Data Article

Satellite data for Singapore, Manila and Kuala Lumpur city growth analysis

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Abstract

This data article presents satellite data related to city growth of Singapore, Manila and Kuala Lumpur cities. The data were collected from NASA and USGS websites. A method has been developed for city built-up density from city center to outward till 50 km by using satellite data. These data sets consists three decade Landsat images. A detailed description is given to show how to use this data to produce urban growth maps. The urban growth maps have been used to know the changes and growth pattern in the Southeast Asia Cities. © 2016 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).
1. Data

The following multi-sensor, multi-resolution and multi-temporal satellite data were used: Landsat 5 TM (Thematic Mapper) for 1989, Landsat 7 ETM+ (Enhanced Thematic Mapper plus) for 2001 and Landsat 8 OLI (Operational Land Imager) for 2014, an image captured by a different type of sensors with less than 20% cloud cover. In addition, Landsat images are frequently updated and are available free of charge through the Global Land Cover Facility repository [1–3]. All data were downloaded free of charge from NASA and USGS website. Fig. 1 presents city growth of Singapore, Manila and Kuala Lumpur in the last three decades.

2. Experimental design, materials and methods

To convert all row satellite data into meaningful data, first rectified and georeferenced the data in UTM projection (WGS 84 datum). To increase the quality of satellite data, all data processed through band ratio, classification and in last change detection techniques [4–6]. All satellite data were preferred to retain the spatial details such as original pixel value and size. Therefore the satellite data were kept without changing their pixel sizes despite the possible varying accuracy level of classification with the different spatial, spectral and radiometric resolutions. All nine satellite images were classified through maximum likelihood supervised classification in ArcGIS 10.2 software [7–9]. To create a closer correspondence between the produced output data maps, the classification was done by only considering four main classes: urban/built-up area, agriculture land, forest land (tree/park) and water body [10–12]. The produced data maps were presented in Fig. 2.

After classification multi-buffer rings were created for every 1 km distance from 1 to 50 km from city center to outward. Than intersect with classified data maps (land cover) for all three dates [13–15]. Later on all land cover classes area were measured from 1 to 50 km distance and derive urban
Fig. 1. Singapore, Manila and Kuala Lumpur city growth from 1989, 2001 and 2014.
density according to following formula.

\[
\text{Urban density} = \frac{\text{Settlement area / ring}}{\text{Total ring area}}
\]  

(1)

In all buffer rings only urban/built-up area was calculated in place of whole ring area. After producing complete land use data maps, the total coverage of different classes were determined. Using this information, we calculated the water, forest, vegetation and built-up area per capita for all the study years (Table 1).

In order to evaluate the spatial distribution of urban expansion intensity, we adapted an indicator called annual urban growth rate (AGR) for evaluating the 'urbanization' speed of per unit area [16,17]. AGR is defined as follows:

\[
\text{AGR} = \frac{UA_{n+i} - UA_i}{nTA_{n+i}} \times 100\%
\]  

(2)
Table 1
Singapore, Manila and Kuala Lumpur land use/cover classes for 1989, 2001 and 2014.

|                  | Area_1989 | %    | Area_2001 | %    | Area_2014 | %    |
|------------------|-----------|------|-----------|------|-----------|------|
| **Singapore**    |           |      |           |      |           |      |
| Settlements      | 196.88    | 66.25| 383.23    | 69.71| 464.69    | 70.19|
| Agriculture      | 34.67     | 11.67| 80.26     | 14.60| 80.84     | 12.21|
| Forest           | 60.74     | 20.44| 62.58     | 11.38| 89.65     | 13.54|
| Water            | 4.89      | 1.65 | 23.64     | 4.30 | 26.87     | 4.06 |
| Total            | 297.18    | 100.00| 549.71    | 100.00| 662.05    | 100.00|
| **Manila**       |           |      |           |      |           |      |
| Settlements      | 189.61    | 96.70| 416.87    | 77.08| 776.65    | 69.12|
| Agriculture      | 6.37      | 3.24 | 110.14    | 20.37| 243.89    | 21.71|
| Forest           | 2.19      | 1.11 | 9.44      | 1.75 | 98.59     | 8.77 |
| Water            | 0.1       | 0.05 | 4.36      | 0.81 | 4.42      | 0.39 |
| Total            | 196.08    | 100.00| 540.81    | 100.00| 1123.55   | 100.00|
| **Kuala Lumpur** |           |      |           |      |           |      |
| Settlements      | 456.99    | 51.81| 1098.48   | 60.22| 1663.23   | 64.36|
| Agriculture      | 345.46    | 39.16| 520.40    | 28.53| 699.21    | 27.06|
| Forest           | 70.50     | 7.99 | 188.74    | 10.35| 209.99    | 8.13 |
| Water            | 9.18      | 1.04 | 16.54     | 0.91 | 11.68     | 0.45 |
| Total            | 882.13    | 100.00| 1824.16   | 100.00| 2584.11   | 100.00|
where $T_{An+i}$ is the total land area of the target unit to be calculated at the time point of $i+n$; $UA_{An+i}$ and $UA_i$ the urban area or built-up area in the target unit at time $i+n$ and $i$, respectively and $n$ is the interval of the calculated period (in years).

2.1. Urban/built-up area, city density and landscape

With the help of ArcGIS 10.2 software, urban/built up area data were created. After creation of built-up data, city density data were generated by Eq. (1) from city center to 50 km outward the city for Singapore, Manila and Kuala Lumpur cities (Fig. 3).

As Fig. 3 represents three dates data of urban density so this data can be utilize as urban growth rate data of Singapore, Manila and Kuala Lumpur city.

![Fig. 3. Singapore, Manila and Kuala Lumpur city density from 1 to 50 km distance for the year of 1989, 2001 and 2014.](image-url)
With the help of supervised classification, previous knowledge and experience, landscape data were created for all three cities for the year of 1989, 2001 and 2014. Here a trimble hand-held GPS with an accuracy of 10 m was used to map and collect the coordinates of important landscape features during pre- and post-classification field visits in order to prepare land-use and land-cover datasets. Fig. 4 shows landscape data with urban growth and urban density datasets for Singapore, Manila and Kuala Lumpur cities from 1989 to 2014.

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