Analysis of Land Cover Change Using Landsat Imagery in Thapangthong District, Savannakhet Province, Lao PDR

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Abstract: The study aimed to quantify the change inland cover between the years 2005 and 2016; using remote sensing and Geographic Information Systems (GIS). The study is based on data collected from the satellite images- Landsat-5Thematic Mapper (TM) 2005 and Landsat-8 Operational Land Imager (OLI) 2016. Also, did an imagination process. There are five classes of land cover as the following numbers; 1) mixed deciduous forest, 2) dry dipterocarp forest, 3) agricultural land, 4) built-up land, and 5) water discrimination. The study found that during this 11- years period, dry dipterocarp forest decreased by 8.72% of the total area whereas agricultural land increased by 7.13% of the total area, followed by built-up land (0.85%),and water (0.62%). In addition, mixed deciduous has slightly increased by 0.85%, especially the agricultural land expanded to a mixed deciduous forest. Besides that, the overall classification accuracy of the map was 84.25%, and Kapa Coefficient was about 0.70%. In addition, the study found out the relative information due to land cover has been changing in Thapangthong district. This information is not currently known. The study is recommending that future research should study the possibility of sustainable forest management in the district.

Keywords: Land cover change, Remote sensing, Geographic Information System, Savannakhet Province, Lao PDR

Land cover refers to the physical and biophysical cover over the surface of the earth, including the distribution of vegetation, water, bare soil, and artificial structures (IGBP-IHDP, 1999), pointing out that, land use and land cover change (LUCC) is commonly grouped into two broad categories: conversion and modification. Conversion refers to a change from one cover or use category to another such as forest to grassland (Meyer & Turner, 1994). On the other hand, modification represents a change within one land use or land cover category (for example, from rain-fed cultivated area to irrigated cultivated area), which can lead to changes in its physical or functional attributes. These changes in land use and land cover systems have important environmental consequences through their impacts on soil and water, biodiversity, and microclimate (Lambin, *et al.* 2003). Land-cover change is influenced by both the increase and decrease in a given population (Lambin, *et al.* 2003). For instance, in developing countries like Ethiopia, population growth has been a dominant cause of land use and land cover change than other forces (Sage, 1994). Also (Meyer & Turner, 1994). point that; there is a significant statistical correlation between population growth and land cover conversion in most African, Asian, and Latin American countries. Leading to the increasing demands of food production, agricultural lands are expanding at the expense of natural vegetation and grassland (Lambin, *et al.* 2003). Normally, knowing the impact of land use and land cover change on natural resources depends on an understanding of past land use and land cover, as affected by population size and distribution, economic development, technology, and other factors. The land use and land cover change assessment is a very important step in planning sustainable land management that can help to minimize agro-biodiversity losses and land degradation, especially in developing countries like Ethiopia (Hadgu, 2008). The Lao People's Democratic Republic (Lao PDR) is a country that used to be a part of Indochina during the French colonial period. Lao PDR has 236.800 square kilometers of land. Lao PDR is located in a tropical area and is extremely rich in biodiversity, as well as having a large number of forest resources in comparison to other ASEAN member countries, which had a forest cover of 70% of the total landarea in 1940, but had decreased to only 41.5% in 2002. During the last decades of the twentieth century, the loss of forest land increased due to land-use practices, e.g., shifting cultivation, commercial logging, commercial agriculture, and tree plantation. According to the results of the forest cover survey in 2002, the total land area of Laos covered by natural forest (canopy density of greater than 20 % and a height of above 5 meters) was 9,824,700 hectares, or about 41.5 percent of the total land area, while the dry lands (lowland dry dipterocarp forest) covered roughly 1,317,200 hectares or 13.88 % of the total land area. Almost all of this land area is located in central and southern Laos. Therefore, the Lao government established a sustainable forest management policy with three forest categories: conservation forest covering 4.827.000 ha (56.45%), protection forest covering 517.000 ha (6.04%), and 3.207.000 ha (37.50%) of production forest (natural forest, natural regeneration, and plantation forests) (MAF, 2005). Laos is a developing country and this is often the reason given as the cause of forest resource changes, especially the change in the forest area. Changes in forest areas are often related to environmental problems associated with economic development and the direct impacts on human livelihoods. Therefore, the change of forest area information is an important key used for resource planning and management in quickly emerging developing countries. One way of assessing forest change is through looking at land use and land-cover changes. However, when investigating this, one needs to consider the budget, labor, and time needed to explore a wide variety of information. Information regarding the forest's status is often outdated and unclear. Savannakhet province is rich in forest resources. It was still about 70% forest covered in 2000 and included three national biodiversity conservation areas (NBCA): Phouxanghe (109,900 hectares), Dongphouvieg (197,000 hectares), and Xebangnouan (150,000 hectares). There are two state-production forests in the province: Dongkapho (51,650 hectares) and Dongsithoune (150,900 hectares) (Prime Minister’s Office, 2006).

Whatever the case, at present, the population and the economy are both rapidly increasing. This drives an increasing demand for land used in building houses, the infrastructure, and especially for agricultural products such as paddy fields, commercial timber for sawmills, and commercial crops. Overall, production in the whole district has been increasing. Forest cover changes are a key factor affecting the changes in the landscapes. Therefore, the change of forest will have an important influence on the living conditions of habitats, livelihoods, or people, the area of agriculture; and the expansion of urbanization. Remote sensing technologies making use of satellite imagery and aerial photos are widely used, along with GIS, to support the allocation of land use, agriculture, forestry, environmental planning, and other planning (Chobtham Somporn, 2008). The main objective of this study is to quantify the change in land cover between 2005 and 2016 in the case study area using remote sensing and GIS technologies and techniques.

1. Research Area Overview

The study sites are located in Thapangthong District, Savannakhet Province, Lao PDR. It lies at 16° 05’ 34.48’’Nlatitude and 105° 51’ 03.81’’E longitude with an elevation of 219 meters above mean sea level. The district was established in 1984 and shares a border with Pin and Xonboury districts to the north; the Lakhonepheng district to the south; the Toumlan and Vapi districts of Salavan province to the east; and the Songkhone district to the west. On the other hand, the totalarea is 211,388.26 hectares. In the Thapangthong district, the forest cover is fairly dense. Thapangthong district is far to the south of the center point of Kaysonephomvihane City in the province by 147 km (Figure 1). Based on the report of the district, the total population of the district is estimated to be 40,708, with 20,199 females, The total households are 6.696, and there are 42 villages in the total area of the district. On the other hand, there are 3 types of forest in the district, such as National Biodiversity Conservation Area (NBCA) (Xebangnouane), Production Forest Area (DongSithouane), and National Protection Forest (Xetanoune) from the Forest Inventory Planning Division (FIPD, 2010).

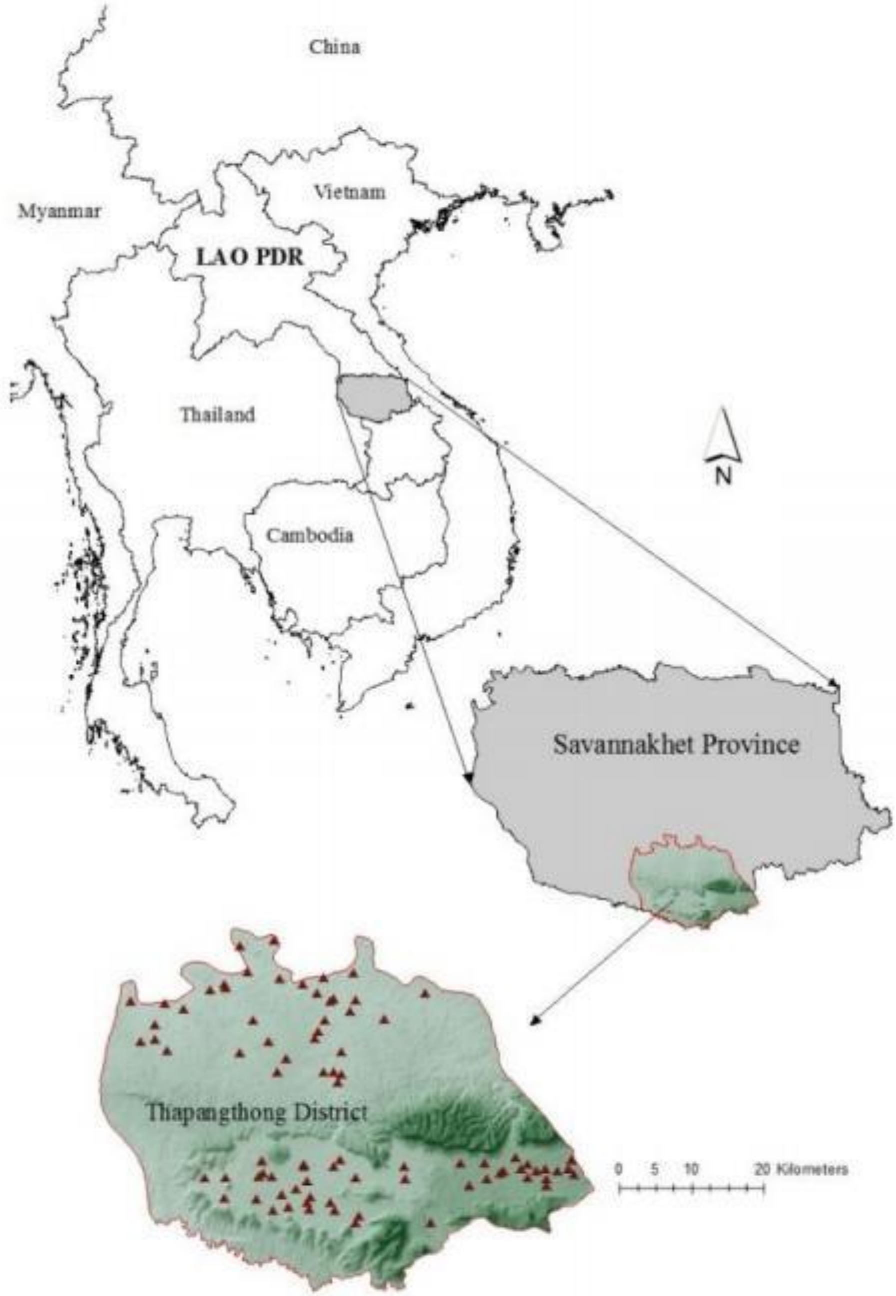

Fig. 1 Location map of the study area

2 Research methods

2.1 Landsat images acquisition

The type of satellite images used are Landsat 5 and Landsat 8, which the Landsat 5-Thematic Mapper (TM) consists of Path/Row (126/049), Number of band 7(3-4-5), Spatial resolution (30x30) & Acquire date (2005-01-03) and Landsat 8-Operational Land Imager (OLI) comprise of Path/Row (126/049), Number of band 11(5-4-3), Spatial resolution (30x30) & Acquire date (2016-03-22) respectively. Two Landsat images containing the study area were obtained from the U.S. Geological Survey (USGS) (https://earthexp lorer.usgs.gov/).

Table 1. Satellite images used inland cover classification

Satellite images	Sensor	WRP: Path/Row	Number of bands	Spatial resolution	Acquire date
Landsat 5	TM	126/049	7 (4-3-2)	30x30 m	2005-01-03
Landsat 8	OLI	126/049	11(5-4-3)	30x30 m	2016-03-22

2.2 Data analysis

Steps in the analysis of Satellite image data are given below:

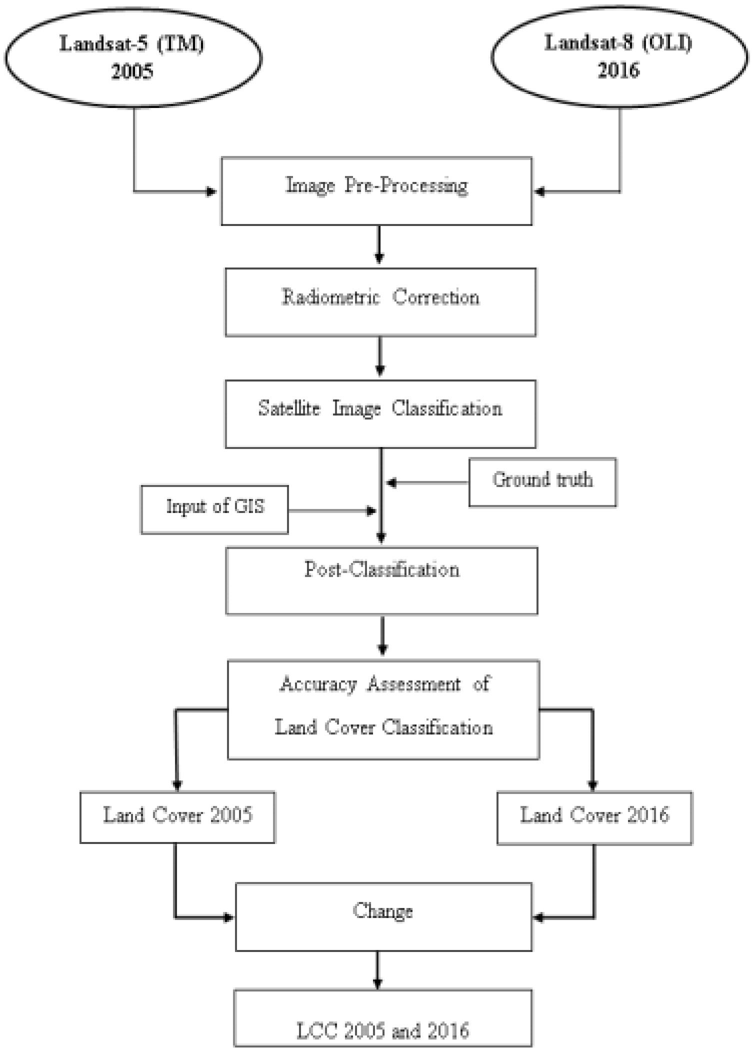

Fig.2. Satellite image of data analysis framework

- Layer stacking

There are two Landsat images (Landsat5-TM 2005 and Landsat 8-OLI 2016) in this study area, all seven bands of Thematic Mapper (TM) and eleven bands of Observational Land Imager (OLI) were considered for Layers stacking to process the satellite imagery. The nature of these different bands had to be considered to decide which three-band combination would be most helpful for classification and visual interpretation. The false color composite of Landsat5_TM used a red band 3 wavelengths (0.63-0.69 µm), band 4 a near-infrared wavelength (0.76-0.90 µm) which is absorbed by water (appearing dark) and reflected by vegetation (appearing bright), and band 5 a mid-infrared wavelength (1.55- 1.74 µm) which contrast well, revealing differences in types and conditions of vegetation and soil (Muttitanon & Tripathi (2005). Furthermore, the false color composite of Landsat 8_OLI images was used in band 5 Near Infrared Wavelength (0.845-0.885 µm). band 4 Red Wavelength (0.630-0.680 µm) and band 3 Green Wavelength (0.525 - 0.600 µm). After layer stacking, all the scenes were re-projected to UTM Zone 48 North using WGS 84 as a datum.

- Radiometric Correction

To improve the visible interpretability of an image by increasing the apparent distinction between the features in the scene, digital enhancement such as level slicing, contrast stretching, spatial filtering, histogram equalization, edge enhancement, and resolution merging, was carried out with the help of visually the information in the images. These processes were done using image enhancement tools/options of QGIS.

- Satellite image classification

Landsat5-(2005) and Landsat8-(2016) images were earlier and very recent images available for study areas. Hence, it was possible to undertake field visits and collect GCPs. Supervised and Unsupervised classification were preferred. The two Landsat images were also included to meet the preferred time horizon of the study. Meanwhile, it must be noted that efforts have been made to integrate historical information acquired from surveys to minimize complete reliance on spectral information and to solve the mystery of spectral similarity of different land cover classes to improve classification accuracy). Data of the different land cover classes obtained from the field study (GPS location) were used as training samples for supervised classification. Land cover was classified into the following five classes.

Table 2. Land cover classification of Thapangthong district, Savannakhet province.

Code	Land Use Classes	Description
MDF	Mixed Deciduous Forest	The tree species more than 50% of the stand
DDF	Dry Dipterocarp Forest	The tree diameter is comparably small and the height of the stand varies from 8 to 25 m.
AL	Agriculture Land	Agriculture land means the land aims for agricultural activities such as grazing cattle, rice fields, and cultivating coffee, coconut, and cocoa
BL	Built-up Land	The built-up lands are areas with small towns, and institutions such as houses, schools, village offices, and others.
W	Water	includes all water bodies (ponds, streams, rivers, and reservoirs).

- Classification Accuracy assessment

According to (Chust*etal.*, 2004; Gary *et al.*, 1995; Congalton, 1991) Classification accuracy assessment and Kappa coefficient error matrix were also defined based on the classification result of images. Eventually, the classified images were exported to ArcGIS 10.3 for map preparation and to describe the situation of the spatial land cover change of the study area. Accuracy of classification is a general term for comparing the classification to geographical data that arepresented to be true, to define the accuracy of the classification process. Normally, the assumed-true data are derived from ground truth data or field surveys. It is usually not practical to ground truth or otherwise test every pixel of a classified image. Consequently, a set ofreference pixels is usually used. Reference pixels are points on the classified image for which actual data are (or will be) known. The reference pixels are randomly selected.

- Change detection

Following the image classification from the individual years, the multi-data post-classification comparison change detection algorithm was used to define the land cover changes. Many methods of change detection have been used the various applications (Ayele, 2011). Example: post-classification comparison, image rationing, image differencing, image regression, principal component analysis. Therefore, this study was used by converting from raster format into vector (shapefile) format for classified images. The vector files were again converted to the raster grid by using the spatial analysis extension of ArcGIS, Conversion of land cover was calculated by using the raster calculator. The analysis and interpretation of different aspects of the numeric data of land use dynamics was done on Microsoft Excel. The results were presented in easily understandable forms such as maps, charts, tables,

and • graphs.

Software used

This study used the software of ArcGIS and QGIS for data analysis, especially spatial data between Raster and

Vector of vector to raster for land cover classification. Moreover, used Microsoft Excel to mix between vector files and Excel. To help the calculation of land cover type.

3 Result and Discussion

3.1 Classification Accuracy Assessment

The overall classification accuracy, producers' accuracy (PA), and user accuracy (UA) were computed from Kappa Statistics and Confusion Matrix (KHAT) (Chust*et al.*, 2004; Gary *et al.*, 1995; Congalton, 1991) . Overall classification accuracy was taken by the probability of correctly mapped location with the ground survey and user accuracy comparing the map with the data of the ground survey. Producers' assessment moreover compares between ground survey data and maps. In addition, the ground survey data was collected by using Global Positioning Systems (GPS). Therefore, the result of the classification accuracy assessment reveals that the overall classification accuracy of the map was found to be 81.25% and Kapa Coefficient about 0.70% (Table 3).

Table 3. Accuracy assessment of image classification

Land Cover Types	Ground truth					total	PA(%)	UA(%)
	MDF	DDF	AL	BL	W			
MDF	2	0	0	0	0	2	66.67	100.00
DDF	0	29	3	5	2	39	90.63	74.36
AL	1	3	29	1	0	34	90.63	85.29
BL	0	0	0	1	0	1	14.63	100.00
W	0	0	0	0	4	4	66.67	100.00
Total	3	32	32	7	6	80		
Overall Classification Accuracy:						81.25		
Kapa Coefficient:						0.70		

3.2 Landsat image classification (2005-2016)

The objective of the image classification is to determine the change in land cover particularly, the attention to five classes of distribution namely mixed deciduous forest, dry dipterocarp forest, agriculture land, built-upland, and water area, For the land cover classification Landsat TM and Landsat OLI images were used. Supervised classification and change detection analysis methods were applied to land cover change between two time periods

(2005 and 2016). The result of the land cover classification shows that the forest is major, mainly forest is mixed deciduous, which is followed by dry dipterocarp and agriculture land. The other land cover types of different dated image data are given below: In 2005, Landsat -5 (TM) was used for satellite image classification. According to the results of land cover classification (Figures 3. And 4) showed that in 2005, dry dipterocarp forest covered 108,920 (ha), mixed deciduous forest 81,400.11 (ha), water 1,280.54 (ha), agriculture land 19,336.80 ha, and built-upland 399.98 (ha) which consist of 51.54%, 38.52%, 9.11%, 0.61%, and 0.19% respectively.

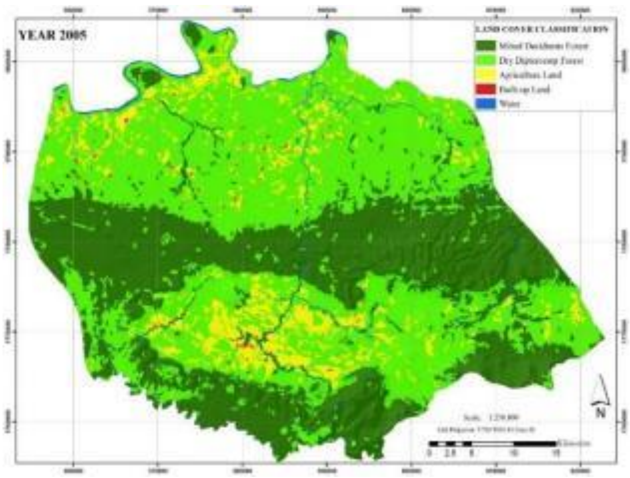

Fig.3. Land Cover Classification in 2005

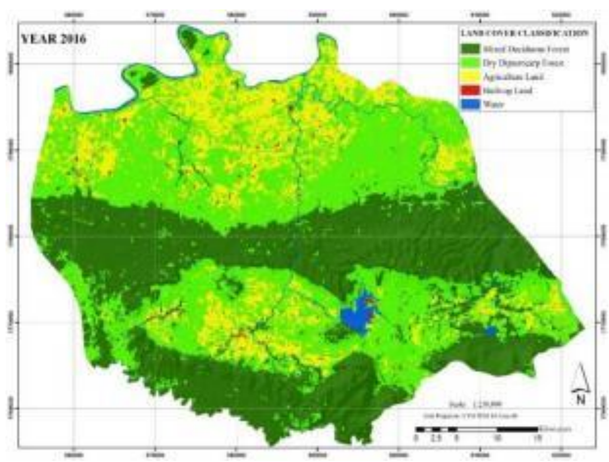

Fig.4 Land Cover Classification in 2016

In 2016, Landsat-8 (OLI) was used for the satellite image classification, the land cover maps (Figure 3 and 4) shows that the mixed deciduous forest has increased to 83,200 ha (39.36%), similarly agriculture land 34,415.19 ha (16.38%), water 2,579.64 ha (1.23%) and built-up land 651.68 ha (0.31%) respectively. whereas dry dipterocarp forest decreased by approximately 90,523 ha (42.81%).

3.3 Comparison of Land Cover between 2005 and 2016

The comparison of land cover change between 2005 and 2016 showed that data registered in (Figure 5 and Table 4.) revealed the positive and negative changes that occurred in the land cover pattern of the Thapangthong District during the last two decades.

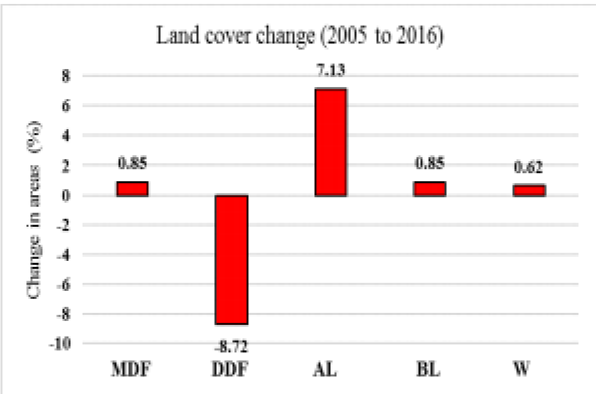

Fig.5 Diagrammatic instance of land cover change in percent between 2005 and 2016

The dry dipterocarp forest of this study area has decreased from 108,920.83 (ha) in 2005 to 90,482.96 (ha) in 2016 which accounts for 8.72% of the total study area. The mixed deciduous forest of this area has slightly increased from 81,400.11(ha) in 2005 to 83,190.78(ha) in 2016 which accounts for 0.85%. The agriculture land has increased from 19,336.80(ha) in 2005 to 34,415.19(ha) in 2016 which accounts for 7.13%. In addition to this, the built-up land from 399.98(ha) in 2005 to 651.68(ha) in 2016. This increase in built-up land accounts for 0.85%. The water in the study area has increased from 1,280.54(ha) in 2005 to 2,597.64(ha) in 2016 which covered 0.62%.

From 2005 to 2016, the result of data analysis found that mostly the dry dipterocarp forest was decreased to convert the agriculture land Table 4 and also slightly mixed deciduous forest was converted into agriculture land, On the other hand, there are some types of forest cover and land use were converted to a water body. However, some agricultural land turned into mixed deciduous forests as well. There are some reasons for the conversion of land cover in the past two decades. the rate of land converted from forest cover to agriculture land due to the population was increased faster and the economic expectation of the farmers change their future views from subsistence to an economic perspective. Otherwise, according to Savannakhet Irrigation Section (SIS-PAFO, 2014). There is a China project (China Gezhouba Group Corporati ... C was established in the year 2011. The totalarea is 2000 hecta ... er intake structure, dam, water reservoir, flood spillway, cana ... O, 2014). The project could be supported water to agriculture ... on and rainy season. However, the land use and forest cover wer ... dy rice, garden, etc. A village was flooded by water thus they m ... re six villages were affected by the reservoir (Figure 6).

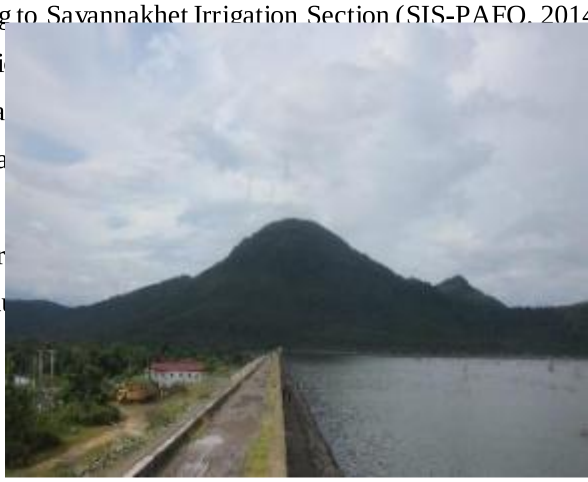

Fig.5 Clear the dry dipterocarp forest for agriculture land

Fig.6 Characteristic of Xesalalong Irrigation Reservoir

The land cover changed in Thapangthong District, Savannakhet Province, LaoPDR between 2005 to 2016 by Landsat satellite imagery (Landsat-5 TM acquired on 2005-01-03 and Landsat-8 OLI acquired on 2016-03-22 date). The method of image classification used maximum likelihood classification (MLC) for the supervised classification, there are five classes of land cover. Land cover types were classified by using Landsat satellite image data such as mixed deciduous forest, dipterocarp forest, agriculture land, built-upland, and water body. Between the years 2005 to 2016, The result of this study shows that type of dry dipterocarp forest decreased dominant (18,437.87 ha) that 8.72 %, whereas agriculture land increased at (15,078.39 ha) by 7.13%; followed by built-upland (25.64 ha) 0.85%; water body at (1,317.10 ha) 0.62% and mixed deciduous forest was slight increase about 1,790.68(ha) and 0.85% of the total study areas respectively, see the Table 3. As the result received from remote sensing and GIS, there are some reasons for land cover change in Thapangthong district, especially the forest cover was converted to agriculture land due to the population having increased faster. Otherwise, the agriculture land was expanded by villagers for paddy rice, gardens, etc. In addition to some forest cover and land use were converted to water bodies, because in the year 2014, the LC was flooded by a reservoir of the Xesalalong Irrigation Project (Savannakhet Irrigation Section, 2014). There are 2000 hectares of the total reservoir area, a length of 22 km of the canal, and water can be supported by plantations and livestock during the rainy season and dry season. Many researchers have used the remote sensing (RS), geographic information system (GIS) technique to assess the forest cover and land-use/land-cover changes (Butt*etal.*, 2015; Olokeoguna *et al.*, 2014; Rai, 2013; Reis, 2008; Manonmani*et al.*, 2010). Similarly, using Landsat satellite imagery to assess the land use and land cover change of Phoukhaokhouay National Protected Area, Lao PDR, to examine the rate of change of land use and land cover change between 1999 to 2014, the image classification was conducted by maximum likelihood classification (MLC) of supervised classification, the result found that forest cover has decreased by 1.11%, from the evergreen forest, mixed deciduous forest to agriculture. Depending on the data of ground truth in the field survey, thus the overall accuracy of remote sensing (RS) and geographical information system (GIS) estimated value was 82% (Chanthakhad, 2015). Impact of land use and land cover change on local livelihood in Pha-Oudom District, Borkoe Province, LaoPDR (Daovorn, 2004) to examine the land cover change through selected villages between the years 1988 to 2017, For the image interpretation was used the supervised of the maximum likelihood classification (MLC) thus the result reveal changes between 1988 to 2007 the landscape were foreseen largely for subsistence upland rice, whereas the data analysis of image interpretation shown a slow change of mature forest to secondary forest and agriculture.

4 Conclusion

The study concludes that the mostly dry dipterocarp forest of this study area has decreased from 108,920.83 (ha) in 2005 to 90,482.96 (ha) in 2016 which accounts for 8.72% of the total study area. Whereas the agriculture land has increased from 19,336.80(ha) in 2005 to 34,415.19(ha) in 2016 which accounts for 7.13%. Following the built-up land from 399.98(ha) in 2005 to 651.68(ha) in 2016. This increase was in the built-up land account for 0.85%. In addition, the water in the study area has increased from 1,280.54(ha) in 2005 to 2,597.64(ha) in 2016. In addition, for classification accuracy assessment, the overall classification accuracy of the map was found to be 81.25% and Kapa Coefficient was about 0.70% Table 3.

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