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Analysis of Environmental and Climate Change for Pyin OO Lwin using Geographic Information System (GIS)

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Abstract
Global warming and Climate Change becomes very serious issue since last decade. Deforestation and Urbanization are the main cause of global warming. The research intends to analyze how deforestation and urbanization has affected the environmental and climate change in Pyin OO Lwin Township, Myanmar. For analyzing deforestation and urbanization, remote sensing and geographic information system (GIS) technologies plays important roles. Landsat images from United States of Geological Survey (USGS) are applied for the research. Other required ancillary data are obtained from government offices. ArcGIS software, urban landscape analysis tool (ULAT) and Google Earth Explorer are used for implementation and analysis work. Maximum likelihood classifier and random forest classifier are used for classification work. A system which can provide the information concerned with temperature changes, percentage for loss of forest area, green space diversity and urban area growth in Pyin OO Lwin Township using Geographic Information System (GIS) is implemented. This information can be applied for environmental conservation and urban planning by regional decision makers. Based on the analysis result, it can also support weather forecasting and climate change detection systems.

Keywords: Deforestation, Geographic Information System, Maximum Likelihood Classification, Urbanization

1. Introduction
It is estimated that the world population have reached 7.6 billion as of December 2017[1]. Due to increasing population, global warming and greenhouse effect emission becomes severe problems all over the world today. Apart from increasing population, urban expansion and deforestation can also lead to climate change.

Myanmar is blessed with an abundance of natural resources including minerals and energy potential, and fertile ecological zones which have traditionally provided extensive agricultural production. These resources have supported a large population and thriving civilizations over many centuries, and they continue to provide the bulk of Myanmar's economic output to this day [2].

In recent years population growth, unsustainable extraction of mineral and forest resources, over-utilization of soils and water and climate-related hazards have combined to progressively undermine the resource base on which Myanmar's economy and society are based. Deforestation, large-scale mining, habitat and land degradation and diminishing water resources are all placing pressure on the web of life supporting the Myanmar people. In addition, the environmental degradation would have great impact on climate change and climate-related disasters [3].

Land use and land cover changes due to city expansion have serious ecological consequences and pose a great deal of challenge to environmental sustainability at local and global scales.

2. Scope of Research Work
The research focuses on the urban changes and deforestation of Pyin Oo Lwin Township. Maximum likelihood classifier is used to classify the urban changes and deforestation of Pyin Oo Lwin Township. ArcGIS and urban landscape analysis tool (ULAT) are utilized for the system implementation. The research work aims to detect the percentage of deforestation and urban expansion and how these factors have affected on climate change. After analyzing the past and present land use land cover changes, yearly environmental changes of the study area will be provided. The result can be used for supporting the regional planning, policy planning and hydrological planning using these environment changes information.

3. Materials and Methods

(1) Study Area

Pyin Oo Lwin is a hill area in Madalay Region, Myanmar. It is located at North Latitude 22.0392' and East Longitude 96.4717' with an average elevation of 3,538 feet above sea level. The Township experiences a cool and pleasant weather. The total population is around 255,000 according to 2014 Census with an area of 1,990 Km^2. Over the past few decades, urban expansion occurs within the Township and the climate has been changed. Thus, it was chosen the area of interest for this research.

(2) Data

The necessary landsat images for Pyin Oo Lwin Township are downloaded from United States of Geological Survey (USGS). Landsat 5 TM is used for 2010 and Landsat 8 OLI is used for 2014 and 2017. Other ancillary data are obtained from government offices including Department of Forest, Pyin Oo Lwin City Development Committee, Ministry of Labor, Immigration and Population and Department of Meteorology and Hydrology. The land use/ land cover information for eight years duration (2010-2017) is analyzed.

(3) Methods

Maximum Likelihood classifier is used as a supervised classification method for classifying the land cover into forests, vegetation, water and others. Moreover, it is used to classify the buildup areas [4]. ULAT is utilized to classify the buildup area into Urban built-up, Suburban built-up, Rural built-up, Urbanized open land, Captured open land and Rural open land. Maximum Likelihood classification is calculated by using equation (1):

$$P(i|\omega) = \frac{P(\omega|i)P(i)}{P(\omega)} \quad (1)$$

Where P(ω|i) is the likelihood function, P(i) is the a priori information, i.e., the probability that class i occurs in the study area and P(ω) is the probability that ω is observed, which can be written as equation (2):

$$P(\omega) = \sum_{k=1}^{M} P(\omega|i)P(i) \quad (2)$$

Where M is the number of classes. P(ω) is often treated as a normalization constant to ensure

$$\sum_{k=1}^{M} P(\omega|i)$$ sums to 1.

Pixel x is assigned to class i by the rule:

$x \in i$ if $P(i|\omega) > P(j|\omega)$ for all $j \neq i$ (3)

Normalized Difference Vegetation Index (NDVI) is used for identifying forest area as a comparative analysis [5]. NDVI is calculated by using equation (4):

$$NDVI = \frac{NIR - R}{NIR + R} \quad (4)$$

For calculating land surface temperature, the following equation is used. [6]

LST = T/1+w*(T/p)*ln(e)) (5)

Where LST = Land Surface Temperature, T= Satellite temperature,

w = wavelength of emitted radiande (11.5µm),
p = h * c / s (1.438*10ˆ-2 mK),
h =Planck's constant (6.626*10ˆ-34 Js),
s = Boltzamn constant (1.38*10ˆ -23 J/K), c = Velocity of light (2.998*10ˆ8m/s),
e = Land Surface Emissivity

4. Results

Firstly, the land use land cover data is classified into water, buildup and others by using maximum likelihood classifier. The classification results of buildup area for 2010, 2014 and 2017 are shown in figure 1, 2 and 3.

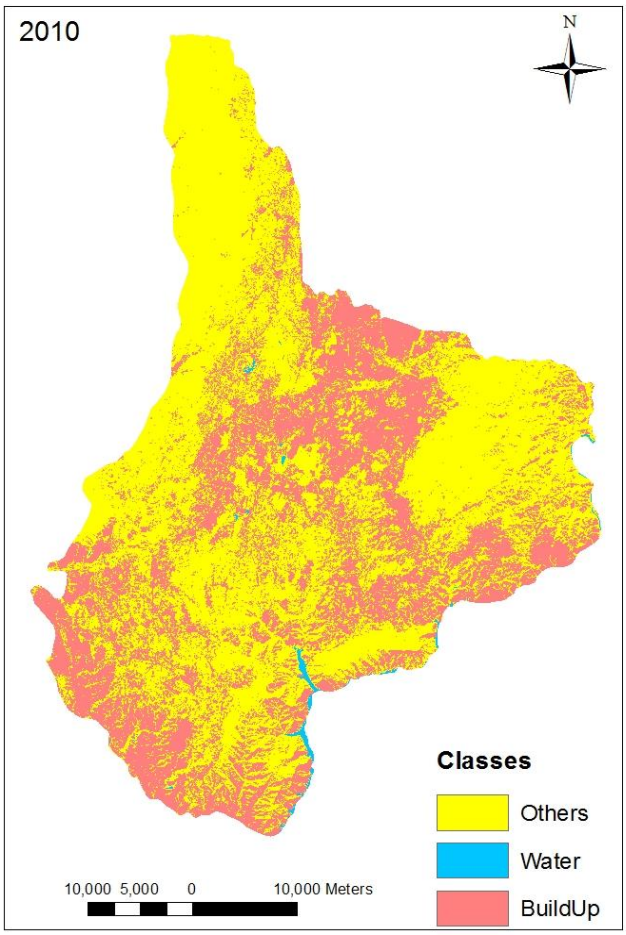

Fig 1(a): Land Cover Map for 2010 (3 classes)

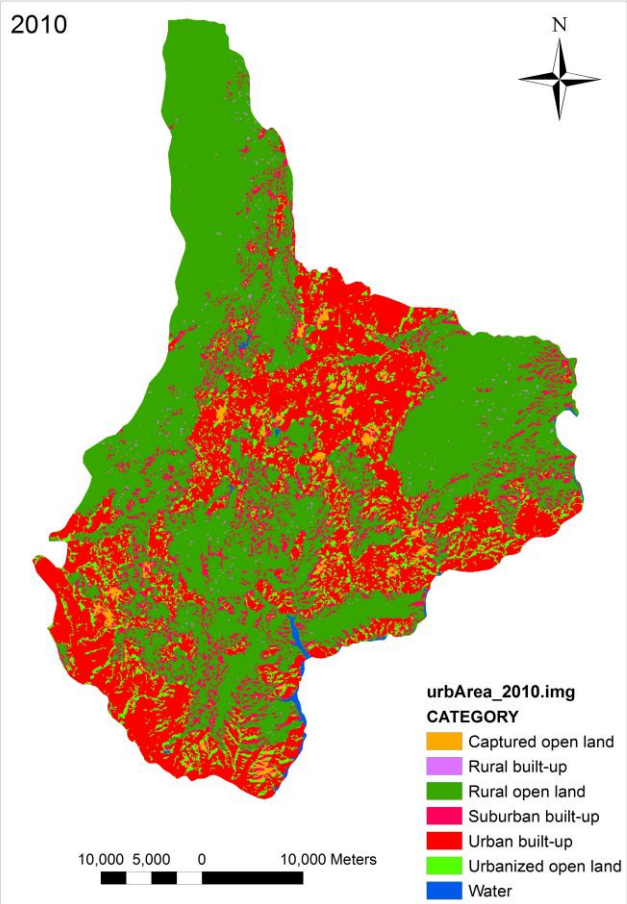

Fig 1(b): Land Cover Map for 2010 (7 classes)

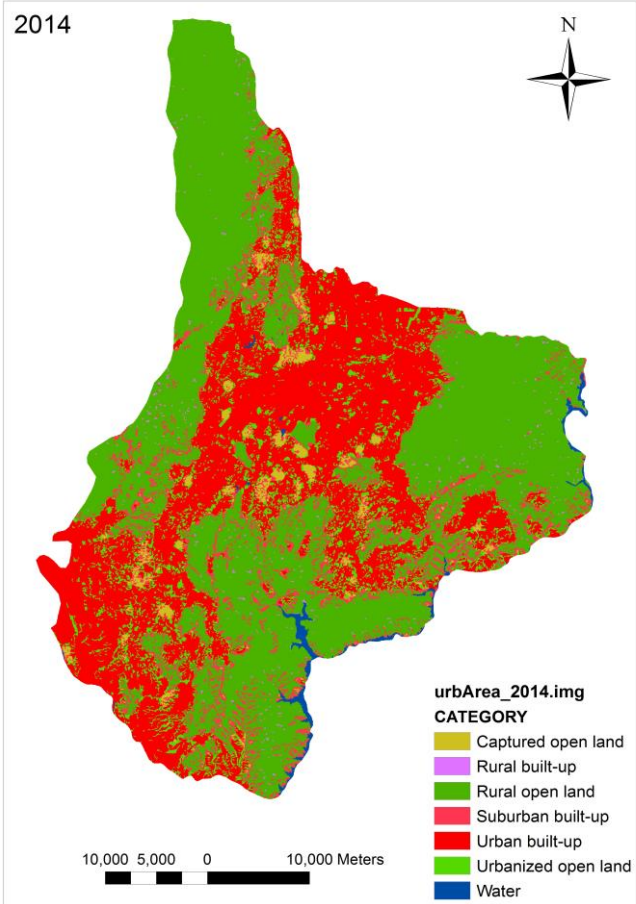

Fig 2(b): Land Cover Map for 2014 (7 classes)

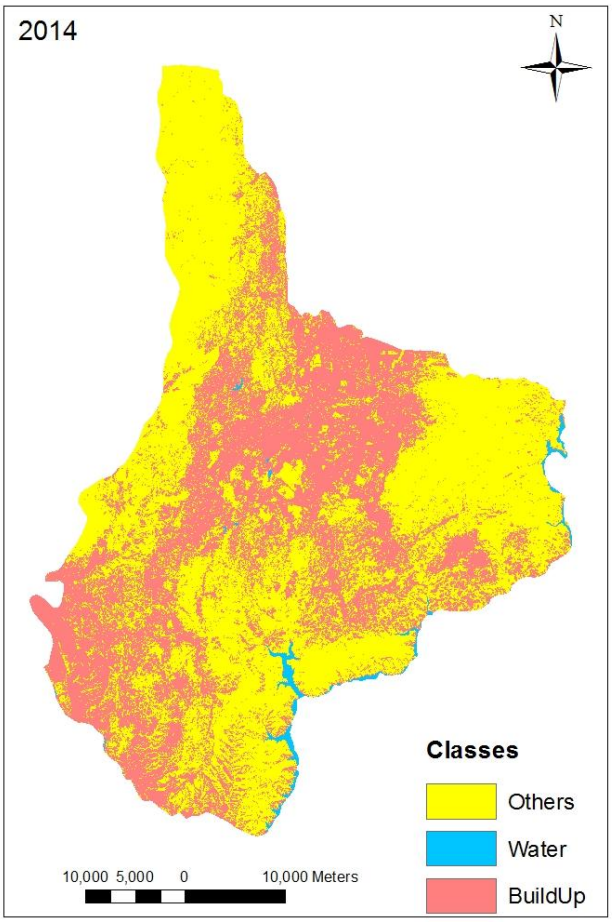

Fig 2(a): Land Cover Map for 2014 (3 classes)

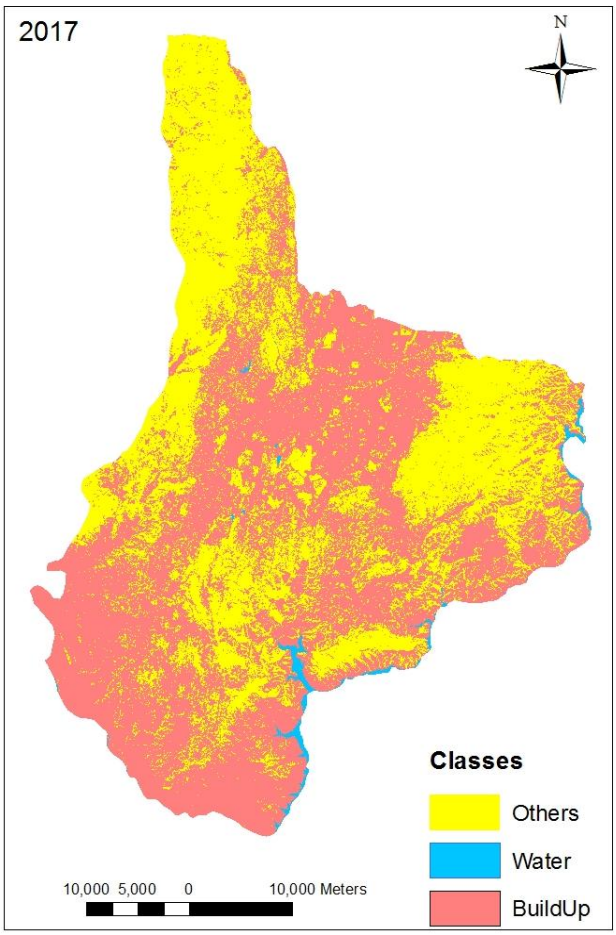

Fig 3(a): Land Cover Map for 2017 (3 classes)

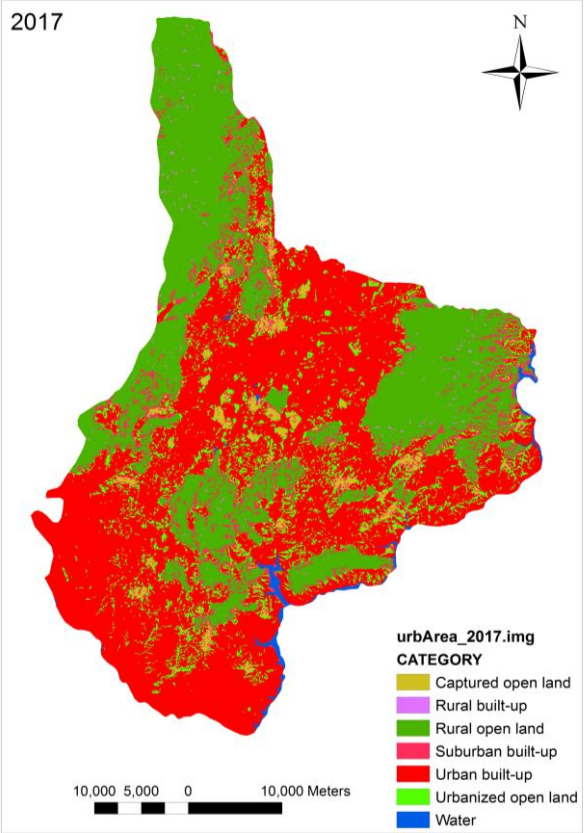

Fig 3(b): Land Cover Map for 2017 (7 classes)

By analyzing the classified results, it can be clearly seen that buildup area is increased to 110397 H from 75363 H by 68%. Water area is also increased to 1727 H from 908 H by 53%. Other area is decreased drastically from 120741 H to 84900 H by 70%. This other area includes forest and vegetation.

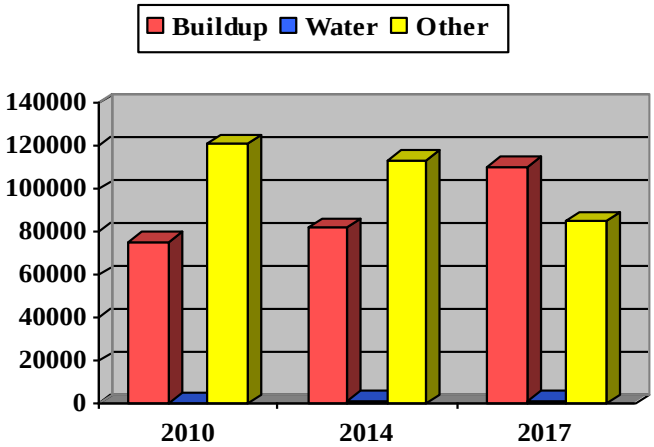

Fig 4: Land Cover Area in Hectares for Three Classes

In case of forest area, it can be seen that forest area has been reduced during this eight years. The classification results of forest area are shown in figure 5,6 and 7.

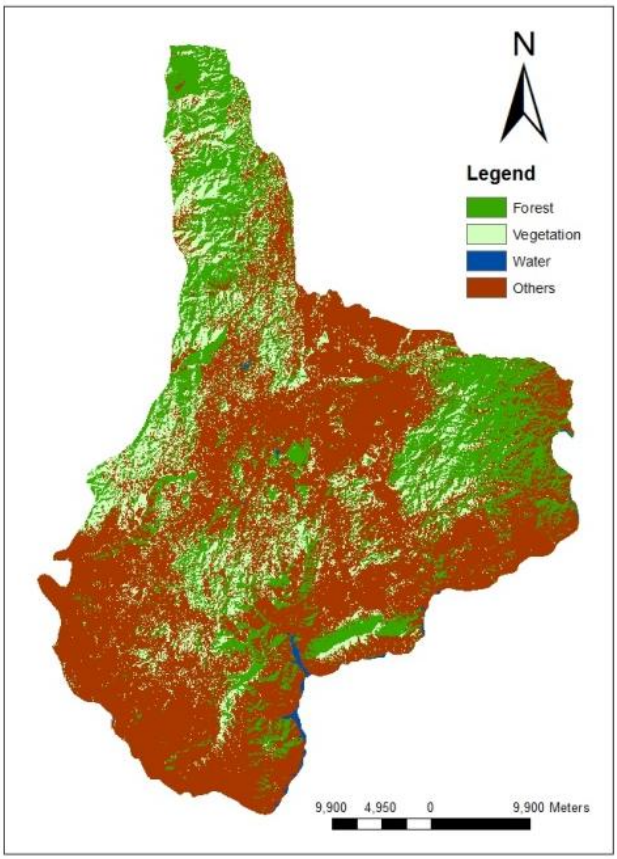

Fig 5: Forest Cover Map for 2010

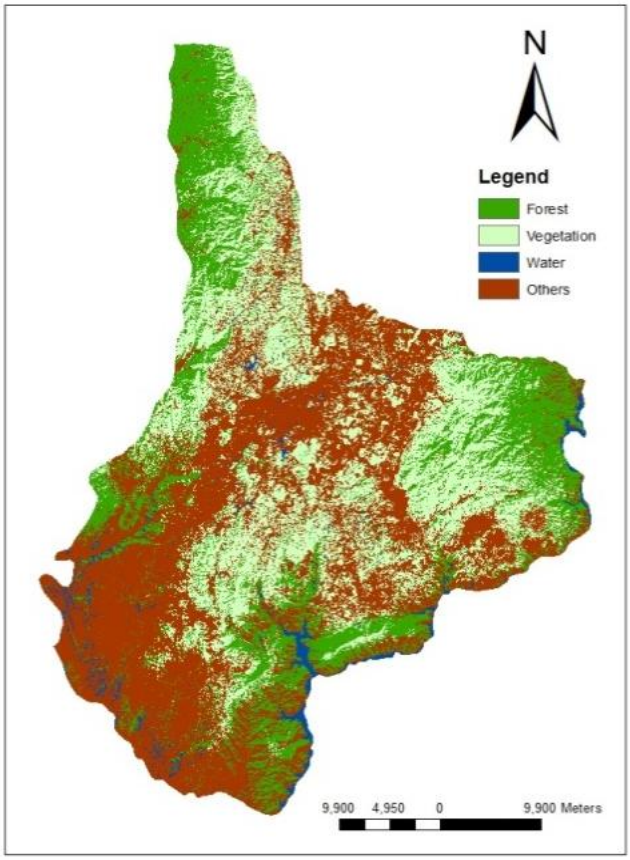

Fig 6: Forest Cover Map for 2014

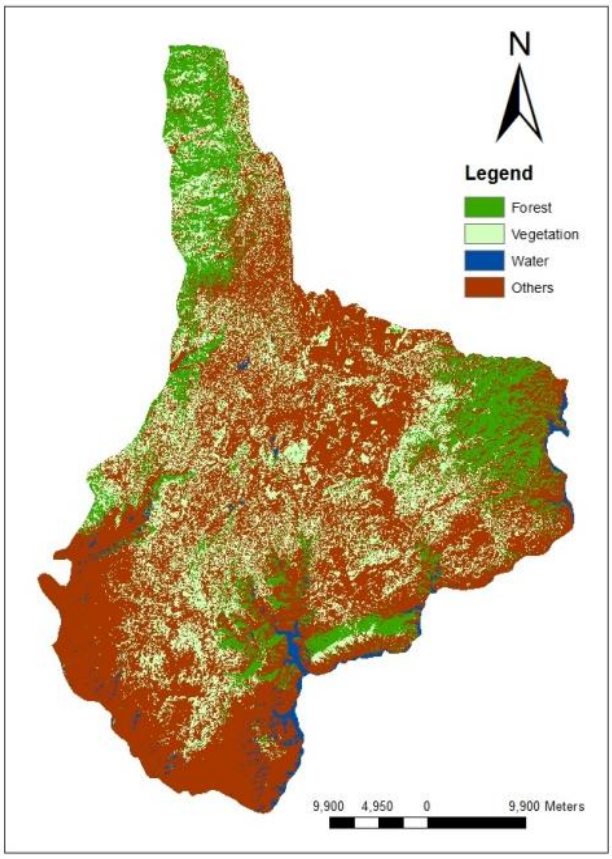

Fig 7: Forest Cover Map for 2017

Classes	Areas in Hectares		
	2010	2014	2017
Forest	48060	38296	27200
Vegetation	31401	53692	58358
Water	808	1863	1702
Others	116475	103163	109754

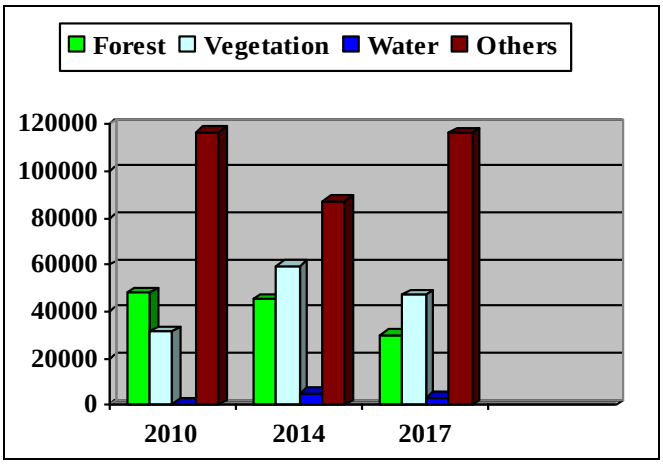

Fig 8: Land Cover Area in Hectares for Four Classes

By analyzing the classified results, it can be clearly seen that Forest area is decreased from 48060 H to 27200 H by 63%. Water area is increased to 1702H from 808 H by 23%. Vegetation area is increased to 47118 H from 31401 H by 67%. Other area is decreased drastically from 12.07 H to 8.49 H by 70%. The other area includes buildup area.

According to the results it can be said that during this eight years, forest area has been decreased as well as the buildup area has been increased. The next phase of research work is to analyze climate change due to landcover change. For carrying out this part, temperature and rainfall data are used as referenced data.

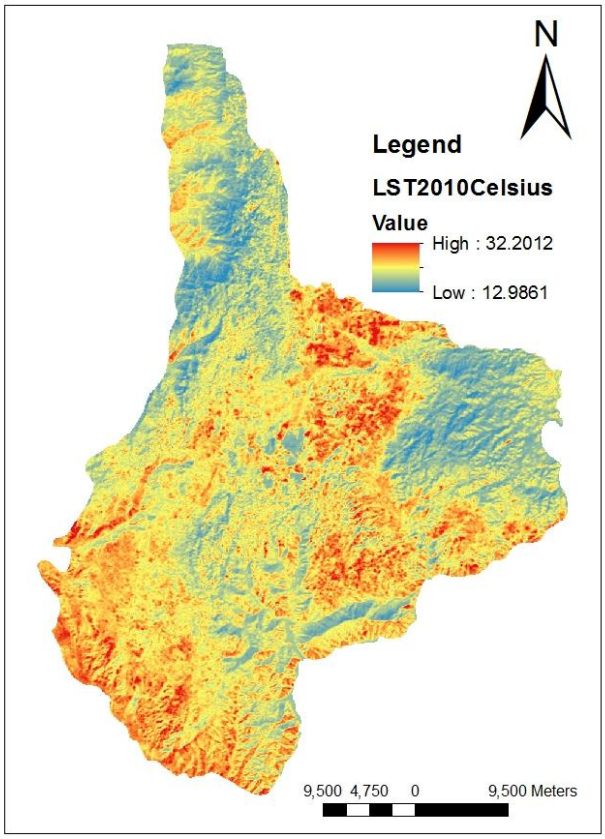

Fig 9: Land Surface Temperature for 2010

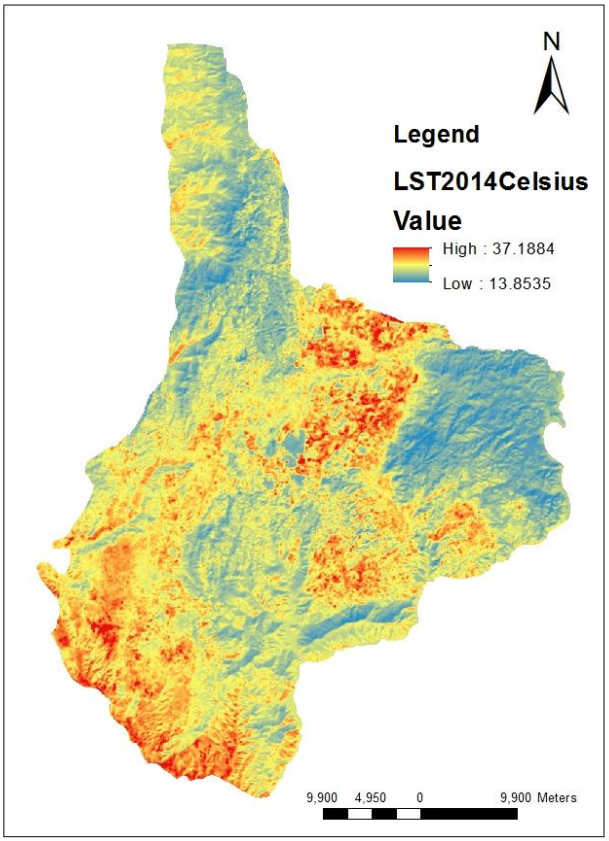

Fig 10: Land Surface Temperature for 2014

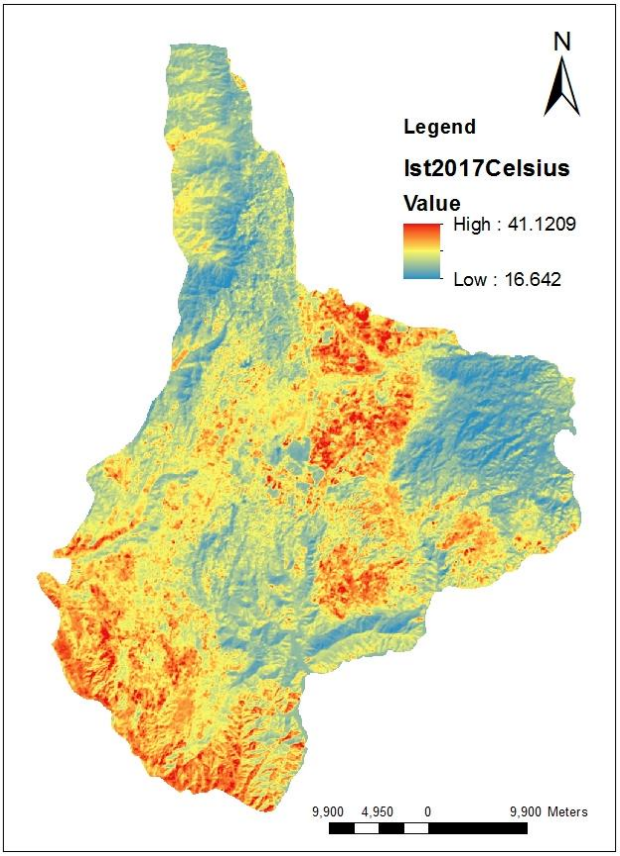

Fig 11: Land Surface Temperature for 2017

By analyzing the land surface temperature results, it can be clearly seen that lowest temperature is increased from 12 degree Celsius in 2010 to 16 degree Celsius in 2017. The highest temperature is increased to 41 degree Celsius in 2017 from 32 degree Celsius in 2010.

Population Growth

According to the record, the Pyin Oo Lwin Township has rapid population growth in later 2010. In 2014, the Township had a total population of 255508 living. In 2017, the city population is becoming 256976. It can be seen that the population growth has been around 1500 over four years.

	Female	Male	Total
2014	127481	128027	255508
2017	128296	128680	256976
Difference			1468

5. Future Work

Rainfall data and soil density of the township can be analyzed for the respective years. Weather forecasting can be performed by using the analyzed data.

6. Conclusion

The Change Detection analysis is an efficient way of describing the changes observed in each land use category. Over three year period, there were considerable variations in forest, vegetation, and built-up area. A high resolution satellite data would suitably improve the land use classification. The normalized difference vegetation index technique with different threshold values has been employed for features extraction. As the population of Pyin Oo Lwin has been increasing significantly in later 2010, the built-up area also increases. The classification result of built-up area is 75363.66(H) in 2010, is 82108.17(H) in 2014 and is 110397.2(H) in 2017 respectively. On the other hand, the classification result of forest area is 48060(H), 38296(H) and 27200(H) in 2010, 2014 and 2017 respectively. Rapid population growth causes to increase build-up areas and deforestation. For these reasons, the climate of the Township gradually changes year by year. In near future, this analysis results would help for regional planning, policy planning and hydrological planning the development of an environmentally sustainable city.

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