Land cover classification using Landsat 8 OLI in West Langsa Sub district, Langsa City

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Abstract. Land cover information is needed by various parties as a consideration in controlling land cover changes. The latest land cover information can be obtained using remote sensing techniques in the form of image classification maps. This technique is very effective in monitoring land cover because of its ability to quickly, precisely, and easily provide spatial information on the earth's surface. The purpose of this study was to classify land cover in West Langsa Sub district, Langsa City using Landsat 8 OLI (Operational Land Imager) imagery. The classification method used in this study is the maximum likelihood classification (MLC) method. There are several considerations of various factors in the MLC method, including the probability of a pixel to be classified into a certain type or class. The results of Landsat 8 OLI image classification in West Langsa Sub district resulted in 6 land cover classes, namely mangrove forests, settlements, rice fields, shrubs, ponds and bodies of water. The largest land cover class is ponds with an area of 1981.54 ha (38.71%) and the smallest land cover is rice fields with an area of 115.58 ha (2.26%) of the total land cover class. Classification accuracy is indicated by the overall accuracy and kappa accuracy of 91.15% and 82.75%, respectively. These results meet the requirements set by the USGS (Overall Accuracy > 85%) and indicate that the Landsat 8 OLI image classification map can be used for various purposes.

1. Introduction
Land cover is a biophysical appearance on the earth's surface consisting of built up land, vegetation area, open land, wetlands and water bodies [1]. Land cover can provide very important information for modeling purposes and for understanding natural phenomena that occur on the earth's surface [2]. Land cover information is needed in a developing area to find out the current land cover in that area. Accurate land cover information is one of the determining factors in improving the performance of ecosystem, hydrological, and atmospheric models [3].

Land cover is very important information in various sectors. Up-to-date land cover information can be obtained using remote sensing techniques. Remote sensing is an important tool in land cover monitoring because of its fast, precise, and easy ability to provide spatial information on the earth's surface [4]. An important factor of remote sensing in the success of land cover classification is the data source [5]. Landsat satellite data are generally used for land cover classification in remote sensing [6]. Remotely sensed data has become the main source of land cover information collection for the last four decades [7].
One of the areas experiencing rapid regional growth is Langsa City. Langsa City has a mangrove forest that is quite extensive but continues to decrease as a result of population growth, changes in land cover from vegetated will cause a decrease in environmental quality. Mangrove forest land cover in West Langsa Sub district between 1990 and 2000 decreased in area of 160.82 ha because mangroves are one of the sources of income for people in West Langsa Sub district which are processed into charcoal, ponds also experienced a decrease in area of 178.97 ha [8].

Information on current land cover can be used as a guide or direction for good and integrated urban planning and development. The availability of data on land cover over a certain period of time is also very important in decision making. This study aims to classify land cover in West Langsa Sub district, Langsa City using Landsat 8 OLI imagery. The classification results obtained are the latest land cover map of West Langsa Sub district which can be used for various studies, especially to maintain the existence of mangroves in the area.

2. Materials and methods

2.1. Research area

West Langsa Sub district, Langsa City, Aceh Province, Indonesia is located at 4°28′13.69″ - 5°31′53.18″ NL and 97°53′48.91″ - 98°0′16.45″ EL (Figure 1). The land surface topography of West Langsa Sub district is relatively flat without hills with an elevation of about 0 – 8 masl [9]. West Langsa Sub district is an area that is mostly dominated by settlements and ponds. Some of its locations bordering the sea are ideal locations for aquaculture/ponds.

![Figure 1. West Langsa Sub district displayed in the natural colour/true colour of the Landsat 8 OLI image recorded on August 29, 2020.](image-url)
2.2. Data processing

Landsat 8 OLI images (path: 129/row: 57) for the study area were downloaded from the United States Geological Survey (USGS) website. To help interpretation the image, the Indonesian Earth Map (RBI) and the 2019 Land Cover map from the Ministry of Environment and Forestry of the Republic of Indonesia were used. The research was carried out in several stages, namely pre-processing of images, composite bands, visual interpretation of images, making class identifiers, image classification, and accuracy assessment.

Pre-processing is done by stacking the image (layer stack) and cutting it (clip) according to the research area so that multispectral analysis can be carried out. This process is done using ArcMap software (ArcGIS 10.5). Composite bands for analysis purposes in this study use a combination of bands that are adapted to the purpose of the study. The combination of bands in Landsat 8 OLI images uses bands 6, 5, 4. This is because these bands have high reflection values and are sensitive to water and vegetation elements [10].

Visual interpretation is based on the appearance of the object's spatial characteristics. Characteristics of objects can be recognized based on interpretation elements such as shape, colour, texture, location, pattern, shadow and association of object appearance. The interpreted image is displayed in RGB format according to the composite band. Class identifiers are data obtained from a training area. A group of training areas can represent a land cover class such as forests, settlements, shrubs, rice fields and water bodies. The training area was created by utilizing ground check data assisted by Google Earth to improve classification accuracy. Determination and sampling are done based on the data obtained from the ground check and then determined the training area for each land cover.

The classification method used in this study is the Maximum Likelihood Classification (MLC). MLC is a method commonly used in remote sensing data classification [11]. There are considerations of various factors in MLC including the probability of a pixel to be classified into a certain type or class, this opportunity is often called the prior probability. The determination of the land cover class is based on the interpretation of Landsat imagery on the appearance in the field and adapted to the conditions in the research area [12]. The determination of the land cover class carried out includes: mangrove forests, settlements, rice fields, shrubs, ponds and water bodies.

Accuracy assessment is carried out to influence the level of user confidence in each type of data and analysis method carried out. Accuracy assessment is carried out by using an error matrix which is a comparison of information from the reference area with the classified image in a number of selected areas. The reference area is a number of pixels in the image that have been identified through ground check activities or photo interpretation and are assumed to be correct. Error matrix is very effective to get the level of accuracy of the image classification results and errors that occur in the classification. Error matrix are shown in table 1. Accuracy assessment is carried out using Kappa accuracy with the help of an error matrix. Mathematically the Kappa accuracy is calculated by the following formula [13]:

\[
\text{Kappa Accuracy} = \frac{\sum_{i} X_{ii} - \sum_{i} X_{i+} X_{+i}}{N^2 - \sum_{i} X_{i+} X_{+i}} \times 100\%
\]

Where:

- \(X_{ii}\) : Diagonal value in row i and column i of the error matrix
- \(X_{i+}\) : Number of pixels in row i
- \(X_{+i}\) : Number of pixels in column i
- \(N\) : Number of pixels
Table 1. Error matrix.

| Land Cover Class | A   | B   | C   | ...... | Total Row | User Accuracy |
|------------------|-----|-----|-----|--------|-----------|--------------|
| A                | A   |     |     | ...... | X_{it}    | X_{it} / X_{it}+ |
| B                |     | B   |     | ...... |           |              |
| C                |     |     | C   | ...... | X_{it}    |              |
| ......            |     |     |     | ...... | X_{it}    | N            |
| Total Column     |     |     |     | ...... | X_{it}    | X_{it} / X_{it}+ |

Producer Accuracy

Overall Accuracy

\[ \sum_{i} X_{it} / N \]

3. Results and discussion

3.1. Image interpretation

The research was conducted based on the existing land cover [14] by classifying the land cover of West Langsa Sub district into 6 land cover classes, namely: mangrove forest, settlements, rice fields, shrubs, ponds and water bodies. Based on the interpretation of Landsat 8 imagery using a combination of bands 6, 5, 4, the appearance of land cover types in Landsat images is displayed in different colours. Land cover characteristics of West Langsa Sub district are shown in figure 2. Areas dominated by vegetation have a light to dark green colour in their appearance on the image, while areas dominated by water have a blue colour.

![Figure 2](image-url)
3.2. Land cover classification in West Langsa Sub district, Langsa City

The results of land cover classification in West Langsa Sub district using MLC are shown in figure 3. Visually, each class is identified using the Maximum Likelihood Classifier based on ground check data and analyst knowledge [15,16]. The northern part is dominated by mangrove forests and there are also settlements. The middle part is mostly ponds which are the largest land cover of other land covers. Ponds located in West Langsa Sub district still apply simple silvicultural techniques [17]. The southern part is mostly residential and there are rice fields and shrubs between the settlements. The area of each type of land cover are shown in table 2.

Figure 3. Land cover classification map of West Langsa Sub district using Landsat 8.

Table 2. Land cover area of West Langsa Sub district.

| No | Land Cover          | Area (ha) | Percentage (%) |
|----|---------------------|-----------|----------------|
| 1  | Mangrove forest     | 1818.64   | 35.53          |
| 2  | Water bodies        | 425.95    | 8.32           |
| 3  | Settlements         | 633.62    | 12.38          |
| 4  | Rice fields         | 115.58    | 2.26           |
| 5  | Ponds               | 1981.54   | 38.71          |
| 6  | Shrub               | 121.72    | 2.38           |
| 7  | Airport / Harbour   | 21.68     | 0.42           |
|    | Total               | 5118.74   | 100            |
3.3. Accuracy of land cover classification

The classification accuracy and kappa accuracy calculated based on the sample and error matrix on the results of Landsat 8 data classification using the MLC are shown in table 3. The overall accuracy obtained is 91.15%. While the accuracy of the kappa obtained is 82.75%. The water body land cover class has the lowest user accuracy (66.67%) and has confusion with the pond. This is due to the similarity between the pond and the water body contained in the image, generally the new pond has an appearance resembling a water body.

The United States Geological Survey (USGS) has set a minimum level of classification or interpretation accuracy using remote sensing, which is less than 85% [18]. The overall accuracy value obtained is 91.15% so that the results of Landsat 8 image classification in West Langsa Sub district can be used for various purposes. While the kappa accuracy value obtained is 82.75%, based on the accuracy value, the classification results provide a fairly high accuracy. The results of Landsat 8 image classification in West Langsa Sub district can be used for forest conservation such as rehabilitating forests directly adjacent to plantations or ponds and must be followed simultaneously with empowering communities living around the area [19].

| Class          | Mangrove forest | Settlements | Rice fields | Shrubs | Ponds | Water Bodies | Total | User Accuracy (%) |
|---------------|-----------------|-------------|-------------|--------|-------|--------------|-------|------------------|
| Mangrove forest | 17              |             |             |        |       |              | 17    | 100.00           |
| Settlements   | 145             | 4           |             |        |       |              | 149   | 97.32            |
| Rice fields   | 2               | 9           | 1           |        |       |              | 12    | 75.00            |
| Shrubs        | 5               |             |             | 12     |       |              | 17    | 70.59            |
| Ponds         | 6               | 1           | 21          |        |       |              | 28    | 75.00            |
| Water Bodies  |                 |             |             |        | 1     | 2            | 3     | 66.67            |
| Total         | 17              | 158         | 9           | 18     | 2     |              | 226   |                  |
| Producer Accuracy (%) | 100.00     | 91.77  | 100.00      | 66.67  | 95.45 | 100.00       |

4. Conclusions

Landsat 8 OLI image classification in West Langsa Sub district resulted in 6 land cover classes. The land cover classes are mangrove forests, settlements, rice fields, shrubs, ponds and water bodies. The results of the classification accuracy assessment show that the accuracy is quite good and meets the requirements set by the USGS (overall accuracy > 85%), namely the overall accuracy obtained is 91.15% and the kappa accuracy is 82.75%. Based on the results of the accuracy assessment, the map from the Landsat 8 image classification of West Langsa Sub district can be used for various purposes.

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