CHAPTER I
INTRODUCTION

The main body of the thesis is organized into several interconnected chapters that form a systematic narrative. The Introduction chapter is the first section, outlining the focus of the research namely, the extraction of the coastline of Java Island using a combination of the BDCN-UNet and OBIA models with multisensor data and explaining the rationale for conducting this research.

1.1 Background

As an archipelago, Indonesia has a fairly long coastline, stretching approximately 108,000 km. This offers many benefits, one of which is the significant potential for Indonesia to develop a marine- and fisheries-based economy, given the many activities carried out by coastal communities [1]. In addition to the economy, coastal areas play an essential role in preserving environmental sustainability by supporting ecological balance. This is because aquatic ecosystems are a vital component of the Earth's ecological balance [2].

The shoreline is not permanent; rather, it is constantly changing depending on various factors, including both natural and external influences. These changes in the shoreline occur over time and can take place over both long and short time frames [3]. However, this also poses a challenge because it can have significant impacts and carries the risk of coastal disasters, thereby threatening the sustainability of coastal and marine resources-which are Indonesia's primary economic and ecological assets. Therefore, accurate and sustainable monitoring of the coastline is crucial for supporting coastal zone management policies. Coastline monitoring can be conducted conventionally through field surveys; however, this method is less effective for further monitoring [4].

Beach conditions vary from location to location; each beach has its own unique environmental characteristics depending on sea conditions and the activities of the local community [3]. The diversity of coastal conditions in Indonesia also presents unique challenges in terms of monitoring and management. Java is one of the regions in Indonesia with complex coastal dynamics. Java has a total coastline stretching approximately 6,223.35 km. The island features diverse coastal

characteristics, ranging from the low-lying, gently sloping northern coast which borders the Java Sea to the southern coast, characterized by steep cliffs and strong wave activity because it directly faces the Indian Ocean.. Meanwhile, the western and eastern parts of Java border the Sunda Strait and the Bali Strait [5]. The northern coastline of Java is one of the coastal regions most affected by sea-level rise in Indonesia. Historically, the rate of sea-level rise along the Java coast has been relatively higher, ranging from 5.6 to 6.2 mm per year, compared to the Sumatra coast, where it is recorded at 4.79 mm per year [6] The diversity of coastal dynamics, influenced by differences in sea-level rise rates, renders conventional monitoring methods less effective, necessitating a more modern approach capable of operating consistently under various coastal environmental conditions.

One method for automatically monitoring coastlines involves computer-based image processing, which utilizes remote sensing technology from satellite imagery. This approach enables comprehensive, consistent, and efficient analysis of coastlines through the automatic detection and modeling of land and sea boundaries. The highly diverse coastal conditions on the island of Java make the process of extracting coastlines via remote sensing increasingly challenging. These conditions indicate that optical imagery alone is insufficient to handle the variations in coastal environments, necessitating the use of other technologies to address its limitations. The combination of optical and SAR imagery has proven to have great potential for coastline extraction and reconstruction under various coastal conditions. Mao and Splinter demonstrated that combining information obtained from various sensors, optical and SAR data yields more accurate results in coastline extraction compared to data using optical imagery alone [7].

Teknologi seperti metode deep learning dapat dimanfaatkan untuk mengekstraksi garis pantai selain dengan penggunaan data multisensor. Perkembangan teknologi pengolahan citra berbasis deep learning semakin banyak yang menjadi solusi untuk mengatasi berbagai kondisi citra, salah satunya yaitu pengembangan model BDCN-Unet. Model tersebut adalah Integrasi Bi-Directional Cascade Network (BDCN) untuk deteksi tepi presisi tinggi dengan arsitektur U-Net untuk segmentasi spasial. Penelitian yang dilakukan oleh Mahmoud et al., hasil menunjukkan integrasi BDCN-UNet mencapai performa tinggi di kisaran 90%

sampai 99%, lebih unggul jika dibandingkan deep learning konvensional maupun teknik thresholding tradisional [8].

Model performance can be enhanced through the combination of deep learning techniques and Object-Based Image Analysis (OBIA) method as a refinement step. Research by Bengoufa et al. shows that the CNN method combined with OBIA is capable of producing precise coastline extractions, with 76% of the results falling within less than 1 meter and 35% within less than 0.5 meters of the reference line. In this method, OBIA converts the CNN output into a polyline, thereby helping to detect object boundaries more accurately and reducing the limitations of CNN at the pixel level in determining coastline boundaries [9].

Based on the previous explanation, this study focuses on extracting coastlines using multi-sensor data and developing an edge detection model using a Bi-Directional Cascade Network (BDCN) and a segmentation model using U-Net. The models are then refined using Object-Based Image Analysis (OBIA) to smooth the lines or polylines. This approach is designed to assist researchers and practitioners in the fields of geomatics and marine science, as well as coastal zone managers, in obtaining precise coastline delineations, particularly in areas with high turbidity and complex sedimentation. All modeling results are implemented in the form of a website so that the coastline extraction process can be used practically and is easily accessible; however, its use is intended specifically for parties with relevant connections and needs in the related fields.

1.2 Problem Statement

Considering the issues outlined in the background section, the following research question is established:

1. How does the BDCN-UNet model, combined with OBIA, perform in extracting coastlines?
2. How do the evaluation results for coastline extraction differ between SAR, optical, and multisensor data when the same method is applied?
3. How to implement the results of the coastline extraction model into a website?

1.3 Objectives

Based on the research questions presented above, the objectives of this study are as follow:

1. Evaluate the performance of the BDCN-UNet model combined with OBIA in extracting coastlines under various conditions.
2. Analyzing differences in the evaluation of coastline extraction results using SAR, optical, and multisensor data types with the application of the same method.
3. Building a website capable of integrating and displaying coastline extraction results from the BDCN-UNet and OBIA models.

1.4 Benefits

The benefits derived from this study are as follows:

1. To provide a reference for effective image processing methods for monitoring coastlines in coastal areas with varying shoreline conditions.
2. Serving as a guide for researchers and practitioners in selecting the most appropriate type of remote sensing data whether SAR, optical, or multisensor for various coastal conditions.
3. Providing preliminary support for coastal area management through the availability of shoreline data that can be utilized in spatial planning and disaster risk reduction initiatives.

1.5 Scope of the Problem

The scope of this study has been defined to ensure that the discussion remains focused and does not stray from the main topic, as follows:

1. This study is limited to the coastal areas of Java, with study sites representing a variety of geomorphological conditions, including the eastern, western, northern, and southern coasts of Java, namely Banyuwangi-Situbondo, Banten, Rembang-Tuban, Pacitan-Wonogiri, Brebes-Cirebon, and Cilacap-Pangandaran.
2. The dataset used is limited to Sentinel-1 (SAR) and Sentinel-2 (optical) images downloaded from the Copernicus Dataspace Ecosystem website.
3. The ground truth data used consists solely of a coastline layer from a geodatabase (GDB) file downloaded from the Ina-Geoportal website operated by the National Geospatial Information Agency.
4. This study uses data covering the period from 2021 to 2025.
5. The main models used are BDCN edge detection, U-Net segmentation, and object-based segmentation using the OBIA method.

6. This study employs a model designed exclusively for shoreline extraction, and therefore does not include object classification or additional spatial analysis tasks.
7. Model performance was assessed using the F1-score and Intersection over Union (IoU) metrics.