LAND SURFACE TEMPERATURE CHANGES BY LAND COVER CHANGES OF INLAY LAKE AREA, MYANAMAR

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ABSTRACT

The Inlay Lake is one of world heritage sites of UNESCO. The cultural traditions of numerous villages around it focus on the lake and have distinctive features. Inlay Lake is the most tourism development area of Myanmar. However, the Inlay Lake is gradually degrading due to the impacts of human activities and climate variability as well as unsustainable natural resource use practices. So, the sustainable development of the relationship between Land Cover Changes (LCC) and Land Surface Temperature (LST) changes seriously important to manage the Inlay Lake area. This paper focuses on the application of remote sensing and geographic information system for change detection, change matrix and analysis on its impact on the surface temperature of the Inlay Lake area. Landsat images have been utilized to quantify the changes of the two periods. Firstly, the images were preprocessed with the calibration and geometric corrections that were performed for land cover changes. The overall accuracy is 85 percent. Secondly, the investigation using remote sensing and geographic information system was further applied to examine the impact of the land cover change on surface temperature of the study area. The findings of this paper revealed a notable land cover change and land surface temperature for the future sustainable environmental conservation of Inlay Lake area.

KEYWORDS: Inlay Lake, Land Cover Changes (LCC), Land Surface Temperature (LST), sustainable environmental conservation

INTRODUCTION

Inlay Lake is the most developed tourist attraction and natural lake of Myanmar. In terms of tourist attractions, Inlay Lake is very famous among local and international tourists for its beautiful scenery and peaceful atmosphere as well as the exotic lifestyle of the lake's populations (Okamoto, 2012, p.1), (Chen Jingyi, et al., 2012, p.5). The Inlay Lake is the second largest lake in Myanmar after the Indawgyi Lake of the Kachin State. Once is north-south length was 17.7 kilometer and east-west breadth was 6.44 kilometer. However, due to the environmental degradation processes, its length from north to south is 16 kilometer and its breadth from east to west is 4.83 kilometer. (Figure 1) shows latest information of Inlay Lake area on 12 and 16 April 2015. This daily newspaper describes the main causes of environmental degradation of Inlay Lake area.

Figure 1. Latest information of Inlay Lake area

Inlay Lake is gradually degrading due to the impacts of increasing population, climate change, climate variability and unsustainable environmental resources. (Kyay Mone Daily Newspaper. 2015.) (Thuyein N.M., 2015). Inlay Lake is also facing with the challenges of changing of land cover and rising of land surface temperature. At present, this area is experiencing an increasing population, over cultivation and degrading watershed forest area. With rapid increasing residents and decreasing forest lead a variety of environmental degradation issues like land cover change and land surface temperatures rising year by year. At the same time, the Inlay Lake area is threated by soil erosion, deforestation, water quality degradation and

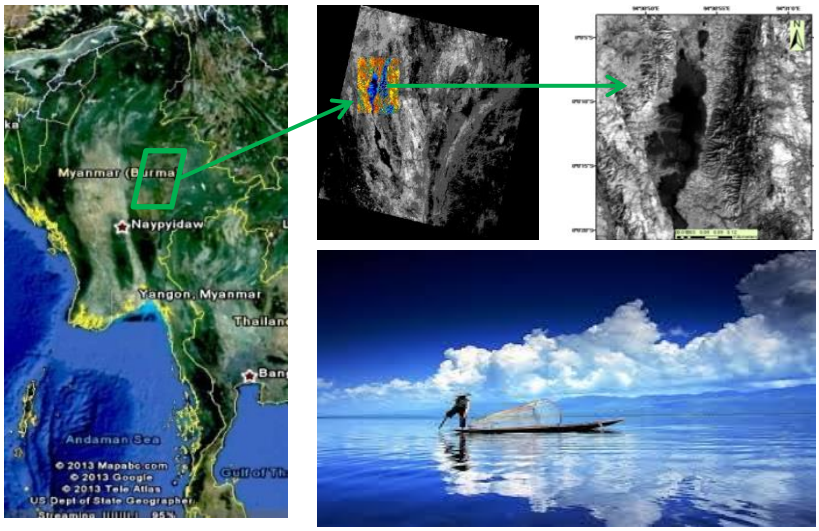

Figure 2. Location of Inlay Area

water surface area shrinkage to the sedimentation due to the natural as well as human activities. (Tun K.K, Maw A.A., et al., 2012).

STUDY AREA

The study area is Inlay Lake and surrounding area that is shown by (Figure 2). It is situated between North Latitudes 21° 18′ 30″ N to 20 ° 48′ 00″ N and East Longitudes 96 ° 46′ 30″ E to 97 ° 06′ 30″ E. The total area of study area is 2258.7 square kilometer.

AIM AND OBJECTIVES

The main aim of this paper is to focus on the serious changes of the land cover and land surface temperature of the Inlay Lake area. The objectives of this paper is to examine the changes of land cover with change detection and change matrix by using visible and near infrared bands, to measure the changes of the land surface temperature with thermal bands, to analysis on the relationship between the land cover changes and land surface temperature changes and the environmental conservation for the sustainable development of the Inlay lake area.

DATA AND METHODOLOGY

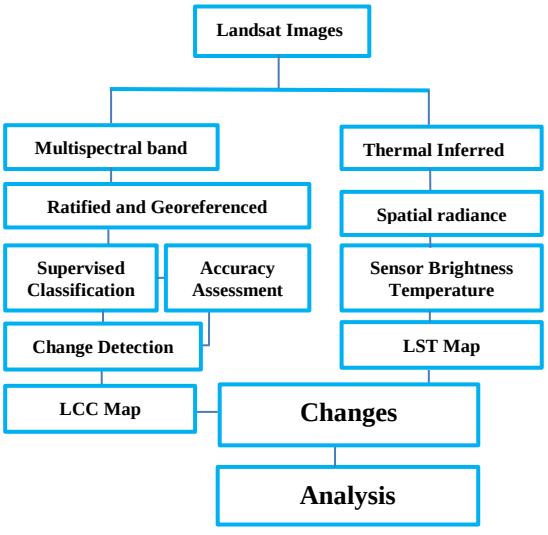

Figure 3. Research Flow

The image satellite is Landsat 7 ETM+ data (path 132, row 46) for 2003 (5 March 2003) and Landsat 8 (OLI) (27 March 2014) data (path 132, row 46) for 2014 with cloudless area. Spatial resolution is 30 m. The image was processed by USGS (U.S Geological Survey), UTM zone is 47 and Datum is WGS 84. Total ground check points are 300 points (50 points for each land cover class). The climate data of the ground station is Nyaung Shwe from 1990 to 2013. The procedures of this paper consist of three phases. The first phase is land cover classification with training sample and calculation of change area by change detection of two periods. The second phase is retrieval of the land surface temperature of 2003 and 2014. The third phase is the data analysis of land cover and land surface temperature changes. (Figure 3) illustrates the diagram of the procedure of the study plan.

CHANGES OF LAND COVER AND LAND SURFACE TEMPERATURE

Land Cover Changes (LCC)

The using satellite images were classified into six classes of land cover types, as shown in (Table 1). The chosen colour composite for Landsat 7 (band 4, 3 and 2) and Landsat 8 (band 5, 4 and 3) were used with training sample sites for land cover classification. For the making map of land cover classification, the land cover pattern was mapped by supervised classification with the support vector machine classification algorithm of ENVI 4.8 and ArcMap 10.2.1.

Table 1. Description of Land Cover Class

Land cover Type	Description
Floating garden	Cultivation on the water making floating land
Water	Water bodies of River, Stream and Lake
Cultivated land	Crops fields, pastures, orchards, vineyards and nurseries
Forest	Forest dominated by deciduous trees
Degraded forest	Scatter Vegetation and mixed vegetation which has a scattered distribution, mostly shrubs and rangeland
Built-up area	Urban and Rural areas/ infrastructures: residential, industrial, commercial and services, transportation and mixed build up land

The six classes of land cover classification considered for the study area are floating garden area, cultivated land, water area, forest area, degraded forest area and built-up area. The results of change detection indicated the difference between 2003 and 2014. Change detection is used to correlate and compare two sets of imagery to identify changes. Using change detection statistics is to compile a detail tabulation of changes between two classification images. There are two periods for classification, first period was the classification image which was 2003 and other was 2014.

Land Surface Temperature (LST)

Land Surface Temperature is derived from geometrically corrected Landsat 7 TM and ETM+ thermal infrared (TIR) channel (band 6) and Landsat 8 OLI thermal infrared (TIR) channel (band 10 and 11). The geometrically rectified images are free from distortions related to the sensors (e.g., jitter, view angle effect etc.,), satellite (e.g., attitude deviations from nominal), and the Earth (e.g., rotation, curvature, relief) (Landsat 7 Science Data Users Handbook, 2010).The Land Surface Temperature was measured with the individual thermal images and were compared between different time periods. Based on the literature, different retrieval methods of brightness temperature from the TM and ETM+ images were applied for the land surface temperature processing (Landsat Project Science Office at NASA's Goddard Space Flight Center: Greenbelt, MD, USA, 2010).

In this paper, a two-step process was also used to retrieve brightness temperature from the Landsat 7 images based on the literature (Landsat 7 Science Data Users Handbook, 2010, 117–120). Landsat Project Science Office at NASA's Goddard Space Flight Center: Greenbelt, MD, USA, 2010). In this study, the image-based method was employed to retrieve Land Surface Temperature from Landsat TM/ETM data due to its simplicity and validity and compared with the other frequently used algorithms, such as mono-window algorithm (Qin, Karnieli, & Berliner, 2001) and the single channel algorithm (Jimenez-Munoz&Sobrino, 2003).

In the first step, the DNs of thermal bands were converted to radiance based on the following formula where, information can be obtained from the header file of the images. In the second step, the effective at-satellite temperature of the viewed Earth-atmosphere system, under the assumption of a uniform emissivity, could be obtained by the following equation:

$$L_\lambda = \text{gain} \times \text{DN} + \text{offset} \quad \text{------- (1)}$$

where L_λ is the radiance of the thermal band pixels in W/(m^2 ster mm μ), gain is the slope of the radiance/DN conversion function, and offset is the intercept of the radiance/DN conversion (Landsat Project Science Office, 2002).

Adopting the conversion formula, the spectral radiance was then converted to an at-satellite brightness temperature under the assumption of uniform emissivity (Landsat Project Science Office, 2002).

$$T_B = \frac{K_2}{\ln\left(1 + \frac{K_1}{L_\lambda}\right)} \quad \text{------- (2)}$$

where T_B is the effective at-satellite temperature in K, and both $K_1$and K_2 are pre-launch calibration constants (K_2 ¼ 1282.71 K, K_1 ¼ 666.09 mW cm^{-2} sr^{-1} mm^{-1}). The different levels of Land Surface Temperature located in the certain regions corresponding to the location of the land cover classes. The high Land Surface Temperature located in the built-up area and cultivated land. Low Land Surface Temperature scattered in the forest, degraded forest, floating garden and the water.

RESULTS AND DISCUSSION

Inlay Lake is one of the many amazing places of interest found in Myanmar. This vast lake has about two hundred thousand residents which live mostly in floating villages. The view at Inlay Lake is second to none and is well known for the unique leg-rowing of the Inthars which are native lake dwellers. (Yee K. M, 2014).

However, land cover changes of human activities are changing Inlay natural environment. The due to human activities results of land cover classification of 2003 and 2014, the results of land cover classes describe in Figure 4 and the results of change detection show in (Table 2). (Figure 5) is the change area of land cover classes of study area of 2003 and 2014. According to change detection algorithm, floating garden, cultivated land and built-up area increased 17.72 square kilometer, 489.66 square kilometer and 51.29 square kilometer respectively. Water area, forest and degraded forest are decreased 17.35 square kilometer, 109.89 square kilometer and 431.43 square kilometer respectively.

The sample size takes 50 points for ground check points of each land cover class. The total 300 ground check points help to calculate the accuracy percentage. Accuracy assessment is very important to understand the output results and making decisions. The overall accuracy is 85 % and shown in (Table 3).

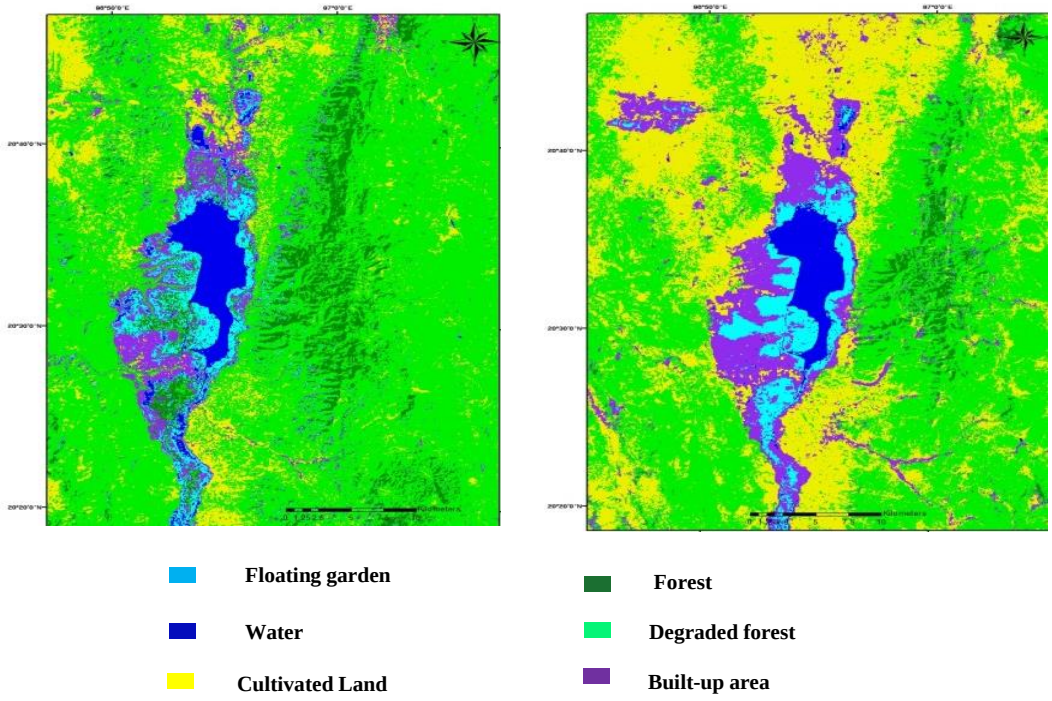

Figure 4.Land Cover Classification of Inlay Lake Area (2003- 2014)

Table 2. Change area of Land Cover Classes (2003-2014)

Land cover	2003 (sq km)	2014 (sq km)	Change area (sq km)
Floating garden	54.79	72.51	17.72
Water	70.26	52.91	-17.35
Cultivated land	277.78	767.44	489.66
Forest	228.96	119.07	-109.89
Degraded forest	1497.36	1065.93	-431.43
Built-up area	129.56	180.85	51.29

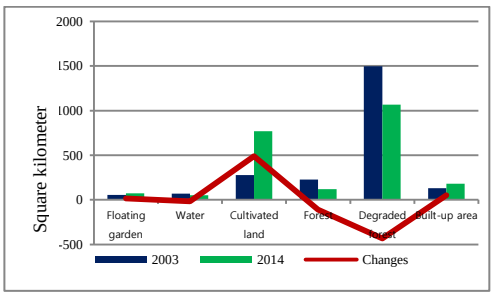

Figure 5. Change area of Land cover class (2003-2014)

Table 3. Accuracy Assessment of Land Cover Classification

Period	Land Cover Class	Floating garden	Water	Cultivated land	Forest	Degraded forest	Built-up area	Sample point	Accuracy
2003	Floating garden	38	6	2	0	2	2	50	76
	Water	6	37	5	0	1	1	50	74
	Cultivated land	2	4	42	1	1	0	50	84
	Forest	1	1	1	47	0	0	50	94
	Degraded forest	2	1	0	1	44	2	50	88
	Built-up area	1	1	0	1	2	45	50	90
								300	84.33
2014	Floating garden	43	4	1	0	1	1	50	76
	Water	3	41	3	0	2	1	50	82
	Cultivated land	0	2	45	1	1	1	50	84
	Forest	1	1	1	47	0	0	50	94
	Degraded forest	2	1	0	1	44	2	50	88
	Built-up area	1	1	0	1	2	45	50	90
								300	85.67
Overall Accuracy 85 %									

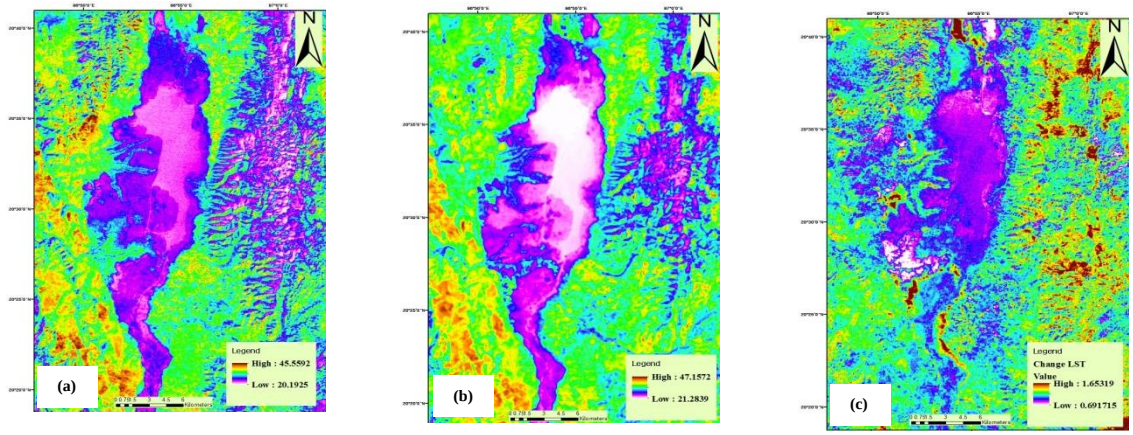

Figure 6. (a)Land Surface Temperature of 2003 (b) Land Surface Temperature of 2014 and (c) Changes Land Surface Temperature (2003- 2014)

(Figure 6) shows clearly the distribution and changes in the two periods of land surface temperature of Inlay Lake area from 2003 and 2014 and changes of land surface temperature. The results of the image processing point out that land surface temperature ranged from 20.19° C to 21.28° C and 45.55° C to 47.15° C within 11 years period. The lowest and highest changes of land surface temperature is 0.69° C and 1.6° C.The built-up area and harvested cultivated land area were higher land surface temperature than the surrounding area. Sparsely degraded forest area of land surface temperature is also higher temperature. The land surface temperature was wider to the built-up area, harvested cultivated area and sparsely degraded forest area.

Limitation of this study

By using multi-temporal remotely sensed data and statistical analysis, this paper presented better results for the spatiotemporal patterns of land cover classification and land surface temperature using fewer remotely sensed data images, (Landsat 7 ETM+ data for 2003 (5 March 2003) and Landsat 8 (OLI) (27 March 2014) data for 2014, or focusing on the relatively the Inlay Lake and surrounding area. Thus, in future research, synchronous data from in-situ observations should be combined with multi-temporal, long time span satellite data to produce more accurate results for the sustainable development of Inlay Lake area.

CONCLUSION

In the heart of the Shan State where 889.41 meter above sea level stands a lake with ringed by purple mountains. This is Inlay Lake, a wide body of water that is a heaven of peace. It is not only form the rolling hills and mountains surrounding this blue lake that a visitors get a mood of meditative tranquility and a sense of magic, but a charm of the inhabitants named Inthar who live on the lake. Inlay Lake is famous due to its

beautiful limnological features, high biodiversity and distinct livelihood styles of local ethnic people. The native people, Inthar, have been living in and surrounding the lake for several years symbiotically with their natural aquatic resources.

Inlay Lake is one such area in the country that is facing the devastating effects of climate change as well as unsustainable natural resource use practices. This paper pointed out that land surface temperature is rising with the increasing human activities of land cover changes. Now, much research has yet to be done to understand present condition of livelihood of local people and identify vulnerable communities and aspects of their livelihood that is vulnerable to climate change.

Therefore, watershed management requires coordinated action to internalize the externalities and to tap the linkages among the various resource uses within an area drained by a stream. Community forestry is also a land cover system devised to increase the productivity of the forest and to reduce land surface temperature, soil erosion and sedimentation for future sustainable development of Inlay Lake and surrounding environment.

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