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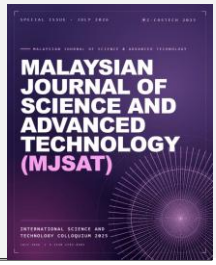

NDVI-Based Assessment of Urban Green Space in Shah Alam and Kota Bharu, Malaysia

Ashiah Rosdi[1], Amal Najihah Muhamad Nor[*1,3,4], Muhammad Azahar Abas [1,3,4], and Kamaruddin Mardhiah[2]

[1]*Faculty of Earth Science, Universiti Malaysia Kelantan, Jeli, Kelantan.*
[2]*Faculty of Entrepreneurship and Business, Universiti Malaysia Kelantan, Kota Bahru, Kelantan.*
[3]*Environment and Sustainable Development Research Group, Universiti Malaysia Kelantan, Jeli, Kelantan.*
[4]*UMK-Tropical Rainforest Research Centre (TRaCe), Universiti Malaysia Kelantan, Jeli, Kelantan.*

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ABSTRACT

Urban green space density serves as a vital indicator of environmental sustainability, public health, and urban resilience. It reflects the extent and quality of vegetated areas within the urban fabric, which play a fundamental role in enhancing ecological balance, mitigating the urban heat island effect, improving air quality, and supporting psychological well-being. However, rapid urbanization has led to a reduction and fragmentation of green spaces in many cities, resulting in unequal access and ecological imbalance. This study evaluates the spatial variation of urban green space density in Shah Alam and Kota Bharu, Malaysia using the Normalized Difference Vegetation Index (NDVI) derived from satellite remote sensing data. Addressing the limited availability of comparative spatial assessments between Malaysian cities with contrasting urban forms and development patterns, the study employs GIS-based spatial analysis to quantify and compare vegetation distribution across the two urban environments. NDVI analysis shows distinct spatial patterns of urban vegetation in Shah Alam and Kota Bharu. Shah Alam has low to moderate NDVI values from -0.307 (minimum) to 0.60 (maximum) with range 0.91, indicating stressed and fragmented vegetation due to intensive urban development. Meanwhile, Kota Bharu reveals moderate to high NDVI values -0.31(minimum) to 0.62 (maximum) with range 0.93, reflecting healthier and more continuous vegetation cover. This analysis is further supported by additional data on population density, land use characteristics and built-up area intensity to provide a multidimensional understanding of green space distribution. The paper address important issue concerning urbanization, green space degradation in Malaysia. The comparative analysis between Shah Alam and Kota Bharu using NDVI provides useful spatial understandings for urban and environmental planning.

1. INTRODUCTION

Urbanization is increasingly recognized as an important issue, and a worldwide public health concern [9]. Concurrently, rapid urban development and escalating population growth have critically contributed to the reduction and degradation of green spaces on a global scale. According to the Department of Statistics Malaysia 2024 (DOSM), population growth in Malaysia for the first quarter of 2024 was 34 million, and has increased 2.3% from the first quarter of 2023. This study focuses on two capital cities, Shah Alam, Selangor and Kota Bharu, Kelantan (Figure 1). According to the Department of Statistics Malaysia (DOSM), as of 2022, Selangor's Petaling district has the highest population density with 2,290,000 people and the population density is 4,702 per km^2, followed by

*Corresponding author:
E-mail address: Amal Najihah Muhamad Nor < amalnajihah@umk.edu.my >.
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Gombak with a moderate density (942,400 residents), and Sabak Bernam with the lowest density (107,057 residents). In Kelantan, Kota Bharu has the highest population density (567,400 people and 1,409 per km^2), Tumpat has a moderate density (179, 943 residents), and Jeli has the lowest density (54,656 residents). This study involves two different urban settings for a comparative analysis where Kota Bharu, Kelantan is considered as state with moderate development compared to Shah Alam, Selangor. The population in Kelantan is 44.1% which considered as the lowest in Malaysia [8]. Through the urbanization process, there is a great impact on land use changes which includes green space degradation. As cities grow, urban green spaces such as parks, gardens, and natural landscapes are increasingly being encroached upon, resulting in reduced access for residents.

Environment for Visualizing Images (ENVI) used widely by integrating advanced spectral image processing and analysis technology with the concept of user friendly. It is basically used to extract important inputs from imagery. ENVI software also integrated advanced spectral image processing and created geospatial analysis with current interface. Beneficial information from LiDAR, Multispectral and hyperspectral can be extracted by using ENVI software which assist users in decision making [1]. In addition, ENVI also used in processing and analysing geospatial imagery. Remote sensing refers to collect data of event or object virtually and commonly used in land surveying, geography and earth science field, for instance geology, hydrology and meteorology. This technology is widely used in diverse field such as commercial, humanitarian sectors and military. Furthermore, ENVI is multipurposed because of its capability to adapt with specific project requirements and can be used in cloud, mobile devices and also desktop. It also versatile as it can be tailored in wide range of airborne sensors, radar, advanced satellite, and infrared. However, ENVI is a costly commercial software package, which may be especially expensive for individual researchers or smaller projects with constrained budgets. This cost factor could limit broader access, potentially impeding wider participation in land cover analysis efforts. ENVI has an extensive feature set, all while maintaining an intuitive user interface, it might take committed study time and effort to fully realize its potential for advanced analysis or customization. Projects with strict deadlines or a lack of technical knowledge among team members may find it challenging to overcome this learning curve.

The Normalized Difference Vegetation Index (NDVI) provides valuable information about land-surface properties, thus time-series data from NOAA/AVHRR, SPOT/VEGETATION, TERRA, or AQUA/MODIS are suitable for detecting long-term land-use/cover changes and for modelling terrestrial ecosystems on global, continental, and regional scales. NDVI is the common vegetation index used for live green plant canopies detection by using multispectral remote sensing data based on spectral reflectance measurements acquired in the visible (red band) and near-infrared regions, respectively.

Urban Green Space (UGS) has a pivotal role in establishing a sustainable and healthy cities. By 2050, approximately 70% of the global population is expected to reside in urban areas, highlighting the critical role of urban green spaces (UGS) in fostering sustainable development. Recently, a study has shown that UGS helps in improving air and water quality, supporting biodiversity conservation, and promoting social cohesion among urban dwellers is an aspect closely linked to Cultural Ecosystem Services (CES), which include the social, recreational, and cultural benefits people gain from interacting with natural environments [6]. Beyond environmental benefits, numerous studies have confirmed the significant contribution of urban green spaces to human mental health by reducing stress, enhancing mood, and supporting overall psychological well-being [2].

Understanding the spatial distribution and urban vegetation pattern is important for effective urban planning and sustainability city management. NDVI-based assessment helps to identify areas of healthy, stressed and fragmented vegetation which essential for ecological quality indicators. This study provides practical insights for urban planners and environmental management in prioritizing green space conservation, guiding urban expansion, mitigating environmental degradation, and supporting evidence-based planning towards more sustainable and resilient cities.

However, studies of comparative evidence spatial assessment between contrasting Malaysian urban forms are limited. Therefore, this study aims to study investigates the spatial variation in green space density between two Malaysian cities, Shah Alam and Kota Bharu using the Normalized Difference Vegetation Index (NDVI) derived from remote sensing imagery. The findings show the spatial NDVI of Kota Bharu has relatively healthier vegetation cover compared to Shah Alam reveals urban form influences vegetation condition.

2. METHODOLOGY

This study helps to emphasize how NDVI is different within two distinct urban settings and provide research information by comparing these two capital cities (Figure 1).

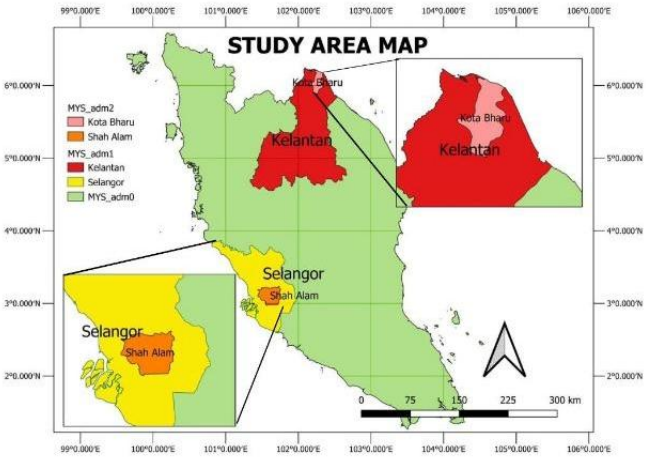


Fig. 1. The location map of two main urban in Malaysia; Shah Alam, Selangor and Kota Bharu, Kelantan

2.1 Data Acquisition

In this study, Environment for Visualizing Images (ENVI) version 4.5 and ArcGIS version 10.3 are utilized for the processing and analysis of satellite imagery within the framework of remote sensing and Geographic Information Systems (GIS). This study utilized Landsat 8 Operational Land Imager (OLI) imagery of August 2025, with a 30 m resolution

used was acquired Shah Alam path 127 and rows 058 and Kota Bharu path 127 and row 056, from Earth Explorer (EE), an online data access platform developed by the United States Geological Survey (USGS).

2.2 Data Processing

Landsat 8 OLI/TIRS was used to capture satellite imagery for both cities of year 2025. Landsat 8 carries the OLI and Thermal Infrared Sensor (TIRS), with spatial resolution of 30 m for multispectral bands and a revisit period of 16 days. The cloud cover below 10% acquired during the same period to ensure temporal consistency between both cities. The Landsat 8 OLI/TIRS imagery was chosen because of its appropriate spectral and spatial resolution and enhancing classification accuracy over large geographic areas. Atmospheric correction has been conducted with the use of vegetation delineation function through the ENVI software version 4.5. Moreover, the radiometric correction has been carried out by using the Landsat calibration function within the tools of ENVI 4.5 software and subset using ENVI 4.5 software to obtain the relevant study areas. NDVI map is generated using the combination of Red and NIR bands to enables visualization and quantitative assessment of vegetation density that cannot be seen by the naked eye. Moreover, the Raster Calculator tool, applying the standard formula (1), where Band 5 and Band 4 represent the near-infrared and red bands, respectively. NDVI will be as then clipped to the green space boundaries to allow focused analysis of vegetation density and distribution. The values of NDVI fall within the range of -1 to 1 which refer to vegetation rates based on spectral reflections, whereby a positive value indicates highly green cover, whilst the density of green cover is lower with a negative value. This process run using ArcMap 10.8. The vegetation health of Kota Bharu, Kelantan and Shah Alam, Selangor cities are comprehensible with the density study. It helps to give a clear perspective to urban planners to focus more on maintaining sustainable cities especially in Malaysia.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)} \quad (1)$$

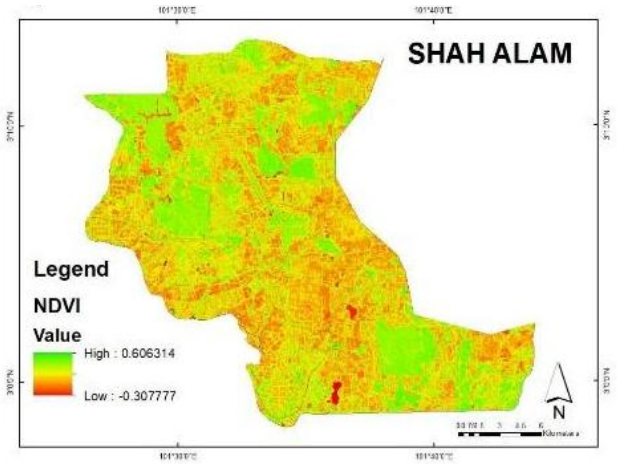
ENVI 4.5 with supervised classification, LULC was identified for instance, water bodies, built-up areas, bare land and green space. This information useful to understand the existing landscape structure and the LULC maps can served as basis for landscape changes study over time. The information is crucial in study of the impacts of land transformation and urban development. An accuracy assessment also conducted to ensure the quality of the output set at 80% or higher. It involved confusion matrix in order to compare the random sample of ground-truth reference points with the classified data. The assessment employed three geoprocessing tools: Construct Accuracy Assessment Points, Update Accuracy Assessment Points, and Calculate Confusion Matrix. Lastly, from ENVI 4.5, the raster data was then converted to vector format using ArcGIS 10.3 for spatial analysis. This step is important to characterized the green space landscape structure, particularly in city of Shah Alam, Selangor and Kota Bharu, Kelantan [5]. Remote sensing helps to capture the changes in vegetation by generating the image of LULC.[10].

2.3 Land Use and Land Cover Maps

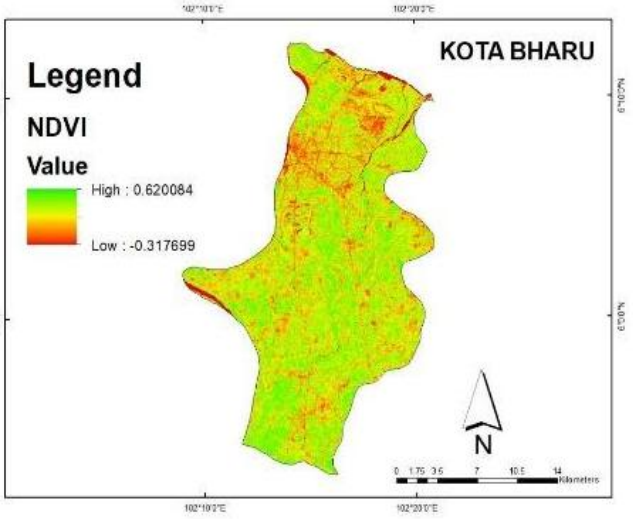
Land Use and Land Cover (LULC) map of 2025 has provided information of geographical distribution in Kota Bharu, Kelantan and Shah Alam, Selangor. The data in both cities highlight the details of water bodies, built-up area, agriculture and vegetation. This information is very important in determining possible chain of events for future research. The LULC map was generated using ArcGIS version 10.8 software for accuracy using ground control points. Referenced against Landsat satellite imagery and Google Earth from the same acquisition year. An overall accuracy value of 86% and 83%, Kappa values of 0.66 and 0.74 were achieved for the NDVI classified map of year 2025 of Shah Alam and Kota Bahru respectively. The attribute data for these maps were edited using Editor tool in ArcGIS and converted from raster to polygon format. Following that, data was transferred to Microsoft Excel for statistical analysis. The primary use of the maps (Figure 4) is to help researchers understand the study area's land use and pattern in terms of spatial of different area in Peninsular Malaysia. Kota Bharu maintain rich with agriculture areas over years [7].

3. RESULT AND DISCUSSION

Figure 2 shows the spatial distribution NDVI value in both cities of different urban setting. Based on NDVI value of Shah Alam (a), the range from -0.36 (minimum) to 0.63 (maximum). Kota Bharu (b) shows NDVI values range from -0.31 (minimum) to 0.61 (maximum). Higher NDVI value indicates healthy and dense vegetation while lower value indicates sparse vegetation, barren land and build-up areas. Table 1 shows the mean of DNVI value Shah Alam is 0.2 and Kota Bharu is reported to have value of mean 0.3. Standard deviation of Shah Alam is 0.132 and Kota Bharu 0.136. Urban areas tend to be hotter because of the urban heat island (UHI). Buildings absorb and retain heat. In this context, urban green space helps reduce heat and provides a cooler temperature. Larger and more connected green spaces provided stronger cooling benefits compared to smaller, fragmented patches [10]. This study did not directly analyse land surface temperature (LST) data. Future studies should integrate thermal remote sensing data to quantify UHI effect. Green space plays significant role in helping slow down surface runoff by allowing water to naturally absorb into the ground, while also supporting cleaner water, moderating the local climate, and encouraging greater biodiversity [4].

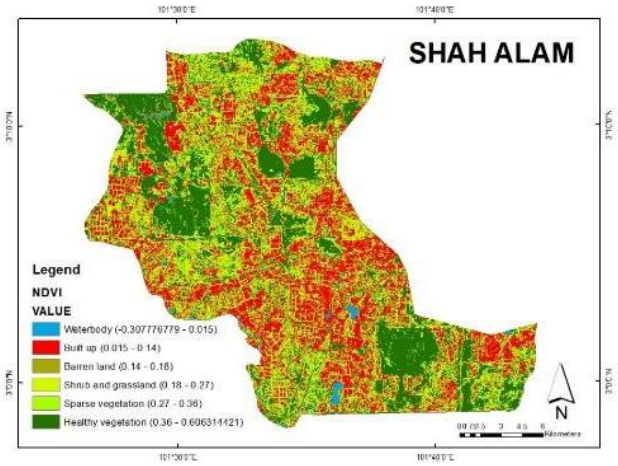


(a)



(b)

Fig. 2. Spatial distribution of NDVI value in Shah Alam, Selangor (a) and Kota Bharu, Kelantan (b),



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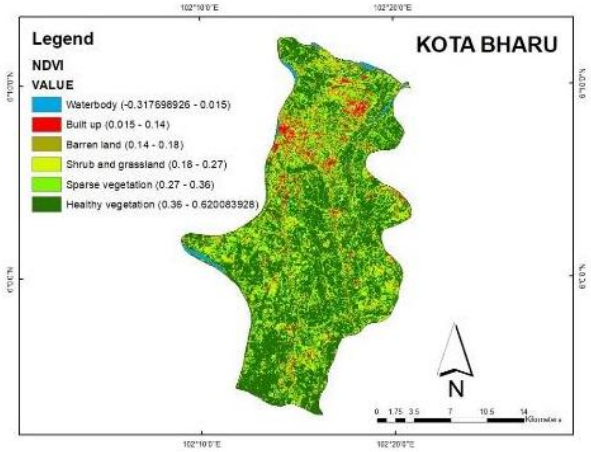
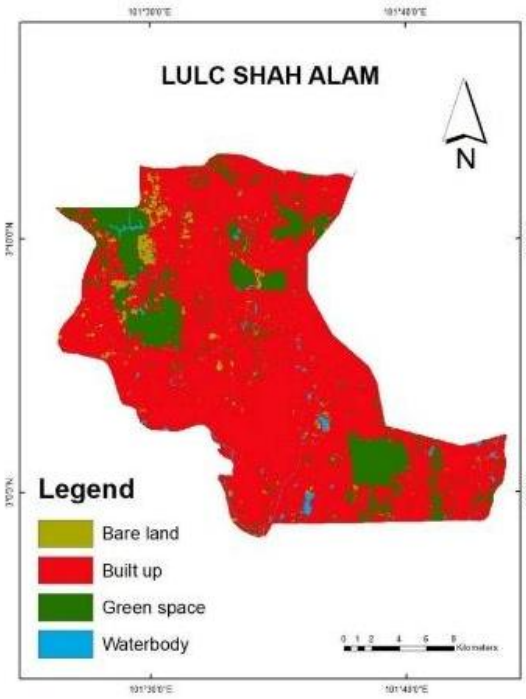
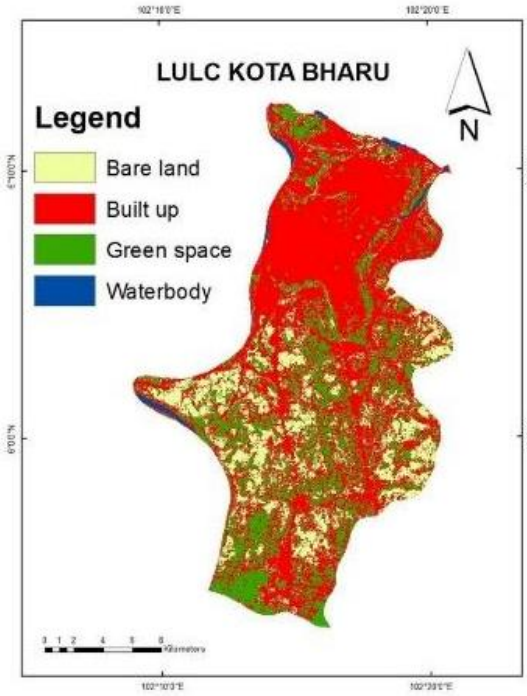


(b)

Fig. 3. Classification of NDVI value in Shah Alam, Selangor (c) and Kota Bharu, Kelantan (d)



(a)



(b)

Fig. 4. Land Use and Land Cover map of (e) Shah Alam, Selangor and (f) Kota Bharu, Kelantan.

Table 1. NDVI values of Shah Alam, Selangor and Kota Bahru, Kelantan

NDVI Value	Shah Alam	Kota Bharu
Minimum	-0.307	-0.317
Maximum	0.60	0.62
Mean	0.2	0.3
Standard deviation	0.132	0.136

3.1 Land Use and Land Cover of Shah Alam, Selangor and Kota Bharu, Kelantan

The result shows the Land Use and Land Cover of Shah Alam, Selangor and Kota Bharu, Kelantan (Fig. 4). Shah Alam is experiencing rapid urbanization in commercial development and housing. This finding suggest future land use planning of Shah Alam should focus on establishing corridors to connect the fragmented patches and enhance green space quality to urban dwellers. A study explain alternative to decrease LST by increasing the NDVI such as vegetation canopy cover even though they are struggling with public space for green vegetation [11].

Detailed hectares and the specific difference between Shah Alam, Selangor and Kota Bharu, Kelantan are represented in Table 2 and Table 3 respectively. The total area of Shah Alam for year 2025 is made of 1288.65 ha of bare land, followed by 37719.32 ha of built-up area, 7210.95 ha of green space and 610.09 ha of water bodies. Kota Bharu's 2025 landscape is made up of 7299.54 ha bare land, 23315.83 ha of built-up areas, followed by 9409.29 ha of green space, and water bodies constituting 418.03 ha.

Shah Alam is dominated by built-up areas with 81% of total area with 37719.32 ha, exceeding its green space coverage with only 15% of total area 7210.95 ha which conclude that Shah Alam has highly urbanized landscape with limited vegetation extent. However, Kota Bharu represent more balance land cover composition with 23% of total area cover with green space and the built-up area 53% of total area. In addition, Kota Bharu suggests more continuous vegetation cover and lower urban intensity compared to Shah Alam. Bare land in Kota Bharu is higher suggested that potentially related to undeveloped or agriculture areas.

Table 2. Area (ha) and Percentage (%) of LULC Shah Alam, Selangor

Classification	Area (ha)	Percentage %
Bare land	1288.65	3%
Built up	37719.32	81%
Green space	7210.95	15%
Waterbody	610.09	1%
Grand Total	46829.01	100%

Table 3. Area (ha) and Percentage (%) of LULC Kota Bharu, Kelantan

Classification	Area (ha)	Percentage%
Bare land	7299.54	18%
Built up	23315.83	58%
Green space	9409.29	23%
Waterbody	418.03	1%
Grand Total	40442.69	100%

Although the 30 m spatial resolution of Landsat imagery limits the detection of fine-scale green features such as street trees, small urban parks and narrow vegetated corridors, the observed NDVI patterns remain robust and suitable for comparative, city-scale assessments [3]. Consequently, the results should be interpreted as representing broader vegetation conditions rather than fine-scale urban greenery distribution.

4. CONCLUSION

In conclusion, this study emphasizes clear spatial contrast in urban vegetation landscape between two urban cities in Malaysia; Shah Alam, Selangor and Kota Bharu, Kelantan based on NDVI analysis derived from Landsat 8 OLI imagery. Shah Alam indicates highly urbanized cities and limited green space coverage which has low NDVI values. This explain Shah Alam is under stress condition due to fragmented vegetation and high proportions of built-up areas. Meanwhile, Kota Bharu shows moderate NDVI values due to continuous vegetation cover and low proportions of built-up areas. The findings also provide evidence to improve sustainable urban development planning. In future research, enhancing analytical precision using high-resolution remote sensing data helps to analyse data precisely by capturing fine-scale and long-term vegetation dynamics in Malaysia. Overall, the quantitative analysis underscores the influence of urban development patterns on vegetation density and ecological conditions in Malaysian cities. The spatial evidence generated by this study can support environmental management and urban planning by identifying areas where vegetation is under stress and where green infrastructure enhancement is needed. For future research, the integration of higher-resolution remote sensing data and multi-temporal analyses would improve analytical precision, enabling the capture of fine-scale and long-term vegetation dynamics to better inform sustainable urban development strategies in Malaysia.

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