Expanding the Little Red Dot:

Urbanization of Singapore 1989 - 2002

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Remote Sensing
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"Globally, over 50% of the population lives in urban areas today. By 2045, the world's urban population will increase by 1.5 times to 6 billion."

– World Bank

Introduction

Urbanization, and the subsequent change of the physical landscape as population and economic growth expands, affects the living environment and well-being of people living in the city. If not managed and regulated, it can have devastating effects socially, environmentally, and economically. One negative consequence is the urban heat island (UHI) effect. Without the cooling effect of transpiration from vegetation, the higher absorption of heat by impervious surfaces causes an increase in land surface temperature.

Between 1965 and 2000, as Singapore's population increased, built-up areas doubled, taking over land that was previously vegetation. By 2030, the Urban Redevelopment Authority projects that Singapore will have a population between 6.5 to 6.9 million. Over the past six decades, temperatures in the city-state have risen at a rate more than double that of the global average. According to the Meteorological Service Singapore (MSS) a major contributing factor is rapid urbanization.

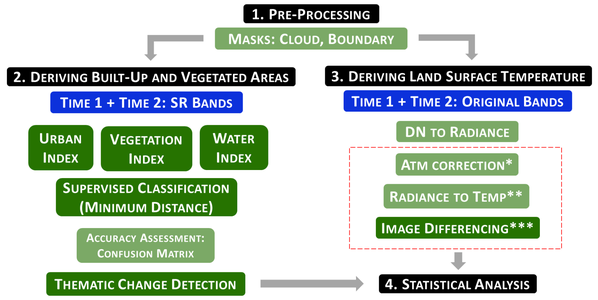
The goal of this project is to use remote sensing to explore the changes in land surface temperature over time as the built environment and vegetation cover changes.

Methodology

Data used:

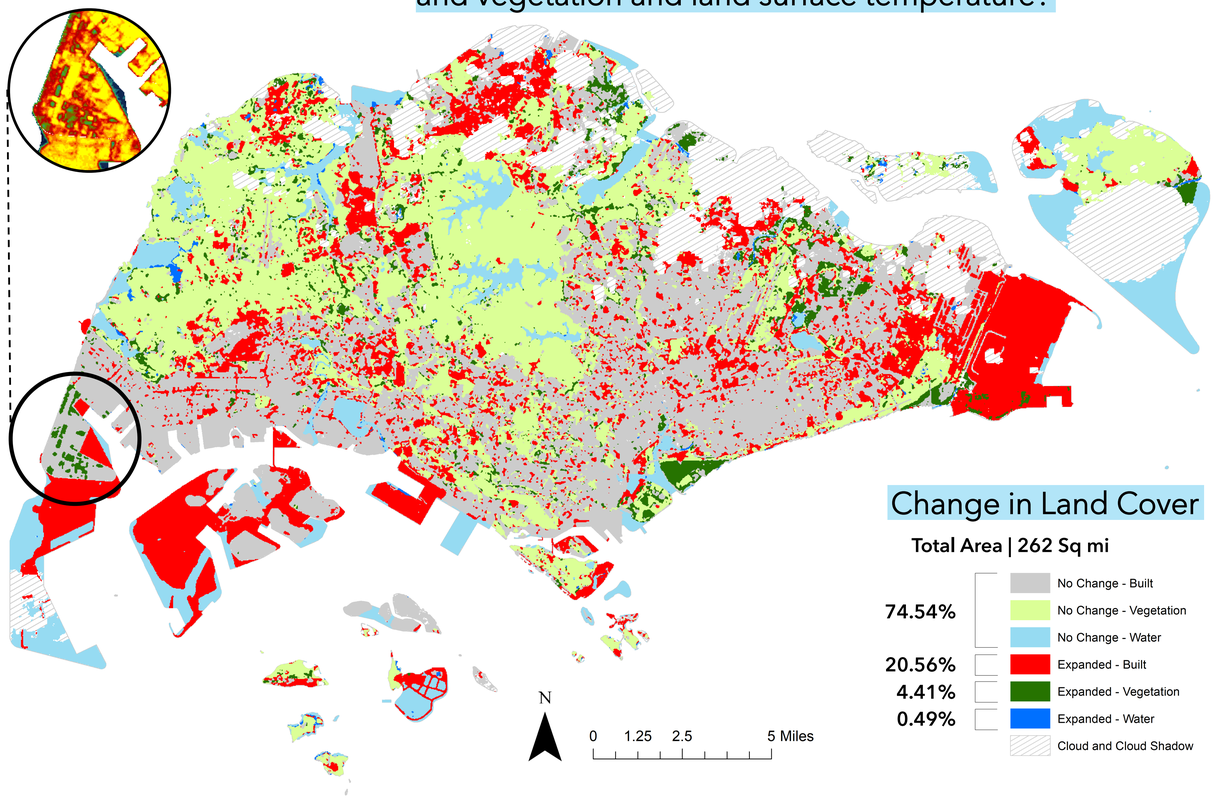
1. 24 May 1989 (Landsat 5 TM)
2. 11 October 2002 (Landsat 7 ETM+)

A post-classification change detection method was chosen for this analysis to identify areas of built and vegetation expansion. This was then compared to a land surface temperature map for 2002.



**Not successful for Time 1 image. Unable to perform atmospheric correction on 1 thermal band before 2000.*
***Only performed for Time 2 image.*
****Unable to perform.*

What spatial patterns exist between change in the built environment and and vegetation and land surface temperature?



Conclusion

The urbanization and expansion of built-up areas in Singapore in just 13 years (1989 – 2002) was rapid. The results clearly show that areas of expanded vegetation in 2002 have lower land surface temperature than the surrounding built environment. This could support the hypothesis that expansion of vegetation helps to decrease land surface temperature.

Innovative solutions to green spaces with limited land availability is needed. Vertical greenery is one solution that Singapore has already engaged in. There is a pressing need for sustainable development models that green the city while still allowing economic development and growth, and Singapore can be a model city for other cities facing similar issues.

Projection: SVY21
Data Sources: USGS Landsat, Singapore Open Data, DIVA-GIS
Photo Source: Chen Siyuan, Wikimedia

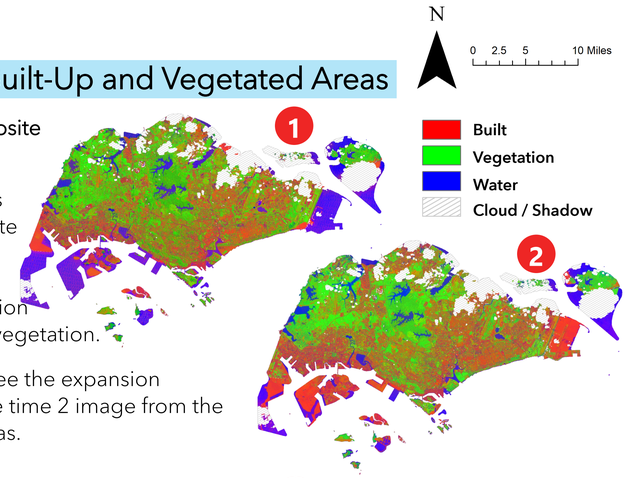
Results

Classifying Built-Up and Vegetated Areas

False-color composite from indices

These composites were used to create training sites for each image to assist in classification of built land and vegetation.

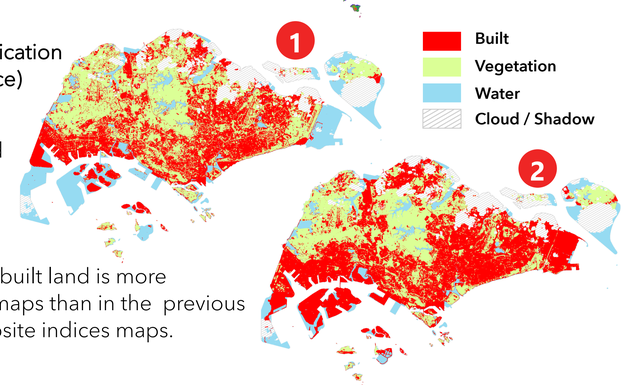
Visually you can see the expansion of built land in the time 2 image from the increased red areas.



Supervised classification (Minimum Distance)

These classified images were used for the thematic change detection analysis.

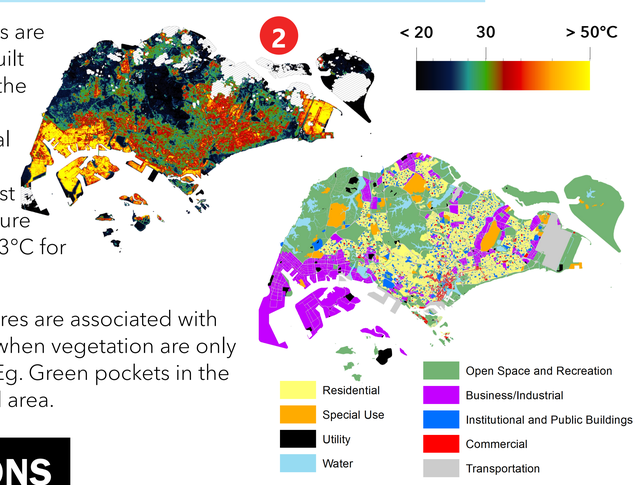
The expansion of built land is more obvious in these maps than in the previous false-color composite indices maps.



Land Surface Temperature and Land Use (2008)

High temperatures are associated with built areas. Looking at the land use map, these are industrial sites and the airport. The highest average temperature by land use was 33°C for industrial areas.

Cooler temperatures are associated with vegetation, even when vegetation are only in small patches. Eg. Green pockets in the Western industrial area.



Limitations

1. Lack of cloudless images and haze.
2. Class confusion between vegetated land and built land due to tree canopy cover created errors for classification of roads.
3. No atmospheric correction for images before 2000.
4. Higher spatial resolution may help improve the accuracy of the classification and change detection.