Land use analysis of coastal belt in the coastal area of Langkat Regency North Sumatra Province using Sentinel 2 Satellite imagery

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Abstract. Population growth increases pressure on land resources and leads to the use of the land that contravenes its allocation. The coastal area of Langkat Regency is an area with high levels of pressure on land. The aimed of this study was to evaluate the use of the coastal belt and river belt in six districts of Langkat Regency North Sumatra Province using Sentinel 2 Imagery. The results of the accuracy test of the land cover classification showed good results with the overall accuracy was 99.56%, and kappa accuracy was 99.18%. We found that land use in this area dominated by oil palm plantations which reached 33,400.31 hectares. Coastal belt with a distance of 0-100 meters dominated by mangrove vegetation with an area of 386 hectares or 38.14% of the total Coastal belt area. Fishponds dominated the land use on the river belt area at a distance of 0-50 meters with an area of 1,217 hectares or 64.73%. We found that land use that contravenes to its function on the coastal belt was mainly for oil palm, fish ponds, and rice fields. It is necessary to rehabilitate the land determined by the government as a forest area to maintain the area's protection function.

1. Introduction

Indonesia is an archipelago country with a total of 13,466 islands and 80.7791 km of coastline. This condition is both an advantage and a challenge for the management of coastal areas in Indonesia. Coastal areas facilitate certain activities such as fishing, industry, tourism, and transportation to support population concentration. Coastal areas experience a very high pressure of land change along with the increasing population and socio-economic development.

Langkat Regency is one of the Regency in North Sumatra Province with a large coastal area. Langkat Regency also has a high population density of 200-479 people per km² [1]. The high population density in the coastal area of Langkat Regency triggers the conversion of forest areas to other uses. Changes in land use and land cover were responsible for decreasing ecosystem service value by 24.04% [2]. The loss of the service ecosystem also results in the deterioration of the quality of the environment and a decrease in the income of the people who depend on the forest and fisheries for their livelihoods.

The failure of coastal area management is caused by unsustainable regulations, improper funding and lack of law enforcement. Sustainable development policies must overcome the effects of loss of...
semi-natural and natural land due to drastic urbanisation [3]. Information on changes in land cover and land use is essential for appropriate coastal management planning. Remote sensing utilisation in developing countries is beneficial in facilitating the development of coastal management strategies. The dynamics of the factors that encourage changes in land cover in coastal areas can be done by utilising multi-year satellite imagery [4]. This study aimed to identify the type of land cover and evaluate the land use of the coastal belt and river belt area in the coastal area of Langkat Regency. The results of this study could help better manage the coastal area of Langkat Regency.

2. Materials and methods
The research was carried out in the Coastal Area, Langkat Regency with six districts namely Babalan, West Berandan, Gebang, Pangkalan Susu, Secanggang and Tanjung Pura. The study was conducted during April-May 2018.

2.1. Tools and materials
The tools used for field data collection were GPS (Global Positioning System), compass, and digital cameras. Image analysis using personal computers, digital cameras, ArcGIS 10.5 software, and ESA SNAP software. The material used in this research was Sentinel 2 satellite imagery, Langkat Regency administration map, the map of forest area from the Ministry of Environment and Forestry. Sentinel-2 satellite imagery used to classify land cover was recorded in May 2018 and obtained freely from www.scihub.copernicus.eu.

2.2. Methods
Ground check data were obtained from direct observation in the field. The survey documented the existing land cover and marked the position of the ground control point (GCP) in the field. All bands of Sentinel-2 imagery were selected and composited together to create a composite image. The composite image was processed using ArcGIS 10.5 software. ArcGIS 10.5 software was used to delineate the image composite by research location boundary.

Supervised Classification method was conducted to classify the land cover class. Area of interest (AOI) found from GPS point from the field survey was used as a reference. The maximum likelihood method was used to separate the land cover classes. Evaluation of the training areas separability for each class was conducted using transformed divergence method. The separability result was classified into five classes [5] as presented in table 1.

| No | Class    | Separability value |
|----|----------|--------------------|
| 1  | Inseparable | < 1600             |
| 2  | Poor     | 1600 - < 1800      |
| 3  | Fair     | 1800 - < 1900      |
| 4  | Good     | 1900 - < 2000      |
| 5  | Excellent | 2000               |

Contingency matrix or confusion matrix of the training area was used to analyse the accuracy of land cover classification. We used four accuracy analyses showing the performance of the classification namely the producer’s accuracy, user accuracy, overall accuracy [6, 7] and kappa accuracy [8].

3. Results and Discussion

3.1. Characteristics of land cover
Field observations aimed to get the actual type of land cover. A total of 336 coordinates of land cover in the field obtained eleven types of land cover in the field consisting of water bodies, forest, mixed gardens, open area, dryland agriculture, mangroves, settlements, rice fields, shrubs, oil palm, and
The results of the separability analysis of all types of closed classes showed that all classes had excellent separations to perfection. The smallest separability value was between palm land cover and plantation forest with a separability value of 1971.65. Results test accuracy of the maximum likelihood method for fourteen land use classes showed satisfactory results. The lowest producer accuracy was obtained for the rice field cover class at 89.34%. The lowest accuracy of user accuracy was 84.50%, obtained for mixed garden land cover class. The overall accuracy and kappa accuracies were 99.56% and 99.18% respectively. Kappa accuracy used all elements in the matrix. The accuracy value provides relatively high accuracy of more than 85% so that the results of the classification can be used to mapping the land cover in the coastal areas of Langkat Regency. The supervised classification in this study used the maximum likelihood method because it considers the opportunity factor of one-pixel to be classified into a particular class or category. Figure 2 shows the land cover map of six sub-regency of Langkat Regency.

The results of the land cover classification showed the most significant percentage of area in six districts of Langkat Regency dominated by oil palm plantations (28.02%) and the lowest percentage area was dryland agriculture (0.18%). The large area of oil palm caused by people's perception that oil palm was more economically promising. Globally, the need for oil palm will continue to increase in response to population growth [9]. The loss of mangroves can cause loss of protection to coastal communities from tsunamis, sea level rise, seawater intrusion and abrasion [10].
Figure 2. Land cover map of the coastal area of six sub-regency of Langkat Regency.

According to SK. 579 / Menhut-II / 2014 protected forest area has an area of ± 1,206,881 ha and part of it is mangrove forest in the Coastal Regency of Langkat. The converted mangrove area in Langkat Regency has a significant area. The common mangrove conversion is to become oil palm plantations and fishponds. Conversion of mangrove forests to oil palm and fishponds resulted in degradation of coastal areas such as abrasion.

Multiple factors shape the rate and direction of forest conversion to oil palm in Indonesia. The economic reason is the primary factor conversion forest to oil palm [11]. The revenue from oil palm plantation is potentially high relative to other activities [12].

The results of the land cover classification on the coastal border as far as 1000 meters towards the land found ten types of land cover namely water bodies, forests, mixed gardens, oil palm, rice fields, open area, shrubs, dryland agriculture, mangroves, and settlements (figure 3). The detail of each land cover at the coastal border at a distance of 100, 500 and 1000 meters presented in table 2. Land cover at a distance of 0-100 meters from the shoreline is a coastal border area intended for coastal safeguards and preservation. By the Ministry of Maritime Affairs and Fisheries Decree No.10 of 2000 concerning Management, the coastal abutment area serves to prevent coastal abrasion and protect beaches from activities that can disrupt or damage the function and preservation of the coastal areas. Coastal border areas are only permitted for plants that function as protection and safety of the coast. Reports on the conversion activities of mangrove forests in Langkat Regency started since 2009 and in 2013 the prosecutors' demands were read out in court against encroachment companies. We found activities rehabilitated the fishponds and oil palm plantations into mangroves in Lubuk Kertang Village, West Brandan District, Langkat Regency.
Mangroves dominated land cover with an area of 386 ha or 3.14% at a distance of 0-100 meters, 1,497 ha or 35.87% at a distance of 100-500 meters while 1,426 ha or 29.08% was at a distance of 500-1000 meters (table 1). Given the essential function of mangroves, this area is still small, so vast improvement through rehabilitation is needed. We found the actual land use that contravened to the function of the area. Fishpond had an area of 279 ha or 27.56% of the total coastal area. Factors that make many ponds are located on the coast because ponds can affect the economy of the community. With the existence of the community, ponds can cultivate fish, shrimp, and crabs so that many people convert mangroves to ponds. The conversion of vast mangroves into ponds can result in a decrease of fisheries production in the surrounding waters. This aquaculture is also suspected to affect the productivity of the estuary waters and the surrounding sea.
The existence of mangrove forests is also crucial for agriculture along the coast, primarily as a protector of wind, high tide, and storm and also for mangrove tourism area. The area of settlement at a distance of 0-100 meters from the coastal border was 256 ha or 25.29% (table 2). It will affect the condition of settlements in coastal areas such as floods and will even affect tsunami. Especially if the settlement directly meets the sea. Some efforts needed in maintaining the coastal area ecosystem are by rehabilitating the converted mangrove into oil palm.

### Table 3. The land cover area in river belt of Langkat Regency.

| Distance (m) | Forest | Mixed garden | Open area | Dryland agriculture | Mangrove | Settlement | Rice field | Oil Palm | Shrub | Fishpond | Total |
|--------------|--------|--------------|-----------|---------------------|----------|------------|------------|---------|-------|----------|-------|
| 0-50         | 38     | 26           | 0         | 1                   | 144      | 361        | 0          | 69      | 24    | 1217     | 1880  |
| 50-100       | 128    | 43           | 1         | 3                   | 569      | 388        | 3          | 349     | 32    | 363      | 1879  |
| Total        | 166    | 69           | 1         | 4                   | 713      | 749        | 3          | 418     | 56    | 1580     | 3759  |

Land use in the river basin area of Langkat Regency with a distance of 0-50 meters dominated by fishpond with an area of 1,217 ha or 64.73% (table 3). Settlements on the river border with a distance of 50-100 meters reached an area of 388 ha or 20.64%. Settlements on the river border with a distance of 50-100 meters had an area of 388 ha or 20.64%. Increased vulnerability of the coastal areas occurred because of the large number of land conversion functions in the area from mangroves to oil palm, tourism areas and agricultural land.

### 4. Conclusion

Sentinel 2 satellite imagery could provide good land cover classification results with high accuracy values. Land use was found in the coastal belt and river belt area which contravened to its function because of the conversion of mangroves into ponds and oil palm.

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