CHAPTER 1 INTRODUCTION

1.1 Background

Coasts are dynamic land areas with spaces that can change in location and shape in response to human activities and natural processes. Understanding the pattern of shoreline changes over a specific perod is essential for the protection and development of coastal regions. One of the main parameters in estimating the hazard of coastal areas due to abrasion and accretion is by understanding changes in the shoreline. Therefore, shoreline monitoring is an important element as a means to predict future shoreline changes as part of proper coastal management (Jonah et al., 2016). Research on shoreline changes using Geographic Information Systems (GIS) and Remote Sensing is crucial to facilitate the rapid and easy recording of current locations, thereby providing key information for long-term management planning (Zeinali et al., 2020). Remote sensing techniques using satellite imagery and GIS integrated with the Digital Shoreline Analysis System (DSAS) can help describe short-term and long-term changes in shorelines more effectively and accurately (Nassar et al., 2019). On the other hand, remote sensing provides multitemporal coverage and multispectral satellite imagery that can support analysis development, thereby improving the assessment and monitoring of shoreline positions (Ruiz-Beltran et al., 2019).

The city of Padang is geographically located on the west coast of Sumatra, Indonesia, with a shoreline of approximately 84 km. Padang faces the Indian Ocean to the west, lies below the equator, and is located between the Eurasian and Indo-Australian tectonic plates (Ramdhan, 2021). This condition makes Padang City vulnerable to coastal hazards and disasters (Gemilang et al., 2017). West Sumatra Province in general and Padang City in particular have low-lying areas along the west coast. In the opposite direction, the volcanic highlands of Bukit Barisan stretch from the northwest to the southeast. This causes the coastal areas of West Sumatra Province to have a high level of hazard to tectonic disasters in the form of earthquakes and tsunamis (Ramdhan et al., 2012). Strong Indian Ocean waves reaching the coast of Padang City influence changes in the shoreline due to the interaction between ocean waves, currents, and sedimentation, leading to abrasion (coastal erosion) or accretion (addition of coastal material).

Several coastal areas, such as Padang Beach, Pasir Jambak Beach, and Air Manis Beach, have experienced significant coastal erosion due to wave activity. The Padang Beach Tourism Area is one of the areas that has been affected by erosion in recent years. Previously, this area experienced quite alarming conditions due to coastal abrasion, which caused the shoreline to recede. To address this issue, in 2021, the central government, through the National Disaster Management Agency, allocated a budget of IDR 19 billion for the construction of a seawall at Padang Beach. The construction of the seawall aims to reduce the impact of abrasion and protect the coastal area from the threat of high waves and more extreme shoreline changes. One internal factor exacerbating abrasion is the conversion of mangrove forests and swamps into shrimp ponds at Pasir Jambak Beach. In 2021, there were 31 shrimp ponds in the area, resulting from the conversion of mangrove forests and swamps.

Continuous abrasion and accretion processes can change the shape of the shoreline and the depth of coastal waters. If the shoreline becomes deeper due to abrasion eroding the material, tsunami waves can store more energy because there are no significant obstacles. As a result, tsunamis can spread faster and further inland, and the area affected by tsunami inundation also becomes wider. Conversely, shallow shorelines tend to reduce tsunami energy due to energy dissipation as waves approach the shore. This results in shorter evacuation distances and higher hazard, as the land is closer to the tsunami wave source, making the area highly hazard to tsunamis (Rasyif et al., 2019). Coastal monitoring enables the identification of areas experiencing severe abrasion, allowing protective measures to be taken, such as installing wave breakers or planting coastal vegetation. Therefore, by monitoring these changes in the shoreline, tsunami-hazard zonations can be mapped more accurately to support tsunami risk reduction analysis (Joesidawati, 2017).

Disaster mitigation efforts require a proper understanding of the areas most vulnerable to the impact of tsunamis. One approach that can be used is tsunami hazard zonation, which is the spatial grouping of areas based on physical and geomorphological parameters such as elevation, slope, distance from the coastline, and proximity to river mouths. This differs from tsunami hazard mapping, which generally refers to inundation modeling based on specific tsunami scenarios. Tsunami hazard zoning is crucial because it enables planners and decision-makers to assess local risks based on the intrinsic characteristics of the landscape, even in the absence of historical tsunami records or detailed wave simulations. This makes it highly valuable for proactive spatial planning, particularly in developing coastal areas with limited access to dynamic modeling tools(Pararas-Carayannis, 2003).

A number of previous studies have analyzed coastal dynamics in Padang City. Yulfa et al. (2022) mapped coastal changes using Landsat imagery with the MNDWI and DSAS methods, finding that abrasion and accretion occurred significantly during 2000–2020. Abrasion was more dominant in the northern part of the Padang City shoreline, while accretion occurred more frequently in the southern bay area of Padang City. Research by Desmayanti and Yudi Aulia Rahman (2022) analyzed coastal changes at Purus Beach using a manual approach with ArcGIS. The shoreline experienced accretion and abrasion in different patterns during each period at Purus Beach in Padang City. The period from 2005 to 2009 was dominated by abrasion, the period from 2009 to 2014 was dominated by accretion, and the period from 2014 to 2019 was dominated by abrasion. They concluded that the accretion process is likely associated with human activities such as the construction of breakwaters, while abrasion is more dominant due to natural factors. Meanwhile, Amalia et al. (2023) studied changes in the shoreline of Semarang City over two decades using DSAS and predicted shoreline shifts up to the year 2041. The study results showed an abrasion rate of 10.31 m/year and an accretion rate of 20.95 m/year, highlighting the importance of long-term spatial adaptation strategies to address coastal damage. This study proves that processing multi-temporal satellite imagery data with DSAS can accurately map coastal changes that are relevant for mitigation policies. However, these studies have not specifically examined the impact of coastal changes on tsunami hazard zonations, nor have they covered the entire coastal area of Padang City.

This study aims to analyze coastal line changes based on remote sensing and assess their relationship with tsunami hazard zonations in Padang City. The methods used are coastal line extraction using Landsat satellite imagery and the Digital Shoreline Analysis System (DSAS) to calculate the rate of coastal line change and the total distance of coastal line displacement from Landsat 8 imagery data from 2013 and 2025. Mapping of tsunami-hazard zonations using a multi-criteria evaluation approach based on four main parameters: coastal line changes, elevation, slope gradient, and distance from river flows. Data processing was conducted using the Google Earth Engine (GEE) platform, which enables rapid access to multi-temporal satellite imagery and efficient cloud-based data processing (Gorelick et al., 2017). Each parameter is assigned a specific weight score, then spatially processed in a Geographic Information System (GIS) to generate a tsunami hazard zonation map (Leli Honesti et al., 2023). This study is expected to fill the gaps in previous studies by integrating the dynamics of coastal change and tsunami risk spatially and quantitatively, and could make a significant scientific contribution to supporting disaster risk reduction and adaptive coastal zonation management in the future.

1.2 Research Purpose

Identifying factors causing shoreline changes that influence the hazard of coastal areas to tsunami hazard and evaluating the spatial relationship between shoreline change dynamics and tsunami hazard zonations based on physical parameters of the area, such as elevation, slope gradient, distance from rivers, and the shoreline, regardless of the specific tsunami scenario.

1.3 Research Benefit

This research is expected to provide useful information for local governments and communities in mitigation efforts and development planning in disaster-hazard coastal areas, as well as being able to provide information for academics/researchers about the utilization of the Google Earth Engine platform to extract and process satellite imagery in mapping shoreline changes.

1.4 Research Scope and Limitations

The scope and limitations of this study are as follows:

1. Analysis of shoreline change and its influence on tsunami hazard zonations was conducted in the coastal area of Padang City.
2. Multi-temporal satellite images were collected and processed through the Google Earth Engine platform.
3. The shoreline change parameters used is Net Shoreline Movement (NSM) and End Point Rate (EPR).
4. Using the Digital Shoreline Analysis System (DSAS) method to calculate shoreline change distance and shoreline change rate.
5. The tsunami hazard zonation parameters used are shoreline change, land surface elevation, river distance and slope.
6. The analysis technique used is a multicriteria evaluation technique, namely the scoring and weighting method with map overlay.
7. Data collection and processing were conducted on the Google Earth Engine platform, and map layout was created using QGIS software.