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ESTIMATION OF LAND SURFACE TEMPERATURE BASED ON LAND USE FROM SATELLITE DATA

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Abstract- This study aimed to estimate Land Surface Temperature (LST) based on landuse from Landsat-8 satellite data over Kantharawichai District, Maha Sarakham, Thailand. Methods were: 1) Landsat-8 datat from OLI sensor were classified into 4 landuse categories: agriculture, forest, urban and water, and 2) Landsat-8 data from TIRS sensor (band 10 and band 11) were analyzed for LST by using split-window (SW) algorithm. The landuse classification results showed that Kantharawichai District, Maha Sarakham Province, with a total land area of 372.200 km^2, had agricultural area of 125.433 km^2 or 34.320%, forest area of 72.476 km^2 or 19.830%, urban area of 80.808 km^2 or 15.39%, and water area of 86.744 km^2 or 23.735%. The LST analysis results show that Kantharawichai District, Maha Sarakham Province has an average temperature of 24.00 °C. In addition, it was found that the LST of the urban area showed the highest average LST, followed by the forest area, agriculture area and water area, respectively.

Keywords: Landsat-8 Data, Split-Window (SW) Algorithm, LST.

1. INTRODUCTION

Today, the greatest threat to global environmental problems is climate change. This mentions to changes in climate as a result of human activities that directly or indirectly change the composition of the global atmosphere and additionally to natural climate variability observed during the same time period, e.g., temperature, humidity, precipitation and season [1]. Climate change increases the average temperature on earth surface and results in global warming, a phenomenon in which the earth is unable to release the heat it receives from the sun as it used to, resulting in an increase in the average temperature worldwide. During the last century, such temperature, even a few degrees rising, has dramatically changed the global climate. It also severely affects living things on earth [2]. Thailand, which is classified as a developing country both economically and industrially, has undergone a rapid landuse shift from agricultural land to industrial land over the past few decades [3]. Under normal circumstances, the temperature area of agricultural is higher than that of forest, but remains lower than that of urban and built-up areas [4]. Such development has resulted in an increase in residential communities, commercial buildings and industries. On the other hand, the green area that absorbs solar radiation and converts it into energy in photosynthesis is less, leading to an increase in urban temperatures [5, 6].

The Land Surface Temperature (LST) study is one of the currently popular methods of measuring heat from the earth surface to track global temperatures [7]. When studying relevant research, it was learned that most of the LST was applied in various fields such as studies on effects of rising LST on polar ice sheets, studies on effects of LST on vegetation in ecosystems in different areas of the world, studies on effects of rising global temperatures on climate change, and studies on climate models from inspecting the increase in greenhouse gases in the atmosphere affecting the LST [8-13]. In addition, several studies have been carry out for analyze LST using remote sensing technology with natural resource observation satellite data, such as changes in LST of landuse [14, 15]. Remote sensing technology from satellite data is considered to be a very advanced and efficient technology for quickly and timely monitoring of phenomena on the earth [16-25]. Given the importance of climate change and global temperature rise as mentioned above, this research aims to estimate LST based on landuse with data from Landsat-8 satellite.

2. STUDY AREA AND SATELLITE DATA

2.1. Study Area

Kantharawichai District (Figure 1) is located in the northeast of Maha Sarakham Province. The territory borders on the following administrative divisions. The north borders on Yang Talat District (Kalasin Province), the east borders on Yang Talat District and Khong Chai District (Kalasin Province), the south borders on Mueang Maha Sarakham District, and the west borders on Kosum Phisai District and Chiang Yuen District. Kantharawichai District has a relatively flat topography to undulating slopes and is about 130-230 m above sea level. Its climate depends on the influence of two seasonal monsoons, namely the northeast monsoon and the southwest monsoon. In general, Kantharawichai District has an average temperature throughout the year at 27.10 °C, an average lowest temperature of 22.00 °C and an average highest temperature of 32.80 °C.

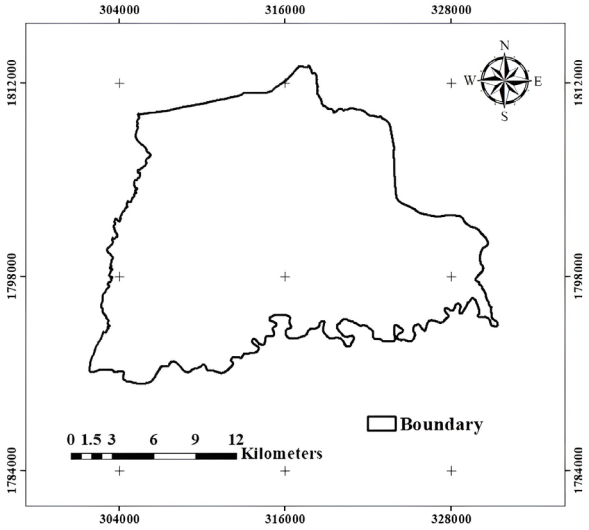

Figure 1. Kantharawichai District, Thailand

2.2. Satellite Data

Landsat-8 OLI/TIRS is a United States Natural Resources Survey satellite developed by NASA and the USGS (U.S. Geological Survey). It was launched into orbit on February 11th, 2013. It repeats its orbit every 16 days, has an imaging line width of 185 km, and includes two imaging systems: Operation land Image (OIL) and Thermal Infrared Sensor (TIRS) of 11 wavelengths (Table 1) giving details of image pixels (pixels). The visible, NIR, SWIR wavelength is 30 m, the thermal wavelength is 100 m, and the panchromatic wavelength is 15 m. This study was based on data from the Landsat-8 OLI/TIRS satellite recorded in December 2021.

Table 1. Spectral bands and resolutions of Landsat 8 OLI/TIRS

Bands	Wavelength (μm)	Resolution (m)
Band 1 - Coastal aerosol	0.43-0.45	30
Band 2 - Blue	0.45-0.51	30
Band 3 - Green	0.53-0.59	30
Band 4 - Red	0.64-0.67	30
Band 5 - Near Infrared (NIR)	0.85-0.88	30
Band 6 - Shortwave Infrared (SWIR) 1	1.57-1.65	30
Band 7 - Shortwave Infrared (SWIR) 2	2.11-2.29	30
Band 8 - Panchromatic	0.50-0.68	15
Band 9 - Cirrus	1.36-1.38	30
Band 10 - Thermal Infrared (TIRS) 1	10.6-11.19	100
Band 11 - Thermal Infrared (TIRS) 2	11.50-12.51	100

3. METHODS

In this study, the researcher divided the operation method into the following steps.

3.1. Land Use Classification

Areas in Kantharawichai District, Maha Sarakham Province were classified into 4 categories by Landsat-8 OLI satellite data, including agriculture, forest, urban and water areas. The reflectance value, known as the Digital Number or DN, recorded by satellites was applied to grouping layers to show the physical changes of objects. In classifying landuse in this research, the Supervised Classification Method (SCM) was used to analyze together with the Maximum Likelihood Statistical Method (MLSM) statistical method.

3.2. LST Analysis

LST was analyzed from Landsat-8 satellite data under split-window (SW) algorithm, divided into the following methods.

3.2.1. Radiance Temperature Analysis

Radiance Temperature (RT) is an analysis of the LST in the TIRS wave range. The analysis of RT was represented as Equations (1) and (2), and Table 2 [26].

$$T = \frac{k_2}{\ln\left(\frac{k_1}{L_\lambda}+1\right)} \quad (1)$$

where,
T: RT in Kelvin
k_1: Fixed value of Landsat-8
k_2: Fixed value of Landsat-8
L_λ: TOA radiance (Watts/(m^2 × srad × μm))

$$L_\lambda = M_L Q_{cal} + A_L \quad (2)$$

where,
M_L: Band Specific from the metadata
A_L: Band Specific from the metadata
Q_{cal}: DN value

Table 2. Landsat-8 band Specific

Band Specific	Value
M_L	0.000342
A_L	0.1

3.2.2. Land Surface Emissivity (LSE) Analysis

Radiation analysis of real-world objects that do not absorb all their energy and emit very little radiation related to black body. Emissivity was evaluated from the ratio of vegetation cover to land obtained from the vegetation difference indices as shown in Equation (3) [27]. From Equation (3), it was needed to analyze the *FVC* (Fractional Vegetation Cover) value as in Equation (4) [28]. This *FVC* value was analyzed from the Vegetation Abundance taken from *NDVI* (Normalized Difference Vegetation Index) which was analyzed as Equation (5) [5]. The ρ was the electromagnetic reflectance of landuse, depending on the wavelength and proportions. The analytical method is shown in Equation (6) [29].

$$LSE = \varepsilon_s\left(1-FVC\right)+\varepsilon_v . FVC \quad (3)$$

where, ε_s is specific value of Landsat-8 and ε_v is specific value of Landsat-8.

$$FVC = \frac{NDVI - NDVI_s}{NDVI_v - NDVI_s} \quad (4)$$

where, $NDVI_v$ is highest value of *NDVI* and $NDVI_s$ is lowest value of *NDVI*.

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (5)$$

where, *NIR* is near Infrared band and *RED* is red band.

$$\rho_\lambda = M_\rho Q_{cal} + A_\rho \quad (6)$$

where, M_ρ is reflectance specific from the metadata, A_ρ is reflectance specific from the metadata and Q_{cal} is DN.

3.2.3. Atmospheric Water Vapor (AWV) Analysis

AWV was analyzed by TIRS electromagnetic waves traveling through the atmosphere. In the analysis, RT values of wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8 were used. The analysis method was display in Equation (7) [30].

$$WV = a + b \times \tau_j / \tau_i \quad (7)$$

where,

$$\frac{\tau_j}{\tau_i} \approx R_{ji} = \sum_{k=1}^{N}\left(T_{i,j} - \overline{T}\right)\left(T_{i,j} - \overline{T}\right) / \sum_{k=1}^{N}\left(T_{i,j} - \overline{T}\right)^2$$

where,

a and b are the coefficients

τ : Ability to transmit electromagnetic waves through the atmosphere of wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8

i, j: wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8

$T_{i,j}$, $T_{j,k}$: RT of wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8

$\overline{T_i}$, $\overline{T_j}$: Mean RT of wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8

3.2.4. LST Analysis in 2 Wavelengths

The LST in this research was analyzed from (1) RT values of wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8, (2) *LSE* values of wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8, and (3) AWV analysis values. The analytical methods were shown in Equation (8) and Table 3 [31].

$$LST = \left(T_{10} + C_{10} - T_{11}\right) + \left(T_{10} - T_{11}\right)^2 C_0 + \\ + \left(C_3 + C_4 W\right)\left(1 - \varepsilon\right) + \left(C_5 + C_6 W\right)\Delta\varepsilon \quad (8)$$

where,

T_{10}, T_{11}: RT of wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8

ε : Mean *LSE* of wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8

$\Delta\varepsilon$: Difference *LSE* of wave range 10 (band 10) and wave range 11 (band 11) of Landsat-8

C_0, C_6: Specific value (see in Table 3)

W: AWV (Atmospheric Water Vapor)

Table 3. Split-window (SW) algorithm

Constant	Value
C_0	-0.678
C_1	1.378
C_2	0.183
C_3	54.30
C_4	-2.238
C_5	-129.2
C_6	16.40

4. RESULTS AND DISCUSSIONS

LST estimation based on landuse from Landsat-8 satellite data were shown as follows:

4.1. Landuse Classification Results

Landsat-8 data from OLI sensor recorded in December 2021 classified four landuses: agriculture, forest, urban and water. The analysis results were shown in Figure 2. When classifying landuse by the SCM together with the MLSM, the analysis results showed that the area of Kantharawichai District, Maha Sarakham Province had the agricultural area of 232.74 km^2, representing 62.52%, the forest area of 64.14 km^2, representing 17.23%, the urban area of 40.13 km^2, representing 10.47%, and the water area of 35.25 km^2, representing 9.47%.

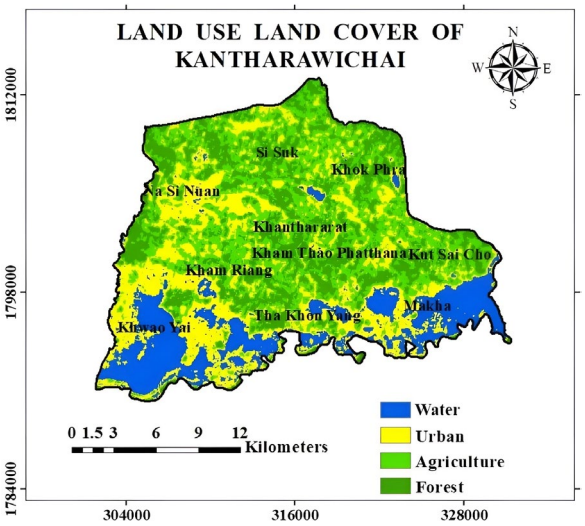

Figure 2. Landuse classification

In addition, when the landuse classification was analyzed at the Sub-district level, it was found that most of the areas were agricultural areas (Table 4).

Table 4. Landuse classification was in sub-district level

Sub-district	Water (km^2)	Forest (km^2)	Agricultural (km^2)	Urban (km^2)	Total (km^2)
Khok Phra	1.07	4.74	14.58	2.51	23.08
Khantharawat	0.06	4.62	15.49	1.23	21.40
Makha	10.08	5.00	16.28	2.02	33.38
Tha Khon Yang	1.23	6.98	20.59	1.20	30.00
Na Si Nuan	0.11	16.21	37.53	10.15	64.00
Kham Riang	7.10	5.10	30.20	6.10	48.50
Si Suk	0.01	8.95	39.63	2.41	51.00
Kut Sai Cho	0.90	2.42	12.44	0.24	16.00
Kham Thao Phatthana	0.20	7.00	22.25	0.10	29.55
Khwao Yai	14.42	3.12	23.65	14.16	55.35
Total (km^2)	34.25	64.14	232.74	40.13	372.26

From Table 4, it was found that the first 3 Sub-districts with the most agricultural area per total area of Kantharawichai District were Si Suk Sub-district with agricultural area 64.14 km^2, representing 17.03%, Na Si Nuan Sub-district with agricultural area 37.53 km^2, representing 16.13%, and Na Si Nuan Sub-district with agricultural area 30.20 km^2, representing 12.98%.

4.2 Statistical Accuracy Analysis Results

Statistical accuracy analysis of landuse classification from Landsat-8 satellite data in this study was used Kappa statistics from all 200 random sampling points by

comparing with Google Earth as shown in the Figure 3 and table 5. From the data in Table 5, the overall accuracy was 95.00%, found that the Kappa Statistics coefficient of consistency was 0.967. Considering only the urban class, it was found that the producer's accuracy was 96.00%, the omission error was 4.00%, and the user's accuracy was 95.00% and commission error was 5.00%.

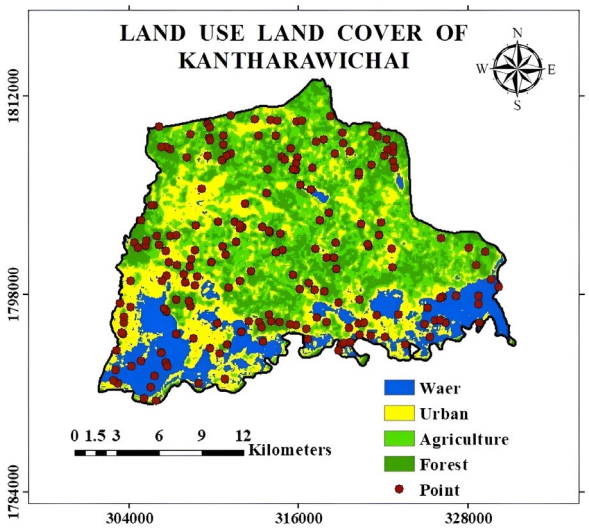

Figure 3. Kappa statistics from all 200 random sampling points

Table 5. Statistical accuracy analysis of landuse classification

Landuse classification	Water	Forest	Agricultural	Urban	Total	User's Accuracy (%)
Water	47	1	1	1	50	94.00
Forest	0	48	1	1	50	96.00
Agricultural	0	2	47	1	50	94.00
Urban	0	1	1	48	50	96.00
Total	47	52	50	51	200	
Producer's accuracy (%)	1	92.30	94.00	94.12		
Overall accuracy (%)	95.00%					

4.3. LST Analysis Results

Analysis of LST over Kantharawichai District, Maha Sarakham Province from Landsat-8 data form TIRS sensor using the split-window (SW) algorithm showed a maximum temperature of 32.00 °C, a minimum temperature of 15.00 °C and an average temperature of 24.00 °C. Moreover, in this study, the temperature was analyzed separately for each Sub-district. Kantharawichai District, Maha Sarakham Province consists of 10 Sub-districts. The analysis of LST by Sub-district can be shown in Table 6. From Table 6, it was found that the first 3 Sub-districts with the maximum average temperature were Khwao Yai with the maximum LST at 32.00 °C, Na Si Nuan with the maximum LST at 32.00 °C, Kham Riang and Si Suk with LST at 31.00 °C.

Table 6. LST analysis results in sub-district

Sub-district	Minimum (°C)	Maximum (°C)	Average (°C)	SD
Khok Phra	20	30	25.00	7.07
Khantharat	20	30	25.00	7.07
Makha	15	28	21.50	9.19
Tha Khon Yang	19	30	24.50	7.78
Na Si Nuan	21	32	26.50	7.78
Kham Riang	20	31	25.50	7.78
Si Suk	20	31	25.50	7.78
Kut Sai Cho	18	29	23.5	7.78
Kham Thao Phatthana	18	30	24.00	8.48
Khwao Yai	22	32	27.00	7.07

4.4. LST Analysis Results based on Landuse

LST analysis results based on landuse over Kantharawichai District, Maha Sarakham Province from Landsat-8 TIRS satellite data were shown in Figure 4. From Figure 4, it could be explained that Kantharawichai District, Maha Sarakham Province had a total of 10 Sub-districts. From the *X*-axis in the graph, Sub-districts were classified into four landuse categories: agriculture, forest, urban, and water. The researchers hypothesized that the urban zone of each sub-district had a more temperature than other landuse areas. From the *Y*-axis in the figure 4, the left side showed the area of landuse in km^2, the right side displays the temperature in degrees Celsius (°C). It could be noticed that the temperature curve changed as stated by each type of landuse in each sub-district. This study showed that there were three Sub-districts with the highest LST of urban areas: Khwao Yai with the highest LST at 27.00 °C, Na Si Nuan with the highest LST at 26.50 °C, and Kham Riang and Si Suk Yai with the highest LST at 25.50 °C. The results of the LST analysis were related to landuse, i.e., the LST analyzed in the urban area was the highest, followed by the forest area, agriculture area, and water area respectively.

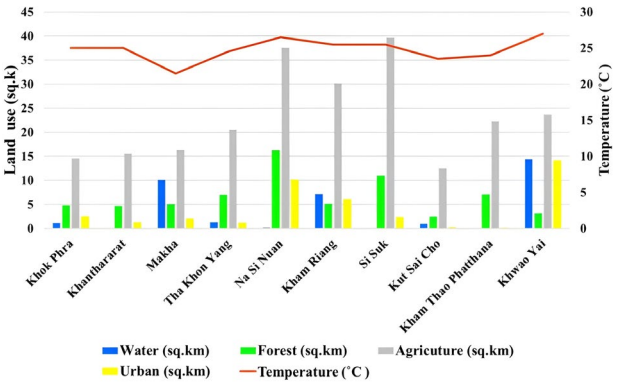

Figure 4. LST Analysis results based on landuse

5. CONCLUSIONS

LST was the study of the Earth's surface temperature, which is measured when touching a particular location. A satellite view of the Earth's surface was viewed through the atmosphere down to areas that could be the roofs of buildings, the tops of trees, ice, or snow. The purpose of this research was to estimate LST based on landuse using Landsat-8 satellite data over the area of Kantharawichai District, Maha Sarakham Province. The results showed that in Kantharawichai District, Maha Sarakham Province, the average LST was 24.00 °C and the urban area showed the highest average LST, followed by forest area, agriculture area and water area, respectively. Moreover, this research was consistent and in the same direction as

the study by [29-33]. It was concluded that the expansion of urban areas resulted in higher density of residential buildings and also resulted in continued high temperatures in urban areas. Therefore, changes in LST in urban areas are increasing due to the expansion of land cover and infrastructure that supports economic and social growth.

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REFERENCES

[1] W. Cai, G. Wang, A. Santoso, M.J. McPhaden, L. Wu, F.F. Jin, A. Timmermann, M. Collins, G. Vecchi, M. Lengaigne, M. England, D. Dommenget, K. Takahashi, E. Guilyardi, "Increased Frequency of Extreme La Nina Events under Greenhouse Warming", Nature Climate Change, Vol. 5, No. 2, pp. 132-137, 2015.

[2] FAO, The World Bank, "Understanding the Drought Impact of El Nino/La Nina in the Grain Production Areas in Eastern Europe and Central Asia: Russia, Ukraine and Kazakhstan", Rome, Italy, 2019.

[3] J. Piamdee, T. Laosuwan, "Estimation of Dynamics of Land Surface Temperature using Terra/Modis Land Surface Temperature Data", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 50, Vol. 14, No. 1, pp. 24-28, March 2022.

[4] W. Charoentrakulpeeti, "Impact of Land Cover on Atmospheric Temperature in Bangkok", NIDA Journal of Environmental Management, Vol. 8, No. 1, pp. 1-18, 2012.

[5] T. Laosuwan, T. Gomasathit, T. Rotjanakusol, "Application of Remote Sensing for Temperature Monitoring: The Technique for Land Surface Temperature Analysis", Journal of Ecological Engineering, Vol. 18, No. 3, pp. 53-60, 2017.

[6] K. Suksabai, K. Nakhapakorn, "Fire Detection Using LANDSAT Thermal Data: In Sai Yok District, Kanchanaburi Province, Thailand", Thai Science and Technology Journal, Vol. 22, No. 4, pp. 462-473, 2014.

[7] S. Khandelwal, R. Goyal, N. Kau, A. Mathew, "Assessment of Land Surface Temperature Variation Due to Change in Elevation of Area Surrounding Jaipur, India", The Egyptian Journal of Remote Sensing and Space Science, Vol. 21, No. 1, pp. 87-94, 2018.

[8] N.H. Wong, C. Yu, "Study of Green Areas and Urban Heat Island in a Tropical City", Habitat International, Vol. 29, No. 3, pp. 547-558, 2005.

[9] J. Zhou, Y.H. Chen, J.F. Wang, W.F. Zhan, "Maximum Nighttime Urban Heat Island (UHI) Intensity Simulation by Integrating Remotely Sensed Data and Meteorological Observations", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, Vol. 4, No. 1, pp. 138-146, 2011.

[10] A. Mathew, S. Sreekumar, S. Khandelwal, N. Kaul, R. Kumar, "Prediction of Surface Temperatures for the Assessment of Urban Heat Island Effect over Ahmedabad City Using Linear Time Series Model", Energy and Buildings, Vol. 128, pp. 605-616, 2016.

[11] S. Youneszadeh, N. Amiri, P. Pilesjo, "The Effect of Land Use Change on Land Surface Temperature in the Netherlands - International Archives of the Photogrammetry", Remote Sensing and Spatial Information Sciences - ISPRS Archives, Vol. 40, No. 1W5, pp. 745-748, 2015.

[12] J. Yang, M. Santamouris, "Urban Heat Island and Mitigation Technologies in Asian and Australian Cities - Impact and Mitigation", Urban Science, Vol. 2, No. 3, p. 74, 2018.

[13] M. Santamouris, S. Haddad, M. Saliari, K. Vasilakopoulou, A. Synnefa, R. Paolini, G. Ulpiani, S. Garshasbi, F. Fiorito, "On the Energy Impact of Urban Heat Island in Sydney: Climate and Energy Potential of Mitigation Technologies", Energy Build, Vol. 166, pp. 154-164, 2018.

[14] T. Rotjanakusol, T. Laosuwan, "Estimation of Land Surface Temperature Using Landsat Satellite Data: A Case Study of Mueang Maha Sarakham District, Maha Sarakham Province, Thailand for the years 2006 and 2015", Scientific Review Engineering and Environmental Sciences, Vol. 7, No. 4, pp. 401-409, 2018.

[15] T. Rotjanakusol, T. Laosuwan, "Model of Relationships between Land Surface Temperature and Urban Built-Up Areas in Mueang Buriram District, Thailand", Polish Journal of Environmental Studies, Vol. 29, No. 5, pp. 3783-3790, 2020.

[16] T. Rotjanakusol, T. Laosuwan. "Inundation Area Investigation Approach using Remote Sensing Technology on 2017 Flooding in Sakon Nakhon Province Thailand", Studia Universitatis Vasile Goldis Arad, Life Sciences Series, Vol. 28, No. 4, pp. 159-166, 2018.

[17] Y. Uttaruk, T. Laosuwan, "Drought Analysis Using Satellite-Based Data and Spectral Index in Upper Northeastern Thailand", Polish Journal of Environmental Studies, Vol. 28, No. 6, pp. 4447-4454, 2019.

[18] T. Prohmdirek, P. Chunpang, T. Laosuwan, "The Relationship between Normalized Difference Vegetation Index and Canopy Temperature that Affects the Urban Heat Island Phenomenon", Technical Geography, Vol. 15, No. 2, pp. 222-234, 2020.

[19] N. Jomsrekrayom, P. Meena, T. Laosuwan, "Spatiotemporal Analysis of Vegetation Drought Variability in the Middle of the Northeast Region of Thailand using Terra/Modis Satellite Data", Technical Geography, Vol. 16, Special Issue, pp. 70-81, 2021.

[20] W. Suriya, P. Chunpang, T. Laosuwan, "Patterns of Relationship between PM10 from Air Monitoring Quality Station and AOT Data from MODIS Sensor Onboard of Terra Satellite", Scientific Review Engineering and Environmental Sciences, Vol. 30, No. 2, pp. 236-249, 2021.

[21] T. Laosuwan, Y. Uttaruk, T. Rotjanakusol, "Analysis of Content and Distribution of Chlorophyll-a on the Sea Surface through Data from Aqua/MODIS Satellite", Polish Journal of Environmental Studies, Vol. 31, No. 5, pp. 4711-4719, 2022.

[22] Y. Uttaruk, T. Rotjanakusol, T. Laosuwan, "Burned Area Evaluation Method for Wildfires in Wildlife Sanctuaries Based on Data from Sentinel-2 Satellite", Polish Journal of Environmental Studies, Vol. 31, No. 6, pp. 5875-5885, 2022.

[23] P. Meena, T. Laosuwan, "Spatiotemporal Variation Analysis of Atmospheric Carbon Dioxide Concentration using Remote Sensing Technology", International Journal

on Technical and Physical Problems of Engineering, Vol. 13, No. 3, pp. 7-13, 2021.
[24] B. Samdaengchai, S. Sinnung, P. Meena, T. Laosuwan, "An Analysis on Disasters Caused by Flood Via Data from Sentinel-1 Satellite", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 51, Vol. 14, No. 2, pp. 21-26, June 2022.
[25] I. Ounrit, S. Sinnung, P. Meena, T. Laosuwan, "Flash Flood Mapping based on Data from Landsat-8 Satellite and Water Indices", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 51, Vol. 14, No. 2, pp. 130-135, June 2022.
[26] C. Auntarin, P. Chunpang, W. Chokkuea, T. Laosuwan, "Using a Split-window Algorithm for the Retrieval of the Land Surface Temperature via Landsat-8 OLI/TIRS", Technical Geography, Vol. 16, Special Issue, pp. 30-42, 2021.
[27] A. Rajeshwari, N.D. Mani, "Estimation of Land Surface Temperature of Dindigul District Using Landsat 8 Data", International Journal of Research in Engineering and Technology, Vol. 3, No. 5, pp. 122-126, 2014.
[28] T. Laosuwan, P. Uttaruk, "Estimating Tree Biomass via Remote Sensing, MSAVI 2, and Fractional Cover Model", IETE Technical Review, Vol. 31, No. 5, pp. 362-368, September 2014.
[29] N. Akhamnuay, A. Sangprajak, T. Laosuwan, "Estimate of Land Surface Temperature of Landuse in Kalasin Municipality Using Landsat 8 OLI/TIRS Data", VRU Research and Development Journal Science and Technology, Vol. 15, No. 3, pp. 89-103, 2020.
[30] H. Ren, C. Du, R. Liu, Q. Qin, G. Yan, Z. Li, J. Meng, "Atmospheric Water Vapor Retrieval from Landsat 8 Thermal Infrared Images", Journal of Geophysical Research Atmospheres, Vol. 120, No. 5, pp. 1723-1738, 2015.
[31] W. Yue, J. Xu, W. Tan, L. Xu, L, "The Relationship between Land Surface Temperature and NDVI with Remote Sensing: Application to Shanghai Landsat 7 ETM+ Data", International Journal of Remote Sensing, Vol. 28, No. 15, pp. 3205-3226, 2007.
[32] W. Dechaphongthana, S. Karnchanasutham, K. Nualchawee, N. Intarawichian, "Estimation of Land Surface Temperature of Land Using Satellite Data", Thai Science and Technology Journal, Vol. 25, No. 3, pp. 377-387, 2017.
[33] S.R. Suwanlee, J. Somard, K. Chainprakhon, N. Nuanhong, S. Ratanatip, "The Relationship between Surface Temperature and Land Use using Multi-Temporal Remote Sensing Imagery in Muang Udon Thani District", Burapha Science Journal, Vol. 26, No. 1, 180-199, 2021.

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