Assess the relationship between the Surface Urban Heat Island (SUHI) and Urbanization in Ho Chi Minh City

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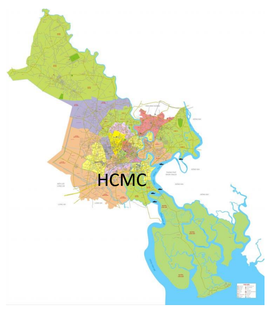

Figure 1. An administration map of HCMC in 2020, with24 urban and sub-urban districts

Abstract

The main objective of the study is to assess the relationship between the surface urban heat island (SUHI) and the urbanization process in Ho Chi Minh City (HCMC) in the period 2014-20. Indicators EVI (Enhanced Vegetation Index), NDBI (Normalized Difference Built-up Index), and DBSI (Dry Bare Sand Index) are used in exploring land-use variability and land-cover variability (LC) in the region. Results show a significant and continuous increase in urban areas and impervious surfaces during the study period. There is a strong linear relationship between LST and NDBI, DBSI, with correlation coefficients being 0.83723 and 8.86633 respectively. In contrast, the relationship between LST and EVI is much less significant. In the period 2014-2020, the trend of increasing hot SUHI and decreasing for cold SUHI. The study used the Google Earth Engine tool for collecting and processing satellite images. As a result, image data collection and processing time are optimized.

Introduction

Ho Chi Minh city, a big economic center of Vietnam, is one of the fast urbanizing city, with 2,095 km2 in size and a population of 8,993 million (2019 statistics). It has been coping with several unpleasant consequences of a developing city, one of them is air temperature anomalies such as surface urban heat island (SUHI).

Many studies suggested that SUHI may have come from factors such that rapid and ill-planned urbanization and industrialization, which result in critical changes in land cover and creating more and more city impervious surfaces.

SUHI is defined as a "*a phenomenon that temperature in urban areas is higher than that in the surrounding non-urban areas due to urbanization*" (Oke, 1982). This can be quantified using Remote Sensing (RS) techniques. The present study aims at assessing the relationship between this SUHI and the urbanization process in Ho Chi Minh City in the period 2014-18 in terms of RS indices EVI (Enhanced Vegetation Index), NDBI (Normalized Difference Built-up Index), and DBSI (Dry Bare Sand Index).

Data and Methodology

Data used: Landsat 8 in 2014, 2018 and 2020.

LST and Landcover maps were derived from Landsat images for the respective years.

The RS indices were computed following formulas below

Dry Bare Soil Index (DBSI)

$$DBSI = \frac{SWIR - GREEN}{SWIR + GREEN} - NDVI$$

Enhanced Vegetation Index (EVI)

$$EVI = 2.5 \times \frac{NIR - RED}{NIR + 6RED - 7.5BLUE + 1}$$

Normalized Difference Built-up Index (NDBI)

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR}$$

The Getis-Ord Gi* hot spot analysis method was used to detect "Hot spots", the potential heat islands that can be obtained through Google Earth Engine (GEE). The GEE encapsulates both the time series of images and the coded algorithm for SUHI detection. This algorithm returns the z-scores for the hot spots detected, which help classify them into 7 classes: Very hot, Hot, Warm, Undefined, Cool, Cold, and Very cold.

Results and Discussions

LST

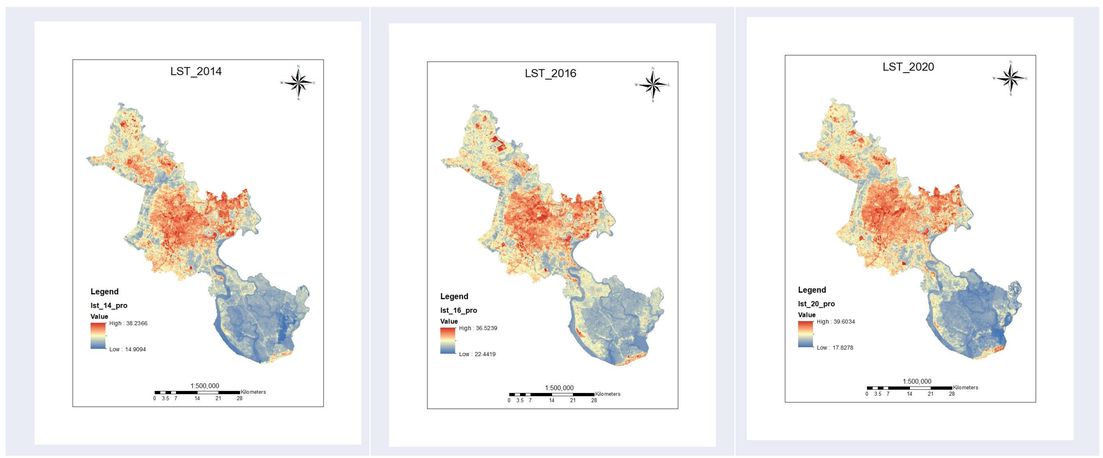

Figure 2. LST maps of HCMC in 2014, 2016 and 2020 derived from Landsat 8 images

DBSI (Dry Bare Sand Index)

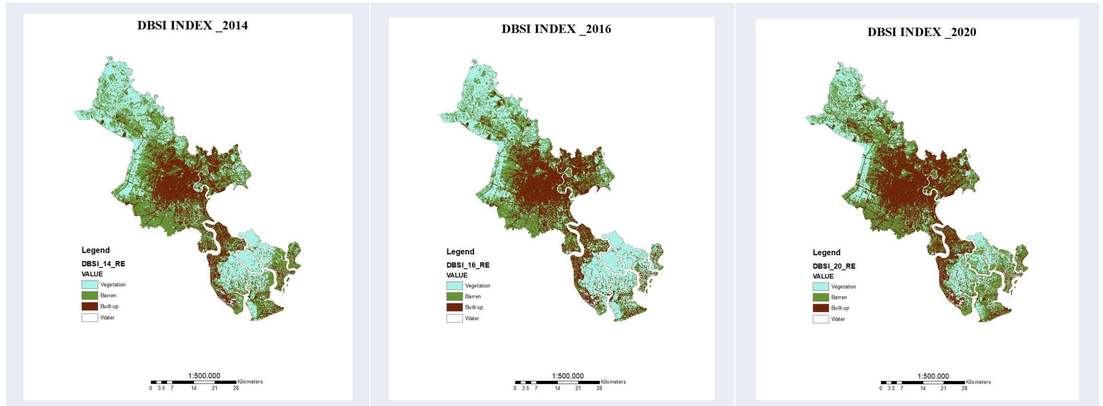

Figure 3. DBSI maps of HCMC in 2014, 2016 and 2020 derived from Landsat 8 images

EVI

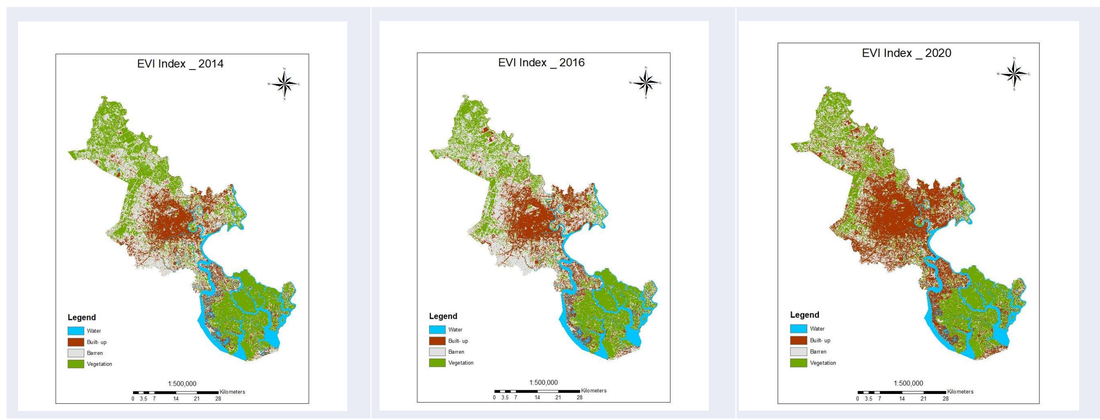

Figure 4. EVI maps of HCMC in 2014, 2016 and 2020 derived from Landsat 8 images

NDBI (Normalized Difference Built-up Index)

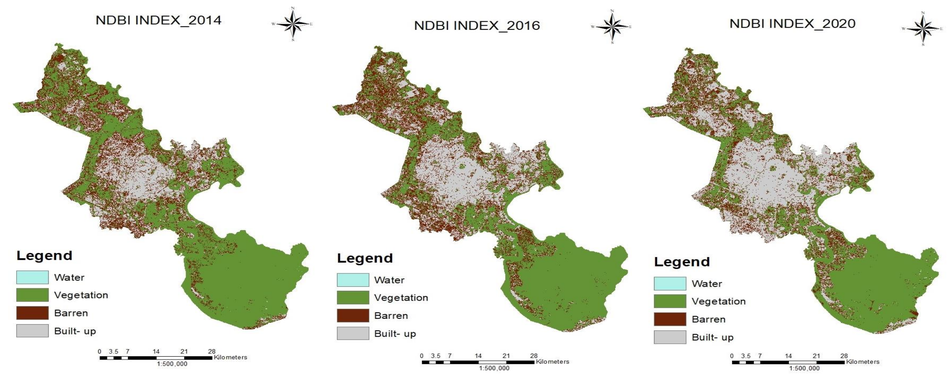

Figure 5. NDBI maps of HCMC in 2014, 2016 and 2020 derived from Landsat 8 images

Correlations

Table 1. Correlations between BDSI, LST and EVI (left); between NDBI, LST and EVI (right)

	BDSI	LST	EVI
BDSI	1	0.86633	-0.92194
LST	0.86633	1	-0.10447
EVI	-0.92194	-0.10447	1

	NDBI	LST	EVI
NDBI	1	0.83723	-0.34204
LST	0.83723	1	-0.10447
EVI	-0.34204	-0.10447	1

The Urban Heat Island map

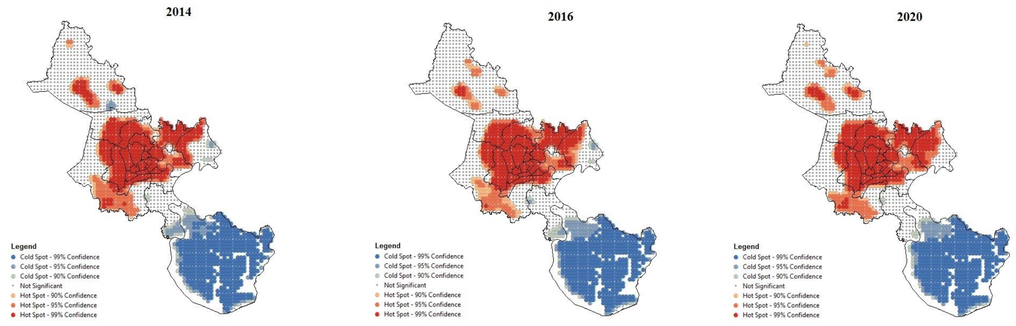

Figure 6. Hot spots and Cold spots maps of HCMC in 2014, 2016 and 2020 (from GEE); there is only a little change

Conclusions

- The average LST in built-up areas are normally >28ºC, while those at vegetated areas normally <25ºC;
- Both the Hot spots and Cold spot sizes have a slightly increasing trend;
- The vegetated areas decrease -3.74%, -5.01% and -12.83% in BDSI, EVI and NDBI calculations, respectively;
- The areas of impervious surfaces increase 5.92%, 15.37% and 15%40% in BDSI, EVI and NDBI calculations, respectively;
- The correlation between LST and NDBI shows high (0.83), also high between LST and BDSI (0.88);
- The deviation of average hot spots temperatures and background shows highest in 2020 (6.74ºC), while is 4.05ºC in 2014 and 3.85ºC in 2016;
- Hot spot SUHI concentrates in central urban districts, while cold spot resides mostly in Can Gio sub-urban district.

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