# Assessment Of Land Use And Land Cover Change In Dong Na Tard Provincial Protected Area, Savannakhet Province, Lao PDR

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**Abstract:** The aim of the present study is to assess land use and land cover change in Dong Na Tard Provincial Protected Area (DNT PPA), Savannakhet Province, Lao PDR. The study was applied the integrated approach of remote sensing (RS) and Geographic Information System (GIS) for the land cover change detection. Historical land use and cover data of the Dong Na Tard PPA were obtained from a classification of Landsat ETM+ imagery obtained from the United States Geological Survey (USGS) Earth Explorer. Land use and land cover classification maps of 2007 and 2017 were extracted from Landsat TM/ETM images. Satellite images were pre-processed before classification. Layer stacking was performed to combine bands and then the images were performed radio-metrically corrected. The supervised classification was carried out using the Maximum Likelihood and a composition of bands 2, 3, 4 for Landsat 5 and bands 3, 4, 5 for Landsat 8. Kapa statistics were applied for accuracy assessment of images classification and magnitude of change were analyzed. The study shown that the percentage of land use and land cover change (LULCC) from 2007 to 2017, the agriculture area had the highest positive value indicating a high expansion of 175.88% from its initial 3955.23 has, followed by plantation area with a percentage increase of 155.77% and urban and built-up area had escalated by 100.51%. On the contrary, mixed deciduous forest, dry dipterocarp forest and bare land had negative values indicating a reduction in the size by 20.51%, 3.00% and 75.68%, respectively. The aid of GIS and RS technology with change detection and change analysis of land cover were helpful and best described. The outcome of the present study has provided useful information for managers and decision makers in sustainable management the protected area.

**Keywords:** Land Use and Land Cover change (LULCC) analysis; GIS and Remote sensing.

## 1. Introduction

Land use and land cover (LULC) change is an important component of global environmental change. The need to understand LULC change is essential for regional development and land use management towards sustainable development. Lao PDR is one of the countries with the richest biodiversity in Southeast Asia. However, the country has undergone profound forest and land cover changes over the last few decades [1]. Lao PDR still has considerable forest resources, but significant deforestation and forest degradation have taken place during the past two decades, as evidenced by a substantial decline in the extent of natural forests [2]. The deforestation rate has increased alarmingly since the 1980s [3]. In 1982, 50% of the country was still covered by forests, but the forest cover dropped to 41% in 2002, before gradually decreasing to 40% of the total land area by 2010 [4]. The massive changes in forest lands and resource use over the past two decades have indeed been driven mainly by demand for land from neighboring countries for the purpose of growing a wide range of cash crops. The expansion of the plantation industry in recent years in Lao PDR has been associated with encroachment into forested lands, loss of farmlands for rural populations, and a range of other impacts. In addition to the result in reduction of the forest cover, there has been a steady fragmentation of forests and a decline in the average growing stock within the residual forest, which have both reduced carbon values and negative impact on biodiversity through the loss of the connectivity that promotes species dispersal [2]-[4]. Dong Na Tard Provincial Protected Area (DNT PPA) has heterogeneous land use/land cover types and is greatly covered by mixed deciduous forest. However, the dry dipterocarp has been converted either to agricultural areas, or to forest plantations, and to the development of human infrastructure for the last decade. Increasing population, agriculture land expansion, and agriculture itself as an industry have led to encroachment to the protected area, in addition to socio-economic developments such as industrial infrastructure development and over extraction of non-timer forest products (NTFP) has led to deteriorate of the forest in the DNT PPA. Therefore, the present study is to determine and evaluate the changes in land use and land cover from two time periods: 2007 and 2017. The integrated approach of remote sensing (RS) and Geographic Information System (GIS) for the land cover change detection pay a major role for land cover change analysis. Historical land use and cover data of the Dong Na Tard PPA were obtained from a classification of Landsat ETM+ imagery obtained from the United States Geological Survey (USGS) Earth Explorer.

## 2. Study Area

Dong Na Tard Provincial Protected Area (DNT PPA) is located in Savannakhet Province, the central of Lao PDR. Dong Na Tard, a 6,385 hectares land located 12 kilometers from Savannakhet City, was declared a provincial protected

area in 1961. Its annual average temperature is 27.2℃, relative humidity 74%, rainfall 1,445 mm, and evaporation 1,250 mm. The PPA shares boundaries to the west with National Road No. 9, Outhoumphone district to the north, and Kaysone Phomvihane district to the west and south. There are 13 villages adjacent to the protected area such as Song, Phon Sim, That Ing Hang, Na That, Na Tuery, Dong Bang, Khuea Khao Kard, Na Cha Lid, Khok, Xai Ya Mong Khoun, Chom Phet, Dong Na Kham, and Nong Kolm Villages. Two villages, namely, That Ing Hang and Phon Sim are located in the proximity of the protected area. Another five villages, Nong Kolm, Xai Ya Mong Khoun, Dong Bang, Khok, and Na That have gardens and paddy fields inside the protected area as displayed in Figure 1, the relative location of the DNT PPA. Dong Na Tard Provincial Protected Area (DNT PPA) as a terrestrial ecosystem, provides services such as provisioning, regulating, cultural and support services [5]. The DNT PPA is the watershed of Tard Creek, Sompoi Creek, and water sources for Nong Lom pond, Nong Kolm pond, Nong Kheng pond and others. It is comprised of dense forest with high value trees, medicinal plants, birds, wildlife and aquatic animals. Its landscape structures and processes play an important role for the local residents and people living in the city in terms of goods and services, especially for its fresh air, which is the reason why the PPA is also called "Lung of the City" [6].

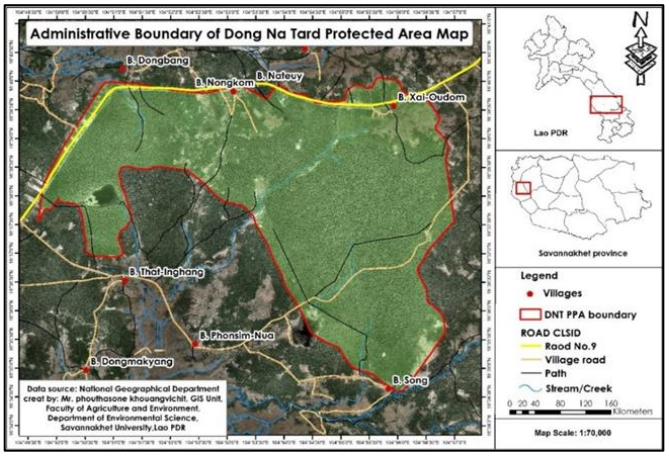


**Figure 1:** Administrative boundary of Dong Na Tard Protected Area (DNT PA)

## 3. Methodology

This study employed GIS and remote sensing in investigating and analyzing the changes over time and space by using forest cover change maps derived from a classification of Landsat ETM+ imagery obtained from the United States Geological Survey (USGS) Earth Explorer.

### 3.1 Landsat images acquisition

Historical land use/cover data of the Dong Na Tard PPA were extracted from the 2007 and 2017 Landsat images. Satellite imagery for land use/cover analysis was acquired from the U.S. Geological Survey website (http:\\glovis.usgs.gov). The Landsat-5 Thematic Mapper (TM) was acquired on 27 February 2007 and Landsat-8 Operational Land Imager (OLI) on 28 February 2018.

**Table 1:** Satellite images used in land cover classification.

| No. | Satellite images | Sensor | RP: Patch/ Row | Number of bands | Spatial Resolution | Acquire date |
|---|---|---|---|---|---|---|
| 1 | Landsat 5 | TM | 127/048 | 7 (4-3-2) | 30x30 m | 27-Feb-07 |
| 2 | Landsat 8 | OLI | 127/048 | 11(5-4-3) | 30x30 m | 28-Feb-17 |

### 3.2 Remote Sensing and GIS Analysis

#### 3.2.1 Image Geo-Processing for Land use and Land Cover classification

Satellite images were pre-processed before classification was performed. Layer stacking was implemented to combine bands and then image edges were trimmed out in ArcMap. Two senses of Landsat Images of 2007 and 2017 were performed radio-metrically corrected. The supervised classification was carried out using the Maximum Likelihood and a composition of bands 2, 3, 4 for Landsat 5 and bands 3, 4, 5 for Landsat 8 by applying the false color composite to select Region of Interest (ROI) for features like water body and shrubs/grass, while the true color composite was applied in choosing the ROI of built up area, farm land and other land. The spectral signature of each class was obtained from the images using ArcGIS 10.3.1. This have been done through the selection of ROI for each of the LULC category. The ROI helps in producing the map by defining an area in the map based on the color assigned to that category and the spectral homogeneity of the pixels of chosen area. Whereby the training sites were selected base on the ground-truth GNSS (Global Satellite Navigation System) coordinates which were collected during field reconnaissance. Other ancillary data like shapefiles of roads, rivers and settlements facilitated the selection of classification training samples. Each imagery was classified into differences class of land use and Land cover types.

#### 3.2.2 Change Detection

Post-Classification: The two independently classified images where then ran for post classification comparison to produce a change detection analysis. By using the change detection statistical tool of the post classification, the matrix Table of ''from – to'' change class were obtained. Finally, this classification proved to be effective because it presents the advantage of indicating the nature and magnitude of change that has taken place through pixel by pixel comparison.

Accuracy Assessment: is a comparison of a classification with ROI or ground-truth data to evaluate how well the classification represents the real world. This is produced in a matrix Table 2 showing six different types of accuracies. However, Accuracy Assessment requires that an adequate number of samples per map class be gathered when the classified results are compared with actual ground conditions [7]. Accuracy classification assessments for 2007 and 2017 images were carried out to determine the quality of information provided by the data. Kappa test is used to perform measurement of the classification accuracy as the test is able to account for all elements in confusion matrix including diagonal elements. A kappa test is a measure calculated using predefined producer and user assigned ratings, which can be expressed as follows:

$$K = \frac{P(A) - P(E)}{1 - P(E)}$$

Where $(A)$ is the number of times the $k$ raters agree and $(E)$ is the number of times the $k$ raters are expected to agree only by chance. Meanwhile, user accuracy can be defined as the probability that a pixel in an image actually represents a class on the ground, while producer's accuracy indicates the probability a pixel being correctly classified and is mainly used to determine how well an area can be classified.

**Table 2:** Rating criteria of Kappa statistics.

| No | Kapa Statistic | Strength of Agreement |
|---|---|---|
| 1 | <0.00 | Poor |
| 2 | 0.00 - 0.20 | Slight |
| 3 | 0.21 - 0.40 | Fair |
| 4 | 0.41 - 0.60 | Moderate |
| 5 | 0.61 - 0.80 | Substantial |
| 6 | 0.81 - 1.00 | Almost perfect |

Source: [8]

**Determination of the magnitude of change:** The magnitude of change is a degree of expansion or reduction in the LULC size. A negative value will present a decrease in LULC size while a positive value will indicate an increase in the size LULC class [9].

- The magnitude of change (K) is calculated by the simple equation

$$K = F - I$$

- The percentage of change (A) is calculated by the formula

$$A = \frac{F-I}{I} x100$$

Where, K = magnitude of change; A = percentage of change; F = Final date (2017); I = Initial date (2007)

## 4. Result and Discussion

The assessment of the changes in LULC was based on the land use and land cover detection and classification procedure. The outcome of the data processing and analysis were presented in the form of digital maps, layout and attribute tables. The area covered by the seven types of LULC classified maps of 2007 and 2017 are shown in Table 3. This type of classification was used to prepare the land use and land cover maps.

**Table 3:** Land use and land cover classification system of the DNT PPA

| No. | Land cover class | Code |
|---|---|---|
| 1 | Mixed deciduous forest | MDF |
| 2 | Dry Dipterocarp forest | DDF |
| 3 | Agriculture land | AL |
| 4 | Urban and Built-up land | UBL |
| 5 | Plantation land | PT |
| 6 | Water | W |
| 7 | Bare land | BL |

Source: National Level Classification System for Lao PDR, Forest Inventory and Planning Division, Department of forestry, Ministry of Agriculture and Forestry.

### 4.1 Land use and Land cover Classification of DNT PPA in 2007

The Landsat 5 Images classification of land use/land cover revealed that in 2007 the dominant land use/land cover in the study area was mixed deciduous forest (59%) and dry dipterocarp (30%), the sum of which was more than 80% of the total area (Table 4 and Figure 2).

**Table 4:** Distribution of land cover and land use classification in 2007

| Land cover classes | Year 2007 | |
|---|---|---|
| | Area (Ha) | (%) |
| Mixed deciduous | 3955.23 | 59 |
| Dry Dipterocarp | 1998.99 | 30 |
| Agriculture area | 355.59 | 5 |
| Urban and Built-up | 124.74 | 2 |
| Plantation | 104.58 | 2 |
| Water | 108.09 | 2 |
| Bare land | 56.61 | 1 |
| Total | 6703.83 | 100 |

The agriculture area covered 355.59 has or no more than 5% of the total area; urban and built-up covered 124.74 has or about 2%; plantation areas covered 104.58 has or about 2%; water body covered 108.09 has or no more than 2% of the total area; and bare land covered 56.61 has or about 1 % of the total area.

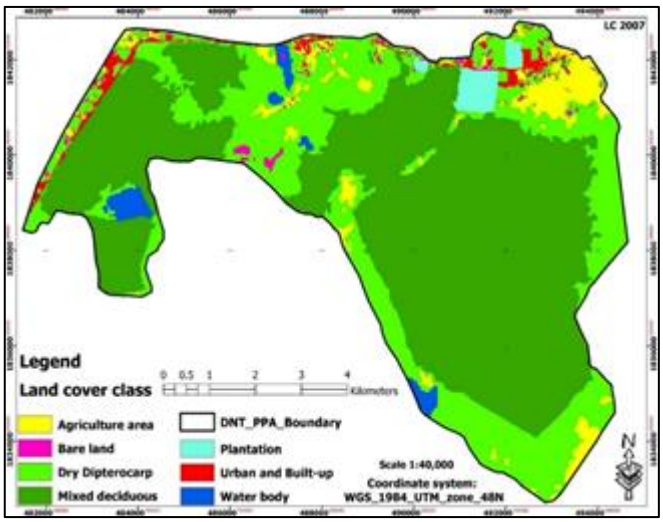


**Figure 2:** Land use and land cover map of DNT PPA in 2007

### 4.2 Land use and Land cover Classification of DNT PPA in 2017

Based on the Landsat 8 Images, the classification of land use/land cover in 2017 revealed that the dominant land use and land cover in study area remained mixed deciduous

forest (47%), dry dipterocarp (29%), and agriculture area (15%), the sum of which was more than 90% of the total area (Table 5 and Figure 3).

**Table 5:** Distribution of land cover and land use classification in 2017

| Land Cover Class | 2017 | |
|---|---|---|
| | Area (Ha) | (%) |
| Mixed deciduous | 3143.88 | 47 |
| Dry Dipterocarp | 1939.05 | 29 |
| Agriculture area | 981 | 15 |
| Urban and Built-up | 250.11 | 4 |
| Plantation | 267.48 | 4 |
| Water | 108.54 | 2 |
| Bare land | 13.77 | 0 |
| Total | 6703.83 | 100 |

The urban and built-up covered 250.11ha (4 %), plantation areas cover 267.48 ha (4 %), water body covered 108.54 ha, no more than 2 % of the total area and bare land covered 13.77 ha which is very small portion when compared to the others land use/land cover classes of the total area.

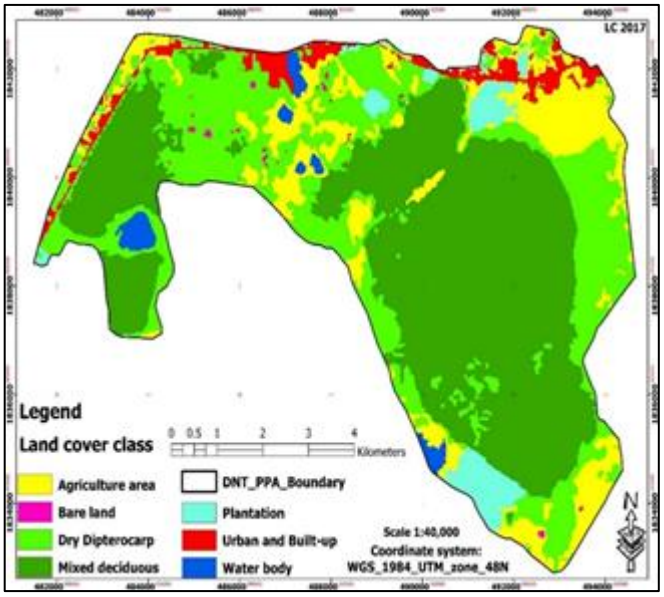


**Figure 3:** Land use and land cover map of DNT PPA in 2017

### 4.3 Determination of Magnitude of Land use and Land Cover Change

The magnitude of change is the degree of expansion or reduction in the land use and land cover size. A negative value represents a decrease in LULC size while a positive value indicates an increase in the LULC class. The magnitude and percentages of LULC change under two time periods, 2007 and 2017 are summarized in Table 6. The results indicate LULC types in 2007 for mixed deciduous forest was 3955.23 has (59%); dry dipterocarp forest, 1998.99 has (30%); agriculture area, 355.59 ha (5%); urban and built-up area, 124.74 (2%); plantation area, 104.58 (2%); water body, 108.09 (2%); and bare land, 56.61 (1%).In 2017, only agriculture, plantation, and urban and built-up areas had increased by about 625.41 has (3421%), 162.90 has (8.91%) and 125.37 has (6.86%) bringing the total to 981.00 has (15%) for agriculture, 267.48 has (4%) for plantation, and 250.11 has (4%) for urban and built-up areas. However, mixed deciduous forest, dry dipterocarp forest, and bare land were reduced by about 44.38%, 3.28% and 2.34%, respectively which resulted in a total area of 811.35 has, 59.94 has and 42.84 has for the three classes. Nevertheless, water body area has increased by about 0.02 % to provide a total area of 108.54 has as shown in Table 6.

**Table 6:** Magnitude and percentage of LULC changes from 2007 to 2017

| Land Cover Class | 2007 | | 2017 | | Magnitude of Change | | Percent age of Change |
|---|---|---|---|---|---|---|---|
| | (Ha) | (%) | (Ha) | % | (Ha) | (%) | (%) |
| Mixed deciduous | 3955.23 | 59 | 3143.88 | 47 | -811.4 | -44.4 | -20.51 |
| Dry Dipterocarp | 1998.99 | 30 | 1939.05 | 29 | -59.94 | -3.28 | -3 |
| Agriculture Land | 355.59 | 5 | 981 | 15 | 625.41 | 34.21 | 175.88 |
| Urban and Built-up | 124.74 | 2 | 250.11 | 4 | 125.37 | 6.86 | 100.51 |
| Plantation | 104.58 | 2 | 267.48 | 4 | 162.9 | 8.91 | 155.77 |
| Water | 108.09 | 2 | 108.54 | 2 | 0.45 | 0.02 | 0.42 |
| Bare land | 56.61 | 1 | 13.77 | 0 | -42.84 | -2.34 | -75.68 |
| Total | 6703.8 | 100 | 6703.8 | 100 | | | |

### 4.4 Determination of Percentage of Land use and Land Cover Change

The percentages of LU/LC change as depicted in the two time periods 2007 to 2017 (Table 6 and Figure 3) showed that the agriculture area had the highest positive value, indicating high increase from the initial 3955.23 has to 175.88%, followed by the plantation area with a percentage increase of 155.77%, and urban and built-up area with an increase of 100.51%. On the contrary, mixed deciduous forest, dry dipterocarp forest, and bare land had the negative value indicating the level of conversion to other categories of land cover which reduced its size by 20.51%, 3.00% and 75.68% respectively. There are different types of land-uses/land cover in Dong Na Tard PPA. The greatest areas originally covered by forests tremendously decreased through the years. According to [6], human activity was a major factor causing land-use/land cover changes and plant disturbances in the park. According to the head of the DNT PPA management unit office, from 1961 to 1990, the PPA was originally 9,288 has composed mainly of natural and agricultural ecosystems. This landscape drastically decreased to its current state where natural ecosystems significantly diminished (that is, dry dipterocarp forest having been reduced from 3,021 has to a meager 99 has). Agricultural areas have expanded from 98 has in 1961 to 250 has in 2005. Since 1991, tree plantations and industrial areas had increased to 255 has and 59 has, respectively. Other land areas were used as sites for secondary schools (5.63 has) and for Na That village's socio-development (23.44 ha). [10] mentioned that the dry dipterocarp forest was reduced due to the active conversion of land into commercial tree plantations (eucalyptus, acacia, rubber, etc.) and agricultural crop production (sugar cane, cassava, etc.). Furthermore, the drastic changes in the LULC can be attributed to its geographic location, that is, being situated in a flat plain area and nestled along a national road making it conducive and accessible to 13 villages with already two strategically located inside the PPA with established gardens. [11] stated that the forest zones with gentle slopes and flat areas, lower elevation, near roads, and settlement had higher probability

for conversion to other land uses due to easier access compared to steep slopes, with high elevation and which are from roads and settlements. The causes of land change are so-called anthropogenic in nature thus physically affecting land cover, not to mention bringing along a more complex array of social, political, economic, demographic, technological, cultural and biophysical variables [12].

### 4.5 Accuracy Assessment

The overall classification accuracy, producers' accuracy, and user accuracy were computed from Kappa Statistics and Confusion Matrix (KHAT) [13]-[7]. Overall classification accuracy was taken from the probability of correctly mapped location with ground survey and user accuracy (UA) comparing the map with the data from the ground survey. Producers' assessment compared ground survey data and maps. T he ground survey data was collected using Global Positioning Systems (GPS). An overall accuracy of 81.72% and Kappa coefficient of 75.93% were obtained from the accuracy assessment, Table 12. In terms of producer's accuracy (PA), all classes except agriculture and urban and built-up were over 80.0%, while for the user's accuracy, all classes were above 84.11% except dry dipterocarp forest and agriculture.

**Table 7:** Confusion matrix Table of LULC derived from satellite data in

| Land Cover Class | MDF | DDF | AL | UBP | PL | W | BL | User Accuracy (%) |
|---|---|---|---|---|---|---|---|---|
| MDF | 88 | 15 | 0 | 0 | 0 | 0 | 0 | 85.44 |
| DDF | 20 | 170 | 20 | 10 | 10 | 2 | 2 | 72.65 |
| AL | 0 | 12 | 100 | 5 | 0 | 10 | 5 | 75.76 |
| UBP | 0 | 0 | 0 | 82 | 1 | 0 | 5 | 93.18 |
| PL | 0 | 1 | 9 | 5 | 90 | 0 | 2 | 84.11 |
| W | 0 | 5 | 0 | 3 | 0 | 78 | 2 | 88.64 |
| BL | 0 | 0 | 6 | 3 | 0 | 0 | 76 | 89.41 |
| PA (%) | 81.5 | 83.7 | 74.1 | 75.9 | 89.1 | 86.7 | 82.6 | 81.72 |

Overall Accuracy (%): 81.72 Kappa Accuracy (%): 75.93

**Note:** MDF= Mixed Deciduous Forest; DDF= Dry Dipterocarp Forest, AL=Agriculture Land; UBL= Urban and Built-up Land, PL= Plantation Land, W= Water and BL= Bare land.

Table 7 shows the results obtained from the classified map of 2017. An overall accuracy of 86.35% and Kappa coefficient of 82.54% were obtained. In terms of the producer's accuracy, all classes were above 80.0%, while for the user's accuracy, all the classes except dry dipterocarp forest were above 81.0%.

**Table 8:** Confusion matrix Table of LULC derived from satellite data in 2017

| Land Cover Class | MDF | DDF | AL | UBP | PL | W | BL | UA (%) |
|---|---|---|---|---|---|---|---|---|
| MDF | 80 | 15 | 0 | 0 | 0 | 0 | 0 | 84.21 |
| DDF | 17 | 95 | 10 | 0 | 5 | 2 | 4 | 71.43 |
| AL | 0 | 0 | 187 | 0 | 2 | 3 | 0 | 97.4 |
| UBP | 0 | 0 | 0 | 98 | 0 | 8 | 5 | 88.29 |
| PL | 0 | 0 | 11 | 1 | 67 | 1 | 0 | 83.75 |
| W | 2 | 2 | 10 | 0 | 0 | 121 | 1 | 88.97 |
| BL | 0 | 1 | 5 | 6 | 0 | 0 | 54 | 81.82 |
| PA (%) | 80.81 | 84.07 | 83.86 | 93.33 | 90.54 | 89.63 | 84.38 | 86.35 |

Overall Accuracy (%): 86.35 Kappa Accuracy (%): 82.54

**Note:** MDF= Mixed Deciduous Forest; DDF= Dry Dipterocarp Forest, AL=Agriculture Land; UBL= Urban and Built-up Land, PL= Plantation Land, W= Water and BL= Bare land, PA= Producer's Accuracy, UA= User's Accuracy

According to Jensen (2003), producer' accuracy presents how well a certain area can be classified. User's accuracy (UA) is when the total number of correct pixels in a class divided by the total number of pixels that were really classified in that class (row total), the results of which is a measure of commission error. User's accuracy (UA) is the probability that a pixel classified on the map represent that class on the ground. Sophia S. et al (2017) reported that Kappa coefficient of 0.41 - 0.60 (41-60%) is moderate accurate, 0.61 - 0.80 (61-80%) is substantial accurate and 0.81 - 1.00 (81-100%) is almost perfect accurate classification.

## 5. Conclusion

The application of integrated approach of remote sensing (RS) and Geographic Information System (GIS) for the land cover change detection and assessing the changes over time and space by using forest cover change maps derived from a classification of Landsat ETM+ imagery obtained from the United States Geological Survey (USGS) Earth Explorer. Results of the study revealed seven different types of land use/land cover in the area namely, 1) mixed deciduous forest, 2) dry dipterocarp forest, 3) agriculture land, 4) urban and built-up, 5) plantation land, 6) water body, and 7) bare land. In 2007, the dominant land use/land cover in the study area was reported to have been mixed deciduous forest and dry dipterocarp, the sum of which was more than 80% of the total area. The LU/LC was also made up of agriculture area, urban and built-up, plantation areas, water body, and bare land. In 2017, the dominant land use/land cover in the study area remained to be mixed deciduous forest, dry dipterocarp, and agricultural area, but the sum of which was more than 90% of the total area. Comparing with 2007, only agriculture, plantation, and urban and built-up areas exhibited an increase. However, mixed deciduous forest, dry dipterocarp forest and bare land decreased. Nevertheless, water body area has increased by about 0.02% to provide a total area of 108.54 has. The percentages of LU/LC change from two time periods, 2007 and 2017 revealed increasing trend from the original size as evidenced by positive values of the agriculture, plantation, and urban and built-up areas with agriculture exhibiting the highest value. On the contrary, mixed deciduous forest, dry dipterocarp forest, and bare land exhibited negative values, indicating a reduction in size attributable to the level of conversion to other categories of land cover.

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