MONITORING MAJOR CITY URBAN EXPANSION IN KUALA LUMPUR AND PENANG CITY CENTRE

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Abstract

Malaysia is currently undergoing heterogeneous land-use allocation and conversion in the city centre, resulting in leapfrog urban expansion to the suburban areas. Identification of the growth pattern from land-use conversion and urban growth has defined the limits of development, which could be a feasible way to alleviate the severity of these challenges. The research aims at the expansion factor for the built-up pattern of Kuala Lumpur (KL) and Penang City Centres. The objective of this research is to create a model on the new knowledge of urban built-up patterns generated from Landsat image data and comparison with built-up area from the change in land use, limitation of plot ratio, and floor space. The assessment of land-use changes is crucial in deciding the outcome for future development while considering the completion of committed development. This mechanism will help in the analysis of the data gathered using a remote sensing approach, which involves identifying the built-up area in KL City Centre using satellite images and examining the impact of land use patterns and varied plot ratios. In detail, the focus is directed towards a factor that influences the change of built-up area and development force. This will provide knowledge of Landsat images for the built-up area in urban expansion and the built-up limitations allocated by the local authority.

Keywords: Urban expansion, landsat image, city development, urban growth

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INTRODUCTION

In 1972, Kuala Lumpur was designated as a city, and in 1974, it was designated as a Federal Territory (Izuandi Yin, 2019). Meanwhile, Penang has undergone urban development since 1840 to this present day (Zhao, Wong, & Hanafi, 2019). It has had considerable infrastructure development between the Greater Kuala Lumpur and Penang conurbations; urban growth is taking place (Grunsven & Benson, 2020). In 2014, Kuala Lumpur's total land-use area was 243 square kilometres, whereas Penang's total land-use area was 1,049 square kilometres (Department of Statistics Malaysia, 2019). Many cities are experiencing rapid urban growth, which necessitates knowledge-based urban development to provide guidance for implementing strategic goals and policies. The application of machine learning for urban growth and development is becoming more prevalent in urban planning research (Ibrahim, Khattab, Khattab, & Abraham, 2021). Traditional urban planning concepts and measures for regulating urban development and service delivery are linked to the phenomenon of urban expansion (Hegazy, Helmi, Qurnfulah, Naji, & Ibrahim, 2021). Urban expansion is influenced by population and traffic circumstances, reflecting urban density around transit areas.

Urban areas were high with the density of built-up floor space in 50 kilometres radius from the city centre (Boori, Netzband, Vozenilek, & Choudhary, 2015) compared to the slowly outward growth to the suburban areas in 2014, while it climbed to 2,573.10 acres in 2015 (Noor et al., 2018). In 2015, many major categories such as residential, commercial, institutional, and public facilities were affected by land-use changes in the Strategic Planning Zone (SPZ) as a result of increased and decreased development. Because urbanisation is a worldwide phenomenon, population growth, the economy, and infrastructure all have the potential to contribute to its spread. A sprawl can arise as a result of an urban region's inability to anticipate growth through planning, law , and decision-making processes (Yasin, Yusof, & Noor, 2019). Urban sprawl is the urbanisation of space next to a city as a result of that city's development. Land development near cities, particularly agricultural land, infrastructure development, and a rise in the number of people who depend on public infrastructure and travel to work in the city are all problems under consideration (Cieslak, Bilozor, & Szuniewicz, 2020). A comparison of the current and traditional urban boundaries before Kuala Lumpur and Penang's upgrade as cities is reasonable to analyse the city's urban sprawl. Before any analytical operations can be done, a recently bought time series of remotely sensed data must be refined (Yasin, Yusof, & Noor, 2019). Although geographical factors are crucial in identifying land uses, total floor area is a second key element, as indicated by the synthesis of landed and high-rise buildings.

PROBLEM STATEMENT

The Landsat image comparison should be investigated as a separate factor influencing the built-up pattern. Understanding the factors that influence the built-up pattern and creating a built-up mapping will have an impact on how projects are developed efficiently and profitably. Understanding the factors that influence the built-up pattern and creating a built-up mapping will have an impact on how projects are developed efficiently and profitably. This includes identifying built-up and non-built-up areas, as well as built-up pattern characteristics such as land-use change, plot ratio, and floor space on various built-up area features. For determining land availability, each built-up area has its own classification system. This notion holds that if a well-constructed plan is in place, development will be easier, and land will be more readily available (Yin et al., 2020).

In the city centre, different plot ratios set by the local authority at the maximum cap resulted in saturation development and shrinkage of multi-storey development; in the suburbs, smaller plot ratios set by the local authority in the suburban area result in lower densities/price for some projects; and imbalance land-use allocation within a city result in transition urban sprawl to the suburbs (Razak & Yin, 2021). The sprawl of expansion to the suburbs cannot be effectively defined by development control measures given the high rate of development. As a result, measuring land-use trends can be done by looking at firm site selections in intra-city locations as well as home location selections. The land value and varying pricing for each area will be determined by this allocation. It also led to a shift in land usage from the city centre to the suburbs.

Rapid urban population growth has fuelled the development of peri-urban zones, which are the transitory boundaries between a city and its outskirts. Although urbanisation can improve an area's economy and infrastructure, uncontrolled development in peri-urban areas harms the economy and the people who live there. To ensure that the urban population in developing countries is sustainable, the boundary of city areas could limit urban expansion strategies, allowing for long-term planning (Samat, Mahamud, Tan, Tilaki, & Tiew, 2020). Because there is no obvious limit to Kuala Lumpur and Penang's urban expansion, a contrast between the existing and previous borders of Kuala Lumpur and Penang's upgrade as cities is reasonable. The building area is the most important factor for remote sensing data, guided by the building height (Samat, Mahamud, Rashid, Elhadary, & Noor, 2019). Furthermore, as indicated by the synthesis of landed and high-rise buildings, total floor area is a second essential component, although spatial features are vital in identifying land uses. Land use patterns are monitored to assist local governments and developers in strategising their constructed development to ensure that urban expansion is managed responsibly (Sharing Earth Observation Resources, 2021).

The development control of City Centre Commercial (CCC) has been assigned. As a result of District Centre Commercial's (DCC) growth, different priorities and growth for specific areas have been formed. The neighbourhood centre is more essential than the city centre's high density of expansion, which may be attributed to a misconception between the CCC's urban regeneration area and the district centre's secondary development area, particularly in the urban area of Kuala Lumpur (Yin & Abdullah, 2020). Although the (Kuala Lumpur City Plan, 2020) prioritises areas located in the city centre, other locations termed district centres appear to have high urbanisation and built-up areas that are practically equal to the city centre, based on current physical conditions. Three development control tools were utilised to detect the issue of urban expansion in Kuala Lumpur and Penang. Location and stress determine the economic traction force, which is more towards concentration and land value. It is founded on the demand for a high urban growth rate as well as commercial attraction, which leads developers to choose a location with a high land value to maximise profit (Marzukhi et al., 2021). To improve its role as a knowledge-based economy, Kuala Lumpur and Penang are also focused on the tertiary sector. While high-density development is important in metropolitan areas, low-rise suburban housing developments are particularly tempting to developers in Kuala Lumpur and Penang due to lower land prices and more demand (Smart City Handbook Malaysia, 2021).

Poorly balanced land use allocation within the Kuala Lumpur and Penang zones should be investigated in terms of economic organisation. As a result, measuring land-use trends can be done by looking at firm site selections in intra-city locations as well as home location selections. The land value and varying pricing for each area will also be determined by this allocation (Penang Economic and Development Report, 2019). It also resulted in a shift in land-use rules from the outskirts of the city centre. The project was dubbed a "mega-project" because of its size and complexity, as well as its placement in the city (Rahimzad, 2018). These initiatives are typically developed in the central region or city centre, adding to the city's economic gains and even allowing for the enlargement of the built-up area.

Based on the importance of directing expansion to the CCC region solely, the authority provides a varied plot percentage to each centre. It did, however, set a higher plot ratio for such centres, as well as some district centres that are not as significant as the city centre. It is founded on a high desire for economic development and a high land value. Urbanised areas agglomerate and develop as the population or economic activity centre within a larger metropolitan area.

RESEARCH QUESTIONS

Monitoring urban development between Kuala Lumpur and Penang City Centre:

i.   What is the expansion trend for built-up development in Kuala Lumpur City Centre and Penang City Centre?
ii.   How does the built-up development control the expansion of the urban area?
iii. How can the built-up area be defined through analysis of Landsat Image and zoning?

RESEARCH PURPOSE

Monitoring the city's expansion by considering the built-up development which directs the development force in the city centres of Kuala Lumpur and Penang (Georgetown) (Figure 1). The objectives of this study are as follows:

i.   To determine the land use distribution and built-up expansion both in GIS and Landsat image for Kuala Lumpur City Centre and Penang City Centre.
ii.   To understand the changes of space in urban areas from built-up, vegetation and non-built-up areas in the years 1987/1988 and 2021.
iii. To analyse the plot ratio, building height, and floor space from the land-use zoning which controls the intensity of development.
iv.   To monitor the built-up expansion which influenced land-use conversion and allocation of plot ratios in defining the direction of development force.
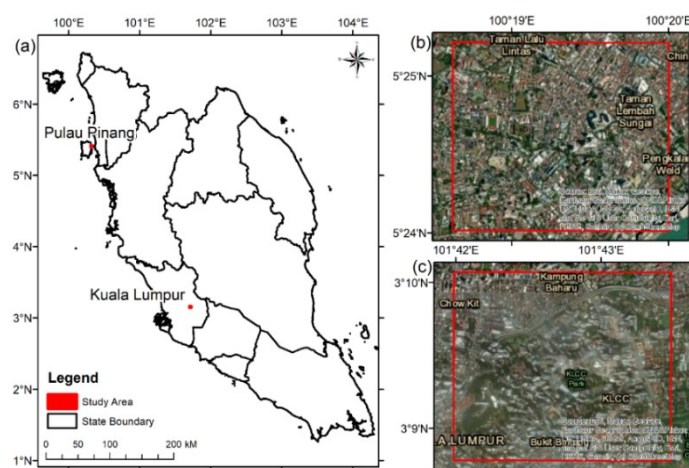

Figure 1: (a) Peninsular Malaysia and the location of study area in (b) Pulau Pinang and (c) Kuala Lumpur.

RESEARCH METHODS

In qualitative research, several observations were made by measuring development control variables allocated in the City Plan and Local Plan, and the Landsat image using remote sensing technique. On-site observation was used to determine the built-up area by calculating the actual floor space and designated plot ratio. The average floor space and built-up size of the building/plot were derived from site observations, which are used for intensity development. The built-up areas for KL City Centre and Penang City Centre were then added to find the average built-up area for each development. The other method of defining the built-up and non-built-up imaginary processes is by using remote sensing analysis where the Landsat image is generated from the satellite image. The value of its built-up area is used to calculate that component of urban expansion. The comparative analysis was made after both data from GIS and Landsat images were overlaid together to find the physical expansion of both cities. Secondary data was gathered from the local authorities, which are Dewan Bandaraya Kuala Lumpur (DBKL), PLANMalaysia Pulau Pinang, and Majlis Bandaraya Pulau Pinang (MBPP). Related data was collected to tabulate the distribution of land use, maximum plinth area, and plot ratio, which have been put by the local authorities to control the development in the city. The method of observation was carried out within a 1 km radius to identify the floor space, actual plinth area, and building height on the ground to get the total built-up area for each lot. The mapping from data analysed was then recorded in GIS plan to overlay (Figure 2) each variable to get the finding on the existing built-up area in both cities.
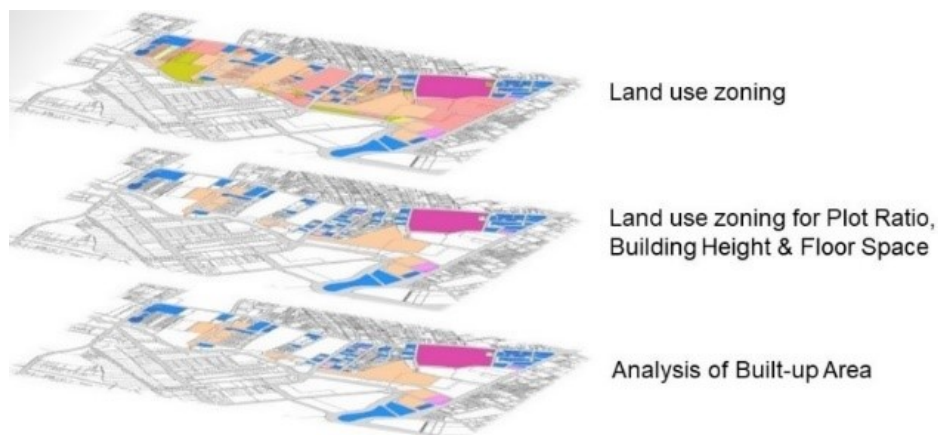

Figure 2: Built-up Area Overlay Technique

The second method used in this study was by generating the Landsat image (Figure 3). This data must be used to retrieve massive built-up areas from one

region to the next within a defined radius. This investigation employs four primary steps of Landsat image processing by using the USGS Earth Explorer to get various sensor categories of Landsat data. Step one retrieves the Landsat image from the USGS Earth Explorer. Step two involves pre-processing of the image, including subsetting and extracting the research region from satellite images, as well as calibration of radiometric instruments and atmospheric image restoration. Step three chooses a region of interest and produces the image of the ground truth in random samples of 50 from Google Earth for picture categorisation and precision testing. The maximum likelihood approach was used to classify the images. Step four uses image differencing to determine the extended urban area. It entails analysing Landsat images from a satellite image to determine the pattern of built-up in the previous years (1987 & 1988) and recent year (2021). It requires a precise image to be able to retrieve better shape. This procedure was carried out in this study to determine the extended urban area between 1987 and 2021 for KL City Centre while Penang City Centre between the years 1988 and 2021. The combination from both years shows the result of image classification of urban expansion for Kuala Lumpur City Centre and Penang City Centre.
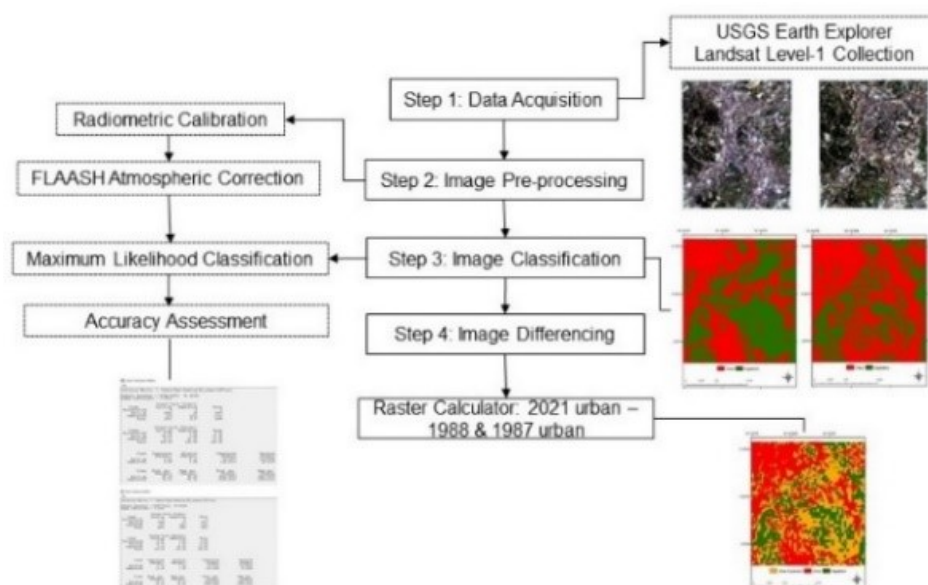

Figure 3: Image processing of Landsat image on urban expansion

FINDINGS

Analysis was done through the correlation of tools of development control used by local authorities, which led to the usage of built-up plot area on the ground and the expansion of built-up area based on the priorities plot ratio.
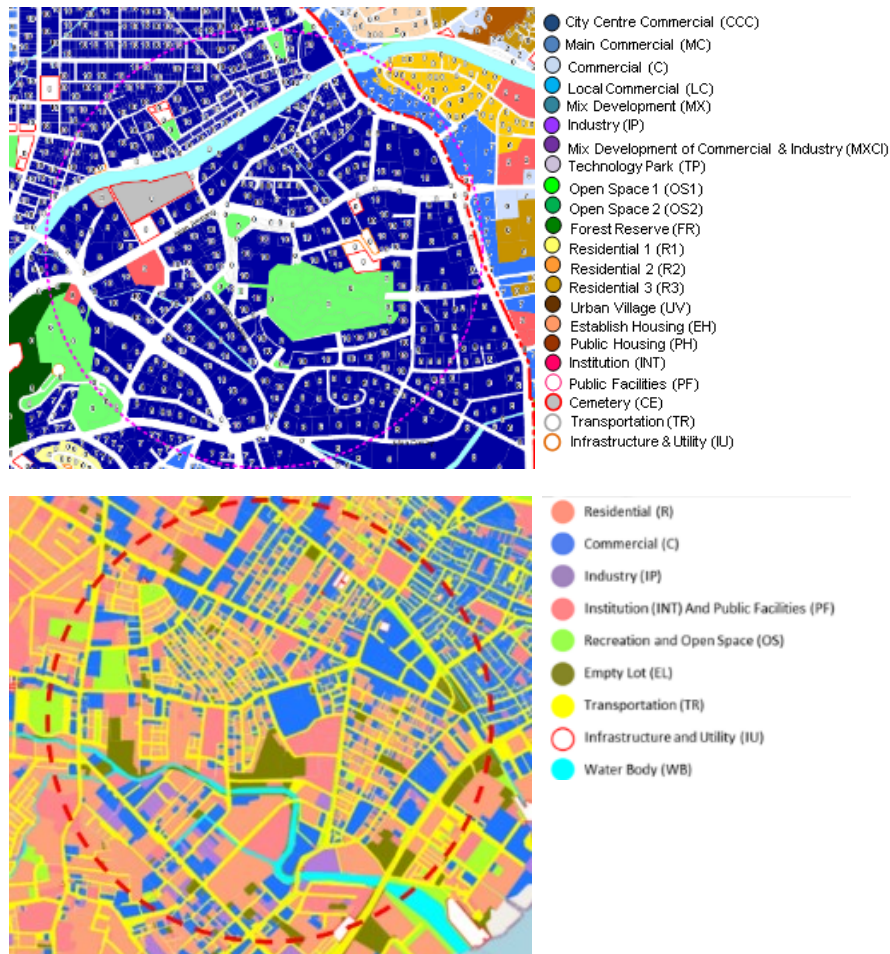

Figure 4: Land use area for Kuala Lumpur City Centre and Penang City Centre

Table 1: Urban Expansion on Built-up Area in 1km radius

Urban Centre	1km Radius of Land Use			Average Plinth Area	Average Building Floor	Total Built Up Area (Sqm)	Average Plot Ratio	Gross Floor Area (Sqm)	Non-Built-up Area (sqm)
	Area (Acre)	Lowest Built-up	Highest Built-up						

KL City Centre	247.1	Industry (0.03%)	Commerc ial (35.4%)	40%	18	175,46 7	1:8	17,668, 700	824,51 1
Penang City Centre	247.0	Industry (0.74%)	Residenti al (13.14%)	60%	14	225,41 0	1:5	11,869, 060	774,16 4

Figure 4 shows the land use (1 km radius) for both cities and shows Kuala Lumpur's area controlling the land use with commercial as the major development activities compared to Penang's area with scattered commercial activities but focusing on residential land uses as most of the areas were located as heritage and buffer zones for UNESCO heritage building area. The highest land built-up area for Kuala Lumpur City Centre is commercial while in Penang City Centre, the highest land use built-up area is residential and the lowest is industry activities for both cities. Based on the GIS analysis in Table 1.0, both areas show that plinth area influenced the size of the built-up area where Kuala Lumpur has an average plinth area of 40%, which led to only 17.5% built-up area that can be developed as structure/ building area while Penang has 22.6% the actual size of building area by using 60% of the average allowable plinth area. Non-built-up area for both cities show a large number of the area consisting of recreation area, open space, transportation, water bodies, infrastructure and utilities, vacant land, cemetery, and forest reserve, which categorises as a non-structure building at 77.5% in Penang City Centre and 82.5% in Kuala Lumpur City Centre.

The gross floor area has been influenced by the plot ratio allocated by the local authorities, where DBKL put the highest plot ratio in Kuala Lumpur City Centre at 1:10 (average plot ratio 1:8), which led to 17 million of floor area compared to Penang City Centre allocated by MBPP, with an average plot ratio of 1:5, which translates to a gross floor area of 11 million constructed in the city area. The development and growth concentrated at the middle of Penang City Centre and the expansion from the Southern to Northern region is due to the limitation of development caused by the development control for heritage building areas and coastal areas. Urban areas continue to expand to the Eastern region of Kuala Lumpur City Centre due to the additional densities allowed by the local authority in this area.
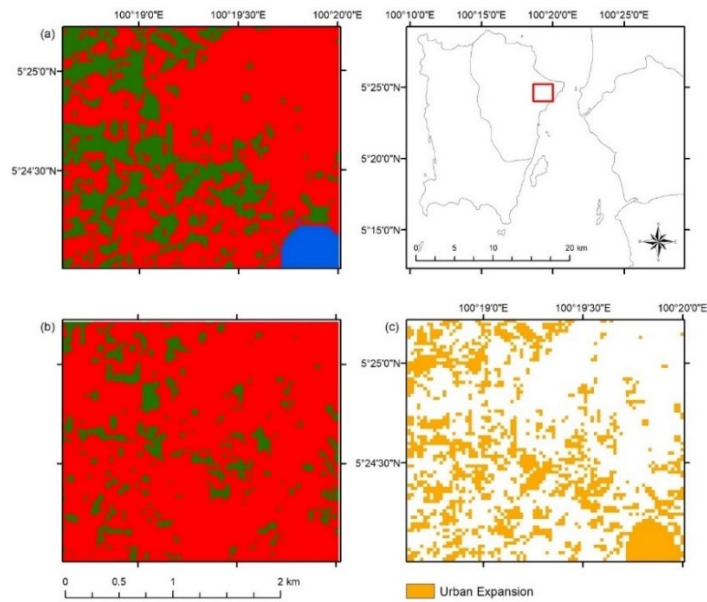
Figure 5: Image Classification for Built Up Area in Kuala Lumpur City Centre for the year of 1987 and 2021
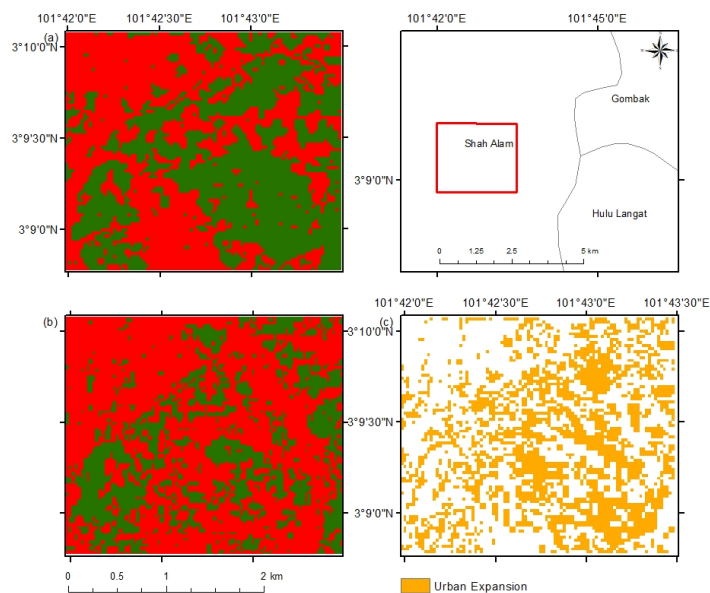

Figure 6: Image Classification for Built Up Area in Penang City Centre for the year of 1988 and 2021

Landsat image data shows that the available non-built-up area (vegetation) and built-up area (urban) for the past three decades since 1987 for Kuala Lumpur City Centre (Figure 5) and since 1988 for Penang City Centre (Figure 6) with the comparison of both using the same year of 2021.

Table 2: Urban Expansion Comparison using Landsat Image

Urban Area	Kuala Lumpur City Centre		Different	Penang City Centre		Different
Year	1987	2021		1988	2021	
Built-up	51.21%	67.41%	+16.21%	69.29%	87.19%	+17.9%
Vegetation	48.79%	32.59%	-16.2%	27.41%	12.11%	-15.3%
Water	-	-		3.30%	0.70%	-2.6%

The change in built-up area shows a movement of development activities (from 1987) in the North and South-Eastern regions of Kuala Lumpur in Figure 5 with the additional +16.2% of built-up taken from the existing vegetation, which decreases to 32.59% in 2021. Meanwhile, in Penang, the built-up area expands (Figure 6) (from 1988) to the West and Southern regions (additional of +17.9%) with the reclamation of the coastal area (decrease water area -2.6%) on the South-Eastern region; and vegetation has decreased -15.3% in 2021. The expansion shows concentrated expansion in the middle of Kuala Lumpur City Centre except for the North-West region. Meanwhile, in Penang City Centre, the expansion focusses towards the central and West regions, while the activities of land reclamation happened at North-East region.

CONCLUSION
The built-up area is expanding every year due to the conversion of non-built-up area to building development which has taken and expanded more than 5% every decade. The expansion is also influenced by the existing plinth area developed in the city centre, which can only be changed by adding up the density of the plot area. The redevelopment of existing vacant land also contributes to the new built-up where the vegetation is decreasing but has been allocated the non-plinth area as their plot open space. Reclamation of water bodies and changing of the utility area into built-up plot area has rapidly expanded, which decreases the water area in the city centre.

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