QUANTIFYING GREEN SPACE COOLING EFFECTS ON THE URBAN MICROCLIMATE USING REMOTE SENSING AND GIS TECHNIQUES

By:

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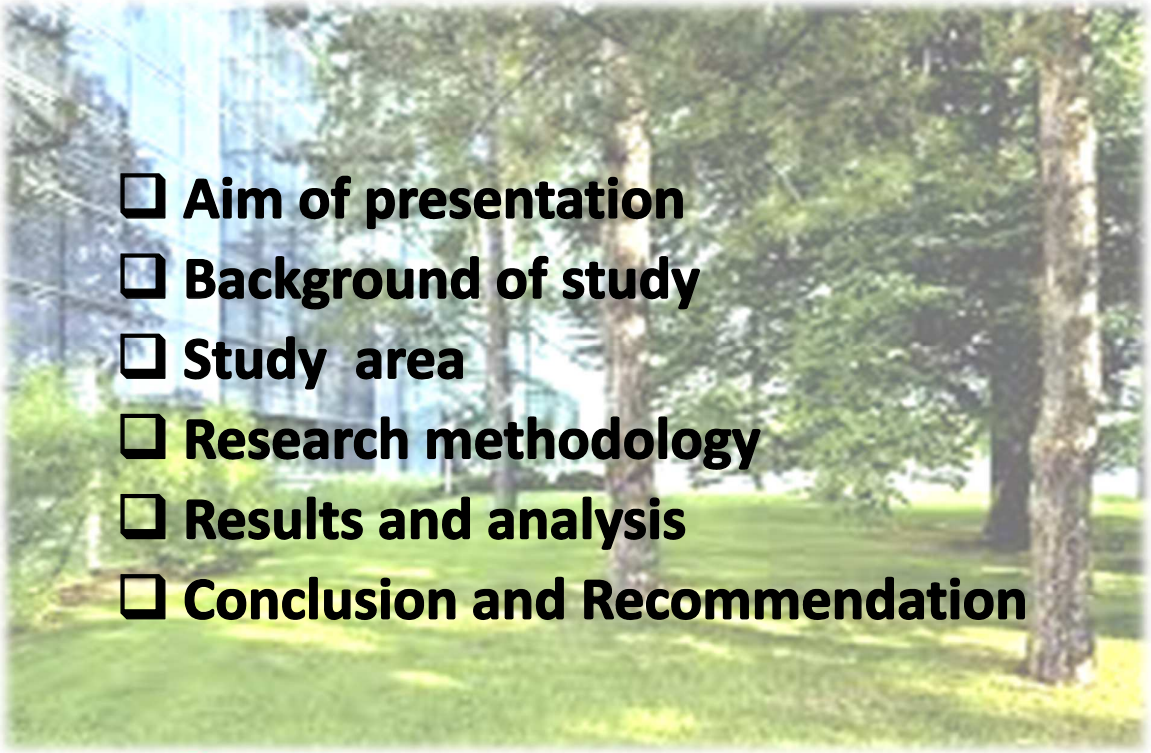
Commission No.: 8

Presentation outline:



- ❑ Aim of presentation
- ❑ Background of study
- ❑ Study area
- ❑ Research methodology
- ❑ Results and analysis
- ❑ Conclusion and Recommendation

Aim of presentation:

To present - the research findings in quantifying the green space cooling effects on the urban microclimate.

Background of Study

- Rapid growth - reduction of vegetated areas, increased the built-up surfaces and also possible cause of UHI.
- UHI phenomenon has been found in cities throughout the world - defined that the urban air and surface temperatures are hotter than their rural surroundings.
- The built-up surfaces trap the incoming solar radiation during the day and then re-radiate it at night.

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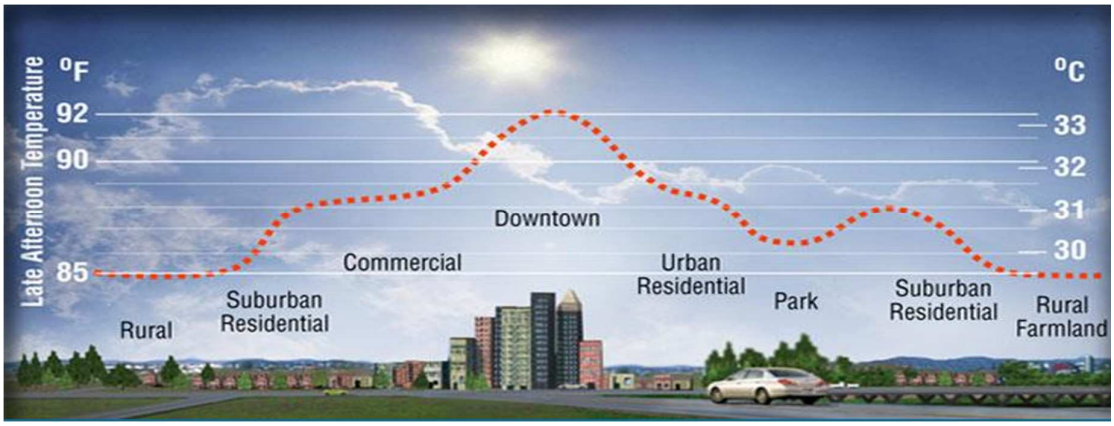
Background of Study

- The vegetated area helps to keep the temperature of the surrounding lower than the developed area by its shadow and evapotranspiration.



Source: Akbari (2011)

Background of Study

- In earlier study - the temperature of urban parks is found to be 1–2°C, and sometimes even 5–7°C cooler than their urban surroundings.
- **Park Cool Island (PCI)-** an irregular pattern of cooler areas within generally warmer urban areas.
- **PCI -** has strong cooling effects on the local surrounding.
- The shadows of high density trees and the water element in the urban green spaces contribute to cooling effect factors.

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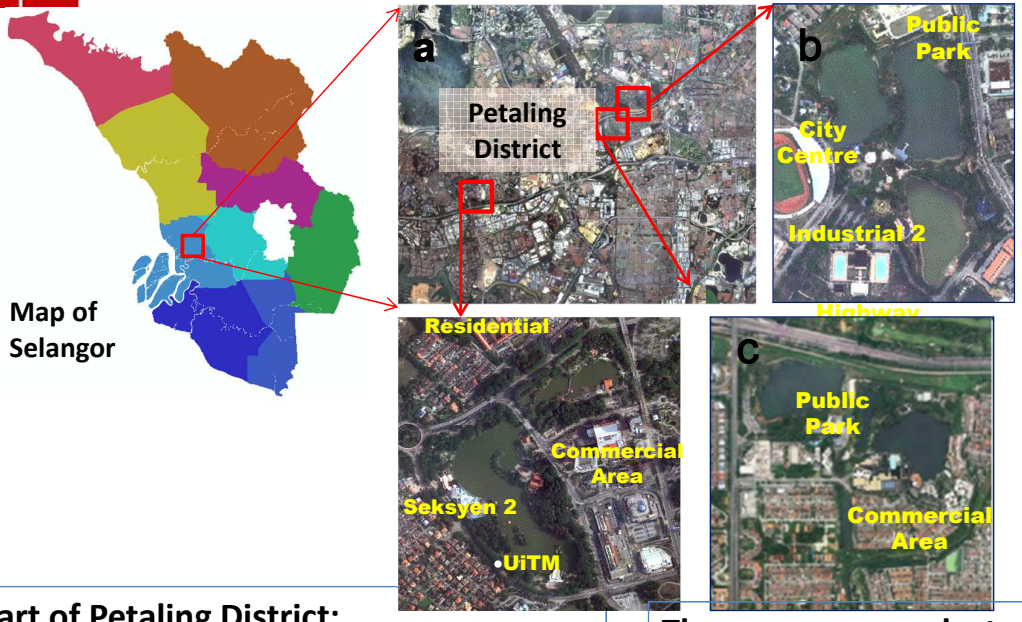
Background of Study

- Urban green spaces – has positive cooling effects within surrounding urban areas even in small size.
- Maximum cooling effects - not reached in the bigger park but was due to the compactness of green space.
- **Satellite imagery + GIS** – used to monitor the land use changes and land surface temperature (LST).
- Green spaces - can create a cooling effect that extends to the surrounding areas.

Area of Study



Part of Petaling District:

a) Shah Alam Lake Garden
b) Tasik Bandaran Kelana Jaya
c) Subang Ria Recreational Park

These areas are selected due to rapid urban development activities and existence of these cities over the last 30 years.

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Research Methodology

Data Acquisition

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Data Pre-Processing

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Data Processing

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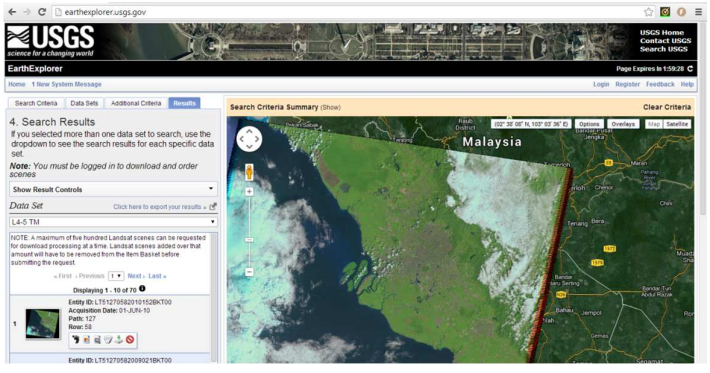
Data Analysis

Research Methodology

Data acquisition:

- Satellite Imagery (Landsat 5TM 2009) Downloaded from USGS website
- Meteorological Data acquired from MMD



JABATAN METEOROLOGI MALAYSIA
Records of Meteorological Data

Station : Subang
Lat. : 3° 07'N
Long. : 101° 33'E
Ht. Above M.S.L. : 16.5 m.

Stnno	Year	Month	Day	Hour (MST)	Dry Bulb Temp. (°C)	Relative Humidity (%)	Mean Surface Wind Direction (°)	Mean Surface Wind Speed (m/s)
48647	2009	1	21	1	26.1	86	300	1.1
48647	2009	1	21	2	26.1	85	050	0.4
48647	2009	1	21	3	25.5	88	300	1.0
48647	2009	1	21	4	25.5	86	000	0.0
48647	2009	1	21	5	25.5	86	000	0.0
48647	2009	1	21	6	25.2	86	000	0.0
48647	2009	1	21	7	25.4	80	090	0.5
48647	2009	1	21	8	25.5	78	110	1.1
48647	2009	1	21	9	26.3	74	060	1.1
48647	2009	1	21	10	28.9	61	070	2.1
48647	2009	1	21	11	30.1	59	050	1.3

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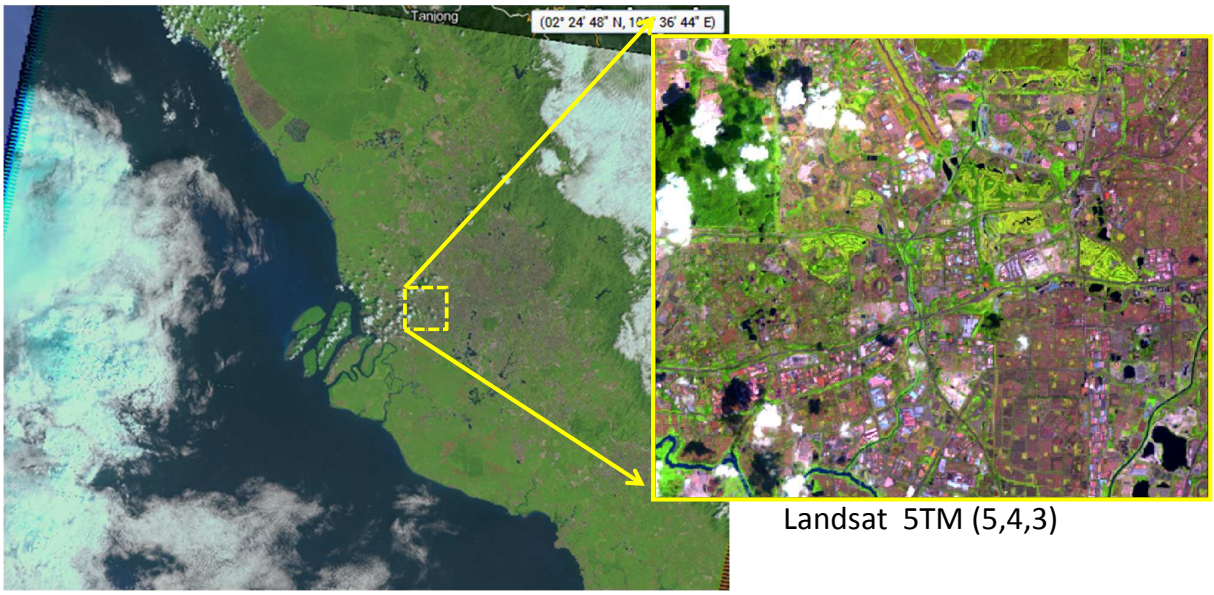
Research Methodology

Data preprocessing – Image Subset for area of study, TIR band and NDVI



Landsat 5TM (5,4,3)

Landsat full scene-path/row (127/58)

Research Methodology

Data Processing:

- **Land use** – unsupervised classification with 5 types of land use classes.
- **NDVI**-

NDVI = (NIR - R) / (NIR + R)
Where, NIR - the pixel digital number (DN) of TM Band 4, R – DN of TM Band 3

- **LST- Mono-Window Algorithm**:

$$T_s = \{a(1-C-D) + [b(1-C-D) + C + D]T_i - DTa\} / C$$

where:- Ts is LST in Kelvin; a = -67.355351; b = 0.458606; ($C = \varepsilon_i \times T_a$;where ε_i=emissivity can be computed from NDVI); $D = (1- T_a)\,[1+(1- \varepsilon_i)\times T_a]$; T_i is the brightness temperature (K) and T_a is the effective mean atmospheric temperature.

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Research Methodology

Data Processing:

- **Park Cooling Effect Intensity** –

  Park cooling intensity $(\Delta T) = T_u - T_p$

  where, T_p is the average LST inside the park

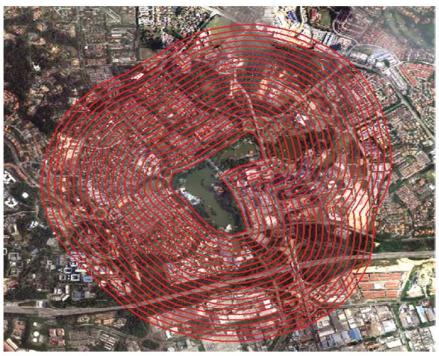
  T_u is the average LST outside the park

- **Relationship with Distance from Park Boundary- Linear Correlation**

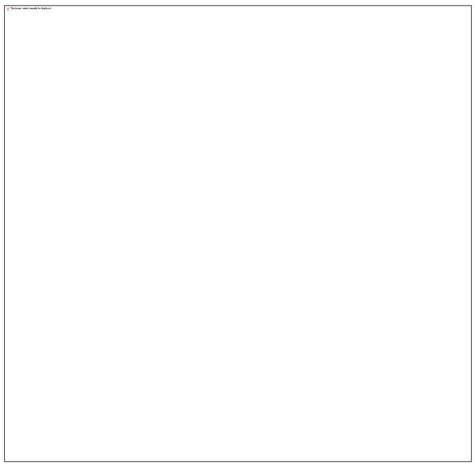
Research Methodology

Green Space Cooling Effects Buffer Distance

a) Shah Alam Lake Garden



b) Bandaran Kelana Park



c) Subang Ria Recreational Park

The 50 m multiple ring buffer with maximum buffer distance of 1000 m generated from outside the green space/park boundary.

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Research Methodology

Data Analysis:

- Surface Temperature Distribution within different land use/ land cover.
- Vegetation cooling effects on surrounding areas.

Results and Analysis

Outputs:

- Map of land use/land cover, NDVI map, LST map in 2009.
- The detail urban green space profile in selected study area.
- The cooling effect intensity and correlation between cooling effect intensity and buffer distance.

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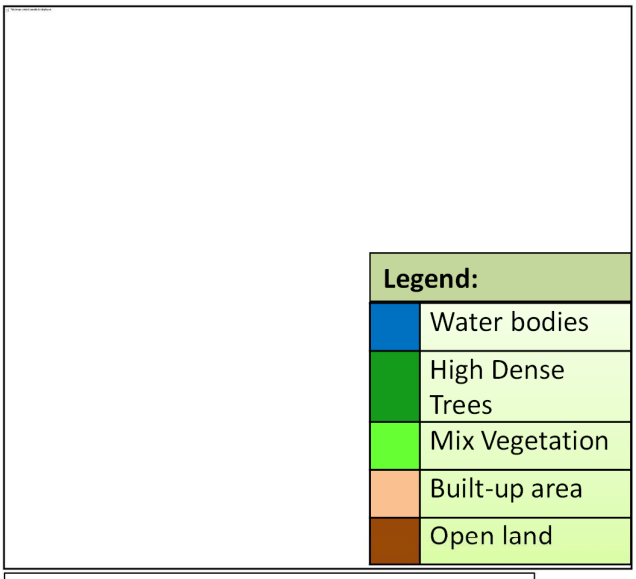
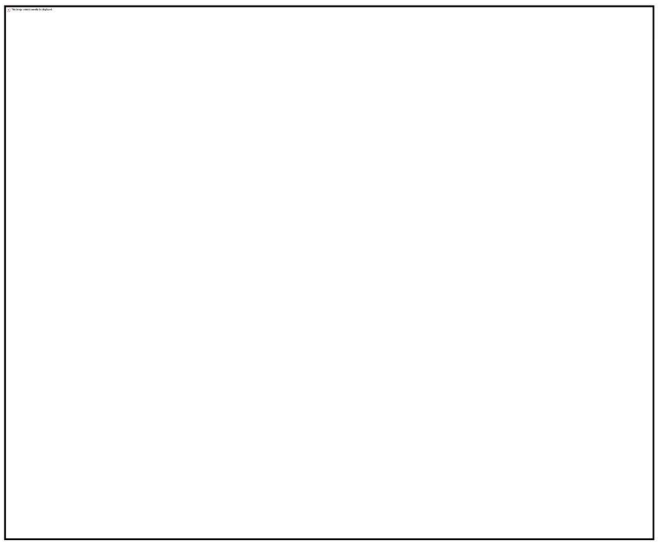
Results and Analysis

Land Use/Land Cover and NDVI Map



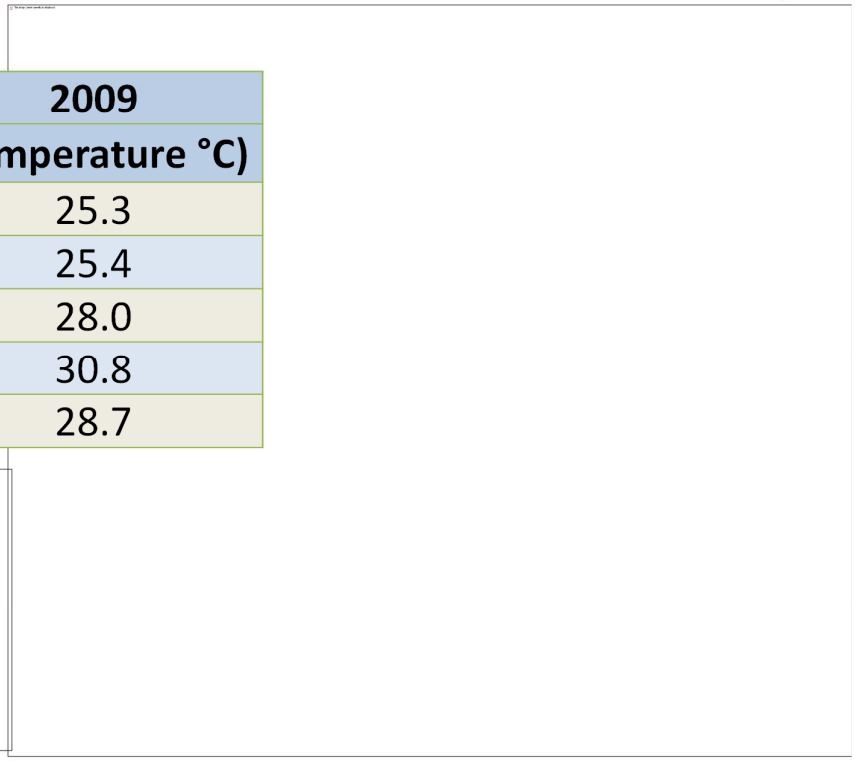
Land Use Map of 2009



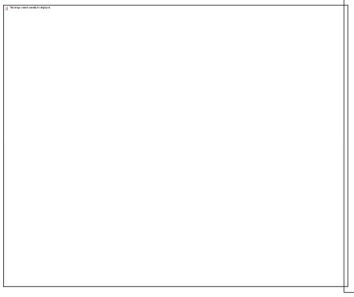
NDVI classification Map of 2009

Results and Analysis

LST Map



Land use/ Land Cover	2009 (Temperature °C)
Water	25.3
High Dense Tree	25.4
Mix Vegetation	28.0
Built-up area	30.8
Cleared Land	28.7



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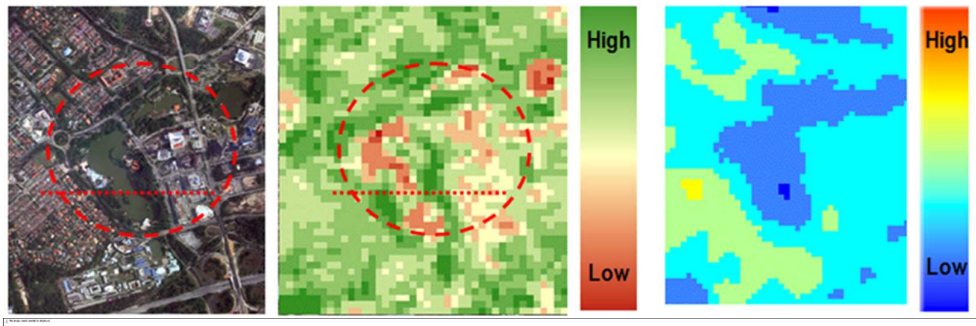
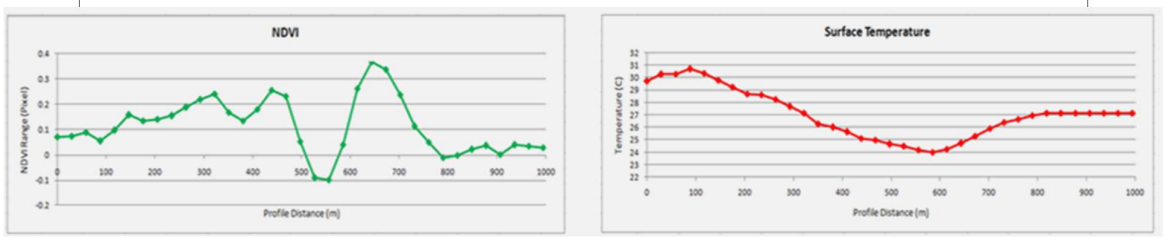
Results and Analysis

Detail Subset of Study Area: Transect Profile of NDVI and LST



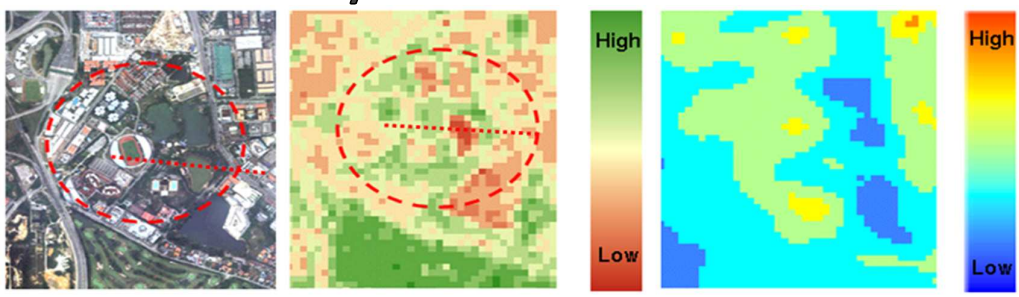


•The lake garden area is surrounded by residential, high rise building, road and commercial areas.

•The surface temperature between built-up areas and high density tree areas is more than 4°C.

Results and Analysis

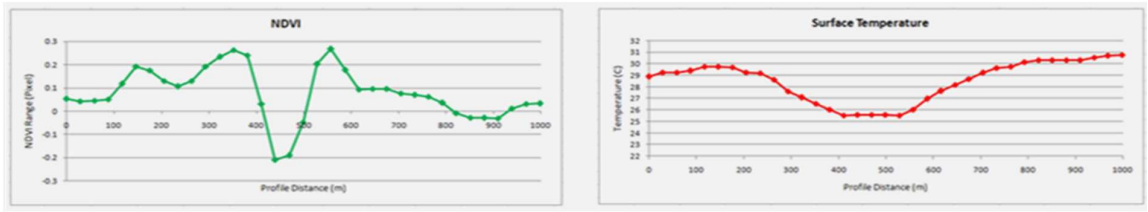
Detail Subset of Study Area: Transect Profile of NDVI and LST



a) Digital Orthophoto of Bandaran Kelana Park in 2009

c) NDVI Image 2009 (High:0.504; Low: -0.224)

c) Surface temperature of Bandaran Kelana Park in 2009



Kelana Jaya area has been transformed to the new urban area and surrounded by industrial area, high rise building, facilities building (i.e.; stadium and sports centre), road and commercial building. As the profile line crossed over the grass area the temperature remain unchanged.

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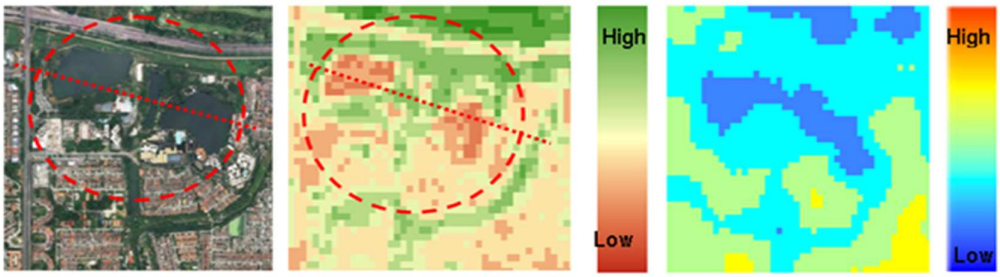
Results and Analysis

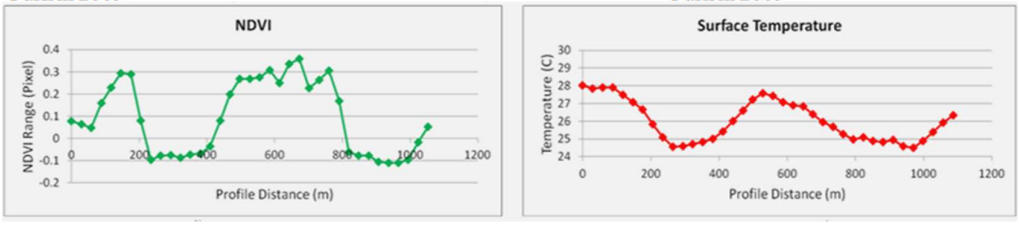
Detail Subset of Study Area: Transect Profile of NDVI and LST



a) Digital Orthophoto of Subang Ria Recreational Park in 2009

b) NDVI Image 2009 (High:0.448; Low: -0.172)

c) Surface temperature of Subang Ria Recreational Park in 2009



The surrounding area consists of multiple land use (i.e.; Highway, high rise building, private club and residential). Water body also could be another variable besides vegetation that can help lowering the surface radiant temperature.

Results and Analysis

Green Space Profile

Land cover profile	LST Distribution	Green Space Profile			
a)		Class Name	Area (Hectare)	%	LST (°C)
		Water	10.26	31.40	24.62
		High_density Trees	17.55	53.72	25.30
		Mix_vegetation	1.98	6.06	25.82
		Built_up	1.26	3.86	25.64
		Open_area	1.62	4.96	26.02
		Total/ Acreage	32.67	100	25.48
b)		Class Name	Area (Hectare)	%	LST (°C)
		Water	7.38	47.40	25.25
		High_density Trees	4.59	29.48	26.25
		Mix_vegetation	0.72	4.62	26.80
		Built_up	2.88	18.50	27.30
		Open_area	-	-	-
		Total/ Acreage	15.57	100	26.4
c)		Class Name	Area (Hectare)	%	LST (°C)
		Water	6.66	55.23	24.50
		High_density Trees	2.79	23.13	25.50
		Mix_vegetation	1.98	16.42	26.32
		Built_up	-	-	-
		Open_area	0.63	5.22	26.80
		Total/ Acreage	12.06	100	25.78

Legend: UGS Profile
Water
High Density Trees
Mix Vegetation
Built-up
Open land

rofile

Results and Analysis

Green Space Cooling Intensity

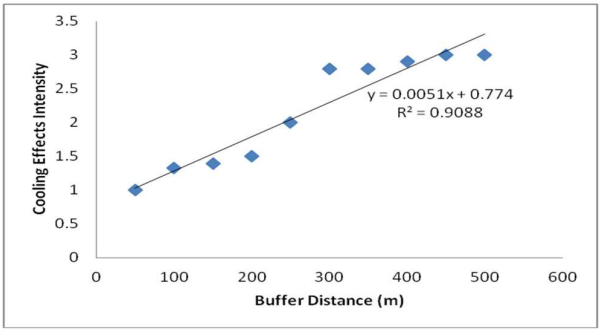
Park	Buffer Range (m)/ PCI Intensity (ΔT°C)										
	T_p(°C)	50	100	150	200	250	300	350	400	450	500
Shah Alam	25.5	1	1.33	1.39	1.5	2	2.8	2.8	2.9	3	3
Kelana Jaya	26.4	1.7	2.2	3.3	3	3.3	3.3	3.6	3.9	3.7	3.2
Subang Jaya	25.8	1	1.1	1.4	2.03	2.5	2.3	2.5	2.56	2.8	3.3
	Tp(°C)	550	600	650	700	750	800	850	900	950	1000
Shah Alam	25.5	3.6	2.2	1.9	1.9	1.9	1.6	2.3	1.6	2.6	3.3
Kelana Jaya	26.4	4.4	3.1	2.8	3.8	3.4	3.1	3.1	3.8	4.4	4.4
Subang Jaya	25.8	2.9	3.3	4.0	3.4	2.7	2.7	4.9	4.9	4.9	4.9

i. In the 50 m buffer zone the intensity range from 1ºC – 1.7ºC.
ii. As the buffer distance reaches the 500 m buffer zone, the intensity value increases by 3ºC to 3.3ºC.
iii. However, the highest intensity value is 3.9ºC at the buffer distance of 400 m in the Bandaran Kelana Park. The land use/land cover types within the 400m buffer zone are mainly commercial and built-up areas. The mean in this region is approximately 26.4ºC.

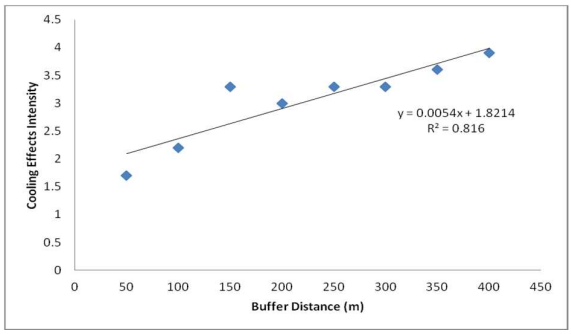
Results and Analysis

Correlation Between Cooling Effect Intensity and Buffer Distance

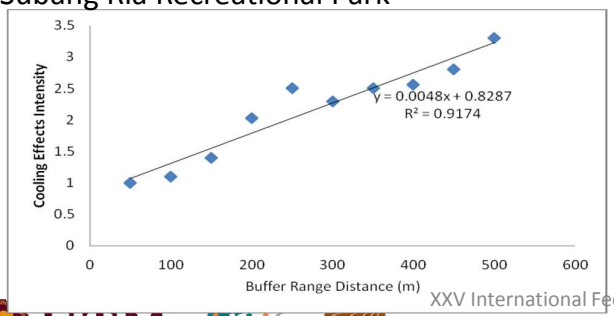
a) Shah Alam Lake Garden



b) Bandaran Kelana Park



c) Subang Ria Recreational Park



- Strong positive correlation between cooling effect intensity and proximity from the park boundary are clearly evident.
- The R^2 coefficients for Shah Alam Lake Garden (0.9088), Bandaran Kelana Park (0.816) and Subang Ria Recreational Park (0.9174).
- Urban green spaces are capable of reducing the high radiant temperature of the surrounding areas

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Conclusion and Recommendation

i. The cooling effects of parks - depends on the park profile (water body, high density trees, mix vegetation, built-up area and open spaces).

ii. The composition of different land use/land cover within the parks generated different average park temperature.

iii. The cooling effect intensity increases as distance from the park boundary increases. The temperature difference between the interior of the park and the zones 500 m from the park boundary is more than 3°C.

Conclusion and Recommendation

iv. Further research should include detailed studies on the urban green spaces cooling effect based on various park design, park size and park orientation.

v. Findings from this study will help urban planners or urban designers to understand the interaction between urban parks and UHI effects especially in a hot and humid tropical climate region like Malaysia.

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Thank you for your attention! 🙂

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