Detection of Land Use Changes in Batam Island Coastal Using Remote Sensing

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Abstract. Batam is one of the fastest growing cities in Indonesia that has resulted in increasing demand for industrial, commercial and residential areas. However, due to limited land supply there is a process of transferring existing land functions. By detecting changes in land use, we can find out how much land use changes are influenced by social, economic and industrial in Batam Island. This research was conducted on the detection of land use change using Remote Sensing multi-temporal or differentiated image of the year with a supervised Classification Technique to obtain Land use information and changes in Batam Island, area percentage of land use change from 2010 and 2016 in Batam Island, determining the relationship of land use change to conditions in the industry sector presented in to the maps. The calculation result of classification accuracy test obtained total overall accuracy of 88% where the classification results can be said true and almost in accordance with the field. The relationship between land use classification change with industrial condition on the Non-Agricultural area I can be said to related with the number of companies and the labors number on the data of labor changes from Central Bureau of Statistic/Badan Pusat Statistik (BPS) 2010-2014 with the assumption of changing function and the many needs of various land uses sector except agriculture, the Non-Agriculture Area II can be said to be related with the number of companies and the number of labors in the data of labor changes BPS 2010-2014 with the assumption of changing function and the many land use needs of various sectors except agriculture, increased farming can be said to be related with the number of agriculture companies that also increases in data of labor changes BPS 2010-2014, the area of the Areas without Vegetation Coverage Class increased can be said to have influence with the number increased of companies and the number of manpower on the data labor changes BPS 2010-2014 with the assumption that there are many land use needs of various sectors except agriculture.

1. Introduction
The Batam City is a very strategic island because it is located in international shipping lanes and directly adjacent to the state of Singapore and Malaysia, this cause Batam including one of the fastest growing cities in Indonesia which requires land as an industrial, commercial and residential area. However, due to limited land supply there is a process of transferring existing land functions. According to Supriharyono (2007) coastal area is a meeting area between the land and sea where the coastal and area includes both dry and submerged in water which is still influenced by ocean properties such as tides, sea breezes, and salt water permeation. While the coastal seas cover the sea that is still influenced by natural processes that occur on land such as sedimentation and fresh water.
flow, or caused by human activities on land such as deforestation, land use change and pollution. From this understanding it can be seen that all sub-districts in Batam Island in the coastal region.

Detection of change is the process of identifying objects or phenomena by observing at different times (Singh, 1989). Land use change is change of land use that differs from previous utilization, whether for social, economic, cultural, or industrial purposes. Physical resources of a region such as soil, climate, topography, and geology determine the potential of a region for various types of use (Hardjowigeno and Widiatmaka, 2001). By detecting land changes, we can find out how much land use change is influenced by social, economic and industrial in Batam Island.

According to Lillesand and Kiefer (1994) remote sensing is the science and art to obtain information about an object, region or phenomenon through the analysis of data obtained by a device without direct contact with the object, area or phenomenon studied. Remote Sensing data collection can be done in various forms according to the power used can be a variety of power distribution, sound wave distribution or electromagnetic energy distribution (Purwadhi, 2001). This research is done by detection of land use change by Remote Sensing Technique of multi temporal image or different year so that detection of land use change area done more efficient and precise. Remote sensing imagery used in this research is Landsat 7 & 8 image that has a spatial resolution of 30 meters (Roziqin, A., & Gustin O., 2017; Gustin, O., Sukojo, B.M., & Handayani, H.H., 2013), this image is believed to be able to accommodate land use information.

2. Methods

2.1. Research Areas

Geographically Batam Island is located at the position 002°29' - 101°00' North Latitude and 103°34' - 104°02' East Longitude with an area of 41,500 hectares and is bordered by (Batum City Government, 2015):

a. North: Singapore Strait
b. South: Senayang District
c. West: Karimun District and Moro
   Karimun District
d. East: North Bintan District

The research location was conducted in the coast of Batam Island by taking data based on field accuracy test. Figure 1 below shows the research location in the coast of Batam.

![Figure 1. Research location in the coast of Batam](image)

2.2. Materials and Research Tools

2.2.1. Materials

The data used in this research consisted of primary and secondary data.
a. Primary data: coordinate point, identification and field location photo around Batam Island for accuracy/validation test
b. Secondary data: Landsat Satellite Imagery in 2010 & 2016, Batam City Administration Map, Local Statistics of Batam City

2.2.2. Tools
The tool used in this research are:
a. Hardware: Laptop, GPS Navigation, Printer, and stationery.
b. Software: OS Windows 7, Microsoft Office 2007, ENVI 4.6, and ArcGIS 10.1

2.3. Stage of Research Activities
Generally phases of the research presented in flow diagram Figure 2 below:

![Research Flowchart](image)

**Figure 2.** Research Flowchart

2.3.1. Preparation
In preparation to collect data of Batam City Administration Map, Citra Landsat of 2010 & 2016, and Local Statistics Data of Batam City

2.3.2. Geometric Correction
Geometric correction is performed between the Landsat image and the Batam City Administration Map for the Landsat image to correspond with the actual coordinates.
2.3.3. Classification
In this process, the supervised classification method for image of 2010 & 2016 is used to be 5 classes, such as: Agricultural Area, Non Agricultural Area I, Non-Agricultural Area II, Area without Vegetation Coverage, and Water Body (Malingreau, 1978).

2.3.4. Accuracy Test
The accuracy test requires a field check data (Ground truth) that serves to test the results of image classification so that it matches the actual field conditions.

2.3.5. Analysis
The analysis conducted in this research is to find the social, economic and industrial relations derived from statistical data of BPS with the result of Land Use Change Classification.

2.3.6. Mapping
Presentation/depiction process the results of Land Classification 2010 an 2016 using ArcGIS software.

3. Result and Discussion

3.1. Geometric Correction
In this research has been done geometric correction Citra Landsat with Map Administration of Batam City to Landsat Image in accordance with the actual coordinates with the value of Root Mean Square Error (RMSE) is 0.32123 pixels as in Figure 3 below.
3.2. **Accuracy Test**

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**Table 1.** Accuracy Test

| Data of Classification | Field Check Data (GroundTruth) | Total Column |
|------------------------|-------------------------------|--------------|
|                        | Agricultural Areas | Non-Agricultural Areas | Non-Agricultural Areas I | Non-Agricultural Areas II | Areas without vegetation | Coverage | Water Body |
| Agriculture Areas      | 5                | -                | -                | -                | 5           |          |           |
| Non-Agricultural Areas | -                | 4                | 3                | -                | -           | 7        |           |
| Non-Agricultural Areas I | -                  |                |                     |                   | -           |          |           |

From Table 1, calculated overall test accuracy and producer accuracy as follows:

a. Overall Accuracy = \(\frac{39}{44} \times 100\% = 88\%\)

b. Producer Accuracy:
Agricultural Areas = 5/1 x 100% = 100%
Non-Agricultural Areas I = 2/6 x 100% = 33%
Non-Agricultural Areas II = 4/4 x 100% = 100%
Areas without Vegetation Coverage = 19/22 x 100% = 86%
Water Body = 6/8 x 100% = 75%
c. User Accuracy:
Agricultural Areas = 5/5 x 100% = 100%
Non-Agricultural Areas I = 5/5 x 100% = 100%
Non-Agricultural Areas II = 4/7 x 100% = 57%
Areas without Vegetation Coverage = 19/21 x 100% = 90%
Water Body = 6/6 x 100% = 100%
The overall accuracy calculation result of the results obtained image accuracy from survey results in the field by 88%. The results of the accuracy obtained meet the standard of accuracy level by 85% (Affan, dkk., 2010), so 88% is said to fit the results of accuracy on image with the results in the field.

3.3. Classification Results

Figure 4. Land Use Classification Map Batam City 2010

Classification and mapping result of Land Use Classification Batam City 2010 as in figure 4 with area for each class that is:
- Non-Agricultural Area I is 490,876,200 m2
- Non-Agricultural Area II is 567,982,800 m2
- Agricultural Area is 153,652,500 m2
- Water Body is 4,823,643 m2
• Area without Vegetation Coverage is 147,255,300 m²

3.4. Change of Land Use Classification 2010-2016
From the results of image classification in 2010 and 2016, there are several classification differences as follows:
• Non-Agricultural Area I is reduced by 207,884,700 m²
• Non-Agricultural Area II is reduced by 546,651,900 m²
• Agricultural Area increased by 94,380,300 m²
• Water Body increased by 248,982 m²
• Area without Vegetation Coverage increased by 809,515,000 m²

3.5. Data of Labor BPS
Table 2. Number of Companies and Labor for each field in 2010

| No | Sector                        | Number of Company | Number of Labor |
|----|-------------------------------|-------------------|-----------------|
| 1  | Agriculture                   | 41                | 2,623           |
| 2  | Mining                        | 24                | 438             |
| 3  | Industry                      | 1,689             | 170,118         |
| 4  | Electricity, Gas, & Water     | 14                | 735             |
|    | Supply                        |                   |                 |
| 5  | Construction                  | 745               | 29,987          |
| 6  | Trade & Hotel                 | 930               | 23,201          |
| 7  | Transportation & Communication| 155               | 3,246           |
| 8  | Finance                       | 321               | 19,920          |
| 9  | Services                      | 432               | 39,158          |
|    | **TOTAL**                     | **4,351**         | **293,426**     |

The number of Companies and Labor of each sector in 2010 as in table 2 is obtained from the office of the Central Bureau of Statistics (BPS) with the largest number of companies in the field of Industry as much as 1,668 companies and the largest number of labors in the field of industry as many as 170,118 labors.

Table 3. Number of Companies and Labor for each field in 2014

| No | Sector                        | Number of Company | Number of Labor |
|----|-------------------------------|-------------------|-----------------|
| 1  | Agriculture                   | 46                | 2,547           |
| 2  | Mining                        | 32                | 801             |
| 3  | Industry                      | 2,082             | 187,132         |
| 4  | Electricity, Gas, & Water     | 19                | 1,101           |
|    | Supply                        |                   |                 |
| 5  | Construction                  | 841               | 38,091          |
| 6  | Trade & Hotel                 | 1,410             | 44,444          |
| 7  | Transportation & Communication| 195               | 4,633           |
| 8  | Finance                       | 506               | 24,867          |
The number of Companies and Labor of each sector in 2014 as in table 3 is obtained from the office of the Central Bureau of Statistics (BPS) with the largest number of companies in the field of Industry as much as 2,082 companies and the largest number of labors in the field of industry as many as 187,132 labors.

Table 4. Number of Companies and labor change for each sector in 2010-2014

| No | Sector | Number of Company | Number of Labor |
|----|--------|------------------|----------------|
| 1  | Agriculture | 5 | -76 |
| 2  | Mining | 8 | 363 |
| 3  | Industry | 393 | 17,014 |
| 4  | Electricity, Gas, & Water Supply | 5 | 366 |
| 5  | Construction | 96 | 8,104 |
| 6  | Trade & Hotel | 480 | 21,243 |
| 7  | Transportation & Communication | 40 | 1,387 |
| 8  | Finance | 185 | 4,947 |
| 9  | Services | 446 | 13,791 |

Number of companies and labor change for each sector in 2010-2014 as in table 4 is obtained from the office of the Central Bureau of Statistics (BPS) with the largest change in the number of companies on Trade & Hotel sector is increased by 480 companies and the largest number of labor on Trade & Hotel Sector is 21,243 labor.

4. Conclusions and Suggestion

4.1. Conclusion
From the results of this research obtained conclusions i.e.
   a. Accuracy calculation of classification obtained
      • total overall accuracy 88% where the classification results can be said to be true and almost in accordance with the field
      • producer accuracy:
          • Agricultural Areas = 100%
          • Non-Agricultural Areas I = 33%
          • Non-Agricultural Areas II = 100%
          • Areas without Vegetation Coverage = 86%
          • Water Body = 75%
- user accuracy:
  - Agricultural Areas = 100%
  - Non-Agricultural Areas I = 100%
  - Non-Agricultural Areas II = 57%
  - Areas without Vegetation Coverage = 90%
  - Water Body = 100%

On the accuracy of producers from the five regions of the class only Non-Agricultural Areas I with an accuracy of 33% due to lack of data collection in the field.

b. From the changes of land use classification results in 2010 and 2016, it is known:
   - The largest decreasing classification is the classification of Non-Agricultural Areas II of 546,651,900 m² where in 2010 it has an area of 567,982,800 m² while in 2016 it is 21,330,900 m².
   - The largest increasing classification is the classification is the Classification Area without Vegetation Coverage of 809,515,000 m² where in 2010 it has an area of 147,255,300 m² while in 2016 it is 956,770,300 m².

c. The relationship between land use classification changes with industrial conditions:
   - The area of the Non-Agricultural Area Class I including dryland, wetland, bushes, grasslands, savannas, grasslands, reduced swamp grass can be said to be related to the number of companies and the number of labor on data labor changes BPS 2010-2014 with the assumption of changing function and the many needs of land use in various sectors except agriculture.
   - The area of the Non-Agricultural Area II Class including open land, lava and volcanic mudflow, coastal shelf, sandbanks, reduces sand dunes can be said to be related to the number of companies and the number of labor on data labor changes BPS 2010-2014 with the assumption of changing function and the many needs of land use in various sectors except agriculture.
   - The area of the Agricultural Area Class increases can be said to be related to the number of companies in the agriculture sector which also increase in the data of labor changes BPS 2010-2014.
   - The area of the Areas without Vegetation Coverage Class including settlement, industry, road network, electric network, airport, harbor increased can be said to be related to the increasing number of companies and the number of labor on data labor BPS 2010-2014 with the assumption of the need land use of various sectors except Agriculture.

4.2. Suggestion
Some text. From the results of this research can be suggested several things namely:
   a. This study can be developed by comparing several other additional parameters such as social and economic.
   b. For comparison the parameters can be compared with smaller administrative scopes such as each sub-districts.
   c. Furthermore, the results of the classification area of each sub-district can be made more complex analysis.

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