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Analysis of urban changes using geographic information system (GIS): Case Area of Pyin Oo Lwin Township (Myanmar)

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Abstract
Urbanization is becoming one of the dynamic phenomenon all over the world. The analysis of urban changes and the measurement of urban growth take part in essential role. Geographic Information System (GIS) technologies are utilized to extract some of the important spatially variable parameter such as analysis of urban landscape process from satellite images. In this paper, the specialized area is Pyin Oo Lwin Township in Myanmar to analyze the urbanized area in three different years. Analysis of urban changes process has been studied using land use pattern derived from Landsat TM/ETM satellite data (2010-2017). At first, maximum likelihood supervised classification technique is applied for classification three difference classes (i) built-up, (ii) water and (iii) others or non-built-up. Based on the spatial density of build-up area, the seven classes are separately identified using the Urban Landscape Analysis Tool (ULAT) which was employed for metrics quantification for urban expansion. These seven classes consist of (i) Urban built-up, (ii) Suburban built-up (iii) Rural built-up (iv) Urbanized open land (v) Captured open land, (vi) Rural open land and (vii) Water. Finally, the urbanized maps are compared with each other between the year 2010 and 2017 to detect the urban changes and urban expansion in the city.

Biography: Aye Pwint Phyu has completed her BE specialized field in Information Science and Technology at the age of 22 years and pursuing Master of engineering at University of Technology (Yatanarpon Cyber City).

Keywords: urban changes, geographic information system, Township

1. Introduction

Nowadays, urbanization can be gradually changed as the expansion of cities by encompassing the rural areas in it. Urbanization is not only just physically growth but also caused by population, social and economic structure. The one of the main reason of urban growth is migrations of people from one place to another. A lot of these migrations are usually done from rural area to urban areas. Therefore, population is growth year by year and the urbanization is also increased continuously. Development of urbanization has both positive sides and negative sides. The economic development is the major advantage of urbanization. The urban-built-up or cities supply more facilities to its citizens with large amount of technological equipment rather than rural built-up. Together with the growth of population, the land use and land cover is gradually developed and changed. On the other hand, a lot of pollutions, traffic congestions and housing problems are also becoming increase. The whole of society is affected by urbanization. All of these negative sides can be arranged as the problems of urbanization. However, if urbanized areas could be systematically developed sustainability, the urbanization problem would be managed and solved. Therefore, analyzing of urban changes is highly essential to protect a more sustainable existence of human society.

Thousands of different organizations and hundreds of thousands of individuals to access and manage fantastically varied sets of geographically related information use Geographic Information System (GIS). Geographic Information System (GIS) is also defined as a system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. GIS provide major opportunities in land and waterway monitoring and management in Egypt, Africa and across South East Asia and the Himalayan region. As elsewhere, information is the key to enabling people to make more sustainable choices and realize benefits from their actions, as well as for education, awareness and support [4]. Myanmar is situated at the cross road between two most populous countries in the region (China and India). Myanmar's economy is based on agriculture and 70% of the population lives in rural areas where their livelihoods depend on agriculture sector.

Over the past several years, Myanmar has taken many steps to craft new plans and policies related to spatial planning and economic development. This background places Myanmar in a unique opportunity for government officials to craft policies that are best in line with Myanmar's promising future and the safety of its people. Systematic development of urban system through Spatial Planning for creation of safer housing and livelihood for the people.

Local level planning is managed in different ways throughout Myanmar depending on the size of town or city. The three largest cities in Myanmar: Yangon, Nay Pyi Taw, and Mandalay all have City Development Committees that are responsible for all land allocation, management and planning, along with distribution of basic services [2].

There are many cool and pleasant towns in Myanmar such as Pyin Oo Lwin (May Myo), Kalaw, Taunggyi, Inn Lay, Pu Tar Oo and etc. Among them, Pyin Oo Lwin is one of the beautiful flower city in Myanmar. Pyin Oo Lwin offers visitors cool days and nights, peaceful rural roads and tracks for walkers and cyclists, trekking in the fruit and flower producing countryside, and interesting shopping. Therefore, this town is continuously developing and urban is significantly increased in year by year. Hence, the research is focus on Pyin Oo Lwin Township to study the development of urban changes year between 2010 and 2017. While Myanmar (and Mandalay City) have many institutions in place to strengthen Disaster Risk Reduction (DRR) throughout urban areas in the country. There are many urban planning tools which can also be integrated into planning practices throughout urban areas in Myanmar. Among other tools and techniques being used by urban planners worldwide, remote sensing is the one that is highly efficient and is frequently used [3]. Geospatial technology is being increasingly used to monitor urban landscapes in numerous ways such as studying land use changes [5], monitoring [8], and modeling urban expansion [6].

The remote sensing input and urban landscape analysis tools (ULAT in GIS domain) to analysis change detection over spatial and temporal domain since 2010 through 2017.The objective is to detect the urban change of Pyin Oo Lwin Township in these specified years. For side effective, the development of urbanization area is becoming not only the deforestation but also the temperature is also increasing year by year.

2. Study Area

Pyin Oo Lwin, also referred to as Maymyo, is a scenic hill town in Mandalay Division, Republic of the Union of Myanmar. Pyin Oo Lwin is located on the western bank of the river Ayeyarwaddy. Approximately 7 miles north of Mandalay. Over 1000 metres above sea-level. Pyin Oo Lwin is a popular hill station about 69km away from Mandalay.

It is well known for its colonial style houses with large compound and pine trees. Eucalyptus and silver-oak abound in town. Delightfully cool and pleasant the whole year round.

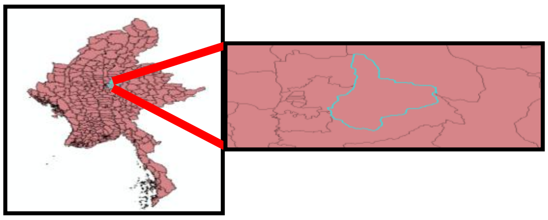

Fig 1. Pyin Oo Lwin township shape file

The region is located within coordinates of 22° 2' 4.38" North, 96° 27' 31.49" East. It is located in 67 kilometers east of Mandalay which is the central part of the country. Its elevation is 3,506 feet height. There are very large communities of the Chinese and Indian people in the city. The population of Pyin Oo Lwin Township is 255000 and the area is 1,990 square kilometers. The economy of the city highly relies on agriculture and farming.

3. Material and Methods

3.1 Satellite Image Data

The three years of Landsat TM/ETM satellite images which were procured from U. S. Geological survey's (USGS) Earth Explorer website (www.usgs.glovis.gov) in Geo TIFF file are collected. Three cloud-free Landsat ETM+ and TM data especially 2010, 2014 and 2017 are collected from USGS and the study area Pyin Oo Lwin region is retrieved to analyze urban changes. These satellite images consist of seven bands for landsat7 and eleven bands for landsat8. And then Universal Transverse Mercator map projection (UTM, Zone 47N) projection and WGS 84 datum are projected. The scenes of Landsat were selected because of their affordability, availability, and medium to high spatial resolution. The details of the collected Landsat satellite images are as shown in Table1

Table 1: Characteristics of the Landsat datasets used in the study

Acquisition Date	Sensor	Path/Row	Spatial Resolution of Reflective Bands	Number of Bands	Format
18 January 2010	Landsat 5 TM	133/45	30	7	GeoTIFF
13 January 2014	Landsat 8 OLI	133/45	30	11	GeoTIFF
16 February2017	Landsat 8 OLI	133/45	30	11	GeoTIFF

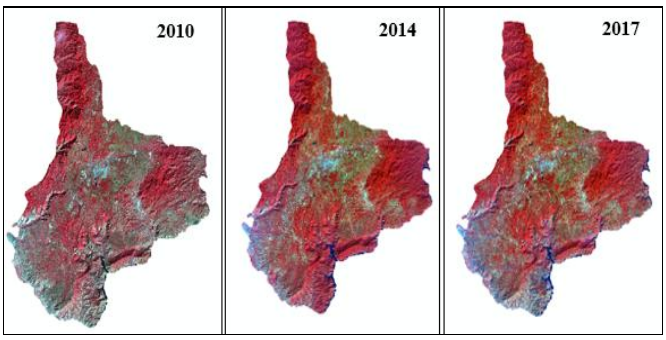

Fig 2. False color images of Pyin Oo Lwin Township

3.2 Methodology

In order to analyze the urban changes, the measurement of urban growth and changes of developing pattern can be decided. The analysis result become essential for the urban planner essential to develop valuable land use and land cover maps, to limit environmental hazards and limit the disaster risk and deforestation. The prime step of this methodology was land use and land cover (LULC) characterization which was done using ArcGIS. Land cover maps are classified with three classes; built-up, water and other by using Maximum Likelihood Classifier (MLC).

After developing build-up, water and other classes, the Urban Landscape Analysis Tool (ULAT) was applied to detect the urban changes by using ArcGIS software. The Centre for Land Use Education and Research (CLEAR) has developed the ULAT tool, University of Connecticut. One land cover map should be specified for each time period of interest. The land cover map should contain three classes with the corresponding pixel values:

- 0 = no data
- 1 = other
- 2 = water
- 3 = urban (impervious surface)

The input land cover data must be input in chronological order when specifying the tool parameters. The ULAT tool can identify and classify the built-up levels, non-developed area and developed lands which are prone to degradation. The attribute table --contains the total area for each identified classes for each output map. All of these total areas are calculated in Unit hectares. Furthermore, the Urban Footprint (UF), Urbanized Area (UA) and New Development (ND) were calculated based on the urban landscape analysis of maps covering two base years [7].

3.3 Maximum Likelihood Classification (MLC)

The maximum likelihood classifier is one of the most popular methods of classification in remote sensing, in which a pixel with the maximum likelihood is classified into the corresponding class. Maximum Likelihood classifier (MLC) is a supervised classification method derived from the Bayes theorem, which states that a posteriori distribution P (i|ω), i. e. the probability that a pixel with feature vector ω belongs to class i, is given by:

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

Where P (ω|i) is the likelihood function,
P (i) is the a priori information
P (ω) is the probability that ω is observed.
Classifies pixels based on the probability that a pixel falls within a certain class [1].

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

Where M is the number of classes. $P(\omega)$ Is often treated as a.

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

Sums to. Sums to. Pixel x is assigned to class i by the rule:

$x \in i$ If P (i|ω) > P (j|ω) for all $j \neq i$

The algorithm used by the Maximum Likelihood Classification is based on two principles:

- The cells in each class sample in the multidimensional space being normally distributed
- Bayes' theorem of decision making

The Maximum Likelihood classifier in ArcGIS considers both the variances and covariances of the class signatures when assigning each cell to one of the classes represented in the signature file. With the assumption that the distribution of a class sample is normal, a class can be characterized by the mean vector and the covariance matrix. Given these two characteristics for each cell value, the statistical probability is computed for each class to determine the membership of the cells to the class. When the default EQUAL. A priori probability weighting option is specified, each cell is assigned to the class to which it has the highest probability of being a member.
By using Maximum Likelihood Classifier (MLC) classified urban (developed) and water for Pyin Oo Lwin region for the three time periods. The "Other" is considered open (undeveloped) land as shown in Figure 3.

Table 2: Land Cover Area of Pyin Oo Lwin Township

Class	Area in Hectares		
	2010	**2014**	**2017**
Other	120741.5	113104.8	84888.63
Water	908.55	1800.72	1727.82
Built-up	75363.66	82108.17	110397.24

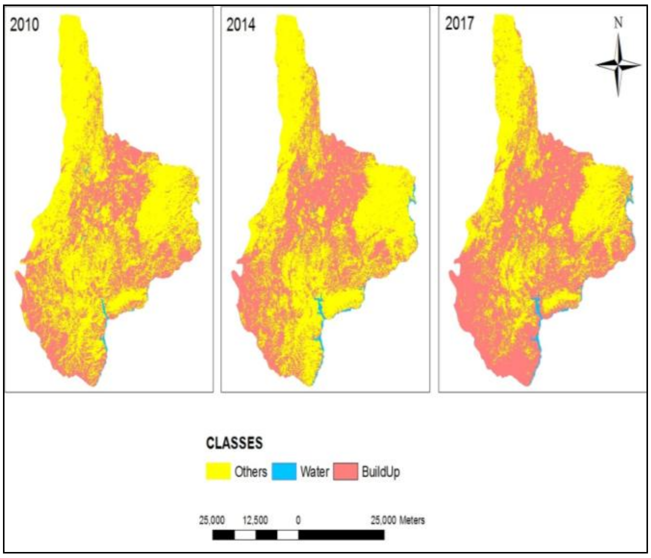

Fig 3. Land cover maps

3.4 Confusion Matrix

The confusion matrix can analysis the accuracy of classification and the reference points of the map.To get the confusion matrix, the ground truth reference points is required. And then all of this reference points and the classified raster image using Maximum Likelihood Classifier (MLC) are combined. After the combination step, the pivot table are produced as a confusion matrix to assess the overall accuracy.63 stratified random points were generated and used. The overall accuracy of three classes is 96.83%.

3.5 Characterization of Urbanized Area Map

By using the Urban Landscape Analysis Tool (ULAT), the seven classes are particularly classified to detect the urban changes. The urbanized area is synthesis of built-up area (impervious surfaces) and urbanized open space where heavily influenced by urbanization (i. e, built-up area is occupied more than 50 % of the open space in defined region). The categorization of seven classes are (i) Urban built-up, (ii) Suburban built-up (iii) Rural built-up (iv) Urbanized open land (v) Captured open land, (vi) Rural open land and (vii) Water. For each category, detail criteria are described in Table 4

Table 4: Urbanized area classes and criteria for each categorization

Class	Criteria
Urban built-up	Built-up, > 50 % urbanness
Suburban built-up	Built-up, 10 – 50 % urbanness
Rural built-up	Built-up, < 10 % urbanness
Captured open land	Undeveloped patches (<200ha), completely surrounded by urban built-up, suburban built-up, and fringe open land.
Urbanized open land	Undeveloped, urbanness> 50 %
Rural open land	Undeveloped, neither fringe nor captured open land
Water	Water in land cover classification

Urbaness for each pixel is percent of developed area in a circle of 1 sq. km (radius of 564 m) area centered on the pixel under consideration.

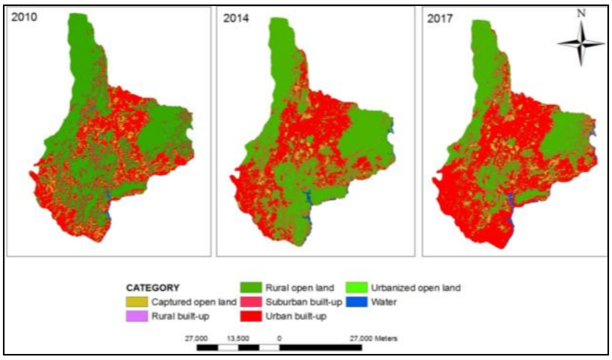

Fig 4. Urbanized Area Maps

4. Result and discussion

(1) Land Cover Area Analysis

According to analyzing of three different years of Pyin Oo Lwin Township, land cover map is significantly increased in built-up area that contains urban, suburban and rural build-ups as shown in Table 2. Build-up increased by 6744.51ha from 2010 to 2014 and 28289.03 ha in years between 2014 to 2017. Urbanized Area Analysis Significant changes occurred in the area under urban built-up which increase from 54321 ha in 2010 to 66437 ha in 2014 and to 98629 ha in 2017 (Table 5). The area of rural open land is decreased from 104037 ha in 2010 to 94733 ha in 2014 and to 63802 ha in 2017. The urbanized area analysis describes that Pyin Oo Lwin Township is becoming changes from rural open land to urban build-up.

Table5: Urbanized area in hectare and percentage during 2010, 2014 and 2017

Category	2010		2014		2017	
	Area	%	Area	%	Area	%
Urban built-up (UB)	54320.6	52.2128	66436.8	34.0591	98628.9	50.52369
Suburban built-up (SB)	19283	9.83432	14552.7	7.46051	11922.9	6.107644
Rural built-up (RB)	752.49	0.38377	811.53	0.41603	624.87	0.320096
Urbanized open land (UOL)	15287.9	7.79678	15084	7.73287	16510.9	8.457859
Captured open land (COL)	2398.23	1.22309	3444.93	1.76606	3723.93	1.907622
Rural open land (ROP)	104037	53.0586	94733.4	48.5654	63801.7	32.68309
Total	196079	100	195063	100	195213	100

Table 6: Change detection matrix showing the class changes between 2010 and 2014

		Land use 2014							
		COL	RB	ROL	SB	UB	UOL	Water	Total
Land use 2010	COL	2.26	0.00	6.69	0.84	8.50	5.50	0.01	23.82
	RB	0.05	0.58	4.25	2.25	0.06	0.00	0.01	7.20
	ROL	26.13	4.12	803.49	54.76	85.90	60.40	7.33	1042.12
	SB	1.99	2.53	55.56	51.19	73.05	6.18	0.82	191.31
	UB	1.99	0.55	46.87	32.89	431.90	28.78	1.12	544.10
	UOL	1.94	0.02	32.04	2.27	65.99	48.46	1.09	151.80
	Water	0.01	0.00	0.04	0.02	0.18	0.24	8.23	8.71
	Total	34.36	7.80	948.93	144.23	665.58	149.56	18.61	1969.06

Table 7: Change detection matrix showing the class changes between 2014 and 2017

		Land use 2017							
		COL	**RB**	**ROL**	**SB**	**UB**	**UOL**	**Water**	**Total**
Land use 2014	COL	9.73	0.00	2.90	1.66	11.39	8.68	0.00	34.36
	RB	0.01	0.67	1.93	3.05	2.07	0.03	0.04	7.80
	ROL	21.13	5.21	617.88	68.06	165.96	70.89	0.09	949.22
	SB	2.10	0.13	12.62	39.59	86.19	3.45	0.16	144.24
	UB	2.50	0.00	1.35	4.72	636.30	20.82	0.07	665.76
	UOL	1.72	0.00	2.76	0.70	84.68	59.70	0.00	149.57
	Water	0.00	0.00	0.03	0.49	1.27	0.03	16.80	18.63
	Total	37.20	6.01	639.48	118.26	987.87	163.60	17.16	1969.57

Table 8. Change detection matrix showing the class changes between 2010 and 2017

		Land use 2017							
		COL	**RB**	**ROL**	**SB**	**UB**	**UOL**	**Water**	**Total**
Land use 2010	COL	2.86	0.0	0.30	0.55	15.65	4.44	0.01	23.82
	RB	0.04	0.68	2.46	3.19	0.75	0.06	0.01	7.20
	ROL	29.83	5.10	622.96	75.40	200.13	102.20	6.48	1042.11
	SB	1.92	0.22	11.42	36.61	132.93	7.56	0.66	191.32
	UB	1.16	0.0	1.03	2.01	524.88	14.16	0.87	544.12
	UOL	1.38	0.0	1.00	0.46	113.07	34.97	0.92	151.80
	Water	0.00	0.00	0.01	0.02	0.28	0.22	8.16	8.69
	Total	37.20	6.01	639.19	118.24	987.70	163.60	17.12	1969.06

5. Conclusion

The study described the pattern of urban development is taking place in Pyin Oo Lwin Township. The Maximum Likelihood Classification (MLC) and Urban Landscape Analysis Tool (ULAT) were mainly used to detect urban change over Pyin Oo Lwin region. During the year 2010-2014, the rural open land (RUL) in 2010 changed to 54.76 ha of suburban built-up (SB) and 85.9 ha of urban built-up (UB) in 2014. Furthermore, the urbanized open land area in 2010 also changed to about 66 ha of urban built-up area in 2014. Between the year 2014 and 2017, a lot of rural open land (ROL) changed to almost 166 ha of urban built-up (UB) and the suburban built-up (SB) area of 2014 also converted to over 86 ha of urban built-up (UB) in 2017. Most of these changes took place in the middle and northern parts of the study area. For more efficient planning, the outcome of this study can be used as input data for urban planners to predict and monitor the important process of urban development.

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