Project Report

Of

Applied GIS Programming

On

Land Surface Temperature Calculator Using Landsat 9 Images for Phnom Penh, Cambodia

Submitted by

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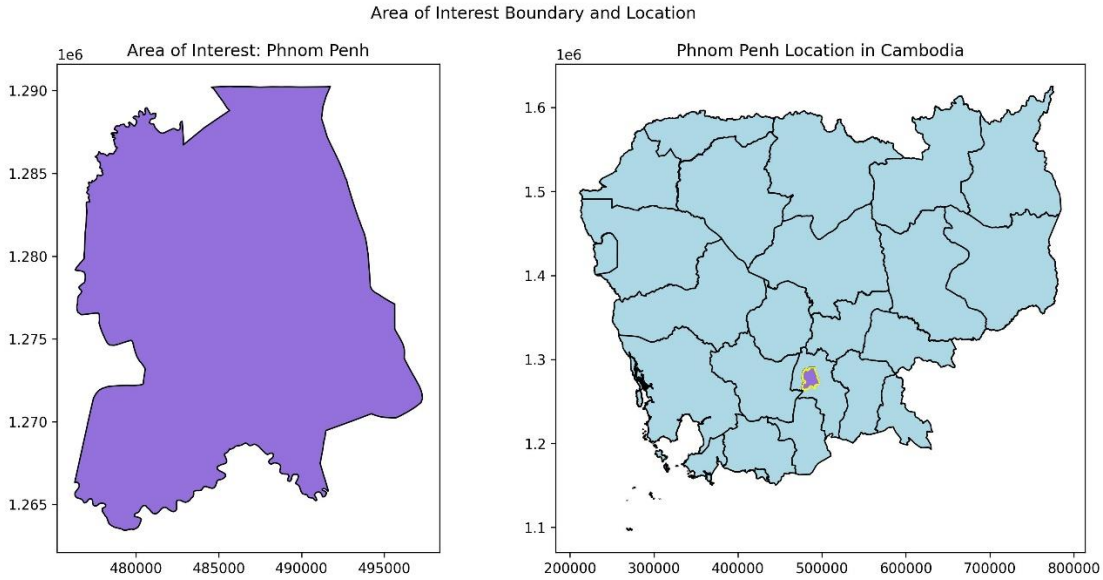
Abstract

This study presents a python approach to calculate Land Surface Temperature for the area of Phnom Penh in Cambodia. and Surface Temperature (LST) refers to the temperature of the Earth's surface as measured from space or remote sensing platforms. It represents the temperature of the land or ground surface itself, excluding any influence from the atmosphere. The Study uses the Satellite Imagery to calculate the LST for the area of interest. During this process, the satellite images have to be processed based on different vector datasets collected from different sources which is done by Python programming languages. The results indicate that, the land surface temperature in the area of Phnom Penh was significantly high in the urban areas.

Introduction

Land Surface Temperature (LST) is the temperature of the Earth's land or ground surface, excluding atmospheric influences. It is measured using remote sensing techniques from space or airborne platforms. LST data is important for climate studies, urban heat island analysis, agriculture, and land use planning. It helps monitor temperature trends, assess climate change impacts, and study the urban heat island effect. There are different ways to calculate the Land Surface Temperature for a location. Using the satellite data is one of them. Using satellite data to calculate LST is preferred as it is more available than the other types of remote sensing data. However, the processing of satellite data is an intricate process. However, it can be easily automated by programming.

In this work, I tried to automate the process of LST calculation by using Python programming language. The area of interest was Phnom Penh, the capital city of Cambodia. It is located in the southern part of the country, situated at the confluence of the Mekong, Tonle Sap, and Bassac rivers. The goal of the project was to analyse the vector data and see how the land use pattern in the area is, and also finding out if there is any correlation between the land use types and the LST.



Materials and Methods

The work follows a very simple methodology to calculate the LST by doing some band maths. During this process, both vector and raster data are used. Python programming language is used for the processing.

Data

For the raster data I used Landsat 9 Level-2 Surface Reflectance data for the date June 22-24, 2023. To clip the data, I used vector data of administrative borders collected from DIVAGIS. Besides that, to understand the land use pattern I use land use field survey data of the year 2017 which was collected from a previous work group in the area.

Programming Language

For processing the data, I used python programming language of version 3.10.9, written on Anaconda Jupyter notebook environment. The environment was run on a Windows 64-bit machine with Intel Core i5 11th Generation processor., 1 Terabyte of storage and 16 Gigabyte of Ram. For the processing the following packages has been used.

Package name	Version
Pandas	*1.5.3*
Geopandas	*0.13.0*
Matplotlib	*3.7.0*
Folium	*0.14.0*
Contextily	*1.3.0*
Numpy	*1.23.5*
Rasterio	*1.3.7*

Methodology

A proper methodology is one of the important parts of the scientific project. However, this work was done as the academic requirement of the course Applied GIS Programming of Warsaw University of Life Sciences. As a result, the priority was given to covering maximum concepts taught in the classroom. In this code, I tried to

apply the concepts of Read/write spatial data from/to file, Reprojecting Data, Spatial queries, Geoprocessing operations like intersection, difference, dissolve etc. The whole task can be divided into 3 sections.

Analysis of vector data to understand land use patterns

i. The vector data form the provinces of Cambodia was imported by geopandas. The provinces data was collected from DIVAGIS.
ii. The area of interest boundary was imported from and visualized using the geopandas, and matplotlib library.
iii. The Khum boundaries were imported and only the Khum's inside Phnom Penh were extracted, visualised, and saved.
iv. Land use vector data was imported. The land use data does not come with the information on khum. Therefore, Khum informations were joined to the land use data with geopandas.
v. Land use data for the Khums inside Phnom Penh municipality was visualised with static and interactive map based on folium. Both maps were exported to local storage.

Analysis of Raster Data to understand the LST

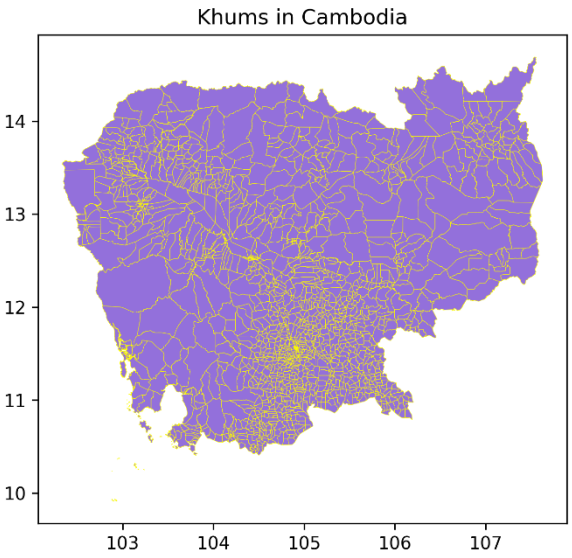
i. Raster bands imported for band 1-7 and band 10 using Rasterio.
ii. Metadata were extracted and visualised.
iii. Individual bands were visualized using matplotlib and Roserio.
iv. Histograms were generated from each band which showed that, the DN values are diverse. So, I applied normalisation on each band.
v. The False Colour composite and True Colour composite were created.
vi. Both composites were visualised and exported.

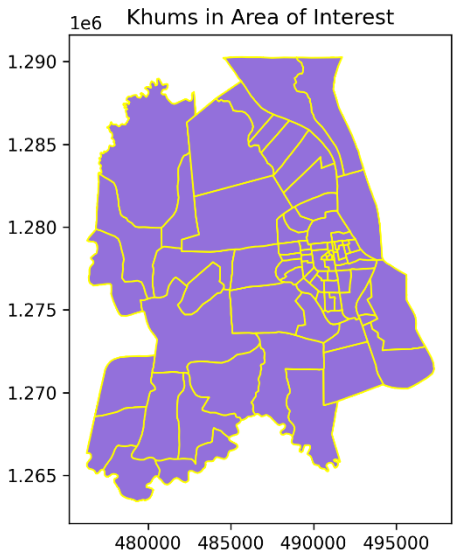
Calculating the LST

i. The formula for LST is
$LST = TB / [1 + (\lambda * TB / C2) * log(E)]$,
where TB = Thermal band(B10), e = Emissivity, λ = 10.8 and C2 = 14388 are constants.
ii. To find Emmisvivty I used the formula is,
$Emissivity, E = PVI * a + b$,
where PVI = Proportional Vegetation Index, a = 0.004, b = 0.986 which are constant.
iii. To find the Proportional Vegetation Index, the formula is
$PVI = ((NDVI - Minimum\ NDVI) / (Maximum\ NDVI - Minimum\ NDVI))^2$
where, NDVI = Normalized-Differenced Vegetation Index
iv. To calculate NDVI the formula that is used is,
$NDVI = (NIR - RED) / (NIR + RED)$
Where, NIR = Near Infreared Band, RED = Band 4
v. Plotting the LST layers as a Raster Image.

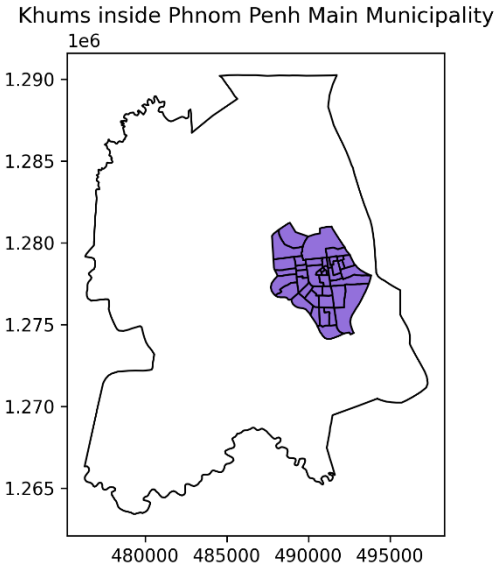
Results and Discussion

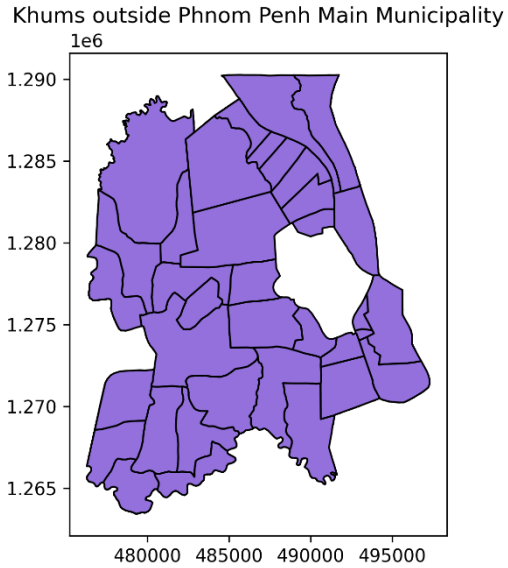
Khums of Cambodia

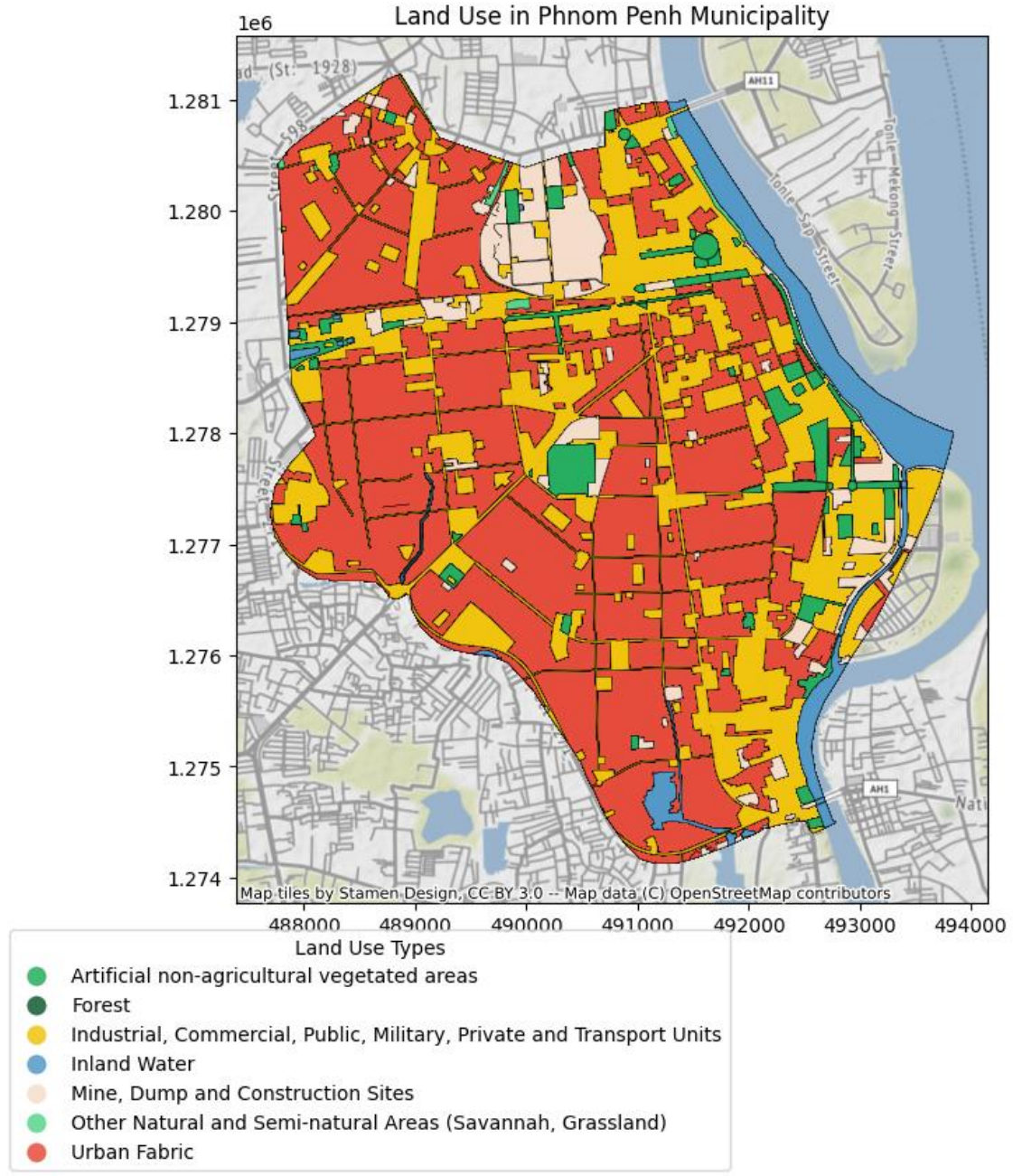


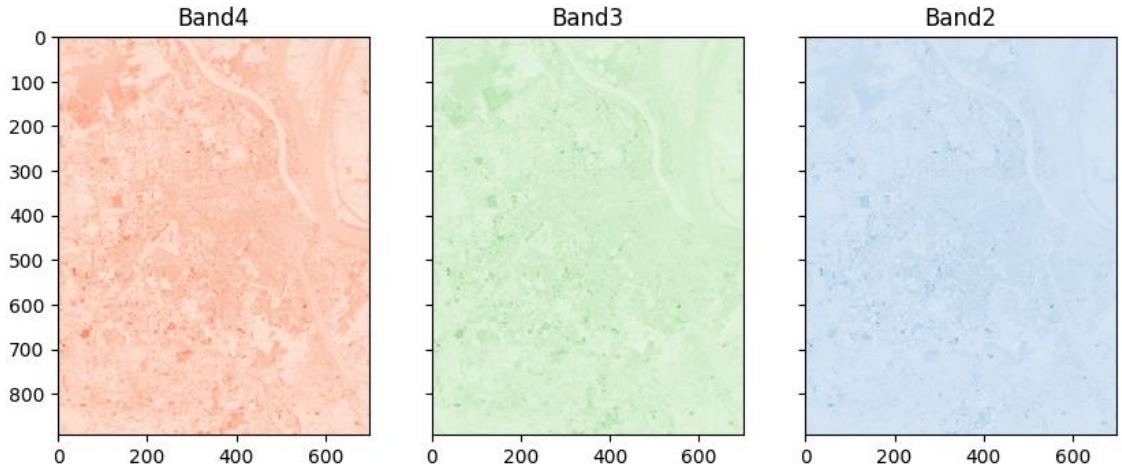


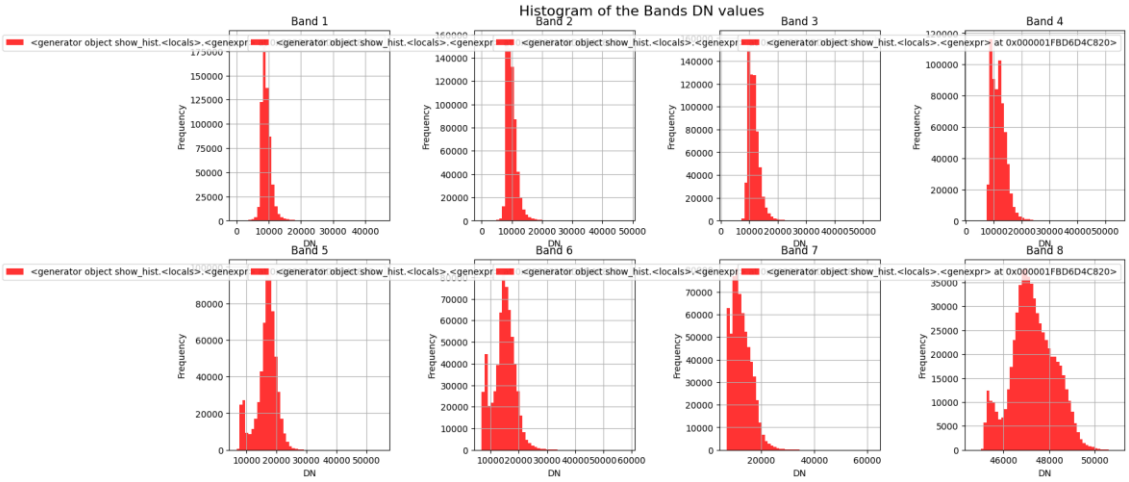
Khums Inside and Outside Phnom Penh Main Municipality

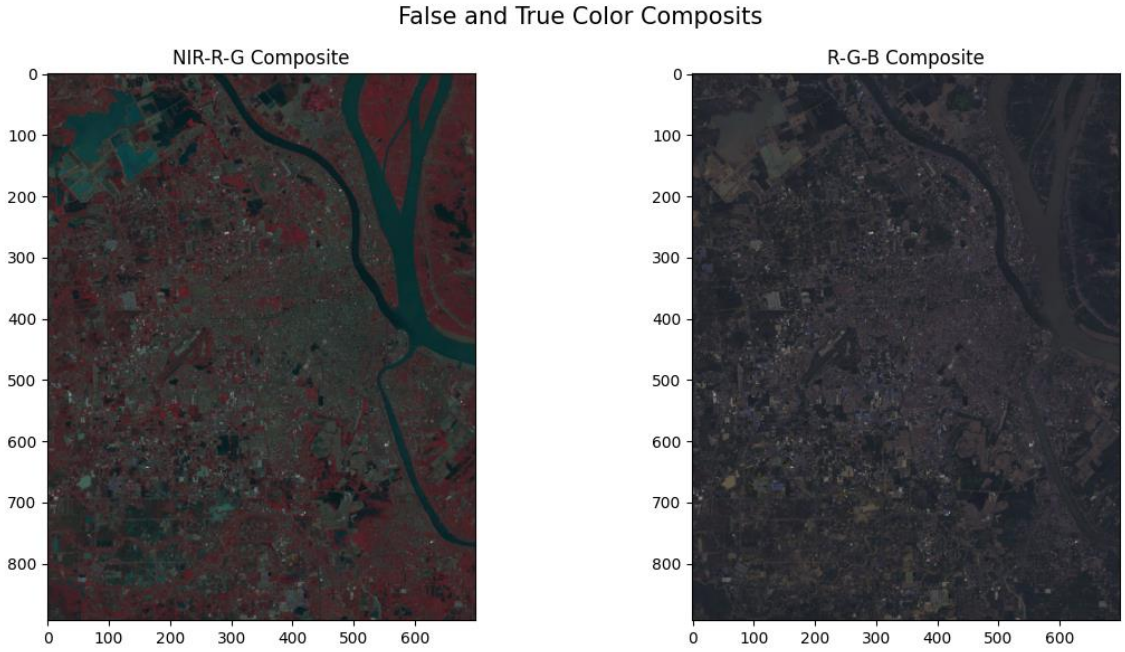


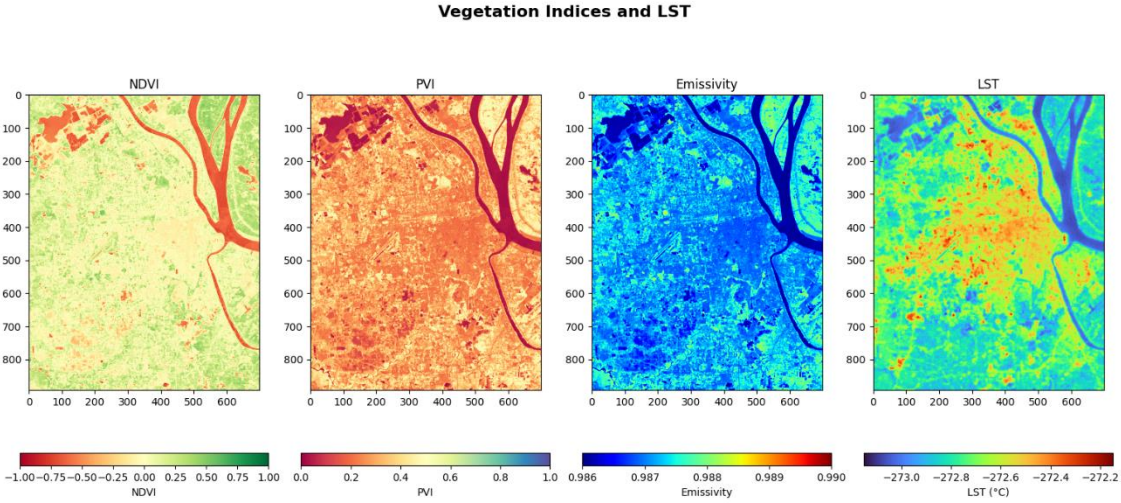



Land Use in Phnom Penh Municipality
1e6
1.281
1.280
1.279
1.278
1.277
1.276
1.275
1.274
488000
489000
490000
491000
492000
493000
494000
Map tiles by Stamen Design, CC BY 3.0 -- Map data (C) OpenStreetMap contributors
Land Use Types
Artificial non-agricultural vegetated areas
Forest
Industrial, Commercial, Public, Military, Private and Transport Units
Inland Water
Mine, Dump and Construction Sites
Other Natural and Semi-natural Areas (Savannah, Grassland)
Urban Fabric


Band4
Band3
Band2
0
100
200
300
400
500
600
700
800
0
200
400
600







The analysis reveals the total number of Khums in Cambodia and identifies the Khums located within the area of interest (Phnom Penh). The study shows the spatial distribution

of Khums within Phnom Penh Main Municipality and highlights areas outside the municipality. Furthermore, the analysis of land use in Phnom Penh Municipality identifies different land use categories and their distribution.

From the LST image we can see that, in centre part of Phnom Penh where Phnom Phen main municipality is located there the land surface temperature is higher than the outskirts.

Conclusion

From this study we can see that the density of urban fabric is extremely high in the main municipality area of Phnom Penh state (Showed in the static map), Furthermore, when the LST images are analysed, it is seen that, the centre part of the LST layers has higher LST which is the Phnom Penh main municipality zone. Therefore, it can be said that, highly urbanised areas have a higher Land Surface Temperature.