2024

Figure D.6: Photo of Farmer #11

Interview Questions and Responses

Can you tell us about your farm?
Fish, tiger prawn, and whiteleg shrimp farming, with a farm size of 4 hectares. Previously, the farm was successful, but in recent years the farming rate has declined. Many shrimp die prematurely due to environmental pollution from high-tech shrimp farming areas.

How long have you been farming in this area?
I have been farming here since 1996.

What changes have you seen around your shrimp farm since they started protecting the mangroves?
We have seen increased issues of pollution and changes in water quality, impacting shrimp survival rates.

How have these mangrove protection actions affected your shrimp farming?
The mangroves have grown too dense, leading to poor water circulation, which reduces shrimp productivity.

What problems do you face when farming shrimp in the mangroves?
The main problems are:

- Shrimp die prematurely.
- Environmental pollution, possibly from nearby high-tech farms.
- Rising sea levels pose a risk of flooding.
- Dense trees and many fallen leaves cause eutrophication and toxic algae, leading to oxygen depletion.

How do you feel your ideas are considered in mangrove projects?
There hasn't been much attention from the local authorities regarding the issues we face.

How do you work with other mangrove farmers to solve problems?
We have formed cooperatives to support each other, but solutions have been limited.

How has your farm changed over the years compared to how it was in the past?
Previously, the farm was much more productive. However, due to environmental degradation and pollution, productivity has significantly decreased.

What do you believe has caused these changes on your farm?
The main cause is environmental pollution from nearby industrial shrimp farms and the growing density of the mangrove forest.

What kind of problems with flooding or extreme weather have you experienced on your farm?
We face risks of flooding due to rising sea levels, although the area is not prone to landslides.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
There has been little to no attention or support from local authorities.

Who would you like to collaborate with more to improve your farming?
I would like to see more research on improving the environment and support for disease-free breeds and loans.

D.1.7. Farmer #12

General information

Name:	Phạm Văn ´ng
Age:	Born in 1954
Farm type:	Ecological
Location of farm:	Inside mangrove
Time spent as farmer:	
Family situation:	
Date of interview:	25th of September, 2024

Figure D.7: Photo of Farmer #12

Interview Questions and Responses

Can you tell us about your farm?
The farm is located inside a mangrove and faces several challenges, including environmental pollution from the city and the lack of good-quality shrimp and fish breeds.

How long have you been farming in this area?
No information retrieved.

What changes have you seen around your shrimp farm since they started protecting the mangroves?
No information retrieved.

How have these mangrove protection actions affected your shrimp farming?
No information retrieved.

What problems do you face when farming shrimp in the mangroves?
The main problems are:

- Environmental pollution due to pollutants from the city.
- Lack of good-quality breeds.

How do you feel your ideas are considered in mangrove projects?
The state needs to pay more attention to the concerns of farmers. It has been suggested that mangrove thinning and better maintenance of water channels could help mitigate some of the problems.

How do you work with other mangrove farmers to solve problems?
No information retrieved.

How has your farm changed over the years compared to how it was in the past?
Pollution has worsened over the years, leading to deteriorating conditions for farming.

What do you believe has caused these changes on your farm?
Increased pollution from nearby cities and the overgrowth of mangroves have negatively impacted the farm.

What kind of problems with flooding or extreme weather have you experienced on your farm?
No specific mention of flooding, but stagnant water and pollution are ongoing concerns.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
There has been little support so far. Farmers have requested financial aid to dredge channels and improve water flow, as well as access to better-quality breeds and soil improvement treatments.

Who would you like to collaborate with more to improve your farming?
The farmer hopes for better support from the government to address environmental issues and provide loans for farm improvements.

D.1.8. Farmer #13

General information

Name:	Cao Thị Vui
Age:	Born in 1967
Farm type:	Ecological
Location of farm:	Inside mangrove
Time spent as farmer:	Since 2000
Family situation:	
Date of interview:	25th of September, 2024

Figure D.8: Photo of Farmer #13

Interview Questions and Responses

Can you tell us about your farm?
The farm is located inside a mangrove forest, and we have been farming shrimp, crabs, and fish since 2000. Over the years, the farm has faced multiple challenges due to environmental changes and a lack of support.

How long have you been farming in this area?
We have been farming here since 2000, combining shrimp farming with mangrove care and protection.

What changes have you seen around your shrimp farm since they started protecting the mangroves?
The forest has grown very dense, leading to the spread of diseases and the death of trees. The trees have also struggled to adapt to rapid climate change.

How have these mangrove protection actions affected your shrimp farming?
The overgrowth of trees and lack of management have negatively impacted our shrimp farming, while water pollution from nearby high-tech shrimp farms has exacerbated the situation.

What problems do you face when farming shrimp in the mangroves?
The main problems are:

- Dense trees leading to tree diseases and death.
- Low embankments causing a high rate of flooding.
- Water pollution from nearby super-intensive shrimp farms.
- Loss of natural shrimp, crab, and fish seed sources, requiring the purchase of seed stock.

How do you feel your ideas are considered in mangrove projects?
There has been little communication with local authorities, and our concerns about thinning the mangroves or improving water quality have not been addressed.

How do you work with other mangrove farmers to solve problems?
We do not have a formal network with other farmers, though we share concerns about pollution and farming challenges. There is a need for greater collaboration.

How has your farm changed over the years compared to how it was in the past?
Previously, we had better farming outcomes when the water was clean and the mangroves were managed. Now, pollution and climate changes have made farming more difficult.

What do you believe has caused these changes on your farm?
Environmental pollution from surrounding shrimp farms and the failure to manage the dense mangrove forests have caused significant changes.

What kind of problems with flooding or extreme weather have you experienced on your farm?
Low embankments lead to frequent flooding, and extreme weather, such as intense rainfall or prolonged droughts, has damaged the forest and our farm.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
We have not received significant support from authorities. However, we would benefit from loans to improve the farm, as well as training on modern aquaculture techniques.

Who would you like to collaborate with more to improve your farming?
We hope to collaborate with various sources, including government agencies, NGOs, and aquaculture experts, to improve farming practices, restore water quality, and manage the mangroves.

D.1.9. Farmer #14

General information

Name:	Nguy˜n Văn Thu´n
Age:	50
Farm type:	Ecological
Location of farm:	Inside mangrove
Time spent as farmer:	Since 2001
Family situation:	3 people
Date of interview:	25th of September, 2024

Figure D.9: Photo of Farmer #14

Interview Questions and Responses

Can you tell us about your farm?
The farm covers an area of 2 hectares, where we raise shrimp, crabs, and fish. The farm is located inside a mangrove forest, and the households in the area share similar issues related to farming and environmental conditions.

How long have you been farming in this area?
I have been farming here since 2001, working with shrimp, crabs, and fish.

What changes have you seen around your shrimp farm since they started protecting the mangroves?
The trees have become too thick, with many fallen leaves, which depletes oxygen levels in the water. This has affected shrimp and crab farming negatively.

How have these mangrove protection actions affected your shrimp farming?
The density of the trees and the lack of proper management have reduced the effectiveness of our shrimp farming, leading to lower productivity and higher mortality rates among the shrimp and crabs.

What problems do you face when farming shrimp in the mangroves?
The main problems are:

- Thick trees and fallen leaves reduce oxygen levels.
- Low embankments, making the area prone to flooding.
- Fish fry and young shrimp die prematurely.
- High loss rates and low income due to environmental challenges.

How do you feel your ideas are considered in mangrove projects?
We feel that there has not been enough attention from local authorities, and more needs to be done to address the environmental and farming issues we face.

How do you work with other mangrove farmers to solve problems?
Since our farms are close together, we share information and concerns. However, we still lack proper institutional support and collaborative solutions to the problems we face.

How has your farm changed over the years compared to how it was in the past?
Farming has become increasingly difficult. The thickening of trees and rising environmental pollution have significantly impacted the health of our shrimp and crabs, leading to more frequent losses.

What do you believe has caused these changes on your farm?
The primary cause is environmental pollution and the mismanagement of the mangrove forests. In addition, the lack of support for maintaining embankments and improving seed quality has further contributed to these challenges.

What kind of problems with flooding or extreme weather have you experienced on your farm?
Flooding is a significant problem, particularly due to the low embankments. During periods of heavy rainfall,

the area becomes easily flooded, which negatively impacts farming.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
There has been very little support from authorities or NGOs. We need more involvement from government agencies to help address the environmental issues and provide access to better seed stock.

Who would you like to collaborate with more to improve your farming?
We would like to collaborate with local government agencies and other institutions that can help find solutions for improving environmental conditions, providing better seed stock, and offering financial support for farm improvement.

D.1.10. Farmer #15

General information

Name:	Cao Văn Th´ng
Age:	Born in 1950
Farm type:	Ecological
Location of farm:	Inside mangrove
Time spent as farmer:	30-40 years
Family situation:	6 people
Date of interview:	25th of September, 2024

Figure D.10: Photo of Farmer #15

Interview Questions and Responses

Can you tell us about your farm?
I have been farming inside the mangroves for 30-40 years, focusing on shrimp, crab, and fish. Like many other farmers in the area, I face similar challenges.

How long have you been farming in this area?
For about 30-40 years.

What changes have you seen around your shrimp farm since they started protecting the mangroves?
The natural sources of shrimp and fish seeds have become depleted, which has made it difficult to sustain farming.

How have these mangrove protection actions affected your shrimp farming?
The lack of natural seeds and worsening environmental conditions have significantly impacted the productivity of shrimp and fish farming.

What problems do you face when farming shrimp in the mangroves?
The main problems are:

- No more natural seeds available.
- Environmental pollution from surrounding areas.
- No support from government agencies.
- Frequent flooding due to low embankments.

How do you feel your ideas are considered in mangrove projects?
We report our issues in meetings with the forest management board, but there has been little action or support from the government.

How do you work with other mangrove farmers to solve problems?
We report our problems during meetings, but there is no collaboration among all farmers. The forest management board occasionally sends representatives to guide us.

How has your farm changed over the years compared to how it was in the past?
The depletion of natural seeds and environmental degradation has made it much more difficult to sustain farming.

What do you believe has caused these changes on your farm?
Environmental pollution, combined with the lack of natural shrimp and fish seeds, has caused a decline in farm productivity.

What kind of problems with flooding or extreme weather have you experienced on your farm?
Frequent flooding due to low embankments is a common issue, though it has not reached catastrophic levels.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
We have not received any significant support from the government or NGOs.

Who would you like to collaborate with more to improve your farming?
We would like to collaborate more with government agencies to receive financial and technical support to improve the farm.

D.1.11. Farmer #16

General information

Name:	Thạch Thị Sa Tháp
Age:	43
Farm type:	Ecological
Location of farm:	Inside mangrove
Time spent as farmer:	
Family situation:	5 people (3 children)
Date of interview:	25th of September, 2024

Figure D.11: Photo of Farmer #16

Interview Questions and Responses

Can you tell us about your farm?
My farm faces significant challenges including dead breeds, severe water pollution due to industrial waste, and frequent flooding.

How long have you been farming in this area?
No information retrieved.

What changes have you seen around your farm since they started protecting the mangroves?
No information retrieved.

How have these mangrove protection actions affected your farming?
No information retrieved.

What problems do you face when farming in the mangroves?
The main problems are:

- High mortality rates in aquatic breeds.
- Severe water pollution and flooding impacting farm operations.

How do you feel your ideas are considered in mangrove projects?
No information retrieved.

How do you work with other mangrove farmers to solve problems?
No information retrieved.

How has your farm changed over the years compared to how it was in the past?
No information retrieved.

What do you believe has caused these changes on your farm?
No information retrieved.

What kind of problems with flooding or extreme weather have you experienced on your farm?
No information retrieved.

What kind of help have you received by authorities or NGOs for your farming in the mangroves?
Despite the challenges, we have not received any significant support from the government or NGOs.

Who would you like to collaborate with more to improve your farming?
I hope to receive support for infrastructure improvements such as bank construction and pond dredging, financial aid for operational sustainability, and access to high-quality breeds. Additionally, I wish for more educational opportunities at home to improve our farming techniques.

D.1.12. Farmer #17

General information

Name:	Phạm Văn Lít
Age:	Born in 1958
Farm type:	Ecological
Location of farm:	Inside mangrove
Time spent as farmer:	Since 1996
Family situation:	3 people (1 child)
Date of interview:	25th of September, 2024

Figure D.12: Photo of Farmer #17

Interview Questions and Responses

Can you tell us about your farm?
I operate a farm specializing in shrimp, crab, and fish, encountering common challenges faced by many farmers in this region.

How long have you been farming in this area?
Since 1996, I have been engaged in aquaculture within the mangrove environment.

What changes have you seen around your farm since they started protecting the mangroves?
No information retrieved.

How have these mangrove protection actions affected your shrimp farming?
No information retrieved.

What problems do you face when farming shrimp in the mangroves?
The main problems are:

- Similar issues as other local farmers including environmental pollution and the need for better infrastructure.

How do you feel your ideas are considered in mangrove projects?
No information retrieved.

How do you work with other mangrove farmers to solve problems?
No information retrieved.

How has your farm changed over the years compared to how it was in the past?
No information retrieved.

What do you believe has caused these changes on your farm?
No information retrieved.

What kind of problems with flooding or extreme weather have you experienced on your farm?
No information retrieved.

What kind of help have you received by authorities or NGOs for your shrimp farming in the mangroves?
I am yet to receive substantial support, but I hope for assistance in financial investment, tree pruning, and pollution management.

Who would you like to collaborate with more to improve your farming?
No information retrieved.

D.2. Intensive farmers

D.2.1. Farmer #6

General Information

Name:	Phạm Thị Chung
Age:	59 years old
Farm type:	Intensive shrimp, crab, and fish farming
Location of farm:	Outside mangrove
Time spent as farmer:	Since 2000
Family situation:	Lives with one child
Date of interview:	24th of September, 2024

Figure D.13: Photo of Farmer #6

Interview Questions and Responses

Can you tell us about your farm?
I manage a 1-hectare farm focusing on whiteleg shrimp, tiger prawn, and crab farming. Unfortunately, the growth conditions have been poor due to unrenovated ponds and lack of local support.

How long have you been farming in this area?
I have been farming in this area since the year 2000.

What changes have you noticed in the water around your farm over the years?
The water quality has severely deteriorated due to contamination from high-tech farming zones nearby. This has led to water pollution issues that affect the health of my aquaculture stock.

What problems do you face in shrimp farming?
The primary problems include polluted water sources, weak and disease-prone breeds, and an overall farming operation that heavily depends on luck due to uncontrollable environmental factors.

To what extent do you feel your ideas are considered in decisions about water use and farming?
My concerns and suggestions have largely been ignored, with no substantial help or attention from local authorities.

How have your personal experiences shaped the way you see changes in Bạc Liêu's environment?
I've witnessed the degradation of natural resources and increased pollution, which has made sustainable farming practices increasingly challenging.

How do you work with other farmers to solve problems when they arise?
We try to collaborate on shared issues like water management, but individual efforts are often hampered by the lack of support and resources.

What kind of support have you received from the government or NGOs for your farming?
So far, I have received minimal to no support from governmental bodies or NGOs, which has compounded the difficulties in managing my farm sustainably.

Who would you like to work with more to improve your farming?
I would greatly appreciate more collaboration with local environmental agencies and agricultural experts to address the issues of water quality and breed health.

What are the benefits of intensive shrimp farming for you?
Intensive farming allows for higher yield within smaller areas, which is economically beneficial when conditions are favorable.

What support would help you farm better?
Support in the form of clean water supplies, access to healthy breeds, and environmental clean-up initiatives

would greatly enhance my farming operations.

D.2.2. Farmer #7

General Information

Name:	Lã Thị Hoa
Age:	56
Farm type:	Intensive shrimp farming
Location of farm:	Outside mangrove
Time spent as farmer:	Since 2000
Family situation:	Lives with husband and son
Date of interview:	24th of September, 2024

Figure D.14: Photo of Farmer #7

Interview Questions and Responses

Can you tell us about your farm?
I manage a 1-hectare farm with 4 ponds dedicated to raising whiteleg and black tiger shrimp. The shrimp are known for their high quality and favorable market price.

How long have you been farming in this area?
I have been farming here since the year 2000, focusing on aquaculture.

What changes have you noticed in the water around your farm over the years?
There has been significant water pollution affecting the health of our shrimp, particularly after heavy rains which reduce salinity and disrupt the shrimp's living conditions.

What problems do you face in shrimp farming?
Key challenges include polluted water sources, non-circulating canals filled with water, weak fry that are susceptible to disease, and the overall unpredictability of aquaculture outcomes.

To what extent do you feel your ideas are considered in decisions about water use and farming?
While local authorities respond to crises, ongoing issues like canal dredging and water treatment need more systematic support.

How have your personal experiences shaped the way you see changes in Bạc Liêu's environment?
My experiences have shown me the direct impact of environmental neglect on farming efficiency and shrimp health.

How do you work with other farmers to solve problems when they arise?
We coordinate with local authorities for emergency responses but need more collaborative efforts to address systemic issues like water quality and canal maintenance.

What kind of support have you received from the government or NGOs for your farming?
Support has been sporadic, primarily in the form of emergency supplies like chlorine for water treatment during crises.

Who would you like to work with more to improve your farming?
I would like to engage more with environmental experts and local government officials to work on sustainable solutions for water management and shrimp health.

What are the benefits of intensive shrimp farming for you?
Intensive farming maximizes yield per area, which is crucial for economic sustainability given the high quality of our shrimp.

What support would help you farm better?
Support for dredging the canals, consistent access to high-quality fry, and more effective water treatment solutions would significantly improve our farming operations.

D.2.3. Farmer #8

General Information

Name:	Vũ Thị Nguyt
Age:	60
Farm type:	Intensive shrimp farming
Location of farm:	Outside mangrove
Time spent as farmer:	Since 2000
Family situation:	Lives with her husband
Date of interview:	24th of September, 2024

Figure D.15: Photo of Farmer #8

Interview Questions and Responses

Can you tell us about your farm?
I oversee a 2000 m2 farm specializing in black tiger shrimp. Our farming practices have been heavily affected by reduced salinity due to excessive rainfall.

How long have you been farming in this area?
I have been involved in shrimp farming since the year 2000, experiencing various challenges and changes in farming techniques over the years.

What changes have you noticed in the water around your farm over the years?
The water quality has significantly deteriorated, mainly due to pollution from high-tech farming discharges nearby, affecting the shrimp's health and our farm's productivity.

What problems do you face in shrimp farming?
Our main issues are polluted water, clogged canals, and the unpredictability of shrimp health even with good care and quality breeds.

To what extent do you feel your ideas are considered in decisions about water use and farming?
There is minimal consideration given to our insights by local authorities, especially concerning the need for regular dredging of canals to improve water circulation.

How have your personal experiences shaped the way you see changes in Bạc Liêu's environment?
My experience highlights the impact of environmental mismanagement on shrimp farming, urging the need for better planning and government intervention.

How do you work with other farmers to solve problems when they arise?
We have established a cooperative to address common issues collectively, but individual action remains crucial due to the inconsistent support from local authorities.

What kind of support have you received from the government or NGOs for your farming?
Support is sporadic and often limited to crisis management rather than preventative measures or sustainable solutions.

Who would you like to work with more to improve your farming?
I would appreciate more involvement from agricultural engineers and environmental planners to help restructure our farming practices for better sustainability.

What are the benefits of intensive shrimp farming for you?
Despite the challenges, intensive farming allows for maximizing output within a limited space, essential for economic viability.

What support would help you farm better?
I urge for governmental dredging of canals, access to reputable aquaculture expertise, and support for developing high-quality shrimp breeds.

D.2.4. Farmer #9

General Information

Name:	Lê Thị Thu
Age:	60
Farm type:	Intensive
Location of farm:	Outside mangrove
Time spent as farmer:	Since 2000
Family situation:	Lives with her son and two grandchildren
Date of interview:	24th of September, 2024

Figure D.16: Photo of Farmer #9

Interview Questions and Responses

Can you tell us about your farm?
I operate a 1.3 ha farm where I primarily raise whiteleg shrimp. Recently, the water hasn't been salty enough due to heavy rainfall, requiring us to add salt to maintain proper conditions.

How long have you been farming in this area?
I have been farming in this area since 2000, facing various challenges but continually learning from them and adapting our practices.

What changes have you noticed in the water around your farm over the years?
The water quality has significantly deteriorated mainly due to pollution from nearby high-tech farming operations which fail to adequately treat their wastewater.

What problems do you face in shrimp farming?
Our primary issues include dealing with polluted water sources and clogged canals, which prevent us from accessing clean water necessary for our shrimp.

To what extent do you feel your ideas are considered in decisions about water use and farming?
My concerns and suggestions have been largely ignored by local authorities, despite multiple contacts regarding the pollution issues.

How have your personal experiences shaped the way you see changes in Bạc Liêu's environment?
These experiences have made me more proactive in seeking solutions and advocating for better environmental practices within our community.

How do you work with other farmers to solve problems when they arise?
I collaborate with other local farmers to share knowledge and resources, and together we have sought to influence local policies.

What kind of support have you received from the government or NGOs for your farming?
Support has been minimal and largely ineffective in addressing the root causes of our farming challenges, particularly regarding water quality and infrastructure.

Who would you like to work with more to improve your farming?
I would appreciate more support from agricultural and environmental experts to develop sustainable farming practices and effective water treatment solutions.

What are the benefits of intensive shrimp farming for you?
Intensive farming allows us to maximize yield within a small area, which is crucial for maintaining our livelihood under challenging environmental conditions.

What support would help you farm better?
I hope for government action to dredge and clear our canals, pollution treatment solutions, and opportunities to attend training sessions on advanced aquaculture techniques provided by the provincial fisheries department.

D.2.5. Farmer #10 (and also part of Peoples committee)

General Information

Name:	Quán Thị Ánh Tuy´t
Age:	45
Farm type:	Intensive
Location of farm:	Outside mangrove
Time spent as farmer:	Since 2000
Family situation:	Lives with husband and three children
Date of interview:	24th of September, 2024

Figure D.17: Photo of Farmer #10

Interview Questions and Responses

Can you tell us about your farm?
I manage a 5 ha farm with 3 shrimp ponds and 7 crab ponds. We face several challenges including water salinity fluctuations and pollution issues, affecting our productivity and profitability.

How long have you been farming in this area?
I have been farming here since 2000, adapting to various environmental challenges over the years.

What changes have you noticed in the water around your farm over the years?
Significant changes include increased salinity in February and decreased salinity due to heavy rains in September, leading to difficulties in maintaining suitable conditions for aquaculture.

What problems do you face in shrimp farming?
Our main issues are water pollution from upstream pesticide use and super-intensive shrimp farming, seasonal flooding that leads to losses, and the low market price which makes profitability a challenge.

To what extent do you feel your ideas are considered in decisions about water use and farming?
Although the government has established pollution inspection teams and provided fines, these measures have been insufficient and have not significantly addressed our concerns.

How have your personal experiences shaped the way you see changes in Bạc Liêu's environment?
My experiences have prompted me to seek better farming practices and advocate for more effective environmental policies to protect our local ecosystem.

How do you work with other farmers to solve problems when they arise?
We share knowledge and resources within a cooperative framework, though it often feels like we're managing independently due to inadequate support.

What kind of support have you received from the government or NGOs for your farming?
While there are training programs and engineering guidance, they often fall short of solving the practical challenges we face, particularly those related to water management and pollution control.

Who would you like to work with more to improve your farming?
I would like to work more with environmental experts and agricultural engineers to develop sustainable and profitable farming techniques that are also environmentally friendly.

What are the benefits of intensive shrimp farming for you?
Intensive farming allows for higher yields within limited space, which is essential for maintaining our livelihood under fluctuating environmental conditions.

What support would help you farm better?
I hope for improved governmental intervention in dredging and cleaning our water channels, better pollution

control, and market support to ensure a fair price for our products. Additionally, offering more practical and applicable training would be beneficial.

E

Interviews Farmers - II

E.1. Ecological farmers

E.1.1. Farmer #18

General Information

Name:	La Thanh Dung + Duan
Age:	66 years old
Farm type:	Seafood
Location of farm:	Tai Nha
Time spent as farmer:	Since 2000
Family situation:	
Date of interview:	30th of September, 2024

Figure E.1: Photo of Farmer #18

Collaboration

- How often do you collaborate with local authorities/DARD (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local authorities?
  - What does collaboration look like to you?

- How often do you collaborate with other farmers (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify): In the past

Follow-up questions:

- Would you like to collaborate more with local farmers?
- What does collaboration look like to you? Spontaneous

- How often do you collaborate with the management board of mangroves (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with the management board of mangroves?
  - What does collaboration look like to you?

Existing Facilities

- Do you know where to go when you have a problem related to farming (check one box)?
  - Yes
  - No

  Follow-up questions:

  - Do you feel like something is being done about it and that you are being heard?
    - Yes
      From government, rangers
    - No
  - Would you like to have more opportunities to share your concerns?
    - Yes
    - No
      - Why not? Improve the environment
  - Is it easy and common for you to get access to information about pollution, mangroves, and sustainable aquaculture? (check one box)
    - Yes
      - Where is that? And what does it look like (what kind of information can you get there, and from whom)? From the government
    - No
      - Would you like to have such a place? And what would it look like?

Ranking Questions

- What is the biggest problem you are currently facing? → Why did you rank it this way?

1. Pollution
2. Lack of oxygen
3. Flooding
4. Landslides
5. No wild breeds
6. Salinity

Pollution is biggest problem, good forest –> thin forest.

- What solution do you see as most necessary? → Why did you rank it this way?

1. Education
2. Collaboration
3. Equipment
4. Medication for breeds
5. New policy for sustainable farming

Foreign Research

- Have you ever seen research being done on the mangroves?
- Were these researchers local people or from abroad?
- Do you believe that research can contribute to a solution?
- Would you like to collaborate more often with international researchers

E.1.2. Farmer #19

General Information

Name:	Ta Chi Hung
Age:	64 years old
Farm type:	Farming 75 (shrimp, crab, fish)
Location of farm:	At home
Time spent as farmer:	
Family situation:	1 wife
Date of interview:	30th of September, 2024

Figure E.2: Photo of Farmer #19

Collaboration

- How often do you collaborate with local authorities/DARD (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local authorities?
  - What does collaboration look like to you?

- How often do you collaborate with other farmers (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local farmers?
  - What does collaboration look like to you? Have cooperative opportunities

- How often do you collaborate with the management board of mangroves (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with the management board of mangroves?

- What does collaboration look like to you?

Existing Facilities

- Do you know where to go when you have a problem related to farming (check one box)?
  - Yes
    Thanks to the government
  - No

  Follow-up questions:

  - Do you feel like something is being done about it and that you are being heard?
    - ◇ Yes
    - ◇ No
  - Would you like to have more opportunities to share your concerns?
    - ◇ Yes
    - ◇ No
      - · Why not?
  - Is it easy and common for you to get access to information about pollution, mangroves, and sustainable aquaculture? (check one box)
    - ◇ Yes
      - · Where is that? And what does it look like (what kind of information can you get there, and from whom)?
    - ◇ No
      - · Would you like to have such a place? And what would it look like?

Ranking Questions

- What is the biggest problem you are currently facing? → Why did you rank it this way?

  1. Pollution
  2. Lack of oxygen
  3. Flooding
  4. Landslides
  5. No wild breeds
  6. Salinity

  Landslides, flood, pollution (most important). Need to handle thermal power from industrial parks, storm and flood problem
- What solution do you see as most necessary? → Why did you rank it this way?

  1. Education
  2. Collaboration
  3. Equipment
  4. Medication for breeds
  5. New policy for sustainable farming

Companies, industrial parks, and CNC waste treatment/exhaust gas/gas

Foreign Research

- Have you ever seen research being done on the mangroves?
- Were these researchers local people or from abroad?
- Do you believe that research can contribute to a solution?
- Would you like to collaborate more often with international researchers

E.1.3. Farmer #20

General Information

Name:	Tran Thi Hanh
Age:	63 years old
Farm type:	Contract farming
Location of farm:	
Time spent as farmer:	20 years
Family situation:	1 child
Date of interview:	30th of September, 2024

Figure E.3: Photo of Farmer #20

Collaboration

- How often do you collaborate with local authorities/DARD (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local authorities?
  - What does collaboration look like to you?

- How often do you collaborate with other farmers (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local farmers?
  - What does collaboration look like to you?

- How often do you collaborate with the management board of mangroves (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with the management board of mangroves?
  - What does collaboration look like to you?

Existing Facilities

- Do you know where to go when you have a problem related to farming (check one box)?

  - Yes
  - No

  Follow-up questions:

  - Do you feel like something is being done about it and that you are being heard?

    - Yes
      But not effective
    - No

  - Would you like to have more opportunities to share your concerns?

    - Yes
    - No

      - Why not?

  - Is it easy and common for you to get access to information about pollution, mangroves, and sustainable aquaculture? (check one box)

    - Yes

      - Where is that? And what does it look like (what kind of information can you get there, and from whom)?

    - No

      - Would you like to have such a place? And what would it look like?

    Forest goes up –> Nurturing goes down

Ranking Questions

- What is the biggest problem you are currently facing? → Why did you rank it this way?

  1. Pollution
  2. Lack of oxygen
  3. Flooding
  4. Landslides
  5. No wild breeds
  6. Salinity

  (Least important) Salinity –> No wild breeeds –> Pollution (most important)
  Catching the young
- What solution do you see as most necessary? → Why did you rank it this way?

  1. Education
  2. Collaboration
  3. Equipment

4. Medication for breeds
5. New policy for sustainable farming

Forest thinning, Sustainable support for natural breeds (most important)

Foreign Research

- Have you ever seen research being done on the mangroves?
- Were these researchers local people or from abroad?
- Do you believe that research can contribute to a solution?
- Would you like to collaborate more often with international researchers

E.1.4. Farmer #21

General Information

Name:	Vo Kim Anh + Tran The Pan
Age:	58 years old
Farm type:	
Location of farm:	At home
Time spent as farmer:	More than 20 years
Family situation:	6
Date of interview:	30th of September, 2024

Figure E.4: Photo of Farmer #21

Collaboration

- How often do you collaborate with local authorities/DARD (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Working for forest management board
  Follow-up questions:
  - Would you like to collaborate more with local authorities?
  - What does collaboration look like to you?

- How often do you collaborate with other farmers (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:
  - Would you like to collaborate more with local farmers?
  - What does collaboration look like to you?

- How often do you collaborate with the management board of mangroves (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with the management board of mangroves?
  - What does collaboration look like to you?

Existing Facilities

- Do you know where to go when you have a problem related to farming (check one box)?

  - Yes
  - No

  Follow-up questions:

  - Do you feel like something is being done about it and that you are being heard?

    ◇ Yes
    ◇ No

  - Would you like to have more opportunities to share your concerns?

    ◇ Yes
    ◇ No

      · Why not?

  - Is it easy and common for you to get access to information about pollution, mangroves, and sustainable aquaculture? (check one box)

    ◇ Yes

      · Where is that? And what does it look like (what kind of information can you get there, and from whom)?

    ◇ No

      · Would you like to have such a place? And what would it look like?

Ranking Questions

- What is the biggest problem you are currently facing? → Why did you rank it this way?

  1. Pollution
  2. Lack of oxygen
  3. Flooding
  4. Landslides
  5. No wild breeds
  6. Salinity

  Pollution is most important

- What solution do you see as most necessary? → Why did you rank it this way?

  1. Education
  2. Collaboration
  3. Equipment
  4. Medication for breeds
  5. New policy for sustainable farming

Treatment of pollution - favorable seed release

Foreign Research

- Have you ever seen research being done on the mangroves?
- Were these researchers local people or from abroad?
- Do you believe that research can contribute to a solution?
- Would you like to collaborate more often with international researchers

E.1.5. Farmer #22

General Information

Name:	Nguyen Van Lam + Len
Age:	67 years old
Farm type:	Shrimp farming + forest contracting
Location of farm:	At home
Time spent as farmer:	
Family situation:	
Date of interview:	30th of September, 2024

Figure E.5: Photo of Farmer #22

Collaboration

- How often do you collaborate with local authorities/DARD (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local authorities?
  - What does collaboration look like to you?

- How often do you collaborate with other farmers (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local farmers?
  - What does collaboration look like to you?

- How often do you collaborate with the management board of mangroves (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with the management board of mangroves?
  - What does collaboration look like to you?

Existing Facilities

- Do you know where to go when you have a problem related to farming (check one box)?
  - Yes
  - No

  Follow-up questions:

  - Do you feel like something is being done about it and that you are being heard?
    - Yes
    - No
      Special agencies are often advertised
  - Would you like to have more opportunities to share your concerns?
    - Yes
    - No
      - Why not?
  - Is it easy and common for you to get access to information about pollution, mangroves, and sustainable aquaculture? (check one box)
    - Yes
      - Where is that? And what does it look like (what kind of information can you get there, and from whom)?
    - No
      - Would you like to have such a place? And what would it look like?

Ranking Questions

- What is the biggest problem you are currently facing? → Why did you rank it this way?

  1. Pollution
  2. Lack of oxygen
  3. Flooding
  4. Landslides
  5. No wild breeds
  6. Salinity

  Pollution is the most important. Catch many breeds. Sea level rise
- What solution do you see as most necessary? → Why did you rank it this way?

  1. Education
  2. Collaboration
  3. Equipment
  4. Medication for breeds
  5. New policy for sustainable farming

Pollution treatment

Foreign Research

- Have you ever seen research being done on the mangroves?
- Were these researchers local people or from abroad?
- Do you believe that research can contribute to a solution?
- Would you like to collaborate more often with international researchers

E.1.6. Farmer #23

General Information

Name:	Nguyen Van Liem + Mun
Age:	66 years old
Farm type:	Contract farming + shrimp farming
Location of farm:	
Time spent as farmer:	
Family situation:	
Date of interview:	30th of September, 2024

Figure E.6: Photo of Farmer #23

Collaboration

- How often do you collaborate with local authorities/DARD (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local authorities?
  - What does collaboration look like to you?

- How often do you collaborate with other farmers (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local farmers?
  - What does collaboration look like to you?

- How often do you collaborate with the management board of mangroves (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with the management board of mangroves?
  - What does collaboration look like to you?

Existing Facilities

- Do you know where to go when you have a problem related to farming (check one box)?

  - Yes
  - No

  Follow-up questions:

  - Do you feel like something is being done about it and that you are being heard?

    ◇ Yes
    ◇ No Not solved

  - Would you like to have more opportunities to share your concerns?

    ◇ Yes
    ◇ No
    Can not listen

      · Why not?

  - Is it easy and common for you to get access to information about pollution, mangroves, and sustainable aquaculture? (check one box)

    ◇ Yes

      · Where is that? And what does it look like (what kind of information can you get there, and from whom)?

    ◇ No

      · Would you like to have such a place? And what would it look like?

Ranking Questions

- What is the biggest problem you are currently facing? → Why did you rank it this way?

  1. Pollution
  2. Lack of oxygen
  3. Flooding
  4. Landslides
  5. No wild breeds
  6. Salinity

  Pollution is the most important.

- What solution do you see as most necessary? → Why did you rank it this way?

  1. Education
  2. Collaboration
  3. Equipment
  4. Medication for breeds
  5. New policy for sustainable farming

Foreign Research

- Have you ever seen research being done on the mangroves? Yes
- Were these researchers local people or from abroad?
- Do you believe that research can contribute to a solution?
- Would you like to collaborate more often with international researchers

E.1.7. Farmer #24

General Information

Name:	Sang
Age:	38 years old
Farm type:	Forest contract + aquaculture
Location of farm:	Tar gra
Time spent as farmer:	25 years
Family situation:	
Date of interview:	30th of September, 2024

Figure E.7: Photo of Farmer #24

Collaboration

- How often do you collaborate with local authorities/DARD (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local authorities?
  - What does collaboration look like to you?

- How often do you collaborate with other farmers (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local farmers? Not many opinions yet.
  - What does collaboration look like to you?

- How often do you collaborate with the management board of mangroves (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with the management board of mangroves?

  - What does collaboration look like to you? Nurture TS, looking after the forest.

Existing Facilities

- Do you know where to go when you have a problem related to farming (check one box)?
  - Yes
  - No

  Follow-up questions:

  - Do you feel like something is being done about it and that you are being heard?
    - Yes
    - No
  - Would you like to have more opportunities to share your concerns?
    - Yes
    - No
      - Why not?
  - Is it easy and common for you to get access to information about pollution, mangroves, and sustainable aquaculture? (check one box)
    - Yes
      - Where is that? And what does it look like (what kind of information can you get there, and from whom)?
    - No
      - Would you like to have such a place? And what would it look like?

Ranking Questions

- What is the biggest problem you are currently facing? → Why did you rank it this way?

  1. Pollution
  2. Lack of oxygen
  3. Flooding
  4. Landslides
  5. No wild breeds
  6. Salinity

  Flooding (most important) - lack of oxygen - pollution - no wild breeds (least important) Many forests, few natural breeds.
- What solution do you see as most necessary? → Why did you rank it this way?

  1. Education
  2. Collaboration
  3. Equipment
  4. Medication for breeds
  5. New policy for sustainable farming

Foreign Research

- Have you ever seen research being done on the mangroves? Yes
- Were these researchers local people or from abroad?
- Do you believe that research can contribute to a solution? Yes
- Would you like to collaborate more often with international researchers? Yes

E.1.8. Farmer #25 and #26

General Information

Name: Le Gong Trinh & Nguyen Va
Age: 57 years old
Farm type: contract farming & NTTS
Location of farm: at home
Time spent as farmer: since 2000
Family situation: husband and children
Date of interview: 30th of September, 2024

Figure E.8: Photo of Farmer #25 and #26

Collaboration

- How often do you collaborate with local authorities/DARD (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with local authorities?
  - What does collaboration look like to you?

- How often do you collaborate with other farmers (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify): cooperative

  Follow-up questions:

  - Would you like to collaborate more with local farmers?
  - What does collaboration look like to you?

- How often do you collaborate with the management board of mangroves (check one circle)?
  - Daily
  - Weekly
  - Monthly
  - Annually
  - Never
  - Other (please specify):

  Follow-up questions:

  - Would you like to collaborate more with the management board of mangroves?

- What does collaboration look like to you?

Existing Facilities

- Do you know where to go when you have a problem related to farming (check one box)?
  - Yes
  - No

  Follow-up questions:

  - Do you feel like something is being done about it and that you are being heard?
    - Yes
    - No
  - Would you like to have more opportunities to share your concerns?
    - Yes
    - No
      - Why not?
  - Is it easy and common for you to get access to information about pollution, mangroves, and sustainable aquaculture? (check one box)
    - Yes
      - Where is that? And what does it look like (what kind of information can you get there, and from whom)?
    - No
      - Would you like to have such a place? And what would it look like?

Ranking Questions

- What is the biggest problem you are currently facing? → Why did you rank it this way?

  1. Pollution
  2. Lack of oxygen
  3. Flooding
  4. Landslides
  5. No wild breeds
  6. Salinity

  Forest density > High-tech zones
  (biggest problem) 1 - 5 - 2 - 3 - 4 - 6 (smallest problem)
- What solution do you see as most necessary? → Why did you rank it this way?

  1. Education
  2. Collaboration
  3. Equipment
  4. Medication for breeds
  5. New policy for sustainable farming

Foreign Research

- Have you ever seen research being done on the mangroves?
- Were these researchers local people or from abroad?
- Do you believe that research can contribute to a solution?
- Would you like to collaborate more often with international researchers

F

Interviews Farmers - III

F.1. Ecological farmers

F.1.1. Farmer #27

General Information

Name:	Tran Van Hieu
Age:	72 years (born: 1952)
Farm type:	Ecological
Location of farm:	Inside mangroves
Time spent as farmer:	More than 30 years
Family situation:	-
Date of interview:	1st of October, 2024

Figure F.1: Photo of Farmer #27

Interview Questions and Responses

Understanding of Climate Change and Protection Measures

Can you tell me what you understand about climate change and how it affects your farm?

The farmer said that she is not highly aware of the effects of climate change on her farm but did notice stronger winds in Bạc Liêu, which lead to higher tides and water levels but she doesn't associate them explicitly with climate change impacts on her farm.

Have you heard about any measures to protect you from the effects of climate change?

Answer: Yes. She mentioned that the government has tasked her and other local farmers with maintaining and protecting the mangroves, which she perceives as an indirect measure to protect against environmental threats such as strong winds and high tides.

Attitudes Toward Mangrove Protection

Do you think it is important to protect the mangroves?

Answer: Yes.

In your opinion, why is it important to protect the mangroves?

The farmer views the protection of mangroves as essential for mitigating the effects of strong winds and tides. She added that since the government entrusted them with this responsibility, they are obligated to maintain and protect the mangroves.

Do you try to protect the mangroves, even if they negatively affect your farm?

Answer: Yes. Although she acknowledges that the mangroves grow too thick, blocking sunlight and affecting water flow, she still maintains them. She said it is her responsibility because the government has given her this task.

Community Beliefs and Environmental Protection
Do you feel that people in your community believe protecting the environment is important?
Answer: Yes. The farmer mentioned that there is awareness within the community regarding the importance of environmental protection. However, she also noted frustration with the lack of consistent leadership in the Bạc Liêu Peoples Committee. Due to constant changes of members of the Bạc Liêu Peoples Committee the request to be allowed to cut the mangrove leaves is not being processed.

Do you think working together with others can help protect the environment?
Answer: I'm not sure. The farmer expressed uncertainty about collaboration with others, especially with high-tech farmers. She is more comfortable engaging with the authorities than working directly with other farmers or companies, as there is no precedent for collaboration.

Collaboration Between Farmers
Do you think working together with intensive shrimp farmers and those farming near mangroves can lead to better solutions?
Answer: No. She explained that her work and the work of high-tech shrimp farmers are separate, and she does not see how they could collaborate effectively. She would rather engage with the authorities than other farmers or companies.

Technology and Farming Practices
Have you heard of any new farming methods or technologies that you think could help improve your work?
She mentioned that high-tech farming is responsible for water pollution due to waste, and while they have advanced technologies to treat the water, she and other small-scale farmers do not have similar resources. She does not engage in or benefit from high-tech methods herself.

Who, in your opinion, has the authority to make decisions regarding policies on mangroves/aquaculture/shrimp and the high-tech zone?
She believes that the decision-makers are above the Department of Agriculture and Rural Development (DARD). Specifically, the Bạc Liêu Committee is responsible, but she expressed frustration that new leaders keep replacing the old ones, which slows down progress.

Do you think that researchers come to investigate problems and then leave without helping?
Answer: Sometimes. The farmer said she has not seen many researchers or external groups working in her area. She feels there has been little engagement or direct assistance from outside researchers, and therefore she has no strong opinions on the matter.

What do you think is the most important change in policy that could help make farming more sustainable here?
The farmer emphasized the importance of addressing water pollution and cutting down the tree canopy to ensure the mangrove forests don't become too thick. These two factors—cleaner water and better management of mangrove density—are her top priorities for policy changes.

Do you think that research or help from outside has been useful or has it caused problems for farming here?
Answer: Helpful. She mentioned that she hasn't seen much direct interaction with researchers, but she believes outside help could be beneficial if properly implemented. However, she remains cautious as she hasn't experienced significant improvements yet.

Would you be willing to accept larger investments in tourism if it negatively affects the mangroves?
Answer: Yes. The farmer supports the development of tourism as a good source of income. She does not believe that tourism will negatively impact the mangroves and is eager to see more customers for her restaurant, which could benefit from an increase in tourists.

F.1.2. Farmer #28

General Information

Name:	Le Thi Hoi
Age:	53 years (born: 1971)
Farm type:	Ecological
Location of farm:	Inside mangroves
Time spent as farmer:	About 20 years
Family situation:	-
Date of interview:	1st of October, 2024

Figure F.2: Photo of Farmer #28

Interview Questions and Responses

Understanding of Climate Change and Protection Measures

Can you tell me what you understand about climate change and how it affects your farm?

This farmer mentioned that while climate change does not seem to affect the mangroves directly, they have experienced its impact over the decades. The environment is not as good as before, and water conditions have decreased over time.

Have you heard about any measures to protect you from the effects of climate change?

Answer: Yes. The farmer has heard about measures to protect against climate change effects. However, he emphasized that meaningful action cannot be taken without government support.

Attitudes Toward Mangrove Protection

Do you think it is important to protect the mangroves?

Answer: Yes. The farmer firmly believes it is important to protect mangroves, viewing it as a duty.

In your opinion, why is it important to protect the mangroves?

The farmer believes that mangroves play a important role in the environment but he explained that mangrove trees extract oxygen from the water through their roots and from the atmosphere through their leaves. Additionally, the farmer acknowledges that sunlight and wind need to reach the water in which the shrimp live otherwise the shrimp will die due to a lack of oxygen.

Do you try to protect the mangroves, even if they negatively affect your farm?

Answer: Yes. The farmer actively tries to protect the mangroves, despite recognizing that it may not benefit his shrimp farming. He and his wife perceive shrimp farming as not their primary income source and view the preservation of mangroves as a broader obligation, their duty for which they are paid by the local government.

Community Beliefs and Environmental Protection

Do you feel that people in your community believe protecting the environment is important?

Answer: Yes. The farmer feels that there is a general belief in the importance of environmental protection within his community. However, he also expresses concern that this belief does not translate into action, primarily due to a lack of support and guidance from higher authorities.

Do you think working together with others can help protect the environment?

Answer: I'm not sure. The farmer believes that collaboration is essential for environmental protection but feels that such efforts can only succeed if there is strong leadership and government support. He expressed uncertainty about the effectiveness of collaboration among farmers without an organized approach.

Collaboration Between Farmers

Do you think working together with intensive shrimp farmers and those farming near mangroves can lead to better solutions?

Answer: No. The farmer does not believe that collaboration with high-tech shrimp farmers would yield better solutions. They feel hesitant about working together due to concerns about the responsibilities involved and potential punishments from higher authorities if they act without official approval.

Technology and Farming Practices
Have you heard of any new farming methods or technologies that you think could help improve your work?
Answer: No. The farmer has not considered any new farming methods or technologies that could improve his farming practices.

Who, in your opinion, has the authority to make decisions regarding policies on mangroves/aquaculture/shrimp and the high-tech zone?
The farmer believes that the Bạc Liêu committee holds the authority to make such decisions. However, he and his wife express frustration about the significant gap between themselves and the committee, which prevents meaningful communication and involvement in decision-making processes.

Do you think that researchers come to investigate problems and then leave without helping?
Answer: Yes. The farmer feels that researchers who visit do not follow up with assistance. They have had several researchers come to their home but have not heard from them afterwards.

What do you think is the most important change in policy that could help make farming more sustainable here?
The farmer emphasizes the need for faster decision-making processes regarding mangrove management. He expresses concerns about the delays caused by frequent changes within the committee, and thus are current policies not conducive to timely action, which is critical for sustainable farming.

Do you think that research or help from outside has been useful or has it caused problems for farming here?
The farmer feels that the help from outside can be both beneficial and disruptive. While he acknowledged the potential for external assistance to be useful, the lack of follow-up leaves him feeling neglected, and that without sustained support, any initial benefits may be undermined.

Would you be willing to accept larger investments in tourism if it negatively affects the mangroves?
The farmer supports the idea of increasing tourism in Bạc Liêu. He did not directly address the question of accepting larger investments in tourism if it negatively impacted the mangroves.

F.1.3. Farmer #29

General Information

Name:	Nguyen Thanh Dung
Age:	70 years (born: 1954)
Farm type:	Ecological
Location of farm:	Inside mangroves
Time spent as farmer:	15 years (since: 2009)
Family situation:	-
Date of interview:	1st of October, 2024

Figure F.3: Photo of Farmer #29

Interview Questions and Responses

Understanding of Climate Change and Protection Measures

Can you tell me what you understand about climate change and how it affects your farm?

The farmer stated that the climate has become more extreme in general nowadays. However, he did not mention specific details about the direct effects of these changes on his farm.

Have you heard about any measures to protect you from the effects of climate change?

Answer: No. The farmer did not mention specific protection measures against climate change. However, he highlighted a lack of funds for new technology that could potentially be used to improve his farming practices.

Attitudes Toward Mangrove Protection

Do you think it is important to protect the mangroves?

Answer: Yes. The farmer believes it is important to protect the mangroves, as he receives financial support for mangrove protection. But he does not get enough money to grow shrimp.

In your opinion, why is it important to protect the mangroves?

The farmer did not provide a detailed explanation of why it is important to protect the mangroves. However, he acknowledges the financial support he receives for this purpose, which is why he is into mangrove protection.

Do you try to protect the mangroves, even if they negatively affect your farm?

Answer: Yes. Despite the fact that the farmer doesn't receive enough funds to grow shrimp, he continues to protect the mangroves using the financial support provided for this purpose.

Community Beliefs and Environmental Protection

Do you feel that people in your community believe protecting the environment is important?

The farmer did not answer this question.

Do you think working together with others can help protect the environment?

Answer: Yes. The farmer emphasized that cooperation with other farmers helps in gaining knowledge about farming techniques, though specific mention of environmental protection through cooperation is not directly made.

Collaboration Between Farmers

Do you think working together with intensive shrimp farmers and those farming near mangroves can lead to better solutions?

Answer: Yes. The farmer believes that sharing knowledge about farming techniques is beneficial. However, the farmer did not specify particular solutions that might arise from such cooperation.

Technology and Farming Practices

Have you heard of any new farming methods or technologies that you think could help improve your work?

Answer: Yes. The farmer mentioned being aware of new technologies that could improve their farming. However, they stated that they currently do not receive the necessary funding to implement these technologies.

Who, in your opinion, has the authority to make decisions regarding policies on mangroves/aquaculture/shrimp and the high-tech zone?

The farmer did not answer this question.

Do you think that researchers come to investigate problems and then leave without helping?
Answer: No. The farmer expressed a desire for researchers, particularly those specializing in aquaculture, to come and help improve his farming. He could see potential value in researchers who can bring new technologies that could benefit their practices.

What do you think is the most important change in policy that could help make farming more sustainable here?
The farmer emphasized that the most important policy change would be for the government to provide more financial support, particularly to help them grow shrimp. The farmer feels that the current level of support is insufficient, especially when it comes to shrimp farming, which has led some farmers to pursue other types of work instead.

Do you think that research or help from outside has been useful or has it caused problems for farming here?
Answer: Helpfull. The farmer expressed a positive attitude towards external research, especially if it involves technology that could help improve farming. He believes that researchers who specialize in aquaculture could be of great assistance if they bring useful innovations.

Would you be willing to accept larger investments in tourism if it negatively affects the mangroves?
Answer: No. The farmer is supportive of increased tourism but is clear that it should not negatively impact the mangroves. He specifically mentioned that the main tourism currently revolves around the pagoda temple and that he prefers to see tourism development that does not harm the environment, particularly the mangroves.

G

Interview Mangrove Management Board

Interviewees: Mr. Thinh and Mr. Hoat
Date of interview: 25th of September, 2024

Interview Questions and Responses

Please explain your duties and how you contribute to the department's activities in Bạc Liêu.
Mr. Thinh and Mr. Hoat work at the Forest Management Board, primarily responsible for managing, protecting, and restoring mangrove forests. They oversee various activities including forest allocation to farmers, thinning of forests, and ensuring that the mangroves are maintained to prevent erosion.

What types of measures have been implemented in Bạc Liêu to address erosion and flooding?
The government has constructed a breakwater from the area near Soc Trang to Vinh Hau A commune to address erosion and flooding. The project continues to expand, aiming to protect the coastline and nearby communities.

How was this coordinated?
Coordination involves the Forest Management Board's guidelines for managing the forests, hiring labour for planting, and working with local communities to ensure their involvement and compliance with forest management practices.

What challenges were there in the implementation of the interventions/mangrove reforestation?
Challenges include low salaries and funding difficulties, which create a stressful work environment. Additionally, there's a lack of modern machinery and facilities, and conflicts with local farmers over resource management.

Who is responsible for maintaining the mangroves?
The Forest Management Board, including workers like Mr. Thinh and Mr. Hoat, is responsible for the maintenance of the mangroves. They manage the overall care and restoration of these forests.

How do you involve local farmers in the planning and decision-making of mangrove restoration projects?
Local farmers are directly involved in the planning and decision-making processes by being allocated portions of the forest (70)%)to plant and protect, while using the remaining (30%) for aquaculture, which integrates their livelihood needs with conservation efforts.

What role do the local communities they play in maintaining these ecosystems?
Local communities, particularly farmers, play a crucial role by planting and protecting the mangroves. They participate in thinning activities and are pivotal in maintaining the health of the ecosystem, which in turn protects their lands from erosion.

How do you think local authorities can contribute to the long-term success of these interventions?
Local authorities can enhance the long-term success of these projects by providing adequate funding and resources, resolving infrastructural issues, and fostering better relations between farmers and conservation

efforts to ensure both economic and environmental objectives are met.

What additional support or resources from the government would help you improve the effectiveness of your work in mangrove restoration and protection?
Additional support needed includes modern machinery and better facilities, financial resources to improve worker salaries and reduce job stress, and means of transportation to manage the large distances between project sites effectively.

Questions asked to Minh
Date of interview: 30th of September, 2024

After the interviews on the 30th of September, we discussed the answers with our translator Minh. During that discussion, a representative of the Mangrove Management Board sat down with us and we had the chance to ask some additional 'informal' questions to both of them.

What could help these farmers?
High-tech farms need to manage their waste. For example, government-imposed fines could be effective, as there are currently no consequences for these companies.

Farmers should collaborate with authorities and work together to thin the trees. While they can do this themselves, government permission is required, and the approval process is slow.

Questions asked to Mangrove Management Board

Who decides on letters from the Mangrove Management Board?
The Mangrove Management Board of Bạc Liêu consists of 25 members and falls under DARD Bạc Liêu, which is overseen by the People's Committee. The Committee is responsible for overall governance, including but not limited to forests.

How does maintenance of the mangroves work? Farmers are eligible to receive 450,000 VND per hectare per year for maintaining the mangrove forest. Cutting down trees without government permission is prohibited. The government encourages farmers to grow and maintain the forest, and when trees are cut, 30% of the profit from the sale of wood goes to the state, which reinvests the funds to support the farmers.

What do you think the solution could be?
There are several administrative steps that need to be completed before the canopy of the trees can be thinned. When farmers submit a request to thin the canopy, the Mangrove Management Board forwards the letter to DARD Bạc Liêu, which in turn seeks approval from the central Committee of Bạc Liêu. This results in a lengthy wait for permission from higher authorities.

Did you learn any new things today?
The Mangrove Management Board monitors the farmers closely and conducts regular visits, so they are aware of the farmers' problems. They also provide training on sustainable aquaculture techniques, but their knowledge is limited to the farmers living near the mangroves.

What do you think about support of international organisations or NGOs? Could they provide any help?
It is difficult to say things about the government.

Questions asked to Nguyên Hôi, Head Forester of Bạc Liêu
Date of interview: 30th of September, 2024

The Forester of Bạc Liêu accompanied the hydraulic team on the 24th, 25th and 30th of September. After conducting the water level measurement at Hoa Binh 1 Windmill pier, where a successful reforestation attempt was witnessed, Mr. Hôi elaborated on this. Follow-up questions were subsequently asked regarding the measurements conducted in recent days, as he was open to providing further information.

Nguyên Hôi, Head forester of Bac Lieu said, explained:
For reforestation, we first investigate the soil. We need hard soil for reforestation projects because otherwise, the waves take away the soft soil and the mangroves. This reforestation beside the (Hoa Binh 1 windmill) pier, was done by me and my team. We first found that this soil was hard. You can state that this project was successful.

Are there many successful reforestation projects?
Yes, I did a lot over the past years. There is a successful project of mangrove restoration in Long Dien Dong village in the Dong Hai district in Bạc Liêu province. This was because of hard ground in the soil. In Nha Mat reforestation was not successful. because the soil was too soft.

Do you know the dates of the last reforestation projects in front of the Nha Mat wharf and the successful reforestation project beside Hoa Binh 1 windmill pier, which you stated you planted yourself?
The final planting time at Nha Mat is August 2019. The final planting time at Hoa Binh 1 Wind Power Plant is August 2023.

We conducted measurements in multiple mangrove belts, of which we need to confirm the species. Can you confirm our assumption that the most abundant pioneer mangrove species we have seen and measured is Avicennia? If not, can you please tell me which mangrove species it is?
I confirm that the pioneer forest species encroaching on the sea is the Avicennia marina (Mam Biên in Vietnamese).

H

Interview Department of Agriculture and Rural Development Bạc Liêu

Interviewees: (this was not communicated to us)
Date of interview: Digital answers received on 8th of October, 2024 (section 7)

Interview Questions and Responses
Please explain your role within your department and the tasks and goals of the department.
The role: Irrigation and hydraulic structure section in DARD

What types of measures have been implemented in Bạc Liêu to address erosion and flooding?

- Breakwater
- Revetment
- Sea dyke system
- Sluice gate

How was this coordinated, and can you take us through the steps of the process (from a problem statement to finding a solution and the implementation of it, how does it work)?
First, we will report that bad, urgent situation to the provincial people's committee to ask for approval to implement the project. Then, we will open a bid to call for design and construction of solutions to solve the above problems.

What challenges were there in the implementation of the interventions or mangrove reforestation? And how did you manage or tackle them?

- State investment capital shortage
- Unsuccessful mangrove plant and restoration

Who is responsible for maintaining the mangroves? In your opinion, do you agree that they are responsible and why?

- Forestry Department: Ensure compliance with forestry laws, is a specialized force in fire prevention and fighting...
- Forest Management Board: forest maintenance and development

How do you involve local farmers in the planning and decision-making of mangrove restoration projects?
Allocate forest land to forest farming households to preserve and exploit forests sustainably and effectively.

What role do the local communities play in maintaining these ecosystems?
Local communities will report to the authorities when anyone encroaches or destroys the forest.

How do you think local authorities can contribute to the long-term success of these interventions?
Local authorities play a key role in funding and management for interventions.

What additional support or resources from the government would help you improve the effectiveness of your work in mangrove restoration and protection?

- Budget
- Research

Do you have a feeling that you are aware of the socio-economic problems of the farmers? How do you know, or in which way would you like to be (more) involved?
We understand the socio-economic problems of the farmers because we often contact together by face-to-face, farmers association, commune people's council...

How would you describe the relation between DARD and the local farmers?

- Close relationship.
- The mission and responsibility of DARD that the State and Government assign is to serve the better life for local farmers.