LAND USE AND LAND COVER CHANGES IN MONG HSAT TOWNSHIP, EASTERN SHAN STATE

Myint Myint Sein[1], Nilar Aye[2], Khun Maung Cho[3], Khin Htay Myint[4]

Abstract

The study area Mong Hsat Township is situated in the Eastern Shan State, bounded on the north by Kyaing Tong Township, on the south by Thailand and on the east by Tachileik and west by Mong Tong townships. It lies between North Latitudes 20°5' 00" and 21° 43' 54", East Longitudes 99° 00' 00"and 99° 40' 00". Being on Shan massif, it has a lot of mountains and a few plains. In Mong Hsat Township, the classification of land use is based on GAD (General Administrative Department) and classified into four types of land use: Forest Area, Agricultural land, Built up Area,Water body and Bare lands. The proportional types of land use in the total area were comprised fallow land 71.33% followed by forest area 19.27%, agriculture land 9.2% and built up area 0.2% respectively. This data are not changed for a long time. In the study area changes of land use and land cover types are studied for 2000 and 2020 based on Landsat 7 and Landsat 8. By studying the changes of LULC between 2000 and 2020, forest area was **decreased** whereas the other LULC types such as settlement or Built up area, agriculture, water body and bare land were apparently seen the **increased** direction within twenty years period. In the overall changes, forest area was decreased from 2753.37 sq.km in 2000 to 1688.43 sq.km in 2020. The other areas of LULC changes were increased: agriculture from 361.83 sq.km to 945.36 km, settlement from 125.52 sq.km to 274.95 sq.km, bare land from 96.97 to 374.72 sq.km and water body 13.94 sq.km to 95.77 sq.km Therefore, the application of GIS/RS methods are to best estimate the temporal and spatial changes of the land use and land cover from the standpoint of natural resources management. It indicates that the land use pattern of office data had not been markedly changed during the period from 2000 to 2020. But the land cover areas in GIS/RS method had been clearly changed on images.

Keywords*:* LULC, GIS, RS, Mong Hsat

Introduction

Land use and land cover change (LUCC) is increasingly recognized as an important driver of environmental change on all spatial and temporal scales (Turner et. al., 1993). By viewing the challenges of the Earth, land use and land cover changes are likely to be the most significant year after year. As the anthropogenic process affected on many parts of the earth's system, climate, hydrology, global biodiversity, and environmental sustainability were experienced the deterioration in the respective spatial location. Thus, Mong Hsat is one of the spot areas on the Earth surface facing LULC change.

When it comes to the research study, Mong Hsat Township was composed of 4,911.5 sq.km (1,896.34 sq. miles) with 9 wards and 26 village tracts including Mongkhoke before 2002. However, Mongkhoke was composed of 3 wards and 6 village tracts after 2002. It was organized separately as sub-township level and excluded from Mong Hsat Township since then. Therefore, Mongkhoke sub-township is not taken into consideration in this research paper.

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In the previous time, Mong Hsat was governed by the Sawbwar. At the present time, it is composed of 6 wards, 20 village tracts and 168 villages.

In the process of studying LULC in Mong Hsat Township, Satellite Imageries with time-interval will mainly be applied and analysed by using Geographic Information Systems (GIS) software platform.

Study Area

Mong Hsat Township is one of ten townships of Eastern Shan State. It lies between North Latitudes 20°5' 00" and 21° 43' 54", East Longitudes 99° 00' 00"and 99° 40' 00". It is 72.42 kilometres (45 miles) wide from east to west and 104.61 kilometres (65 miles) long from north to south and the area is 3,352.24 square kilometres (1,294.81 square miles). It is surrounded by lofty mountains. It is fairly compact in shape. The study area is bounded on the north by Kyaing Tong Township, on the south by Thailand and on the east by Tachileik and west by Mong Tong townships (Figure 1). It is situated at an elevation about 572 meters (1,875 feet) above sea level.

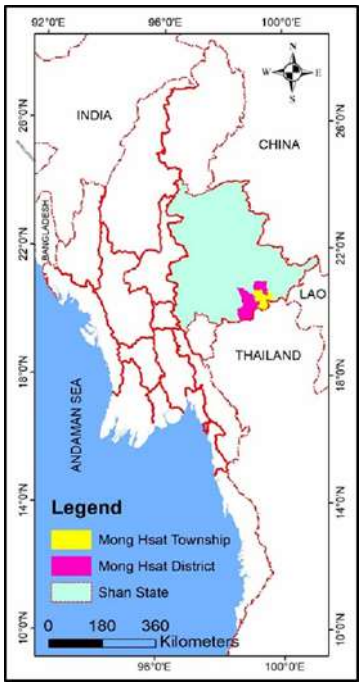

Figure 1. Location of Mong Hsat Township
Source: Myanmar Information Management Unit (MIMU_2019).

Aims

The aim of this research is to examine the Land Use and Land Cover changes pattern in the study area.

Objectives

The objectives are comparatively study to the changes of LULC types that derived from the governmental office data and remote sensing Satellite Imageries by using the application of GIS/RS methods.

Materials And Methods

Materials

There is no ideal classification of land cover, and it is unlikely that one could ever be developed. In attempting to develop a classification system for use with remote sensing techniques that will provide a frame work to satisfy the need of the majority of users, certain guidelines of criteria for evaluation must first be established (J.R. Anderson. et al.).

Land use and land cover are not separated to each other and originally closely related to each other as well. Thus, the source of data in this analysis will be applied as satellite imageries with multi-spectral scanner.

The major information of LULC is mainly obtained from Landsat TM 7 and Landsat TM 8 images with 30 metres resolution in (Table 1). The temporal variations of LULC have been revealed by different time periods of image classification data which is mainly based on object base image classification. The ground survey checking has been used as data validity of LULC classification.

Moreover, Universal Transverse Mercator (UTM) map with the scale of 1:50,000 was applied in this research. Based on those based maps, vector point of settlement's (town or village) location was created as a point algorithm and displayed on the map for ground truthing where the settlement position was. These functions help the right training samples of LULC classification as well.

Table 1. Description of the Satellite Image used in the Study

Satellite	Sensor	Date acquired	Bands used	Wavelengt (µm)	Spatial Resolutio	WRS Path/Ro
Landsat 7	Thematic Mapper (TM)	2000	Band 1 Visible blue	0.45 - 0.52	30 m	131/45
			Band 2 Visible green	0.52 - 0.60	30 m	
			Band 3 Visible red	0.63 - 0.69	30 m	
			Band 4 Near-Infrared	0.76 - 0.90	30 m	
			Band 5 Near-Infrared	1.55 - 1.75	30 m	
			Band 6 Thermal	10.40 - 12.50	120 m	
			Band 7 Mid-Infrared	2.08 - 2.35	30 m	
Landsat 8	The Operational Land Imager and Thermal Infrared Sensor (OLI_TIRS)	2020	Band 1 Coastal / Aerosol	0.433 - 0.453	30 meter	131/45
			Band 2 Visible blue	0.450 - 0.515	30 meter	
			Band 3 Visible green	0.525 - 0.600	30 meter	
			Band 4 Visible red	0.630 - 0.680	30 meter	
			Band 5 Near-infrared	0.845 - 0.885	30 meter	
			Band 6 Short wavelength infrared	1.56 - 1.66	30 meter	
			Band 7 Short wavelength infrared	2.10 - 2.30	60 meter	

Methods

Image classification was carried out to classify the land cover type in the study area. Generating a thematic map from digital remote sensing imagery by first clustering pixel are processed into classes according to their spectral similarity then using the researcher's knowledge of the area to be able to label spectral classes as a feature of interest.

In the LULC identification process, the solely geospatial techniques: GIS software 10.8.1 was operated in this research. To generate the LULC classes, False Colour Composite was used as a training sample (Trolle et al., 2019). Thus, the total training sites are collected

1,037 and 1,787 polygon samples with a variety of LULC classes in 2000 and 2020 to capture spectral variability respectively.

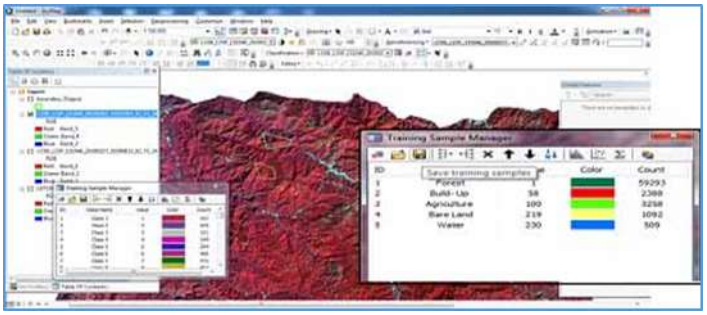

Figure 2. Training sites for five classification of false colour composite image

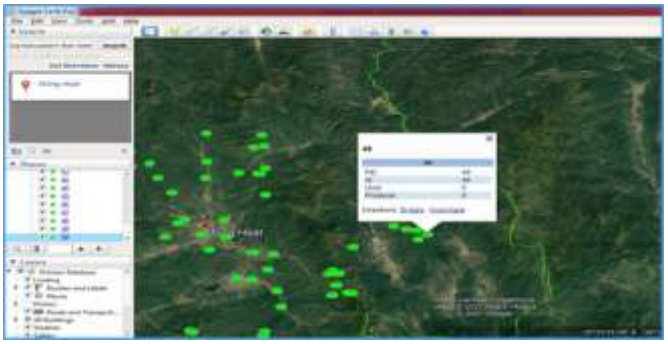

Figure 3. Connect points with Google Earth for ground truth checking
Source: Google Earth Pro

This process needs a number of training sites for all the classes spread across the study area. At that time, Maximum Likelihood Classifier was applied to extract LULC classes information from satellite images and declare training sample to be transformed as respective LULC classes. Then, the information from Satellites Imageries were classified into five LULC classes: agriculture land and bare land, built-up area, forest, and water-body in (Figure 2and 3).

Results and Discussion

Field Survey and Accuracy assessment

In the case of field survey, the wide-spread ongoing global pandemic of coronavirus disease 2019 makes a tough period for personally ground truthing. Instead of this activity, Google Earth Pro helps in checking the consistent between the data actually measured in the field and the classified remote sensed images.

The most common way to assess the accuracy of a classified map is to create a set of random points from the ground truth data and compare that to the classified images data in a confusion matrix.

In this study, LULC is defined with 50 sample points based on field observation and map measurement (satellite imagery). Water body is found 13 points (8 points on 2000 image and 5 points on 2020 image) in field observation and also found on map. So, it shows percentage accuracy with 100% in user (ground) and producer (imagery). Sometimes, types of land cover are

not the same situation in user (ground) and producer (imagery). For example, study on agriculture lands has engaged only agriculture with 12 points, 5 points are reached on other land used types such as settlement with 3 points and 2 points on bare land.The two variations of referenced between user accuracy and producer's accuracy are:_

Kappa Coefficient(T) for 2000 image = (TS*TCS)- ∑(column total X Row total)/ X 100 TS2 - ∑(column total - Row total) = 84%

Kappa Coefficient(T) for 2020 image = (TS*TCS)- ∑(column total X Row total)/ X 100 TS2 - ∑(column total - Row total) = 86%

This description can be considered to other check points of LULC types respectively. Table 2 and 3 show the five types of LULC comparison with error matrix of ground check points and satellite imagery (2000 and 2020). According to the calculation and observation data, the overall accuracy of 84% for 2000 and 86% for 2020 are defined i.e., the high enough for use.

Kappa Coefficient

TS = Total number of specified pixel

TCS = Total number of correctly classified pixels

Table 2. Accuracy Assessment for 2000

	Forest	Settlement	Agriculture	Water body	Bare Land	Total (user)
Forest	11	0	0	0	0	11
Settlement	1	8	1	0	0	10
Agriculture	2	0	8	0	0	10
Water body	1	1	1	8	0	11
Bare land	0	0	1	0	7	8
Total (producer)	15	9	11	8	7	50

Source: Landsat 7 (2000), Google Pro and Field Survey

Table 3. Accuracy Assessment for 2020

	Forest	Settlement	Agriculture	Water body	Bare Land	Total (user)
Forest	17	0	0	0	0	17
Settlement	1	3	3	0	0	7
Agriculture	0	0	12	0	0	12
Water	0	0	0	5	0	5
Bare land	1	0	2	0	6	9
Total (producer)	19	3	17	5	6	50

Source: Landsat 8 (2020), Google Earth Pro and Field Survey

The tabulation of accuracies, which is **user accuracy** and **producer accuracy**, per individual LULC class are illustrated in Table 2 and 3. Thus, the reflected pixel value of Satellite Images of LULC classes and the ground truth point from Google Earth Pro were checked how much consistency is? **Kappa coefficient**, the final calculation of those reference pixels and correctly classified pixels (diagonal) is resulted 84 % and 86% in each time frame, 2000 and 2020 respectively. As the Cohen's Kappa coefficient interpretation, it is revealed that almost perfect agreement because the minimum of those satisfied agreement level is 85%.

LULC Distribution Pattern

The area composition of LULC in Mong Hsat Township in Table 4 and Figure 4.

Table 4. Types of LULC Condition in Mong Hsat Township

No.	LULC Types	2000		2020	
		Area (sq.km)	%	Area (sq.km)	%
1	Forest	2,753.97	82.15	1,688.43	50.37
2	Settlement	125.52	3.74	274.95	8.20
3	Agriculture	361.83	10.79	945.36	28.20
4	Water Body	13.94	0.42	95.77	2.86
5	Bare Land	96.97	2.89	347.72	10.37
Total		3,352.24	100.00	3,352.24	100.00

Source: Landsat 7 and Landsat 8

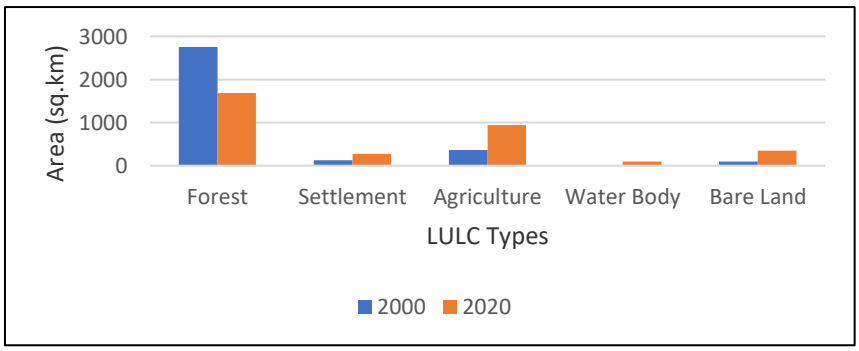

Figure 4. Area Composition of LULC Types in 2000 and 2020
Source: Table 4

By studying the changes of LULC between 2000 and 2020, forest area was in the **decreased** trend, whereas the other LULC types such as settlement, agriculture, water body and bare land were apparently seen in **increased** direction within twenty years period.

The most significant change area of LULC types was found in forest land. The change in forest area was the largest change of land use and land cover during the 20 years period from 2000 to 2020. In 2000, the forest area was 2,753.37 sq.km which accounted for 82.15 percent of the total study area. However, in the year 2020, it was decreased to 1,688.43 sq.km which accounted for 50.37 percent of the study area. The decrease of forest area during the 20 years period was 1,065.54 sq.km with 31.79% (Table 5, Figure 5 and Figure 6). The decrease of forest area was due to the expansion of population and deforestation in the study area.

The other changes of LULC types were agriculture land which was occupied 361.83 sq.km in 2020 and 945.36 sq.km in 2020. It was increased 583.53 sq.km or 17.41% during twenty years' time span. Population number and agriculture land is directly correlated with each other. Therefore, the more population number was increased, agriculture land was also increased. The other LULC types such as bare land, settlement and water body area were increased with less changes of 250.75 sq.km or 7.48%, 149.43 sq.km or 4.46% and 81.83 sq.km or 2.44% respectively (Table 5, Figure 5). The increased area of agriculture land and settlement area was subjected to population number increased as well. The total population was 70,065 persons in 2017 and 8,8516 persons in 2019. It was increased 1,8451 persons even during 3 years period.

Table 5. Changes of LULC Types in Mong Hsat Township

No.	LULC Types	2000		2020		Increase or Decrease	
		Area (sq.km)	%	Area (sq.km)	%	Area (sq.km)	%
1	Forest	2,753.97	82.15	1,688.43	50.37	-1,065.54	-31.79
2	Settlement	125.52	3.74	274.95	8.20	149.43	4.46
3	Agriculture	361.83	10.79	945.36	28.20	583.53	17.41
4	Water Body	13.94	0.42	95.77	2.86	81.83	2.44
5	Bare Land	96.97	2.89	347.72	10.37	250.75	7.48
Total		3,352.24	100.00	3,352.24	100.00		

Source: Landsat 7 and Landsat 8, Google Earth Pro

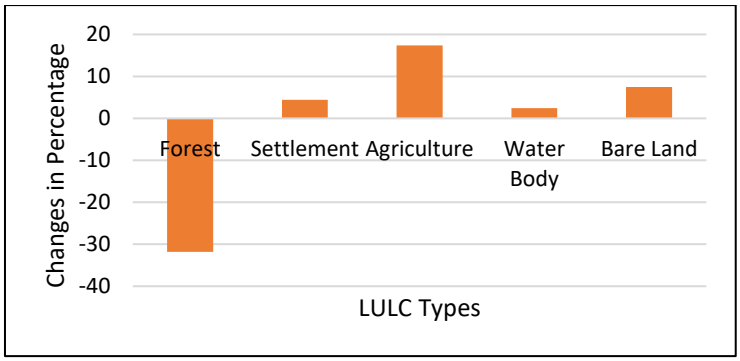

Figure 5. Changes in Percentage of LULC Types between 2000 and 2020
Source: Table 6

After classification, land cover map is produced. To get the ground truth for image classification and accuracy assessment, many sample points are surveyed in the field. These sampling points cover all land cover classes of the classified satellite image. Considering the accessibility, these points are not randomly distributed but practically selected for convenience purpose. Figure 6 shows the land cover classification of the study area for the years 2000 and 2020 respectively.

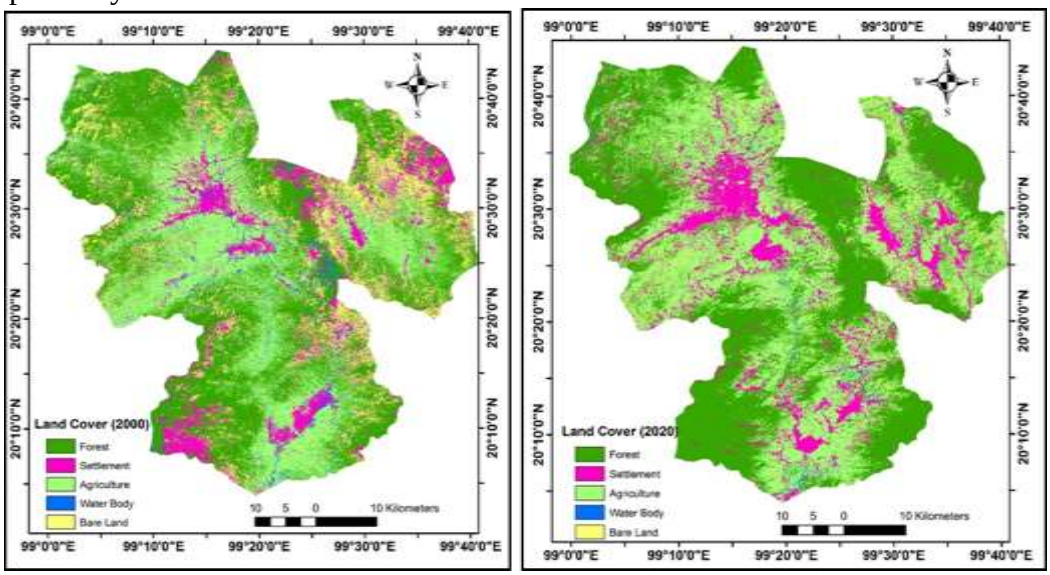

Figure 6. Changes Area of LULC Classification in the Study Area (2000 and 2020)
Source: Landsat 7 ETM and Landsat 8 (OLI_TIRS) satellite image, 30 m resolution

Change Matrix of LULC Types in Mong Hsat Township

In the change matrix portion, the retrieved sources of data from Landsat 7 and Landsat 8 were portrayed over twenty years period between 2000 and 2020 in the study area of Mong Hsat Township. This matrix table shows the main information of LULC categories. The detailed results of LULC change is shown in Table 4. The bold or highlighted grid cells were shown the stable or no change area in the respective types whereas the other cells were illustrated the dynamic or change types of LULC.

In the overall changes, forest area was decreased from 2753.37 sq.km in 2000 to 1688.43 sq.km in 2020. The other areas of LULC changes were increased: agriculture from 361.83 sq.km to 945.36 km, settlement from 125.52 sq.km to 274.95 sq.km, bare land from 96.97 to 374.72 sq.km and water body 13.94 sq.km to 95.77 sq.km Table 6.

Table 6. **Land Cover Change Area (sq.km) between 2000 and 2020**

LULC (2000)	LULC (2020)						
		Forest	**Settlement**	**Agriculture**	**Water Body**	**Bare Land**	**Total in 2000**
	Forest	**1,688.43**	131.68	713.61	54.77	165.48	2,753.97
	Settlement	-	**33.10**	46.81	17.55	28.07	125.52
	Agriculture	-	64.26	**152.81**	19.83	124.92	361.83
	Water Body	-	1.61	7.27	**0.82**	4.24	13.94
	Bare Land	-	44.30	24.86	2.80	**25.01**	96.97
	Total in 2020	1,688.43	274.95	945.36	95.77	347.72	3,352.24

Source: Satellite Imagery 2000 and 2020

Changes of LULC Types in Mong Hsat Township

During twenty years period, from 2000 to 2020, there are three types of changes in LULC types: positive change, negative change and no change in Mong Hsat Township. The positive changed area is found 1,066.72 sq.km, the negative changed with 385.36 sq.km and no change area with 1,900.18 sq.km respectively (Table 7).

Table 7. Changes of LULC Types within 20 years period

Increased Change		Decreased Change		No Change	
Land Cover Type	**Area (sq-km)**	**Land Cover Type**	**Area (sq-km)**	**Land Cover Type**	**Area (sq-km)**
Forest to Agriculture	418.68	Forest to Bare Land	143.20	Forest to Forest	1,688.43
Bare Land to Agriculture	24.86	Agriculture to Bare Land	124.92	Bare Land to Bare Land	25.01
Forest to Settlement	48.84	Forest to Water Body	44.75	Agriculture to Agriculture	152.82
Bare Land to Settlement	44.30	Settlement to Bare Land	28.07	Settlement to Settlement	33.10
Bare Land to Forest	22.28	Bare Land to Water Body	2.81	Water Body to Water Body	0.82
Agriculture to Settlement	64.26	Agriculture to Water Body	19.83		
Agriculture to Forest	294.93	Settlement to Water Body	17.55		
Settlement to Forest	82.85	Water Body to Bare Land	4.24		
Settlement to Agriculture	46.82				
Water Body to Forest	10.03				
Water Body to Agriculture	7.27				
Water Body to Settlement	1.60				
Total	1,066.72	Total	385.36	Total	1,900.18

Source: Satellite Imagery 2000 and 2020

Spatially, the **increase changed** area was distinctly found in the southern and western parts of Mong Hsat Township (Figure 7 and Figure 8). Those areas are converted **from forest**

land to agriculture land and then from agricultural land to settlement area. In addition, the **decrease changed** areas are found as scatter patterns within the whole of the study area. It was discovered **the transition from forest to bare land area and water body**. Lastly, Most of the Mong Hsat area are found **no changed** areas especially in the northwest parts and in the eastern peripheral area of the township (Figure 8). In the stable area, villages and settlement area is not found in the higher elevation and rugged ranges region. The range of elevation between 943 and 1,149, 1,149 and 1,397, and 1,397 and 2,104 meters are rarely found settlement settled area. Moreover, no villages are found in altitude above 1,397 meters.

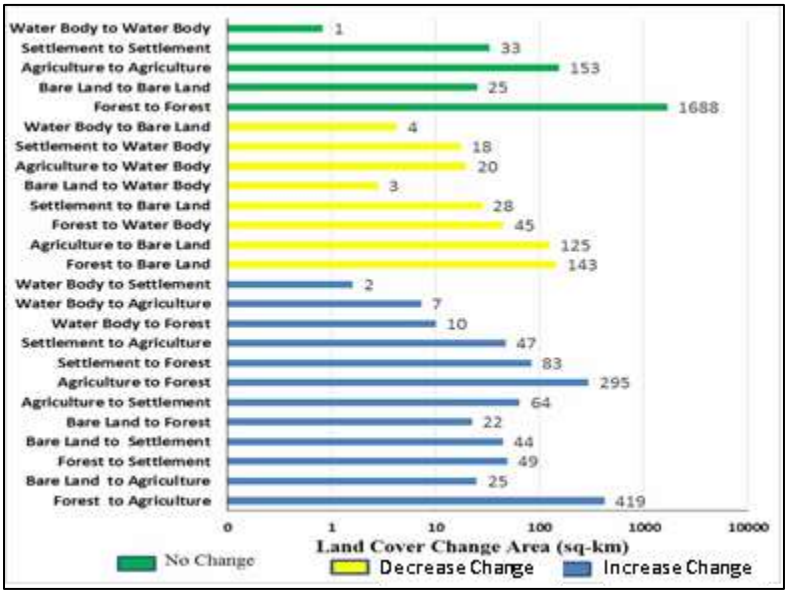

Figure 7. Land Cover Change Types for 2000 and 2020
Source: table 7

In the changes pattern, the prominent one is settlement among five types of land use and land cover. These changes are especially found in the urban area Figure 9.

For the Mong Hsat, the settlement or built up areas were 6.66 sq km in Office data, but on the 2020 satellite image, the area of settlement land is 125.52 square kilometers and on the 2020 satellite image, the area of settlement land is clearly increasing to 274.95 square kilometers. These land use areas are not changed in office records, although the area under settlement area changed as positive change which revealed in GIS-RS images. Beside the land use for railway, roads, and industrial are double records for the settlement or built up areas in the office data. These records are not included as double on images.

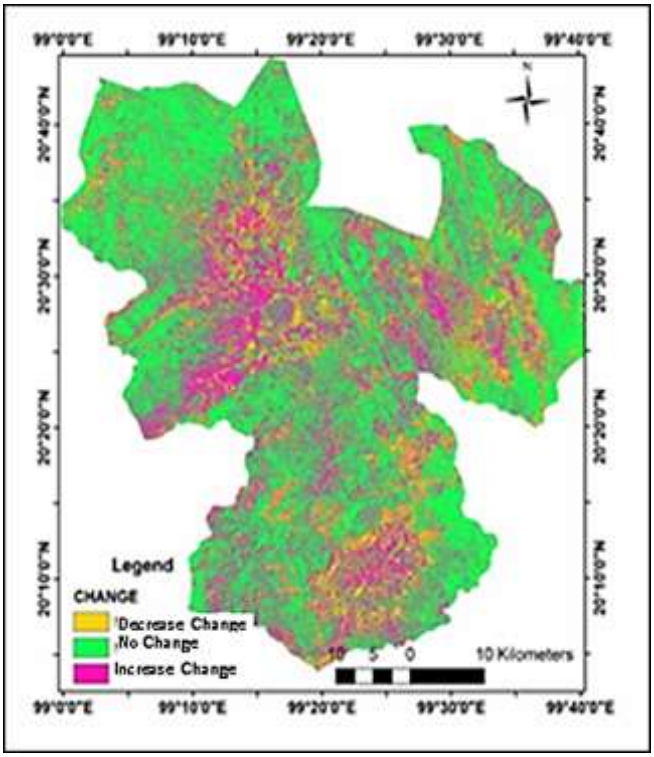

Figure 8. LULC Change Types of Mong Hsat Area (sq.km)
Source: Satellite Imagery 2000 and 2020

Change Detection

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it in different times (Singh, 1989). This is considered an important process in monitoring LULC because it provides quantitative analysis of the spatial distribution.

In the change detection portion, change matrix from the reference source Landsat 7 and Landsat 8 were analysed over 20 years period between 2000 and 2020. Change matrix displays the key information of LULC. (Shalaby and Tateishi, 2007).

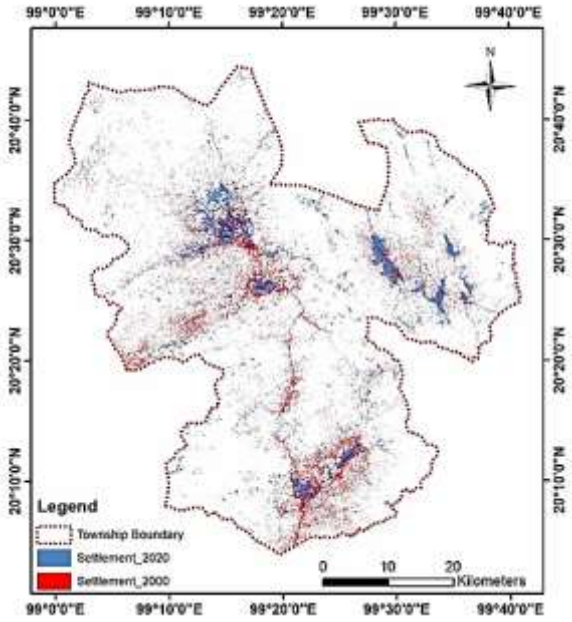

Figure 9. Changes of Settlement Pattern between 2000 and 2020
Source: Landsat 7 and Landsat 8

The detail result of change matrix is shown in (Table 6). Mong Hast Township is composed of six wards and twenty village tracts. The total area cover is 3,352.24 square kilometres (1,294.81 square miles). The statistical data of land use in Mong Hsat Township is applied from the Department of Agricultural Land Management and Statistics (DALMS) office data in 2019.

Types of land use vary from rural area to urban area in Mong Hsat Township. Generally, built up area and agriculture land are found in the urban area and near the environs of settlement pattern. However, forest area and fallow land are fairly occurred in the remote area.

Table 8. Land Use Types and Its Proportional Area in Mong Hsat Township (2019)

No.	Type of Landuse		Area (sq.km)	Area (sq.km)	%
1	Forest Area		645.96	645.96	19.27
2	Build up Area	Industrial Land Area	0.04	6.66	0.20
		Urban Settlement	1.40		
		Rural Settlement	5.22		
3	Agriculture Land	Le Land	50.15	308.50	9.20
		Ya Land	75.16		
		Taungya Land	44.60		
		Garden Land	132.09		
		Uncultivable Land	6.49		
4	Fallow Land	Le Land	0.40	2,391.12	71.33
		Ya Land	3.36		
		Wild Land	1,167.81		
		Virgin Land	1,219.54		
Total				3,352.24	100.00

Source: Compiled by Researcher based on DALMS, Mong Hsat

According to the available data, the change area or type of land use cannot be compared, because the acquired data is only one year. Therefore, only land use data in 2019 can be described in Table 8 and Figure 10. The proportional types of land use in the total area comprised fallow land 71.33% followed by forest area 19.27%, agriculture land 9.2% and built up area 0.2% respectively.

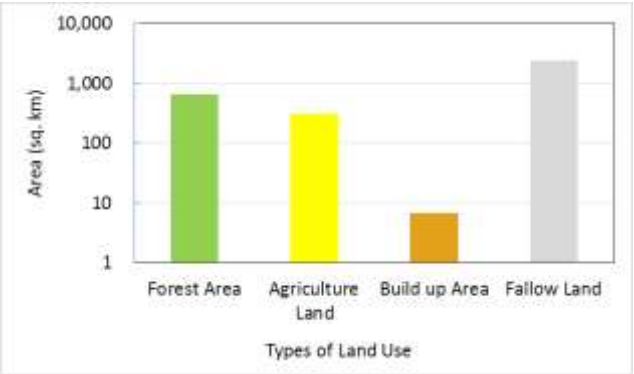

Figure 10. Types of Land Use and Its Proportional Area in Mong Hsat Township (2019)

Source: Table 8

Forest area is the second largest proportion in the study area. By the quantitative data, forest area covers 19% or 645.96 sq.km of its township. This area is especially found in the higher elevation area in the peripheral region of its township where the settlement pattern is sparse.

This area is especially found in the urban area and rural settlement pattern gathered area. It was accounted for the least area among land use area in its township. Built up area includes industrial land area, urban settlement area and rural settlement area with 0.04, 1.4 and 5.22 square kilometres respectively. The total area was 6.66 square kilometres and constituted as 0.2 percent of its township area Table 8 and Figure 10.

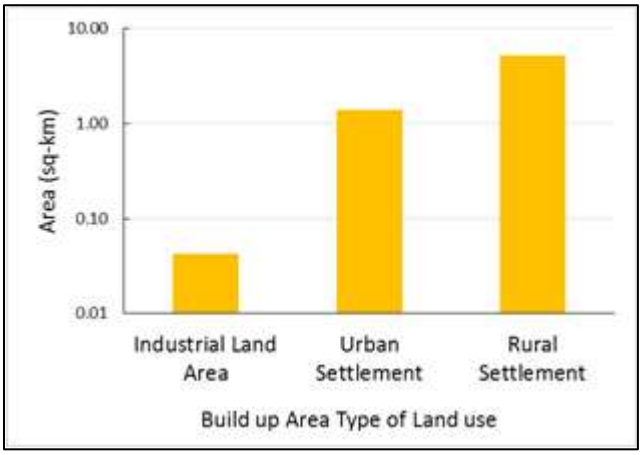

Figure 11. Built up Area Type of Land Use in Mong Hsat Township (2019)
Source: Table 8

Agriculture is the main economic activity and widely spread in Mong Hsat and represented the third largest area of its township. Garden land was composed of 132.09 square kilometres, followed by *Ya* land with 75.16 square kilometres, Le land was accounted for 50.15 square kilometres, Taungya land with 44.6 square kilometres, and Uncultivable land for agriculture with 6.49 square kilometres. The most significant one in agriculture land is garden land which is occurred the highest area in its land use pattern Table 8 and Figure 12. The cultivated land is widely spread in the whole township.

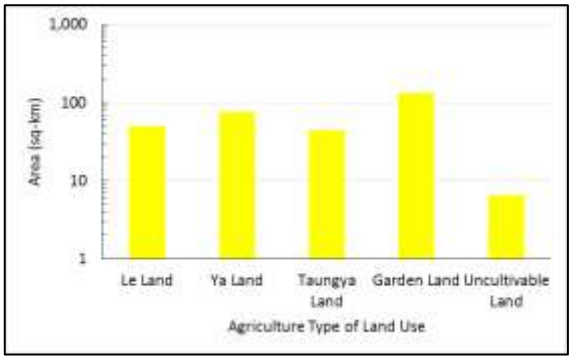

Figure 12. Agriculture Land Type of Land Use in Mong Hsat Township (2019)
Source: Table 8

Fallow Land is the most dominant type of land use in Mong Hsat Township. It was comprised the largest area with 71.33% and 2391.12 square kilometres of its township Table 8 and Figure 13. Fallow land covered three fourths or three quarters of its township area. Among them, Virgin land is found 1219.54 sq.km, Wild land with 1167.81 sq.km, Ya land with 3.36 sq.km and Le land with 0.4 sq.km respectively.

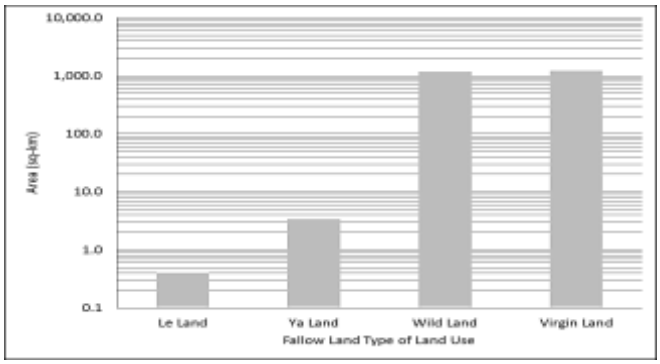

Figure 13. Fallow Land Type of Land Use in Mong Hsat Township (2019)
Source: Table 8

Conclusion

Land use and land cover (LULC) is the most prominent configuration of the environmental change phenomenon occurring at spatial and temporal scales. This research is conducted to identify the LULC changes pattern in the two time-frames of 2000 and 2020 in Mong Hsat Township. LULC classes had been produced on the basis of remote sensing Landsat data sources.

The population or the residing people in a particular area plays an important role for the changing pattern of land use and land cover. In the study area, the growth of population is the major factor for degradation of soil and deforestation which in turn caused to change both land use and land cover of the study area.

In Mong Hsat Township, the main drivers of LULC change are physical setting and social factors. Based on the physical environments such as relief and drainage, natural vegetation, soil and climate, the existence of land use and land cover is the existing LULC types. As well as the non-physical factors such as demographic factors: population, population growth, distribution and density and housing number is also affected on land use and land cover. Thus, human activity is the most important driving force for land use and land cover change especially population growth.

The total population was 70,065 persons in 2017 and 8,8516 persons in 2019. It was increased 1,8451 persons even during 3 years period.

In the accuracy validation process, the remote sensing images and ground truth (Office data) data were compared and checked to be consistent with those sources of data.

The types of land use recorded by General Administrative Department (GAD) shows that the area of the reserved forest and protected forest in Mong Hsat Township are 645.96 sq.km, but on the image the remaining forest area is 1688.43 sq-km, therefore about 1000 sq-km area of forests are not found, although 713 sq-km which is far from the area of the agriculture cover as revealed by the GIS–RS images. Likewise, the areas of the office data for the Fallow Land areas 2391 sq-km are revealed as Bare Land (347.72 sq-km), Agriculture (945.36 sq-km), Settlement (274.95 sq km), Water Body (95.77 sq km) and other spreading in Forest covered by GIS- RS images has been observed. Therefore, bare land cover on images are significant differences with the office land used data. Water Body area is not defined at office land use data. Fallow lands are also being used on satellite imagery as bare lands and agricultural lands, as well as settlement areas and water body areas.

For this reason, the land cover estimation is seen to be fairly good as compared to the total land use area recorded by GAD of the Mong Hsat. Office data does not show land use and land cover by location, but satellite imagery and google images show the actual use of different types of land use on the ground. The sequences of the land cover changes are seen to be "from forest to agricultural lands", "from agricultural lands to settlement" as the increasingly changed from 2000 to 2020, 20 years periods. In the study area, the settlement or built up areas were 6.66 sq. km in office data, but on the 2020 satellite image, the area of settlement land is noticeable increasing to 274.95 square kilometers because of population growth. Therefore, the application of GIS/RS methods are best estimate for the temporal and spatial changes of the land use and land cover particularly agriculture and settlement types of land cover in the whole of Mong Hsat Township from the standpoint of natural resources management.

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