Green and Blue Infrastructure in a Changing Urban Environment

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Land Cover/Land Use Changes (LC/LUC) and Impacts on Environment in South/Southeast Asia
28-30th May, 2018
Urban development and impacts on environment

- People living in urban will increase
- Increase pressure on land
- LULC change will impact the environment, social and economy
- Essential to focus on urban environment and various issues
- One of the pressing environmental issue is loss of green space
Green and Blue Infrastructure

- Surfaces covered by vegetation and water features
- Green infrastructure provides various services and functions
- Importantly improves public health
  - Air quality, urban temperature, noise level
- Sustainable Development Goal 11: Make cities inclusive, safe, resilient and sustainable
  - Target 11.7: Provide universal access to safe, inclusive and accessible, green and public spaces
  - Indicator 11.7.1 The average share of the built-up area of cities that is open space for public use
Green infrastructure issues

- Destruction of green space and fragmentation
- Maintaining and/or increasing urban green space is essential
- Provision of the benefits of green space is depending on its compositional and structural attributes:
  - Availability (Ha or %)
  - Accessibility (distance between settlements and green spaces)
  - Configuration (species richness, composition)
- Availability is proxy indicator of health and other environmental benefits
- Lack of data and knowledge on existing green space, their types etc. especially in SEA

Kanniah, 2017
Current study

• Quantify the availability of different types of green (trees/shrubs and grass) and compute green space per capita
• Green space data is important for assessing current scenario and to set goals to effectively manage resources in cities
• For Kuala Lumpur- it aspires to become top 20 most liveable cities in the world and tropical garden city by 2020
Previous studies and Motivation

Richards et al. (2017)

- Green space availability in 111 SEA cities using Landsat images of 2012

Huang et al. (2017)

- Two cities in SEA were included
- Increase in green space (6% in Manila and 1% in Jakarta between 2005 and 2015

Nor et al. (2017)

- Decreasing trend over time
Motivation

• Kanniah and Ho (2016)- tree cover change in several cities in Malaysia (4-17% tree cover lost between 2000 and 2012)

• Kanniah (2017)- Green space availability and change in Kuala Lumpur (2001-2016) - increase since 2010
Study Focus: Kuala Lumpur

Total land area = 242 km²
Population in 2016 = 1.73 million
Data

- Geo-eye data 2016
  - Orthorectified image
  - Fine resolution- 0.46 m
  - 4 spectral bands
- Object oriented Classification
- Pre-processing (cloud and shadow detection)
- Image segmentation
- Rule based classification
Hierarchical rules

**LEVEL 1**
- All objects
  - NDVI < 0.3
    - Non-vegetation
      - Mean brightness < 350 & NDWI > -0.1
        - Water
      - NDVI ≤ 0.15
        - 0 ≤ BRI ≥ 0.008
          - Bare soil
      - NDVI > 0.15
        - Urban
  - NDVI > 0.3
    - Vegetation
      - Red/Blue ≤ 0.77 & GNDVI > 0.15
        - Trees
      - Red/Blue > 0.77 & BNDVI ≥ 0.3
        - Grass

**LEVEL 2**
- Shadow with BNDVI ≤ -0.05 & NDWI > -0.1
- Shadow with SD (B) < 10
- Water with SD (B) < 20
- Water with SD (NIR) > 25
- Water with Brightness (G) > 350
- SAVI ≤ 0.2
- GLCM Homogeneity (all dir.) < 0.05
- Grass with NIR ≤ 650
- Relative border to Trees > 0.3
- Relative border to Grass > 0.3
### Classification Results

#### Accuracy Assessment

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Water</td>
<td>89.62</td>
<td>98.32</td>
</tr>
<tr>
<td>Grass</td>
<td>93.08</td>
<td>99.27</td>
</tr>
<tr>
<td>Urban</td>
<td>91.30</td>
<td>94.32</td>
</tr>
<tr>
<td>Tree</td>
<td>99.56</td>
<td>90.54</td>
</tr>
<tr>
<td>Bare land</td>
<td>91.67</td>
<td>79.39</td>
</tr>
</tbody>
</table>

Overall accuracy: 93.58%  
Kappa coefficient: 0.91

#### Land Cover Area

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>Area (Ha)</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Trees &amp; Shrubs</td>
<td>6807</td>
<td>28</td>
</tr>
<tr>
<td>Grass</td>
<td>2509</td>
<td>10</td>
</tr>
<tr>
<td>Bare land</td>
<td>1226</td>
<td>5</td>
</tr>
<tr>
<td>Urban</td>
<td>9598</td>
<td>40</td>
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<tr>
<td>Water</td>
<td>744</td>
<td>3</td>
</tr>
<tr>
<td>Shadow</td>
<td>1287</td>
<td>5</td>
</tr>
<tr>
<td>Cloud</td>
<td>2068</td>
<td>8.5</td>
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</tbody>
</table>
Green Space By Strategic Zones

- Bandar Tun Razak
- Bukit Jalil Seputeh
- Damansara Penchala
- City Centre
- Sentul Manjalara
- Wangsa Maju Maluri

Legend:
- Trees and Shrubs
- Grass
- Bare land
- Shadow
- Urban
- Clouds
- Water
Land use covered by green
Green Space Per Capita

WHO standard 9m²-50m²

City Centre  Sentul Manjalara  Bukit Jalil Seputeh  Wangsa Maju Maluri  Bandar Tun Razak Sungai Besi  Damansara Penchala

45 m²/person
Implication of the results

• Useful for making policies to maintain and/or increase green cover in KL- Low Carbon City Blueprint
• 25 specific programmes were suggested in the Blueprint
  • Establish canopy cover target
  • Identify new planting space (vacant lands can be converted to pocket parks)
Challenges

• Clouds and shadows on high spatial resolution images
• Trees and shrubs cannot be separated
Future Works

• Results from OO classification can be improved using Lidar data
• Detect green space availability and types in other cities in Malaysia
• Connect fragmented green space
• Calculate ecosystem services of green space (carbon storage and sequestration, pollutant removal etc.)
References


• Nor, A.N.M., Corstanjea, R., Harrisa, J.A., and Brewera, T., 2017, Impact of rapid urban expansion on green space structure, Ecological Indicators 81, 274–284

