ASSESSMENT OF THE RELATIONSHIP BETWEEN THE RAINFALL AND THE LAND SURFACE TEMPERATURE USING THE MULTI-TEMPORAL LANDSAT SATELLITE IMAGES ACQUIRED IN SEOUL

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ABSTRACT: Assessing the relationship between the rainfalls and the Land Surface Temperatures (LST) is significant for measuring the effects of the rainfalls on urban heat island. This research assessed the relationship between the rainfalls and the LST using the multi-temporal Landsat satellite images acquired in Seoul City, South Korea between 2013 and 2018 through the following steps. First, the data for the total amount of the monthly rainfalls observed in the weather stations was acquired. Next, the average LST in the entire area of Seoul City was calculated using the multi-temporal Landsat satellite images. Finally, the relationship between the rainfall and the LST was assessed by calculating the correlation coefficients between the total amount of the monthly rainfalls and the LST derived from the multi-temporal Landsat-8 satellite images.

1. INTRODUCTION

Assessment of the relationship between the Land Surface Temperatures (LST) and the total amount of rainfalls is necessary for measuring the effects of the rainfalls on the urban heat island. This research carried out for assessing the relationship between the amount of the monthly rainfalls and the LST derived from the Landsat-8 satellite images through the following steps. First, the data for the total amount of the monthly rainfalls observed in the weather stations was acquired. Next, the LST in the entire area of Seoul City was calculated using the multi-temporal Landsat satellite images. Finally, the relationship between the rainfall and the LST was assessed by calculating the correlation coefficients between these two variables (rainfalls and LST).

2. DATASETS AND STUDY AREA

In this research, the datasets of the total amount of the monthly rainfalls and LST in Seoul City, South Korea were utilized due to data availability. The monthly rainfall data in Seoul City were collected in the website of the portal of the Korean weather data (https://data.kma.go.kr/cmmn/static/staticPage.do?page=intro), and the LST data in Seoul City was derived from the multi-temporal Landsat-8 satellite images acquired between 2014 and 2018 that can be downloaded through the website of the earth explorer (https://earthexplorer.usgs.gov/).

3. METHODOLOGY

This LST was calculated by using the thermal infrared band (Band 10) of the given Landsat-8 satellite image through the following steps (Geogeek, 2019; National Institute of Meteorological Sciences (NIMS), 2016). First, the TOA (Top of Atmospheric) spectral radiance was calculated through the below equation.

$$TOA = M_L * Q_{cal} + A_L \quad (1)$$

, where M_L represents the band-specific multiplicative rescaling factor from the metadata, Q_{cal} represents Band 10, and A_L represents the band-specific additive rescaling factor from the metadata.
Then, the brightness temperature (BT) was converted from the TOA spectral radiance through the below equation.

$$BT = \frac{K_2}{\ln\left(\frac{K_1}{TOA}+1\right)} \quad (2)$$

, where K_1 and K_2 represent the band-specific thermal conversion constants from the metadata. The next step was

to calculate the NDVI (Normalized Difference Vegetation Index) through the below equation.

NDVI = (Nir - Red) / (Nir + Red) (3)

, where Nir represents the near infrared band while Red represents the red bands of the given Landsat-8 satellite image. Then the LSE (Land Surface Emissivity) was determined depending on the ranges of the values of the calculated NDVI (see Table 1).

Table 1. Values of the LSE determined depending on the ranges of the values of the calculated NDVI (NIMS, 2016)

Range of the values of the calculated NDVI	Value of the LSE
NDVI < -0.185	0.995
-0.185 ≤ NDVI < 0.157	0.970
0.157 ≤ NDVI ≤ 0.727	1.0094 + 0.047ln(NDVI)
0.727 < NDVI	0.990

Finally, the LST was calculated through the below equation.

LST = $LSE^{1/4}BT$ (4)

Figure 1 shows one scene of the LST image generated through the above equations.

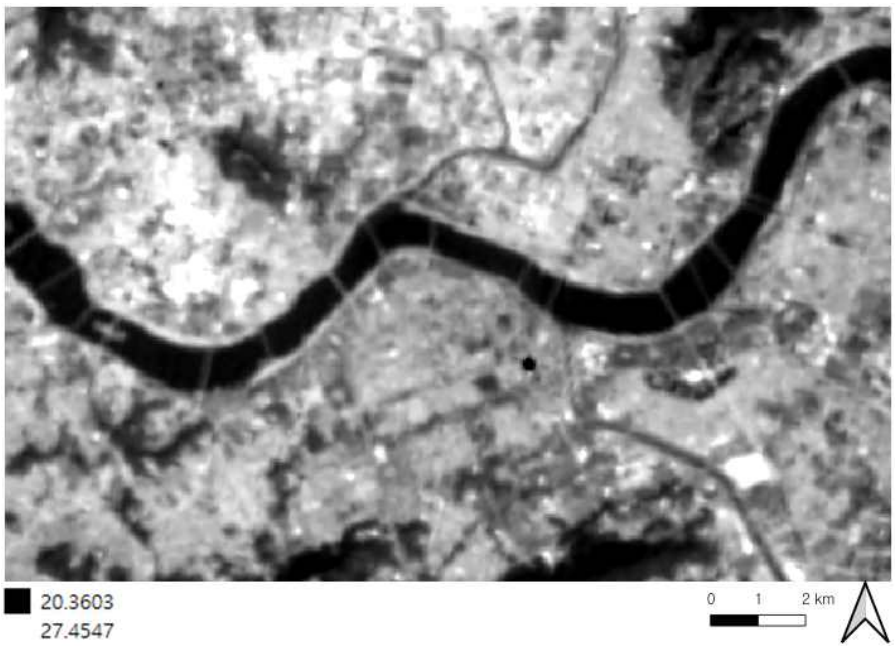

Figure 1. One scene of the LST image generated through the above equations.

Then, the average LST of Seoul City was calculated using all LST images generated from the multi-temporal Landsat-8 satellite images.

Table 2 shows the examples of the monthly rainfall data in Seoul, acquired through the website of the portal of the Korean weather data.

Table 2. Examples of the monthly rainfall data in Seoul, acquired through the website of the portal of the Korean weather data (https://data.kma.go.kr/cmmn/static/staticPage.do?page=intro)

Month / Year	Monthly rainfalls (mm)	Periods (day)
09 / 2013	138.5	9
12 / 2013	24.7	9
01 / 2014	808.9	10

4. RESULTS AND CONCLUSIONS

After both datasets (the monthly rainfalls and the LST in Seoul) were acquired, the correlation coefficient between these two variables. The correlation coefficient is a statistical measure that evaluate the strength between the two variables (Investopedia, 2019). The values of the correlation coefficient range between -1 and 1. In general, a correlation coefficient of -1 shows the negative correlation, a relationship between two variables in which one variable increases as the other decreases, and vice versa, while a correlation coefficient of 1 shows the positive correlation, a relationship between the two variables in which both variables increase, and vice versa (Investopedia, 2019). The correlation coefficient (CC) was calculated through the below equation.

$$CC = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{(n\sum X^2 - (\sum X)^2)(n\sum Y^2 - (\sum Y)^2)}} \quad (7)$$

, where X represents the data of the total amount of the monthly rainfalls and Y represents the LST.
Table 3 shows the statistics of the correlation coefficient between the monthly rainfalls and the LST in Seoul, South Korea.

Table 3. Statistics of the correlation coefficient between the monthly rainfalls and the LST in Seoul, South Korea.

The correlation coefficient between the monthly rainfalls and the LST in Seoul, South Korea	-0.115

As can be seen in Table 2, the correlation coefficient between these two variables has the value of -0.115, which means that there is the minimal or no relationship between the monthly rainfalls and the LST in Seoul, South Korea. This research carried out to assess the relationship between the monthly rainfalls and the LST derived from the Landsat-8 satellite images acquired in Seoul, South Korea by calculating the correlation coefficient between these two variables.

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