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ANALYZING THE EFFECTS OF LAND COVER CHANGE ON SURFACE TEMPERATURE IN MOUNT MAKILING FOREST RESERVE (MMFR) AND ITS NEIGHBORING MUNICIPALITIES USING LANDSAT DATA

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ABSRACT:

Land Surface Temperature (LST) is said to be affected by frequent changes in the land cover. Over the years, the immediate environs of Mount Makiling Forest Reserve (MMFR) have experienced such kind of change due to rapid economic growth of the area that also led to the expansion of urban centers. The study utilized Landsat imageries to determine the possible effects of land cover change on surface temperature using the integration of remote sensing and GIS technologies. Initially, the multispectral bands were radiometrically corrected using Dark Object Subtraction (DOS) while the thermal bands were corrected using Land Surface Emissivity (LSE). After these corrections were applied, the images were classified using supervised image classification technique where seven land cover types have been identified. The classified images were then validated using 200 reference data and this revealed an overall accuracy of 87.5% and 86.0% for the May 2003 and July 2015 images, respectively. Results showed that changes in land cover resulted to a significant change in Land Surface Temperature (LST). The LST in 2003 (16.49°C - 40.44°C) was found higher than that of 2015 which was observed between 13.35°C and 33.83°C only. The reason behind this is the increase in green spaces from 2003 to 2015. Among the major land cover types, forest lands exhibited the lowest mean surface temperature for both years having 27.27°C in 2003 and 21.35°C in 2015 while built-up areas had the highest surface temperature having 32.60°C in 2003 and 26.00°C in 2015.

I. INTRODUCTION

Population growth and economic expansion are some of the major causes of land cover changes worldwide, especially in developing countries. Urbanization has been the primary transformer of land cover patterns worldwide. Most people migrate on areas where there are high economic and employment opportunities. These occurrences may both have profound positive and negative impacts on the social, economic, environmental, and political patterns in an area. Land Surface Temperature (LST) have been seen to be affected by the frequent changes in climate and rapid urbanization around the world. The green spaces around the world increasingly turns into buildings and other infrastructures that have been brought by the population growth. The immense decrease of vegetation cover tends to affect the Earth's temperature and causes global warming.

Due to the varying temperature worldwide, agricultural and forestry sectors have been affected by these drastic changes. Temperature is one of the indicators on the choice of species to be planted in an area. Moreover, it affects the growth and development of wildlife. Yield loss may result if ever the temperature does not meet the crop's optimum requirement. The diversity of species has also been affected with their survival to extreme temperatures. Thus, surface temperature is critical in forestry. The loss of forest land, increase in built-up areas, and increase in barren or open lands are some of the possible land cover changes brought about by the rapid urbanization. In the Philippines, around one-third of our forest is converted into agricultural and residential lands between 1990 and 2010. Because of these land conversions, different events such as landslides, flooding, and drought occurred. In 1934, forests cover is approximately 57% of the country's total land area but in 2010, the forest cover decreased about 34% or 6.8 million hectares of forest cover since 1934 due to the increase of human population and commercial industries (SEPO, 2015). Today, the frequent land conversion that we experience is mainly caused by an increasing population and urbanization. One cannot disagree that the Philippines is really a highly urbanized nation. By the end of 2010, the Philippines had an urban population of about 48.8% of the total population and an annual rate of urbanization increase of 2.16 percent (CIA, 2014).

Region IV-A (Calabarzon) having a land area of 17,597 square kilometers (ati.da.gov.ph) ranked second in the most densely populated region in the Philippines as of 2010. Its land is converted from forest to agriculture then to built-up area for only a short period of time to accommodate the increase in population. This is primarily because of its proximity to Metro Manila and the economic and industrial opportunities that exist in the region. As of the year 2000, 67 percent of Calabarzon's population is in urban areas (Lusterio-Berja, et al., 2008). With this massive population growth in the said region, environmental issues such as forest degradation, pollution, climate change, and global warming increasingly became a major concern. Since the early 2000's, the Mount Makiling Forest Reserve (MMFR) has been bounded by growing settlements that consistently threaten the resources being provided by the reserve. The neighboring towns and cities of MMFR are: Bay, Calamba, Calauan, and Los Baños in the province of Laguna, and Santo Tomas located in the province of Batangas have witnessed remarkable expansion, population growth and developmental activities such as buildings, road constructions, deforestation, and many other anthropogenic activities (Cruz, et al., 1991). Migration of people in these areas is one of the major causes of the increase in surface temperature (Solecki et al., 2005). However, the declaration of the MMFR as a national park has slowed down the expansion of these settlements in the area (Torres & Rebugio, 1991).

The analysis of the effect of land cover changes on the land surface temperature that surrounds Mt. Makiling was conducted by integrating remote sensing and GIS technologies. Remote sensing provides historical and up-to-date imagery obtained from satellites that is an effective tool in monitoring land cover changes. Geographic Information Systems (GIS) is a powerful tool in analyzing and presenting information obtained from satellite images. Utilizing these effective and efficient tools helps researchers, the government, and urban planners to understand and monitor the possible effects of land cover in the land surface temperature.

The main objective of this study is to analyze the changes in land cover and surface temperature of Mount Makiling Forest Reserve (MMFR) and its neighboring municipalities using Landsat data. Land cover maps and land surface temperature (LST) maps were generated based on the multispectral bands; and on the surface emissivity and brightness temperature from thermal bands of Landsat 7 and 8, respectively.

2. METHODOLOGY

2.1 Study Area

The Mt. Makiling Forest Reserve (MMFR) was established in 1910 and was declared as a National Botanic Garden in 1920 (Torres & Rebugio, 1991). On September 2013, it was declared as the 33rd ASEAN Heritage Park which homes to different species of flowering plants. It became a training laboratory for research and extension through the enactment of Republic Act 6967 (Lapitan et al., 2013). The forest reserve and its surrounding urban areas have a mean annual rainfall of 2,200 mm and a mean annual temperature ranging from 23.8ºC - 30.4ºC. The study area also experiences dry season from January to April and wet season from May to December (Cruz, et al., 1991). Most of the reserve's land uses are composed of botanic gardens, parks, old growth forest, mahogany plantation, agroforestry lands, settlement areas and location for such institutions that are found in the Jamboree area. Although the reserve is considered as a protected area, variations of land cover has been one of its major problems as well as the urban areas within its vicinity.

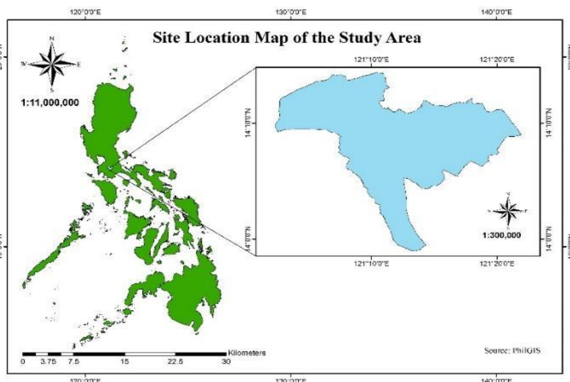

Figure 1. Site location map of the study area

2.2 Data Collection

Secondary data used in this study were downloaded from U.S. Geological Survey (USGS) and PhilGIS websites. The USGS provided the necessary satellite images (Table 1) for the creation of land cover and land surface temperature maps while PhilGIS provided the shapefiles of the study area.

ENVI 5.1 Service Pack 3 was the main software used for the processing of the satellite images. ArcGIS 10.1 was used in layouting, extracting, and presentation of maps.

Image Acquisition	Spatial Resolution	Path/Row	Sensor
May 8, 2003	30m	116/50	Landsat 7 ETM+
July 20, 2015	30m	116/50	Landsat 8 OLI-TIRS

Table 1. Detailed information of the Landsat satellite images acquired for analysis

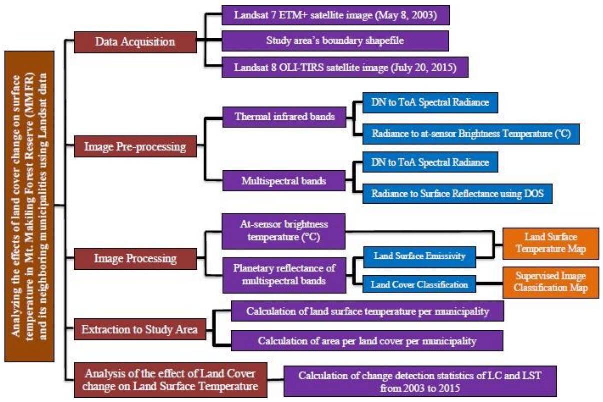

Figure 2. Methodological framework

2.3 Image Pre-processing

Pre-processing operation, also known as image restoration and rectification, is done for radiometric correction and calibration. This is to enhance the scene illumination and remove atmospheric effects and noise that are present in satellite images. This operation involves dark object subtraction, radiance conversion, and reflectance conversion.

2.3.1 Conversion of digital number to top-of-atmosphere (ToA) spectral radiance

Both the digital numbers of multispectral and thermal infrared bands of the satellite images was first converted into top-of-atmosphere spectral radiance.

$$L\lambda = (ML * DN) + AL \tag{1}$$

where:

$L\lambda$ - top-of-atmosphere (ToA) spectral radiance
ML - band specific multiplicative rescaling factor
AL - band specific additive rescaling factor
DN - digital number

2.3.2 Conversion of top-of-atmosphere (ToA) spectral radiance to surface reflectance using dark object subtraction (DOS)

This process was only used on the ToA spectral radiance of the multispectral bands of the satellite images. Dark object subtraction searches each band for the darkest pixel value. This darkest pixel value is then subtracted from every pixel and serves as an effective haze reduction for the multispectral bands of satellite images (Chavez, 1988). The darkest value that can be subtracted from the pixel can be the band minimum, average of the region of interests (ROI), or a specified value by the user.

2.3.3 Conversion of top-of-atmosphere (ToA) spectral radiance to at-sensor brightness temperature in Kelvin

This process is applicable only for the ToA spectral radiance of the thermal infrared bands of the satellite images. The equation below was used for the conversion of ToA spectral radiance values to at-sensor brightness temperature in Kelvin.

$$BTK = \frac{K2}{[\, ln\,(\frac{K1}{L\lambda})+1\,]} \quad (2)$$

where:

BTK - at-sensor brightness temperature in Kelvin
$L\lambda$ - top-of-atmosphere (ToA) spectral radiance
K1/K2 - band-specific thermal calibration constant

2.3.4 Conversion of at-sensor brightness temperature in Kelvin to degree Celsius

Further conversion of the at-sensor brightness temperature in Kelvin to degree Celsius was conducted for an easier and more appropriate analysis. The equation below was used for the conversion of Kelvin to degree Celsius.

$$BTC = BTK - 273.15 \quad (3)$$

where:

BTC - at-sensor brightness temperature in degree Celsius
BTK - at-sensor brightness temperature in Kelvin

2.4 Image Processing

2.4.1 Defining land cover types

Seven land cover types were used in classifying the images. These include: (1) agricultural land, (2) built-up area, (3) clouds, (4) forest land, (5) open land, (6) shadow, and (7) water. Clouds and shadows created by the clouds were included in the classifications since the image is not cloud-free.

2.4.2 Supervised image classification

Training sites were defined and created by the user which served as samples of each land cover type. The decision used in the creation of training sites is typically based on the analyst or the user but mostly secondary data such as aerial photographs, and available maps or the use of software such as Google Earth Pro served as guides in the creation of training sites.

The study used a total of 350 training sites or region of interest (ROI) (50 per land cover) per map with the aid of Google Earth Pro and the combination of different bands. The creation of training sites was done using the polygon tool. The distance between two training sites created was at least 1,000 meters to avoid confusion during the supervised image classification.

2.5 Accuracy Assessment

Since reference data cannot be obtained using a Global Positioning System (GPS) because the study area is too immense, the study used 200 randomly created points using ArcGIS software that served as the validation points or reference points for both the years 2003 and 2015. The randomly created reference points were the basis for the creation of confusion or error matrices of the generated land cover map from the original satellite images. The correct or incorrect classified land cover type was manually counted and recorded in the confusion matrix.

2.6 Change Detection

Change detection technique using post classification is conducted for the land cover maps using ENVI. On the other hand, the change detection statistics for the land surface temperature were conducted by subtracting the mean or average land surface temperature obtained from the year 2003 to the year 2015. Thematic change map from 2003 to 2015 was also produced to present the changes from one land cover type to another that happened through time.

3. RESULT AND DISCUSSION

3.1 Supervised Image Classification

Table 2 and Figure 3 shows the area covered by each land cover in Bay, Calamba, Calauan, Los Baños, and Sto. Tomas for the year 2003 and 2015. Based on the year 2003, open land has the majority of share on the land cover of the study area having 16,865.51 ha of the 39,348.91 ha of land or 42.86% of the total land area. This is followed by forest land having 30.32% of the total land area. Agricultural land and built-up areas only cover 12.30% and 11.37% of the land, respectively. Water comprises the least share on the land cover which is only 0.32% of the study area. Laguna de Bay, which serves as a fishing site for some of the residents in Laguna, is the primary water that is covered within the study area. Clouds and shadows created by clouds occupied a total of 2.83% or approximately 1,114 hectares of land. Majority of the clouds lies on the peak of Mt. Makiling and on the built-up areas in Sto. Tomas, Batangas (Figure 4).

For the year 2015, it is evident that there is a significant increase of green spaces in Mt. Makiling and its neighboring municipalities. Despite of urbanization, population growth, and several land conversions that occurred in the area, the government and the local people has still managed and maintained their forest cover that will benefit them in the near future. Forest land has the greatest land cover for the year 2015 having 30.84% or 12,136.27 hectares of the total land area, which is slightly higher than of the year 2003. This is followed by open land which has decreased by approximately 20% from the year 2003 and only covers 22.97% of the land area. The decrease of open land can be attributed to the economic expansion and population growth, leading to the conversion of open land for productive uses such as infrastructures, and agriculture and forest uses. Built-up areas have also seen a significant increase for about 4% of the total land area. Due to its proximity to Metro Manila, it is evident that there would be an increase in built-up areas due to the economic and environmental benefits that people could get to these areas. The population pressure resulted to the conversion of open lands into residential areas and other infrastructures such as buildings, and impervious

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surfaces. Clouds and shadows from clouds, which comprise of 7.12% and 3.25% of the total land area respectively, is mostly located on the urban areas of Bay, Calamba, and Calauan. The large cloud cover can influence the land surface temperature for these areas (Figure 5). Water this year has also less than 1% of the total land area.

Land Cover	2003		2015	
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
Agricultural Land	4,841.74	12.30	8,007.57	20.35
Built-up Area	4,474.4	11.37	5,925.87	15.06
Clouds	632.45	1.61	2,800.95	7.12
Forest Land	11,928.78	30.32	12,136.27	30.84
Open Land	16,865.51	42.86	9,037.44	22.97
Shadow	481.79	1.22	1,279.22	3.25
Water	124.24	0.32	161.60	0.41
Total	**39,348.91**	**100**	**39,348.91**	**100**

Table 2. Area and percentage for each land cover type for the year 2003 and 2015

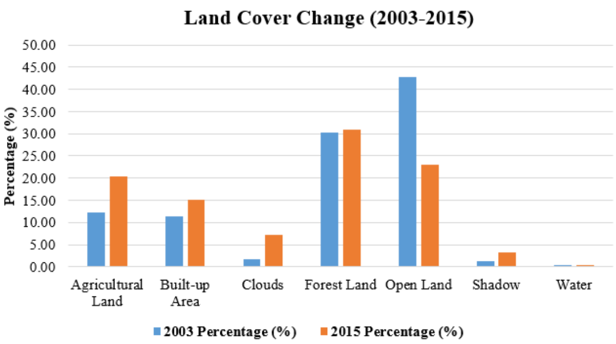

Figure 3. Bar graph showing the percentage of each land cover type of the whole study area for the year 2003 and 2015

From the land cover changes for the year 2003 and 2015, there is a significant increase of green spaces which include both agricultural and forest lands. An increase in built-up areas is also noticed from 2003 to 2015. However, a great decrease of open land for about 50% in 2015, from its cover in 2003, can be attributed to the economic activities in the area. Water experienced minimal changes from 2003 to 2015. There is also an increase of cloud cover and shadow cover.

For the year 2003, it can be noticed that Calamba has the largest agricultural area, built-up area, and open lands which is composed of 5.03%, 6.40%, and 18.58% of the total land area respectively. This may be because it is the largest municipality, covering 33.21% of the whole study area. Despite of being the largest municipality, Calamba has the lowest forest cover which has only 2.87%. The low forest cover may be due to the high population of the municipality. Bay has the lowest built-up area, covering 0.62%, for it is the smallest among the five municipalities and has the lowest population. Forest land is predominantly found on Calauan, Sto. Tomas, and Los Baños having 9.60%, 7.88%, and 6.73% of the forest cover respectively. Calauan has the largest forest cover for it is where Mt. Kalisungan is found. Los Baños and Sto. Tomas also have a large forest cover due to the fact that Mt. Makiling can be found here. Also, some parts of Mt. Manabu in Batangas has been occupied by Sto. Tomas. Los Baños registered the lowest percentage of open land having only 2.76%. The land cover of Los Baños is mostly covered with trees and other vegetation, that is why the green spaces of Los Baños is higher compared to the other municipalities. The high percentage of green spaces in Los Baños may be attributed to the actions done by the University of the Philippines Los Baños for it is the center of excellence in forestry and agriculture. Cloud cover and shadows caused by clouds is mostly located in Sto. Tomas having 0.93% and 0.69%. Clouds and shadow were added as a land cover type in order not to affect the result of the image classification. Water comprises only a total of 0.32% for all the municipalities and majority of it is coming from the part of Laguna de Bay.

For the year 2015, Calamba still covers the largest area for agricultural land, built-up area, and open land having 7.15%, 8.95%, and 10.48% respectively. It is also seen that there is an increase of forest cover in the said municipality for about 1% from the year 2003. However, the forest cover is still lowest and is statistically tied with the forest cover in Bay. A significant increase of forest cover is evident in Los Baños, and Sto. Tomas. Calauan, having the highest forest cover in 2003, has decreased to 7.52% and this may be caused by insufficient management of forest resources due to population growth. Cloud cover may also have affected the area covered by the forest for it covers 3.07% of land in Calauan.

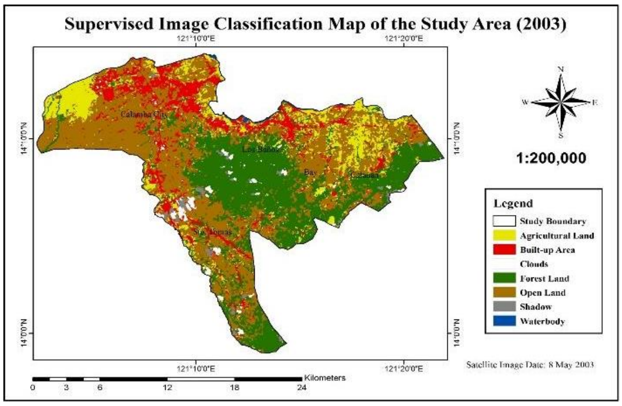

Figure 4. Supervised image classification of the study area dated May 8, 2003

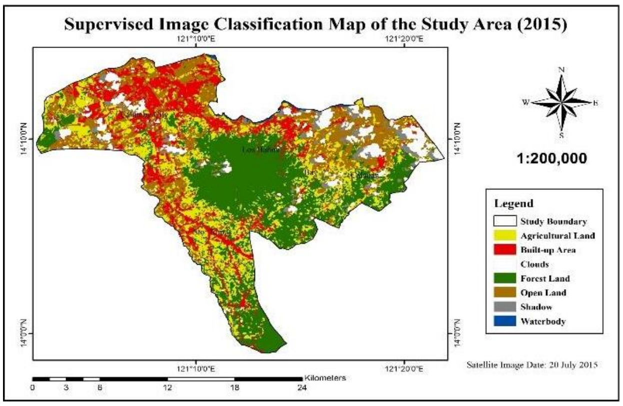

Figure 5. Supervised image classification of the study area dated July 20, 2015

3.2 Accuracy Assessment

The generated confusion matrices for the study area have resulted in a considerably high overall accuracy of about 87.50% for 2003 and 86.50 for 2015 from the 200 randomly generated reference points. Cohen's Kappa were found to be 83.39% in

2003 and 82.57% in 2015. This implies that there is a higher accuracy on the year 2003 than of the year 2015, this is because its overall accuracy is higher compared to 2015.

The confusion matrix for the year 2003 showed that built-up areas, forest lands, open lands, water, shadow, and cloud cover have higher and acceptable user's accuracy of about 82.35%, 93.33%, 87.32%, 100%, 100%, and 88.89%, respectively. These land cover types tend to result into a much lower commission error which means that the class is assigned to the wrong pixel. For the agricultural land, it has a user's accuracy of 61.90%. This may be due to some spectral confusion of agricultural land to the forest and open lands during the classification of images. The same with producer's accuracy, agricultural land has the lowest accuracy of only 68.42% compared to the 87.50% of built-up areas, 86.15% of forest lands, 88.57% of open lands, and 100% of water bodies. This implies also that agricultural land has the highest omission error of 31.58%. Omission error is an error for a given class in which a pixel was not assigned in a class on where it is supposed to be assigned.

On the other hand, the confusion matrix for the year 2015 showed that forest lands, open lands, water, shadow, and cloud cover have higher and acceptable user's accuracy of about 89.47%, 93.75, 100%, 85.71%, and 100%, respectively. For the agricultural land and built-up areas, it has a user's accuracy of 73.47% and 75% respectively. The low user's accuracy for the two land cover types resulted into a higher commission error compared with the open lands, water, shadow, and clouds. However, the producer's accuracy for both agricultural land and built-up areas is highly accepted which is 87.80% and 100% respectively. Also, the producer's accuracy of open land poorly resulted into only 69.70%. This means that the image classification conducted during the software's processing resulted in a much higher accuracy compared to what the user did during the accuracy assessment. The producer's accuracy for the other land cover types has an acceptable result.

3.3 Land Surface Temperature (LST)

The land surface temperature changes were determined by using the Zonal statistics tool in ArcGIS 10.1. Statistics such as minimum, maximum, and mean were obtained from the years 2003 and 2015.

The land surface temperature per land cover type shows that all the land cover types has decreased in its average temperature from the year 2003 to 2015 (Table 3). The greatest decrease in temperature was seen on the open land which is about 8.23°C, this is followed by agricultural land which decreased by 6.66°C, built-up areas which decreased by 6.61°C, forest land decreased by 5.91°C, and water decreased by 4.92°C. However, we can see that the highest average temperature was recorded in the built-up areas for the years 2003 and 2015, having 32.60°C and 26°C respectively. The lowest recorded temperature was recorded in water for both years, 25.85°C in 2003 and 20.93°C in 2015. Green spaces such as agricultural land and forest land has recorded a temperature of 29.69°C (2003) and 23.03°C (2015) for the agricultural land; 27.27°C (2003) and 21.35°C (2015) for the forest land. Open land has a higher temperature than these green spaces, 31.78°C in 2003 and 23.54°C in 2015. This implies that impervious areas or areas that reflects more heat tends to have higher surface temperature than those who do not reflect more heat (e.g. forest land and agricultural land).

The land surface temperature per municipality also showed that all the municipalities has decreased in its average temperature from the year 2003 to 2015 (Table 4). The greatest decrease in temperature was seen in Calauan which is about 8.01°C while the smallest decrease is on Los Baños which is 6.17°C. Bay decreased its temperature by 7.57°C, Calamba decreased by 7.81°C, and Sto. Tomas decreased by 6.66°C. Calauan may have the greatest decrease in temperature because it was found out that the majority of its open land was converted into forest lands. This is also were Mt. Kalisungan, in addition with Mt. Makiling, is found that is also monitored by the government and the people. The decrease in temperature has resulted due to the increase of green spaces nationwide and due to the implementation of such laws that tends to protect the nation's natural resources, especially the forests.

Based on the land cover change from 2003 to 2015, it was observed that there is a significant increase in green spaces in the area which came mostly from agricultural and forest lands. An increase in built-up areas was also noticed from 2003 to 2015. However, a great decrease of open lands for about half of its cover in 2003 can be attributed to the economic activities in the area. Water bodies experienced minimal change from 2003 to 2015.

Land Cover	**Average Temperature (°C)**		**Temperature Change (°C)**
	2003	**2015**	
Agricultural Land	29.69	23.03	-6.66
Built-up Area	32.60	26.00	-6.61
Clouds	24.95	19.13	-5.82
Forest Land	27.27	21.35	-5.91
Open Land	31.78	23.54	-8.23
Shadow	27.41	20.82	-6.59
Water	25.85	20.93	-4.92
Overall Average	28.51	22.12	-6.39

Table 3. Land surface temperature changes per land cover for the year 2003 and 2015

Municipality	**Average Temperature (°C)**		**Temperature Change (°C)**
	2003	2015	
Bay	29.14	21.57	-7.57
Calamba	32.38	24.57	-7.81
Calauan	28.80	20.80	-8.01
Los Baños	28.01	21.84	-6.17
Santo Tomas	29.41	22.75	-6.66
Overall Average	29.55	22.31	-7.24

Table 4. Land surface temperature changes per municipality for the year 2003 and 2015

The LST in 2003 was observed between 16.49°C and 40.44°C while LST in 2015 was found lower compared to the previous period (13.35°C - 33.83°C). This may be caused by the increase in green spaces in the area. Higher LST can be observed on open lands and built-up areas. Agricultural areas, forest lands, and

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water bodies have lower mean temperatures compared to other land cover types. This can be attributed to the ability of green spaces to absorb more heat while impervious surfaces such as the built-up areas tend to reflect more heat resulting to a higher temperature.

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It was found out that the surface temperature of Band 10 is quite larger compared with the Band 11. Further research shows that since Landsat 8 has two thermal infrared bands which include Band 10 and Band 11, there is a larger uncertainty in the obtained values for Band 11. It is highly suggested that users must use the sensor of Band 10 for it is more accurate compared to the other band. The thermal energy that is obtained during the satellite data collection on the Earth's surface is said to be affected by stray light and was stored in both Bands 10 and 11. However, Band 11 is more contaminated by the stray light compared to Band 10 (Shippert, 2013). That is why it is more advisable to use Band 10 for the computation of land surface temperature.

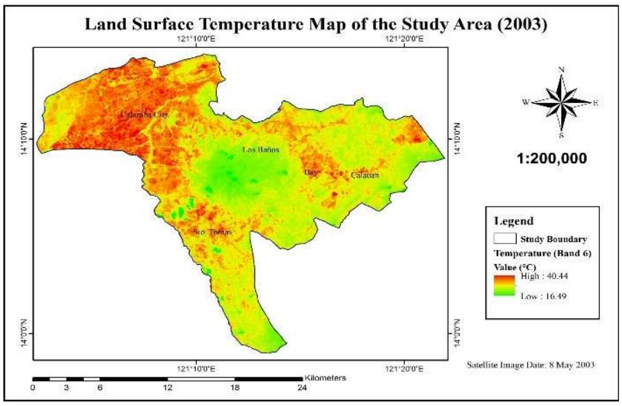

Figure 6. Land surface temperature map of the TIR band (band 6) of Landsat 7 dated May 8, 2003

Through visual interpretation, we can clearly say that LST and land cover are related with each other. It has been noticed that although there is a significant increase of built-up areas due to population growth, agricultural and forest land also increased. The increase of built-up areas can be related to the increase of agricultural and forest land because many of the local people especially on Bay, Calauan, and Los Baños are mostly dependent on forest and agriculture as their source of living, as well as their source of food. The implementation of the National Greening Program (NGP) and the Executive Order No. 23, which suspends the harvesting of timber in natural forests within the boundary of our country, are some of the reasons why there is an increase of forest cover in our country.

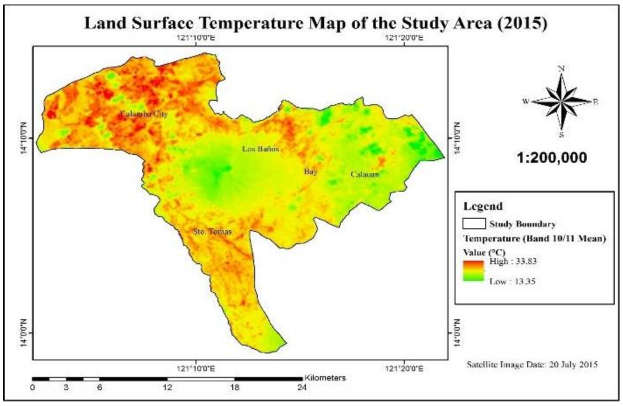

Figure 7. Land surface temperature map of the averaged bands 10 and 11 TIR band of Landsat 8 dated July 20, 2015

The land cover composition of materials such as bare soil, roads, vegetation, trees, and other materials have its own surface temperature because these materials differ in their absorption property. Impervious surfaces that are mainly created by man, such as roads, houses, and buildings are covered by solid and impenetrable materials like concrete, asphalt, roofs, stone, bricks, and cement tend to have higher surface temperatures. Soils that are compacted due to population pressures are also considered impervious surfaces.

Since open land has a larger cover in 2003, it tends to result to a higher surface temperature compared to 2015 despite of the increase in population. There is also a great increase in green spaces, including both agricultural land and forest land during the year 2015 and resulted into a much lower surface temperature. Also, this is because green spaces absorb more heat coming from the sun while impervious surfaces such as those in the built-up areas reflects more, resulting to a higher temperature.

3.4 Change Detection Statistics of Land Cover

The thematic change map from the year 2003 to 2015 was shown in Figure 8. It represents the transition of a land cover type to another. The tabulation for the changes from one land cover type to another type was shown in Table 5. From the seven land cover types that are initially identified, it was simplified and grouped into three which consists of the forest land (FL), non-forest land (NF), and agricultural land (AL). These land cover types were simplified to easily understand and clearly present the changes of land cover from 2003 to 2015. Non-forest land comprises the built-up areas, open lands, water bodies, clouds, and shadows.

Results show that non-forest land to non-forest land from the year 2003 to 2015 has the greatest land cover of about 41.79% or 41, 978.97 ha of the study area. This implies that a large non-forest land cover in 2003 hasn't largely changed into other land cover in 2015. The unchanged forest land, from 2003 to 2015, covers 19.09% or 19,182.15 ha. which has a huge difference from the unchanged non-forest land. Agricultural land in 2015 has 3.05% or 3,066.93 ha. of the total land cover. It can also be noticed that there is an increase of green spaces from 2003 to 2015. From the 22.12% or 22,221.27 ha. non-forest land to green space transition in 2015, 12.81% (12,872.79 ha.) comprises of the agricultural land and 9.31% (9,348.48 ha.) has been occupied by the forest land. Also, it was found out that the greatest transition was seen on non-forest land to agricultural land. This is because of the combined efforts conducted by the people and the government. This transition can be also attributed to the lowering of temperature from 2003 to 2015.

In terms of the transition to non-forest land, 5.73% or 5,758.38 ha. comes from agricultural areas, and 4.06% or 4,081.32 ha. is from the forest land. When totaled, it resulted to 9,839.70 or 9.79% of the total land area, a huge difference from the 22.12% of the converted non-forest lands to green spaces. Also, the transition of forest land to agricultural land in 2015 results to 2.93% or 2,941.20 while the transition of agricultural land to forest land records 1.23% or 1,232.28 ha.

Although non-forest land covers more than half of the study area, it is evident that there is a great increase of green spaces from the year 2003 to 2015. Majority of the green spaces is coming from the forest lands which has 29,762.91 ha. or 29.63% while agricultural land has an area of 18,880.92 ha. or 18.79% of the total land area for the year 2015. For non-forest land, 51.58% or 55,408.77 ha. covers the Mt. Makiling Forest Reserve and its surrounding municipalities.

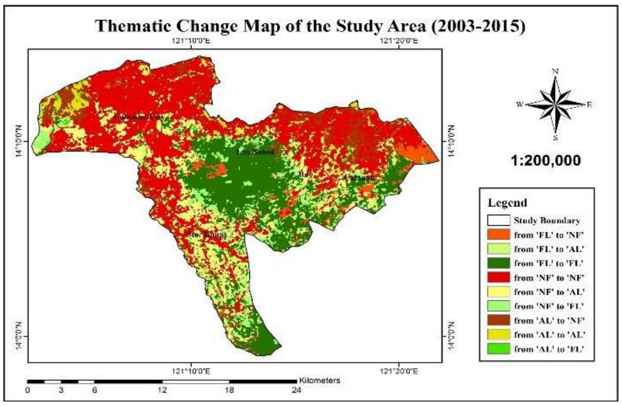

Figure 8. Thematic change map of the study area from 2003 to 2015

Table 5. Changes from one land cover type to another from the year 2003 to 2015.

Land Cover (2003)	Land Cover (2015)	Area (ha)	Percentage (%)
Forest Land	Non-forest Land	4,081.32	4.06
Forest Land	Agricultural Land	2,941.20	2.93
Forest Land	Forest Land	19,182.15	19.09
Non-forest Land	Non-forest Land	41,978.97	41.79
Non-forest Land	Agricultural Land	12,872.79	12.81
Non-forest Land	Forest Land	9,348.48	9.31
Agricultural Land	Agricultural Land	3,066.93	3.05
Agricultural Land	Non-forest Land	5,758.38	5.73
Agricultural Land	Forest Land	1,232.28	1.23

4. CONCLUSIONS

The study had focused on the analysis of land cover changes and on how it affects the land surface temperature in Mt. Makiling Forest Reserve and its surrounding areas which include Bay, Calamba, Calauan, and Los Baños in the province of Laguna and Sto. Tomas in Batangas using remote sensing and GIS technologies. The study utilized Landsat 7 and 8 imageries dated May 8, 2003 and July 20, 2015, respectively. It revealed that even though there is a significant increase in built-up areas from 2003 to 2015, the temperature in 2015 is still lower than that of 2003 because of the increase in green spaces. Among the major land cover types, forest lands exhibited the lowest mean surface temperature for both years having 27.27°C in 2003 and 21.35°C in 2015 while built-up areas had the highest surface temperature having 32.60°C in 2003 and 26.00°C in 2015. This is because green spaces tend to absorb more heat coming from the sun while impervious surfaces such as those in the built-up areas tend to reflect more heat resulting to a higher temperature.

Utilizing remote sensing and GIS technologies provides historical and up-to-date imagery obtained from satellites. These effective and efficient tools help researchers, the government, and the urban planners to understand and monitor the possible effects of land cover in the land surface temperature.

Hence, this study is helpful in determining the change in land surface temperature and land cover through time. These can be inputs in deriving mathematical relationships in the forecast of different climatic variables. The up-to-date information of the land cover and surface temperature of each municipality bounded by the Mt. Makiling Forest Reserve with the help of intelligent tools such as remote sensing and GIS could be the basis for the creation of laws for the sustainable management of our country's remaining natural resources. The use of technology in the conduct of this study contributes insights to the science community and provide future opportunities in this field of science.

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