MONITORING LAND USE AND LAND COVER (LULC) CHANGES OF JEMBRANA COASTAL AREAS USING PLANETSCOPE IMAGERIES DATA

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ABSTRACT: Coastal areas provide multiple ecosystem services of environmental, economic, and social value, which encourage population growth and development, thus causing rapid changes in the coastal area. These changes can be seen in land use and land cover (LULC) in recent years, as a result of human activities. Therefore, coastal areas are most vulnerable to LULC changes. LULC changes are considered to be an important signal of regional environmental changes. Recently, the utilization of remote sensing technology is effective for periodic assessment of the coastal LULC changes, especially for *PlanetScope* imagery data. *PlanetScope* data with high temporal resolution provides great advantages for acquiring high-quality images with 3-meter spatial resolution. This study aims to map and assess the LULC changes in the coastal area of Jembrana Regency, Bali Province, Indonesia within the past six years from 2016 to 2022 using *PlanetScope* imagery data. Monitoring periods to observe LULC changes was divided into three time periods: Period I (2016-2018), Period II (2018-2020), and Period III (2020-2022). Supervised classification was made to produce LULC classified map. The results show that the LULC of Jembrana Regency has changed significantly over the study period. This study provides up-to-date quantitative and descriptive information on the LULC map, for better understanding on how the coast changes over time to help decision-makers and related stakeholders to develop efficient management strategies for coastal resources.

1. INTRODUCTION

Coastal areas are dynamic geographical features, constantly changing as the atmosphere, land and ocean interact in various ways (Nicholls et al., 2007). These areas are important because a majority of the world's population inhabits such areas. Coastal areas contribute to socioeconomic growth due to their productive potential of its resources, such as soil, water and landscape, which gave chances for development of economic activities like fishing, industry, tourism, and transportation (Abdrabo, 2008; Dronkers & Stojanovic, 2016). However, those activities often come with a wide range of negative impacts on the environment.

This study will analyze the change in land use and land cover (LULC) to determine how human activities influence the changes in the coastal area. Changes in LULC are emerging as critical components of global social, economic, and environmental changes. In addition, the LULC pattern is described as a dynamic process (Mondal et al., 2016). Land use and land cover are fundamentally different (Nedd et al., 2021). Land use refers to human activities which are carried out on the land (Roy & Giriraj, 2008), intending to use and utilize the land and resources to obtain products and/or benefits (Lindgren, 1985; Vink, 1975). Meanwhile, land cover is the biophysical and natural material on the ground surface (Herold et al., 2007; Veeraswamy et al., 2017).

Collecting LULC data can be effective and efficient by using remote sensing technology. The detail of LULC information using remote sensing was obtained by spatial resolution which is owned by the remote sensing image. Satellite imagery data can cover large geographic extents and have high temporal coverage. Additionally, remote sensing can provide data in inaccessible areas and is also used to investigate historical LULC. Several existing studies showed the ability of satellite remote sensing technology in image classification and processing techniques to detect LULC at regional, national, and global levels (Jun et al., 2014; Leinenkugel et al., 2019).

A vast fleet of Doves, small satellites powered by the *PlanetScope* sensor, was launched by the commercial company Planet. *PlanetScope* sensors are low-earth sun-synchronous orbits with near-daily global coverage. They collect 12-bit radiometric resolution red, green, blue and NIR images with 3–5 meters of spatial resolution, depending on the satellite orbit altitude and the data are distributed to 3 meters as 16-bit GeoTIFF images. The images are defined in the Universal

Transverse Mercator (UTM) projection and have reported the location accuracy of orthorectified data products with a root mean square (RMSE) of less than 10 meters (Planet.com, 2022).

This study utilized *PlanetScope* imagery data integrated with the Geographic Information System (GIS) to assess the LULC change over 6 years in the coastal zone of Jembrana Regency, Bali Province from 2016 to 2022. It is important to investigate the LULC change to understand environmental change. This data is a fundamental component of the planning and decision-making processes for coastal communities and related stakeholders because it helps to understand the basis of the development of sustainable communities and ecological activities.

2. METHODS

2.1 Study Area

This study was conducted on the coastal village in Jembrana Regency, Bali Province, Indonesia (Figure 1). Astronomically located at 08°09’58” – 08°28’02”S and 114°26’28” – 115°51’28”E with a total area of 841,80 km^2. With the population of around 322,000 people, the majority of whom lives in coastal areas. A wet climate is experienced from October to March and a dry climate between April and September. Climatologically, this area is divided into two patterns, a wet climate (October to March) and a dry climate (April to September). The temperature remains steady throughout the year, with only slight decreases during the dry season, with minimum temperature ranges of 19–24°C and maximum temperature is 30–34°C. Monthly precipitation ranges from 200–500 mm in the wet season and less than 150 mm in the dry season (Badan Pusat Statistik - Statistics of Bali Province., 2022). Jembrana Regency has a coastline of approximately 76 km and is characterized by a low-lying landscape with an elevation of less than 10 m above mean sea level. The coastal village (*desa*) of Jembrana Regency is located in five districts (*kecamatan*), i.e., 5 villages in Melaya District, 5 villages in Negara District, 3 villages in Jembrana District, 5 villages in Mendoyo District and 6 villages in Pekutatan District.

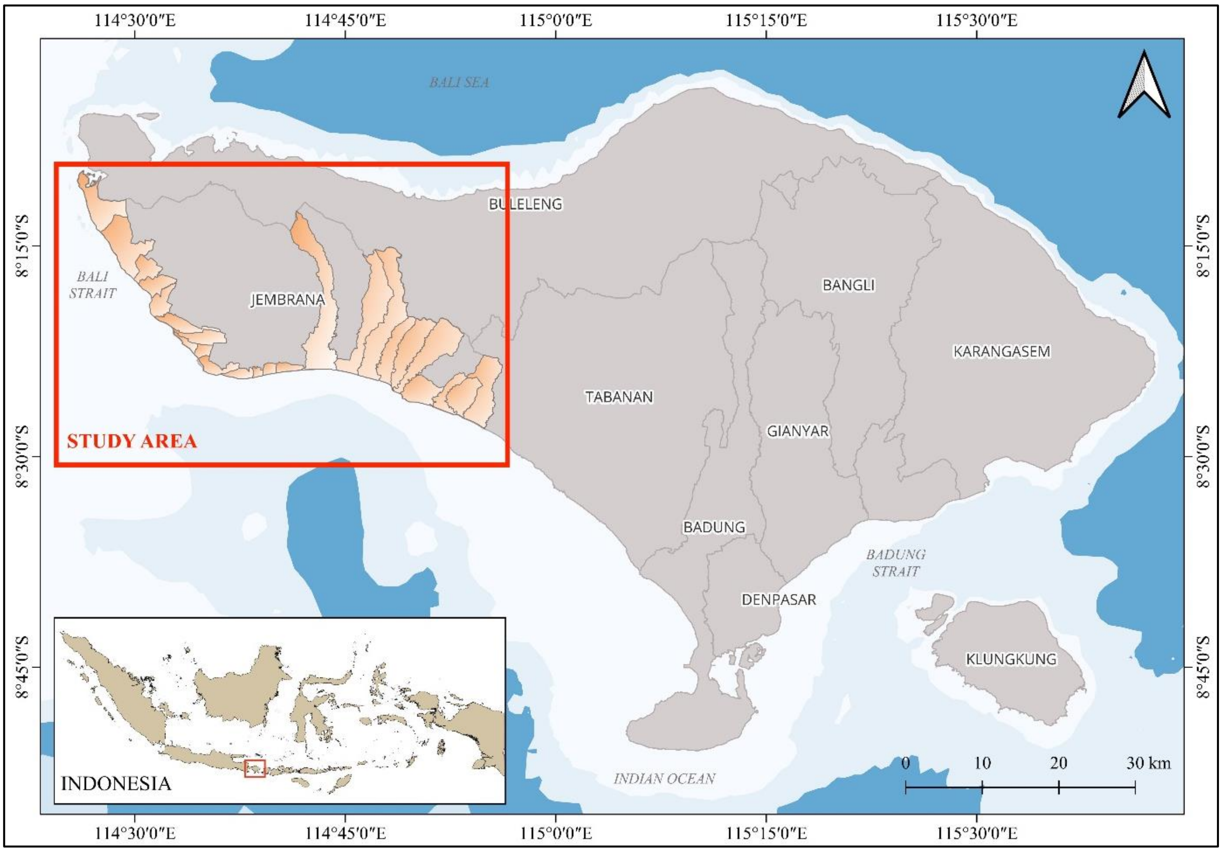


Figure 1. Study area.

In this study, the coastal zone was buffered to 500 m inland from the shoreline (Fig. 2). These buffer zones were chosen considering the regulations, i.e., Presidential Regulation No 51 of 2016 concerning Coastal Boundaries and Regulation of the Minister of Marine Affairs and Fisheries No 21 of 2018 concerning Procedure for Calculation of Coastal Boundaries.

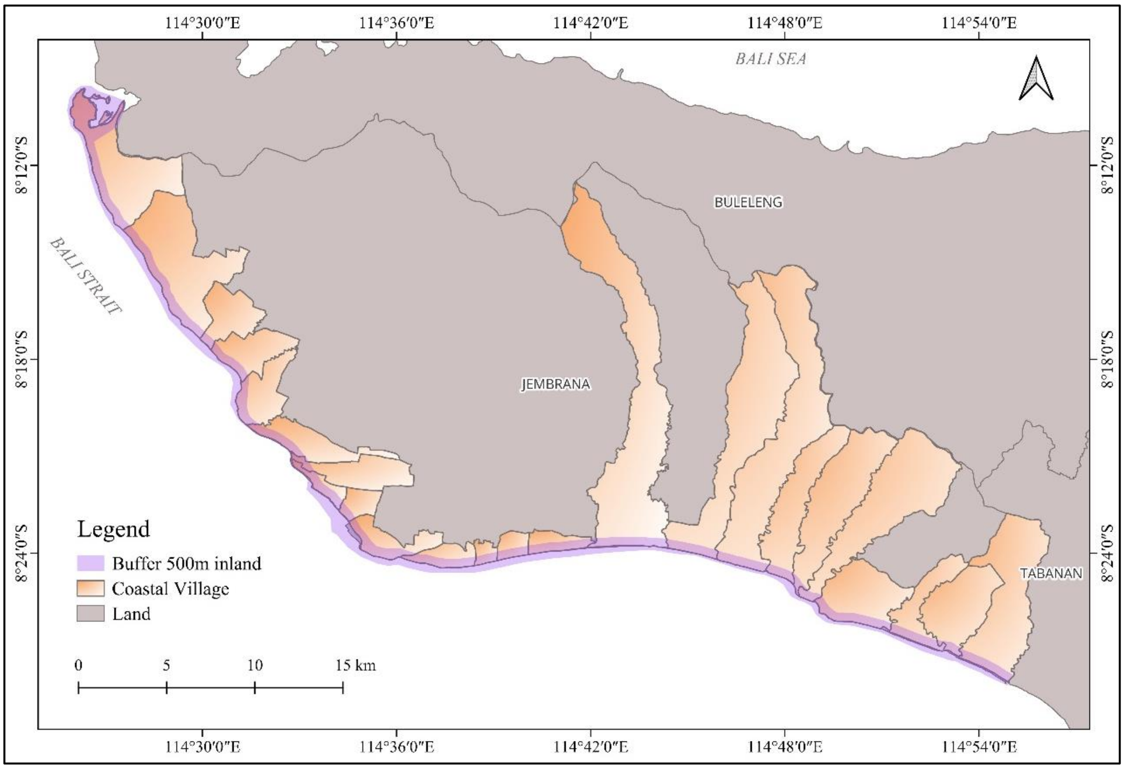


Figure 2. The coastal boundary along Jembrana Regency that used as the area of interest.

2.2 Datasets and Research Framework

Multitemporal satellite image data is needed to monitor and analyse the LULC change. Image data acquired in 2016, 2018, 2020, and 2022 were obtained from *PlanetScope* (https://www.planet.com/explorer/) which consists of four spectral bands in Level 3B. These bands are radiometrically and atmospherically corrected to surface reflectance. Additionally, *PlanetScope* data are geolocated and orthorectified using digital elevation models (DEMs) and ground control points (GCPs). All images were processed (mosaic, reprojection to WGS84/UTM zone 50S, and clipping) using QGIS 3.16. The images were classified using the supervised classification (maximum likelihood) method and delineated into five LULC categories, i.e., water bodies, vegetation/flooded vegetation, agricultural land, built-up areas, and bare ground based on the LULC Classification taxonomy adopted by (Brown et al., 2022).

2.3 LULC Change Detection

The LULC change was estimated using three independent classification results from *PlanetScope* 2016, 2018, 2020 and 2022. The change estimation technique is used to determine the change of LULC from one time period to another and quantifies the different rates and magnitudes of change. The equation to calculate the annual change of LULC is given below:

$$\Delta = \frac{A2 - A1}{A1 \times (T2 - T1)} \times 100 \quad (1)$$

where: Δ = average annual change rate (%)

A1 = total area (ha) of land use type in time 1 (T1)

A2 = total area (ha) of land use type in time 2 (T2)

3. RESULT AND DISCUSSION

The LULC Maps of 2016–2022 are given in Fig. 3. These maps represent the distribution of the five classes taken for the study in the year 2016 to 2022, thus displaying the magnitude of change for each class and the location thereof.

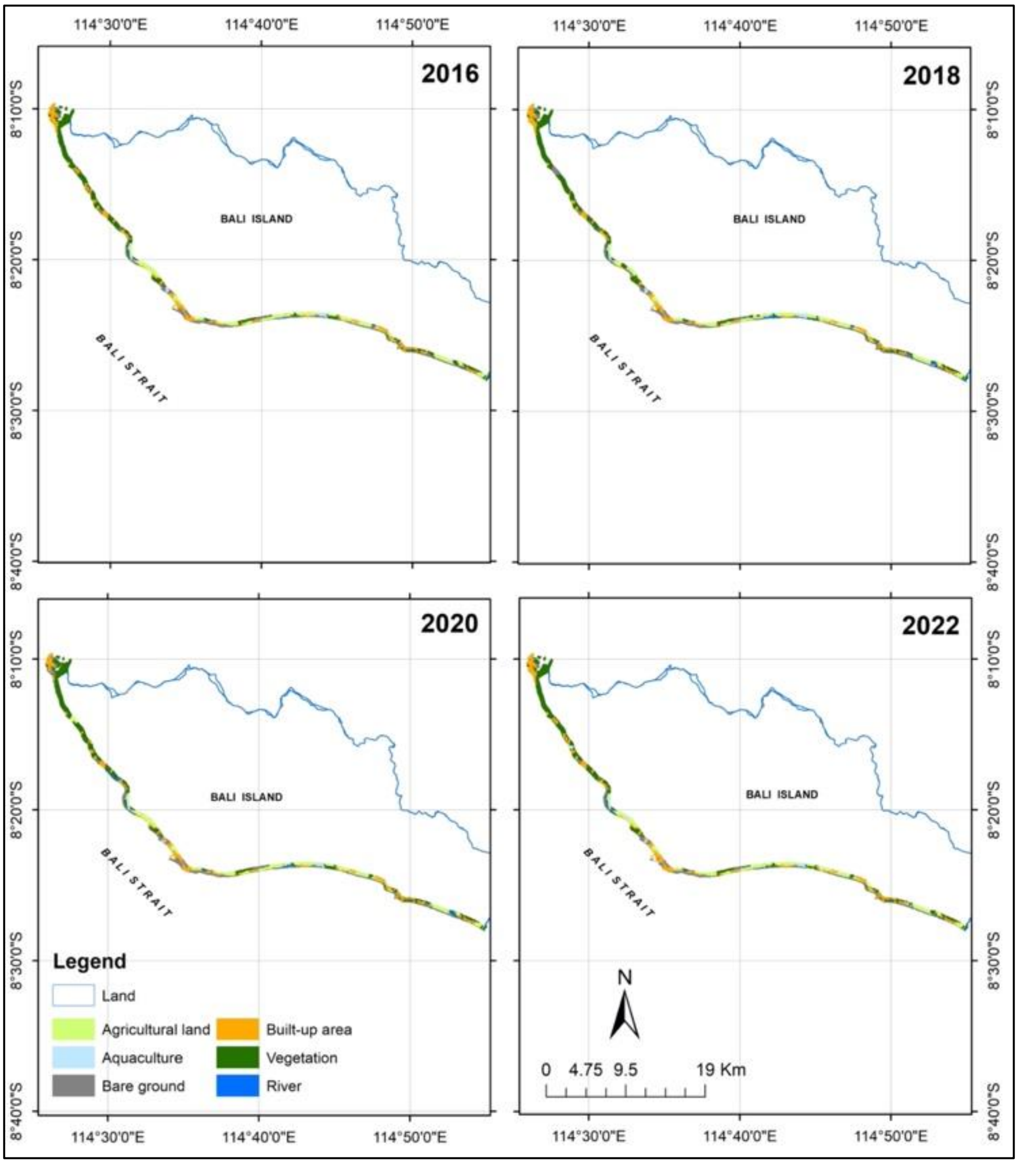
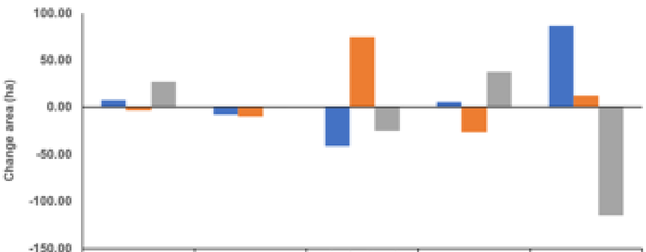


Figure 3. LULC change at Jembrana Regency between 2016–2022.

Monitoring of LULC change shows that ponds and built-up areas significantly increase over time, while vegetation, agricultural land, and bare ground tend to decrease. The expansion of the pond area was initiated by the development program for the aquaculture sector through the millennial fishpond program and public housing program in 2020. The trends of LULC changes in Jembrana regency during 2016–2022 are presented in Figure 4.



	Ponds	Vegetation	Agricultural land	Built-up area	Bare ground
2016-2018	7.90	-7.64	-41.64	5.39	86.29
2018-2020	-3.70	-10.12	74.86	-26.35	12.40
2020-2022	27.08	-0.30	-24.96	37.61	-114.90

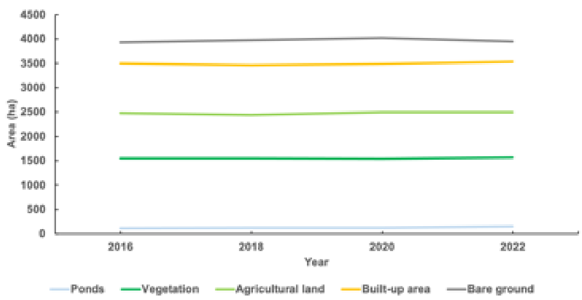


Figure 4. LULC change graph and trend from 2016 to 2022 at Jembrana Regency.

Based on the LULC changes analysis, it was found that the study areas were mainly dominated by the expansion of the ponds area with a rate of change of 27.08 ha (22.21%) during 2020–2022 and the increase of built-up area with 37.61 ha

(3.78%) in the same period. The changes were mainly located in the area of the central and local government work programs which aims to provide public housing and increase aquaculture production.

The change in coverage of built-up area was 5.39 ha (0.53%) in 2016–2018 and a decrease of 26.35 ha (2.58%) is seen in the period 2018–2020. Vegetation areas showed a decreasing trend from 2016–2018, 2018–2020, and 2020–2022 with a rate of change of 7.64 ha (0.53%), 10.12 ha (0.71%), and 0.30 ha (0.02%) respectively.

The agricultural land showed significant decrease in the period of 2016–2018 and 2020–2022 with 41.64 ha (4.50%) and 24.96 ha (2.60%) respectively, due to the conversion of agricultural land into the residential area. Meanwhile, an increase of 74.86 ha (8.47%) is seen in the second period (2018–2020) due to the conversion of forest vegetation and bare ground into agricultural land.

The bare ground area also decreases significantly with 114.90 ha (21.50%) during 2020–2022 but increases to 86.29 ha (19.81%) in 2016–2018 and 12.40 ha (2.38%) in 2018–2020. The changes in the bare ground area are due to the changes of sediment deposition in the river mouth. Furthermore, the reduction of bare ground is caused by the construction activities of Jembrana Marine and Fisheries Education Campus (Politeknik Kelautan dan Perikanan Jembrana) in depositional land near the Pengambengan Port since 2019 and the installation of millennial fishpond that uses seawater for aquaculture activities.

The findings about LULC change and trend during the study period indicate that the general change in the area is dominated by the expansion of built-up areas for housing activities, the expansion of ponds and construction of canning factory for economic activities, and the construction of educational facilities, all of which reduce the vegetation, agricultural land, and bare ground areas.

Information on LULC changes is important for coastal zone spatial planning since it reflects the level of pressure caused by human activities. In addition, Jembrana Regency is also vulnerable to natural disasters such as erosion which affected the loss of coastal areas. The impact of coastal erosion in Jembrana regency has destroyed the sandy beaches and has begun to devour the surrounding private properties, houses and agricultural land.

4. CONCLUSION

The trend of LULC change showed that the ponds and built-up areas were constantly developing. LULC change analysis is an important phase in scenario development since it provides information about the trends, implications, and identifies the driving factors of changes. The high-resolution LULC map obtained in this study will help decision-makers and related stakeholders to develop efficient management strategies for coastal resources.

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