CHAPTER I
INTRODUCTION

The Introduction chapter serves as a basis for understanding the context and direction of the research being conducted. This chapter explains the background of the topic being raised, the formulation of the problem to be solved, the objectives to be achieved, the scope or limitations of the research, and the contributions or benefits that it can provide.

I.1 Background

Land use and land cover (LULC) has become a critical and complex global environmental issue in recent years, as it affects ecosystem sustainability, environmental quality, and regional spatial planning. In the international context, changes in LULC are frequently motivated by population pressure, rapid urbanization, and industrialization. According to Brondízio et al. (2019), human activities have significantly reduced biodiversity, and many species live intimidated by extinction due to land conversion, pollution, and climate change.

The report shows that more than one million species live intimidated by extinction, with land conversion for agriculture and infrastructure development being the significant contributors. In addition, a study by Schirpke et al. (2023) showed that land use change contributes to the loss of ecosystem services, resulting in increased greenhouse gas emissions and accelerated global climate change. The report also highlights that urbanization and agricultural expansion lead to land degradation and biodiversity loss, significantly affecting ecosystem functions. This phenomenon encourages policymakers to seek sustainable solutions when monitoring land use change, especially in areas experiencing rapid economic growth.

In Indonesia, the rate of land cover change is of particular concern, especially as deforestation and grassland conversion rates continue to increase. According to a report from Kementerian Lingkungan Hidup dan Kehutanan (KLHK) (2023), deforestation in Indonesia has increased significantly, with forest loss of around 104,000 hectares in 2021-2022. Additionally, there are significant concerns regarding the escalating threat of natural disasters, such as floods, along with a

decline in the quality of the local environment. Land transformation also impacts biodiversity and disrupts the ecological balance, particularly on densely populated islands like Bali. Bali, one of Indonesia's top tourist destinations, faces significant challenges in balancing economic growth and environmental protection. Based on data published by Kementerian Pertanian (2019), the conversion of agricultural land in Bali has increased in recent years. Based on the data, between 2015 and 2019, many agricultural lands were converted into residential and commercial land, especially in areas related to the tourism and infrastructure sectors. This situation increases the environmental vulnerability of Bali, as pressure on natural resources, land degradation, and unregulated urbanization could threaten the island's long-term aspirations as a natural and cultural tourism destination.

To address the challenges of balancing development and environmental sustainability, the Bali government has established a Regional Spatial Plan (RTRW) as a guiding framework. The RTRW serves as a critical foundation for the Bali Regional Development Planning Agency (Bappeda) in making informed land allocation and spatial planning decisions. However, its effective implementation is hindered by the lack of accurate, up-to-date land use and land cover (LULC) data. Conventional mapping methods and earlier classification techniques are insufficient to capture the rapid and complex changes in land use, thereby limiting the region's capacity to monitor and plan effectively.

While numerous studies have attempted to classify LULC using traditional machine learning techniques, such approaches often remain theoretical and fail to translate into practical tools that can support regional policymaking. For example, Southworth et al. (2024) used Random Forest in tropical forest zones but reported substantial misclassification concerns in places with mixed land cover. In a similar vein, Pushpalatha et al. (2024) investigated the application of Support Vector Machines within agricultural settings, emphasizing the method's sensitivity to noise and reliance on manual feature selection. This research gap underscores the need for a more integrated approach that combines advanced computational modeling with actionable insights. To address these limitations, this study proposes the application of deep learning methods, specifically U-Net, a variant of convolutional neural networks (CNN), to perform high-resolution LULC classification in Bali.

This study seeks to overcome existing constraints by implementing a deep learning technique that employs the U-Net architecture to classify land use and land cover (LULC) using satellite imagery. The U-Net's encoder-decoder structure enables precise spatial segmentation, improving classification accuracy, particularly in complex and heterogeneous landscapes. Its ability to integrate multi-source data makes it suitable for capturing detailed land cover patterns across different temporal and environmental conditions (Hao et al., 2024; Solórzano et al., 2021; Zhang et al., 2023). Geospatial processing in this study was conducted using two open-source platforms: Google Earth Engine (GEE) and QGIS. According to Bahri et al. (2020), the use of QGIS significantly enhances data collection and spatial analysis workflows, providing a robust foundation for producing detailed and accurate thematic maps. Meanwhile, GEE offers a cloud-based environment for rapid and scalable analysis of satellite data, with infrastructure capable of processing large-scale satellite imagery (Gorelick et al., 2017). The integration of these tools enables reproducible, efficient, and high-resolution satellite data for land use and land cover (LULC) classification. The ultimate objective of this study is to support long-term environmental monitoring and inform spatial planning efforts in Bali through the development of a reliable LULC classification model.

I.2 Problem Statement

The problem formulation underlying this research is:

1. How can a U-Net based deep learning model be developed for classify in Land Use and Cover (LULC) using satellite data?
2. How accurate and effective is the U-Net model in classifying land use and land cover (LULC) in Bali using Landsat imagery?
3. How results of the pixel-level classification model can be used to support spatial planning, land use monitoring and sustainable land management in Bali?

I.3 Research Objectives

The objectives of this study are to:

1. Develop a model for monitoring land cover in Bali by utilizing satellite data and deep learning techniques, including U-Net.
2. Determine the accuracy of the U-Net, a variant of Convolutional Neural Networks (CNN) in classify land use and land cover (LULC) in Bali.
3. Implementing the model so that it can be used to easily support spatial planning, land use monitoring and sustainable land management in Bali.

I.4 Research Scopes

This research examines the classification of land use and land cover (LULC) in Bali province. This study employs Landsat satellite imagery from 2014, 2019, and 2024, processed through Google Earth Engine (GEE). The U-Net architecture is utilized as a deep learning method for modeling land use and land cover classification. The classification comprises nine distinct land cover categories: dryland forest, mangrove forest, plantation forest, bare land, savanna and grasses, water body, dry agriculture, paddy field, and built-up area. The research focuses solely on pixel-level classification accuracy, excluding temporal prediction and socio-economic analysis.

I.5 Research Benefits

Benefits of this research:

1. This research can provide models for Bali government in spatial planning, monitoring land use and land resource management, as well as assist in making data-based decisions for environmental sustainability.
2. For Researchers, this can be a reference in developing more accurate classification models for land use and cover, as well as providing guidance for decision-making in spatial planning, monitoring land use and sustainable land management.

3. For readers, provides valuable insights for readers, especially researchers and practitioners in the fields of information systems, environment, and regional planning.

I.6 Writing System Final Project

The systematics of writing this final research project are as follows:

1. **Chapter I Introduction**

   This chapter contains the background that explains the context and purpose of this research. It also contains a problem formulation that identifies the main issues to be solved, as well as research objectives that describe the results to be achieved. This chapter also describes the benefits of the research, the scope of the research, and the systematics of writing the thesis to provide guidance on the structure and flow of the research.

2. **Chapter II Literature Review**

   This chapter discusses basic theories and concepts that are relevant to the research topic. This chapter also presents a literature review of previous research, analyzes previous findings, and identifies the knowledge gaps that this research aims to answer.

3. **Chapter III Research Methods**

   This chapter explains the approach, strategy, data collection techniques, and analysis methods that will be applied to achieve the research objectives.

4. **Chapter IV Problem Solving**

   This chapter provides a discussion conducted on the processing and analysis of relevant data, as well as how the design of the model or system used supports the research objectives.

5. **Chapter V Validation, Result Analysis, and Implications**

   This chapter explains the implementation process of the designed model and the results of the tests carried out. An explanation of the steps taken, challenges, and solutions applied is provided.

6. **Chapter VI Conclusions and Suggestions**

   This chapter concludes the overall research results by providing a summary. In addition, constructive suggestions and recommendations are also provided for the development of further research.