CHAPTER 1: INTRODUCTION

1.1 Background

Coastal regions worldwide often face challenges related to the dynamic interplay between riverine discharge, wave action, and sediment transport at the mouths of floodways and estuaries. These interactions can lead to significant sedimentation, impacting the navigability of crucial waterways and hindering the livelihoods of coastal communities (Li et al., 1998[1]; Yang, 1999[2]; Warrick, 2020[3]; Lawson et al., 2022[4]; Kusuma et al., 2023[5]).

In the specific context of the mouth of a coastal floodway in Padang Beach, West Sumatra, Indonesia, substantial sedimentation has emerged as a critical issue, despite prior coastal protection measures. Initially, Padang Beach experienced significant abrasion due to wave action. To mitigate this, the Sumatera V River Basin Agency (Balai Wilayah Sungai Sumatera V - BWSSV) constructed a series of groynes spanning 3.15 km, effectively halting shoreline erosion.

However, this intervention effectively halted shoreline erosion but the dynamic coastal environment, as seen in the 2006 imagery (Figure 1.1, prior to jetty construction), still presented significant sedimentation challenges within the body and mouth of the Batang Arau Floodway, leading to shallowing of the navigation channel (Mera, 2023)[6]. This sedimentation severely restricts

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1 Li, G., H. Wei, S. Yue, Y. Cheng & Y. Han, 1998. "Sedimentation in the Yellow River delta, part II: suspended sediment dispersal and deposition on the subaqueous delta". *Marine Geology* **149**(1-4), 113-131. doi: 10.1016/S0025-3227(98)00032-2

2 Yang, S.L., 1999. "Sedimentation on a Growing Intertidal Island in the Yangtze River Mouth". *Estuarine, Coastal and Shelf Science* **49**(3), 401-410, doi: 10.1006/ecss.1999.0501

3 Warrick, J.A., 2020. "Littoral Sediment from Rivers: Patterns, Rates and Processes of River Mouth Morphodynamics". *Frontiers in Earth Science* **8**(1), 1-22, doi: 10.3389/feart.2020.00355.

4 Lawson, S.K., H. Tanaka, K. Udo, N.T. Hiep, N. Xuan & Tinh, 2022. "Assessment of River Mouth Variability after Jetty and Groyne Construction: A Case Study of the Volta River Mouth, Ghana". *Tohoku Rgional Disaster Science Research* **58**, 111-116, Available at: http://nds-tohoku.in.arena.ne.jp/ndsjournal/volume58/58-20.pdf

5 Kusuma, M.D., M.B. Adityawan & A.N. Chaidar, 2018. "Effect of Jetty to the Capacity of Bogowonto River Mouth, Kulon Progo Daerah Istimewa Yogyakarta". *Jurnal Teknik Sipil ITB* **30**(1), 17–24, doi: 10.5614/jts.2023.30.1.3.

6 Mera, M, 2023. *Lecture notes: Shore protection structures*. Padang: University of Andalas.

the maximum draft of vessels that can safely pass and impedes the access of local fishing vessels to the waterway.

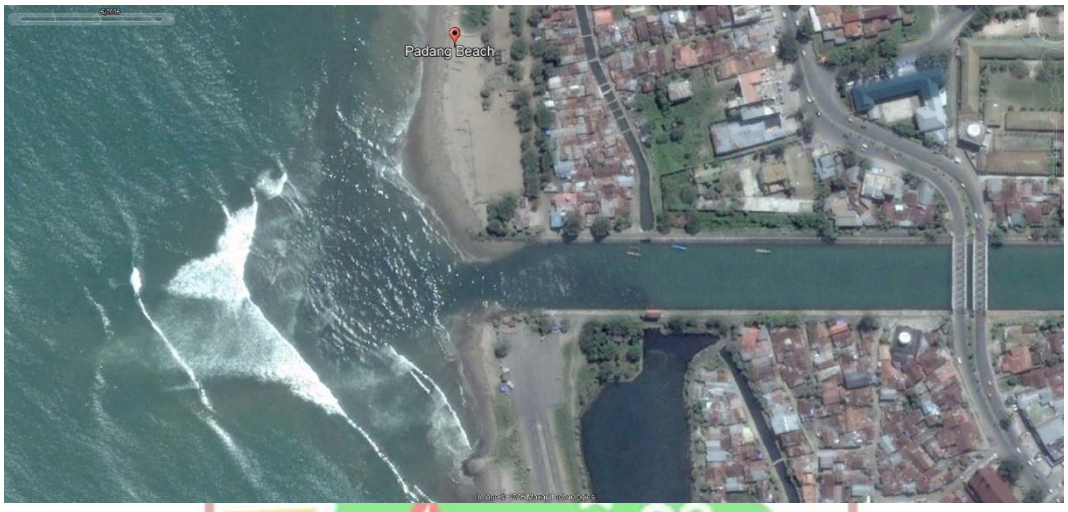

Figure 1.1 Changes in the Padang Beach Floodway Condition: Google Earth satellite imagery from 2006 (prior to jetty construction) (Google Earth, 2025*a*)[7], illustrating the initial condition before structural intervention.

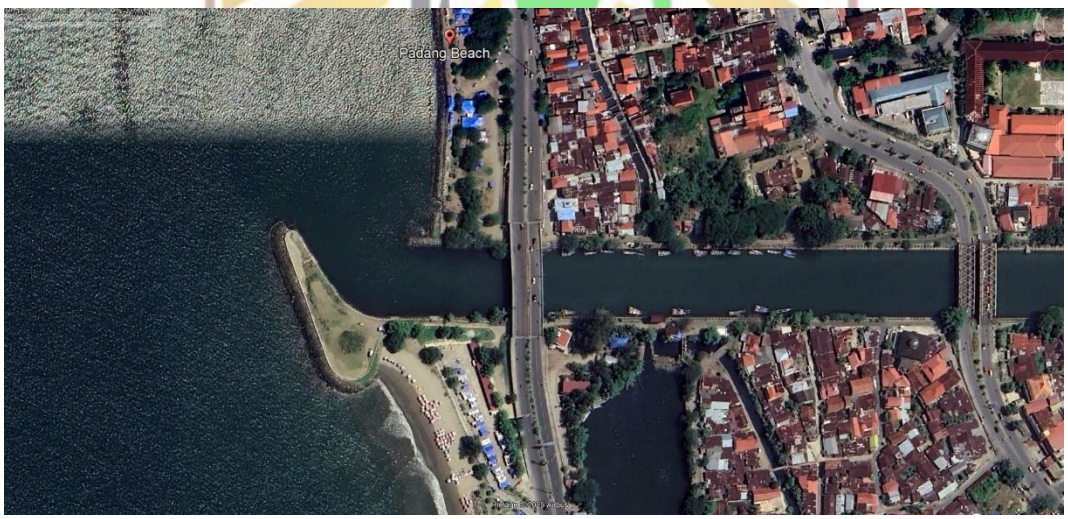

Figure 1.2 Changes in the Padang Beach Floodway Condition: Google Earth satellite imagery from 2024 (post-jetty construction), illustrating the impact of structural intervention (Google Earth, 2025*b*)[8].

Recognizing this challenge, the Water Resources Development Agency (Dinas Pengembangan Sumber Daya Air - PSDA) of West Sumatra Province

7 Google Earth, 2025*a*. *Padang Beach Floodway in 2006*. Accessed: April 12, 2025. [Online] Available at: https://earth.google.com/ .

8 Google Earth, 2025*b*. *Padang Beach Floodway in 2024*. Accessed: April 12, 2025. [Online] Available at: https://earth.google.com/ .

undertook efforts in 2007, including the construction of jetties and dredging at the floodway mouth. While satellite imagery from 2024 (Figure 1.2) suggests that the jetty construction partially reduced sedimentation at the immediate mouth, the bed elevation within the canal remains insufficient, particularly for traditional lift net fishing vessels (kapal bagan) longer than 10 m (Figure 1.3). Currently, only smaller sampan boats with a maximum length of 10 m can navigate the canal (Figure 1.4). This situation negatively impacts the local fishermen's economy, limiting their operational capacity and economic growth.

Figure 1.3 Fishing Vessels in the Study Area: Traditional lift net fishing vessel (kapal bagan) with outriggers and lights, representing vessels longer than 10 m that are currently impeded from accessing the floodway.

The problem of sedimentation obstructing navigation is a globally recognized issue. Studies focusing on structural engineering solutions, particularly the strategic implementation of jetties, have demonstrated potential for mitigating sedimentation and improving navigation access in similar environments, such as Bodega Harbor (Magoon et al., 2011)[9] and the

[9] Magoon, O. T., D. D. Treadwell & P. S. Atwood, 2011. "Jetties at Bodega Harbor". *Coastal Engineering Proceedings* **32**, 52. doi: 10.9753/icce.v32.structures.52.

Versilia River (Bertoni et al., 2021)[10]., as well as the successfully implemented case at the mouth of the Prajagumiwang River (Abdurrahman et al., 2021)[11].

Figure 1.4 Fishing Vessels in the Study Area: Sampan boats, illustrating the currently navigable vessel type in the floodway (maximum length of 10 m).

1.2 Objective

Given the persistent challenge of shallowing at the mouth of the Batang Arau Floodway in Padang Beach and the potential for jetty engineering to offer a viable solution, the objectives of this study are:

1. To evaluate, compare, and optimize the jetty layout configuration by simulating six distinct scenarios to minimize sedimentation and increase the depth of the navigation channel using a numerical simulation approach.
2. To assess the long-term viability of the optimized jetty configuration when combined with a floodway dredging scenario under both normal and flood discharge conditions.

[10] Bertoni, D., M. Bini, M. Luppichini, L.E., Cipriani, A. Carli & G. Sarti, 2021. "Anthropogenic impact on beach heterogeneity within a littoral cell (Northern Tuscany, Italy)". *Journal of Marine Science and Engineering* **9**(2), 151. doi: 10.3390/jmse9020151.

[11] Abdurrahman, U., H. Park & T. Suprijo, 2021. "Study of shoreline evolution under the influence of jetty construction: A case study of Karangsong Beach, Indramayu, Indonesia". *IOP Conference Series: Earth and Environmental Science* **698**(1), 012038. doi: 10.1088/1755-1315/698/1/012038.

1.3 Benefits of the Study

This study is expected to yield the following benefits:

1. **Practical Benefit:** The findings provide a blueprint for the sustainable management of the Batang Arau Floodway mouth, directly supporting the livelihoods of coastal fishing communities by restoring and enhancing year-round access for vessels longer than 10 m.
2. **Academic Benefit:** The study contributes valuable, transferable insights into the optimal design of coastal engineering solutions—specifically, asymmetrical jetty layouts—for other similar floodway mouths and estuarine environments facing chronic sedimentation challenges across Indonesia and globally.
3. **Policy Benefit:** The results offer numerical evidence and data to support the Sumatera V River Basin Agency (BWSSV) and the local government in planning and implementing effective, cost-efficient mitigation measures, reducing the reliance on frequent, costly dredging operations.

1.4 Limitations

The scope of this study is subject to the following limitations:

1. **Simulation Period:** The numerical simulations were conducted over a **26-day period** due to computational constraints. Longer-term simulations incorporating seasonal variations in wind, wave, and discharge patterns would provide a more comprehensive understanding of the long-term effectiveness of the proposed jetty layouts.
2. **Bathymetry Data:** The study utilized **DEMNas bathymetry data** with a resolution that might limit the accurate representation of fine-scale features and detailed bed morphology immediately surrounding the existing jetty structures.
3. **Model Scope:** The study focuses primarily on **morphological changes driven by wave, current, and river discharge interaction** at the floodway mouth; it does not explicitly model or account for sediment sources from the upstream river catchment.

1.5 Report Layout

This engineering report is organized into five chapters as follows:

1. **Chapter 1: Introduction:** Presents the background of the problem, the urgency of sedimentation at the Batang Arau Floodway mouth, the objectives, expected benefits, and limitations of the study.
2. **Chapter 2: Literature Review and Theoretical Framework:** Discusses the fundamental theories governing coastal hydrodynamics, sediment transport in estuaries, the influence of jetty structures on morphology, and previous case studies related to navigational channel maintenance.
3. **Chapter 3: Materials and Methods:** Describes the study area, data acquisition (bathymetry, wind, wave, tide, and discharge), the setup of the MIKE 21/3 numerical model, and the detailed configurations of the six simulated jetty scenarios.
4. **Chapter 4: Results and Discussion:** Presents the characteristics of the environmental data, analyzes the hydrodynamic and sediment transport response for all simulated scenarios, discusses the effectiveness of the optimal jetty configuration (Scenario 5), and compares the findings with relevant previous study.
5. **Chapter 5: Conclusion and Recommendations:** Summarizes the key findings, states the conclusion regarding the optimal solution for preserving navigational depth, and provides recommendations for future study and practical implementation.