Land Cover and NDBI analysis to map built up area in Iskandar Malaysia

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Abstract. The growth of Iskandar Malaysia as a regional development corridor is inescapable large and rapid. The study area has been transformed from predominantly agricultural and forest land prior to 1990s into the second largest and third most urbanized area in peninsular Malaysia. The aim of this paper is to map Iskandar land cover change from 1991 to 2019 using sequential Landsat multi-spectral images with Normalized Difference Building Index (NDBI) analysis to assess spatio-temporal urban built up and its pattern. Accuracy assessment of kappa coefficient is used to measure the accuracy of classification. Research has proved a significant rapid land cover change and a vast transformation of agricultural and forest land into low density urbanized area scattered in Iskandar. A rapid land cover change of regional development corridor has significant influence on urban expansion especially to their periphery.

1. Introduction
The study area has been transformed from predominantly agricultural and forest land prior to 1990s [1] into second largest and third most urbanized area in peninsular Malaysia. The Johor state capital is Johor Bahru, located within Iskandar region with a population of 704,471 in 1991 increased to 1,159,079 in 2001 [2]. Iskandar region and Johor Bahru were seemingly suitable as a research area particularly pertaining to urban growth because of its considerable transformation rate in term of economic growth and population number besides being the neighbour to island city-state of Singapore.

The aim of this paper is to map Iskandar land cover changes from 1991 to 2019 using Normalized Difference Building Index (NDBI) analysis. The scope is to observe the density classes of its area. The urban rapid development of Iskandar has unlocked plenty of new urbanized areas and change much of its green landscape into low density urban built up area. The economic agglomeration and spatial externalities have created new growth onto many parts of Iskandar with rising population and plentiful businesses [3].

The growth of Iskandar is inescapable large and rapid. However, efforts can be made to manage and contain growth from negative consequences such as intrusion into agricultural and fragile environmental land to the low-density urbanized area. This effort eventually can improve the livelihoods of not only the rural population, but urban population will obtain the benefit as well. To
achieve this, urban and regional authority requires huge amount of information and advance technique to closely monitor land cover changes.

2. Materials and Methods
The selected study area is Iskandar Malaysia region, Johor. The geographical coordinate of Iskandar is within 2°6'13.6332" to 2°4'15.0558" and 103°9'58.251" to 104°2'32.4234". Major attributes in Iskandar includes residential, commercial, institution, transportation, plantation, forest and open space. Rapid land cover change and population increase in Iskandar region and its periphery is due to the demand of human capital, caused by economic agglomeration, spatial externalities and institutional reform [4].

![Figure 1. Iskandar Malaysia region. Inset: State of Johor.](image)

Remotely sensed data of Landsat images were acquired from the United States Geological Survey (USGS) to produce a set of NDBI image classification of year 1991, 2005, and 2019. The acquired information of Landsat images is as shown in Table 1.
Table 1. Remotely sensed data acquired for NDBI analysis.

| Satellite  | Date         | Sensor                                                                 | Spatial Resolution | Projection            | True Colour Composition          |
|------------|--------------|------------------------------------------------------------------------|--------------------|-----------------------|----------------------------------|
| Landsat 5  | 21.05.1991   | Thematic mapper TM                                                     | 30m                | WGS84 UTM Zone 41N    | Band 1,2,3,4,7                   |
| Landsat 5  | 04.06.2005   | Thematic mapper TM                                                     | 30m                | WGS84 UTM Zone 41N    | Band 1,2,3,4,7                   |
| Landsat 8  | 13.04.2019   | Operational land manager and thermal infra-red sensor                  | 30m                | WGS84 UTM Zone 41N    | Band 2,3,4,5,7                   |

For most land cover change detection, digital satellite images with cloud coverage of less than 5% are acceptable [5], and the images must be reorganized through pre-processing techniques. The pre-processing techniques involves radiometric correction due to the variation in scene illumination and viewing geometry, atmospheric conditions, and sensor noise and responses. Subsequently, the band combinations of 3-2-1 also known as natural colour combination is utilize for land cover change detection, while band combination of 7-4-3 is utilize for NDBI. The NDBI can map urban built up in a single calculation because it applies near infrared (NIR) and short-wave infra-red (SWIR) simultaneously. Further analysis of land cover changes as well as NDBI can only be carried out after the process of accuracy assessment.

A supervised maximum likelihood classification (MLC) incorporated with Regions of Interest (ROI) is used for this study, whereby the classes of land cover is divided into urban built-up, vegetation area, waterbody, and open space. The major attributes for urban built up are residential, commercial, industrial, transportation and mixed built up, the major attributes for vegetation area are crop land, agricultural land and forest; major attributes of open space is urban parks, rural parks, shrubs and barren land; while water body takes up rivers, lakes, streams, and reservoirs.

Accuracy assessment in image classification is a compulsory process to compare the classified image to another data source that is considered to be accurate. For a land cover change analysis, the goal of accuracy assessment is to quantitatively determine how effectively pixels were grouped into the correct feature classes. Accuracy assessment of kappa coefficient is used to measure the accuracy of classification that have capability to test all confusion matrix elements based on minimum requirement [6]. There are basically two types of data collected in support of accuracy assessment: remotely sense data and ground-based data. The ground-based data is Peninsular Malaysia digital topographic map. Kappa coefficient is a measure of how the classification results compared to values assigned by chance. It can take values range from 0 to 1. If kappa coefficient equals to 0, there is no agreement between the classified image and the referenced image or the ground-based data. In this study, four (4) type of land cover (Table 2) is designed with Kappa value delineated at least with $p < 0.05$ for every feature class to enhance the accuracy level with minor variation [7].
Table 2. Four (4) category of land cover classes in the study.

| Land Cover         | Major attributes                                      |
|--------------------|------------------------------------------------------|
| Urban Built Up (UBU)| Residential, commercial, industrial, transportation, mixed built up |
| Vegetation Area (VA)| Crop land, agricultural land and forest              |
| Open Space (OS)    | Urban parks, rural parks, shrubs, barren land        |
| Waterbody (WB)     | Rivers, streams, lakes, drains, and reservoirs       |

The accuracy assessment of kappa coefficient value for classified image of year 1991, 2005 and 2019 are 0.82, 0.85, and 0.88, respectively. The minimum requirement for agreement of kappa coefficient value are at least 0.8 to proceed for further analysis [8].

This study applied post-classification detection technique for land cover change, which at least two classified images were observed to analyse the changes of the basic pixel. The 1991 image and the 2005 were observed to determine the first phase land cover change. Then the 2005 image and the 2019 image were observed to determine the second phase of land cover change.

In the process, 30m x 30m resolution of Landsat TM images from space to Earth’s surface were resampled and Geo-rectified based on WGS84 UTM with root means square error (RMSE) of less than 0.5 pixels and then were projected. Next, a cross tabulation analysis of these classified images will be presented to determine the qualitative and quantitative changes from 1991 to 2005, and 2005 to 2019.

As mentioned above, the NDBI applies NIR and SWIR, with the NDBI value ranging between -1 to 1. The negative value indicates the pixel area are in non-built-up coverage areas, while positive value indicates possibility of urban built-up areas. The higher the NDBI value means the higher concentration of urban built within the surrounding area. The changes over the years provide the map of the urban built up area and the rate of change.

3. Results and Discussions

Based on Table 3, the results show land cover changes from 1991 to 2019 with the urban built up, vegetation area, open space, and waterbody (Figure 2). Urban built up in 1991 is approximately 33,803.1 hectares increased 276% to 93,415.0 hectares in 2005, and continuously increase 157% to 147,116.3 hectares in 2019. The reverse figure of vegetation area shows steady declined of 17.8% from 39,789.7 hectares in 1991 to 33,788.4 hectares in 2005 and later declined 38.3% to 24,427.9 hectares in 2019. Open space land cover shows wider declined of 62.0% from 93,450.3 hectares in 1991 to 35,934 in 2005 and further 65.7% to 12,308.3 hectares in 2019. For waterbody land cover, the figure was fluctuated with increased 6.7% from 54,581.9 hectares in 1991 to 58,496.6 hectares in 2005. But then the waterbody declined 35.4% to 37,781.5 hectares in 2019.
Table 3. Land cover changes from 1991 to 2019.

| Land cover (hectares) | 1991  | 2005  | 2019  |
|-----------------------|-------|-------|-------|
| Urban Built Up        | 33,803.1| 93,415.0| 147,116.3|
| Vegetation Area       | 39,789.7| 33,788.4| 24,427.9|
| Open Space            | 93,459.3| 35,934.0| 12,308.3|
| Waterbody             | 54,581.9| 58,496.6| 37,781.5|
| **TOTAL**             | **221,634.0**|   |   |

Based on land cover in 1991, majority area is covered by open space (42.2%) and waterbody (24.6%) while urban built up only account for 15.3%. Between 1991 to 2005, Iskandar are shifting from ‘green spaces’ into ‘red spaces’, which explained the urban built up is increasing by 22.9% (Table 3) due to economic agglomeration and spatial externalities that affect the demand of residential, commercial, and industrial, while the need to create more spaces to make way for roads and highways (transportation). Increase of urban built up means increase of demand of human capital and possibly increase the technological innovation [3]. This led to population growth and rapid urbanization. Consequently, rapid urbanization would create sprawl [9] and environmental change to air [10], water [11], as well as soil [12].

Meanwhile, examination of the density classes of NDBI has shown different trends in increasing and/or decreasing total area of expense (Table 4). Naturally, NDBI density classes’ values showed the opposite determination of green index. The spatial expansion of high-density urban class is clearly visible. NDBI high density classes has showed a slightly lessened 3.1% from 1991 to 2005 but picking up 9.2% from 2005 to 2019. (Table 4). This is probably due to a marginal downturn for the first phase...
and subsequently picking up phase after IRDA was established. However, the spatial distribution pattern showed a continuous dispersed, backed by a steady increased of NDBI medium density classes throughout 1991 to 2019, increased 5.2% from 1991 to 2005 and 1.9% from 2005 to 2019. NDBI low density classes have shown a gradual decreased 2.1% from 1991 to 2005 and 11.1% from 2005 to 2019. While the NDBI high and medium density values showed a continuous dispersed, the low-density value is perceived as a multinucleated extension (Figure 3). Being a neighbour to the island nation of Singapore, Iskandar need to be extremely competitive and at the same time being strategically significant. Iskandar regional corridor has been consistent with the tenet of equitable growth and value creation [13]. It has a strong and resilient economy and infrastructures enablers. Nevertheless, there is a need for a check and balance for the rapid land cover change in Iskandar, consequently, to mitigate an appalling environmental change.

### Table 4. The NDBI density classes of image classification year 1991, 2005 and 2019.

| NDBI density classes | 1991     | 2005     | 2019     |
|----------------------|----------|----------|----------|
|                      | Ha       | %        | Ha       | %        | Ha       | %        |
| High                 | 77,572.0 | 35.0     | 70,922.8 | 31.9     | 90,870.0 | 41.1     |
| Medium               | 88,653.6 | 39.9     | 99,735.4 | 45.1     | 104,168.1| 47.0     |
| Low                  | 55,408.5 | 25.1     | 50,975.8 | 23.0     | 26,595.9 | 11.9     |

![Figure 3. NDBI maps for land cover change in 1991, 2005, and 2019.](image)

#### 4. Conclusion

In this paper, we have observed the land cover change using NDBI analysis, utilizing a series of Landsat multi-spectral images. Urban built up has quadrupled from 1991 to 2019 with most rapid changes was on the first phase of 1991 to 2005. This is due to a greater low-density development and a discontinue urban built up pattern compared with much sustainable higher-density development in the second phase of 2005 to 2019. To further make way for development, vegetation and waterbody loss
38.6% and 30.7% consecutively in the observed period. These facts have significant weightage in environmental change. Mapping land cover change using Landsat images provide crucial information for policymakers and planners in understanding urban growth consequences especially toward the environment. Thus, it represents greater importance of prioritizing policies and specific regulations for the regional development authority.

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