Integrated land use-transportation approach in controlling the growth of urban sprawl using remote sensing and GIS application

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Abstract. Integrated land use-transportation approach in urban planning has provided a new direction in urban sprawl studies. The spatial analysis of the current land use will provide an insight of the development density and the effect of active transportation activities on urban sprawl growth. This paper focuses on the integrated land use-transportation approach in controlling the urban sprawl by assimilating the application of remote sensing and GIS with Land Use Geospatial Indices (LUGI). Remote sensing and GIS is applied in measuring the phases of urban sprawl growth focusing on the aspect of the land use-transportation relationship. Two components of LUGI; 1) strip sprawl and 2) leapfrog development sprawl are designated to measure the spatial interruption caused by the urban sprawl. Strip and leapfrog analyses are useful in determining the existence of urban sprawl from the transportation perspectives. Transportation elements of road hierarchy and geometric, as well as transportation infrastructure are included as variables in the measurement process to validate the indication of both types of sprawl. Kuala Lumpur, Malaysia is chosen as the study area. Currently, the city served as capital and premier location that accommodates the regional headquarters of national and multinational business companies. Thus, the rapid population growth has contributed to the growth of urban sprawl in Kuala Lumpur, yet there are no substantial measures to identify the type, pattern and how to kerb it. The findings proved that Kuala Lumpur is currently facing the urban sprawl issues pertinent to the two components of LUGI calculated. These geospatial indices sprawl not only occurred at the city fringe but currently transpired within the city as well. The integrated land use-transportation approach is necessary for controlling the settlement development within the city to reduce the sprawling effects to the land use density and transportation system.

Keywords: Strip sprawl, leapfrog sprawl, urban sprawl, remote sensing and GIS, transportation

1. Introduction
Sustainable land use and transportation arrangement would enable towns and cities to function better and enhance the quality of life of its occupants. Land use and transportation planning have critical roles in shaping the cities and conveying social, economic and environmental sustainability [1]. The
pattern of land use activities at the different spatial zones will increase travel demand. Thus, without proper spatial planning of land use and transportation, the development of an area tends to sprawl specifically along the major road, leaving the vacant land area in between development. Urban sprawl existence within the urbanised city centre indirectly will add to an adverse impact on the existing traffic flow and the surplus of travel demand among the residents and road users [2]. Moreover, the expansion of population away from the planned city centre will be associated with the increase of automobile-dependent communities, the low level of service of road capacity, as well as other issues of parking services and public transportation catchment area. These uncontrolled commuting travel behaviours lead to the inefficiency of the transportation system and less dynamic of spatial planning patterns of the city centre [3]. Thus, the successful delivery of sustainability requires comprehensive and robust integration of land use and transportation planning.

The paper aims to measure two components of Land Use Geospatial Indices (LUGI) urban sprawl that is closely related to transportation sector in order to determine the pattern of sprawl and to find a solution by integrating the geospatial indices with transportation approach. In Malaysia to be specific, the rapid growth of urbanisation and economics concentration has caused the increasing demand not only in housing and infrastructure but also better transportation and road network [4]. The demand for transportation will directly create economics, social, and environmental impacts [5]. Hence, a sustainable transportation system is vital to ensure the balance of resource availability and the reserve for future needs [6]. A comprehensive transportation system also plays a role in connecting a Central Business District (CBD) and its peripheral with workplaces and other districts. In this case, an integrated land use-transportation system is needed to reduce the effect of urban sprawl, yet it requires extensive approach following the differences of the city environment, operation system, and institutional context [7], [8].

1.1. Theories and definitions of leapfrog development sprawl

Discontinuity of land use is one of the most cited dimensions of urban sprawl. Leapfrog sprawl defined as a discontinuous pattern of development especially in an urban area which is often fragmented, widely separated and has blurred boundaries [9][10]. Researchers have characterised the form of leapfrog sprawl as a discontinuously new development from the central core of urban area due to the intervening undeveloped areas, leaving behind vacant land in between these developed areas [11], [12]. Leapfrog sprawl is caused by different factors such as the physical geography which make continuous development prohibitively expensive to be executed or other factors such as different land-use policies between political jurisdiction [9]. The government policies such as the split-rate tax are causing the discontinuous jump at jurisdictional boundaries [13]. Moreover, the leapfrog sprawl occurred due to the inexpensive land area at the outskirts of the city, plus the development control is also loose [14] [10]. Some researchers identified leapfrogging development in their study area is mostly orchestrated by natural factors rather than anthropogenic factors [11], while others firmly asserted that natural features like water bodies, preserved wetlands, forests, public reservations and facilities are not viewed as interruptions of continuous development [15], [16]. In this research, the leapfrog sprawl is defined as any new residential development that occurred outside the 1500m radius from the CBD as depicted in Figure 1.

Figure 1. Depiction of Leapfrog Development Sprawl

Continuous Development – Less Sprawling
Leapfrog Development – More Sprawling
Lacks coordination among government, developers, planner and public are leading to development speculation causing early development growth without proper planning resulting in leapfrog sprawl which later requires the instalment of more roads to connect this new development with the CBD. The development speculation has a domino effect on landscape functionality. The high rate of population growth in an urban area initiating higher the expectations of land appreciation. As a result, more land will be withheld for future development causing an increasingly fragmented land use pattern that in turn leads to elevated transportation requirements [2]. Valuable agricultural lands are consumed or are otherwise impacted, and wildlife habitat fragmentation is accelerated [17]–[19]. Also, leapfrog sprawl causes increased congestion and air pollution from greater vehicle travel, reduced ecosystem services from either deforestation or reduced connectivity of natural areas, and loss of local farmland [20].

1.2. Theories and definitions of strip sprawl
Sprawl is urbanisation process that takes place in either a radial direction around a well-established city or linearly along the highways, over a given period [21]. Highway strip development also is known as ribbon development, is commonly cited characteristic of sprawl [18], [22]–[27]. As depicted in Figure 2, highway strip sprawl is a type of development that follows vital transportation arteries outward from urban cores causing the land area adjacent to the corridors to be well-developed, but the area without direct access remain as rural users [9], [11], [28], [29]. As time passed, these nearby “raw” lands may be converted to urban uses as land values increase and infrastructure is extended perpendicularly from the major roads and lines [9]. As a consequence, it is also being referred to as excess sprawl where the part of sprawl is caused by distortions [30], [31]. The automobile-related distortion such as highway strip development is causing the excessive sprawling of land use and traffic congestion. The misuse of cost-benefit rules by transportation planners has resulted in too much highway-building causing too much urban expansion into suburban areas where land was initially cheap [32]. Also, urban growth resulting from highway construction may adversely impact an area when growth is not in line with local planning policies [34].

![Figure 2. Depiction of Strip Sprawl (modified from Hasse, 2004)](image)

2. Research Methodology

2.1. Study area
Kuala Lumpur Metropolitan is Malaysia central urban area which also serves as the Capital City and National Growth Conurbation. Kuala Lumpur, one of the three Malaysia’s Federal Territories is situated in the West Peninsular Malaysia within the Selangor state (3.1390° N, 101.6869° E) which covers an administrative area spreading over 59,880.65 acres. The National Physical Plan has identified Kuala Lumpur, Klang Valley and Seremban as the National Growth Conurbation which covers an area of approximately 1,245,411.12 acres. The main aim of National Growth Conurbation is to provide for a potential population of 8.5 million or 32% of the Peninsular Malaysia population by 2020 which is more than five times of Kuala Lumpur total population in 2005 (1.6 million). The high regional population base will enhance Kuala Lumpur’s role as an international regional commercial and financial centre.
2.2. Method

The methodology was designed with the aim to determine the best measurement method for each component of land use geospatial indices in order to distinguish the degree of development practice that was considered as common, neutral or sprawl development (refer Figure 3). The research defined the common development as urban growth that coherent with the policies and guideline established by the planning authorities, followed by neutral development which is considered as prone to sprawl without the installment of proper planning, and lastly sprawl development.

Figure 3. Research Methodology Framework

2.2.1. Land use change detection method. Land cover and land use changes have been associated with urban development process which leads to sprawl and environmental degradation. Change detection is the process of identifying alteration of the phenomenon or objects due to human modification of the environment by remotely observing it at different times [35]–[37]. The change detection analysis conducted in this research includes several essential steps, namely the satellite images classification process, accuracy assessment and post-classification comparison techniques. Since the urban land use sprawl quantification requires information on landscape alterations of two different time, the Post-
Classification Comparison (PCC) techniques are chosen for this research. This change detection technique has been widely used in built environment studies especially in urban planning [38]–[41]. In this research, the magnitude of change for land cover classes (K) is calculated by the simple equation adopted from [42].

\[
K = F - I
\]  

(1)

While the percentage of change (A) is calculated by the formula as shown below.

\[
A = \frac{F - I}{I} \times 100
\]  

(1)

where \(K\) = magnitude of change \\
A = percentage of change \\
F = first date (2005) \\
I = reference date (2015)

Table 1 shows the outcome of change detection techniques applied for this research based on the equation above. Based on the land use change detection analysis, the land area for residential development in Kuala Lumpur has decreased approximately 336.99 acres in the year 2015. However, the trend of decreasing residential land use does not indicate that there is no residential development at all from the year 2005 to 2015 but shows that the land area allocated for residential development have decreased due to the policy of Kuala Lumpur City Council encouraging the development of vertical residential area due to the scarcity of land and other development pressure. Based on the spatial distribution analysis, there are new residential development patches that have been detected in each strategic planning zone where the lowest area is in City Centre SPZ due to the scarcity and high value of land. In this research, the newly developed residential area in the year 2015 is used as a variable to measure the leapfrog and strip land use geospatial indices urban sprawl.

Table 1. Kuala Lumpur Land Use Change Detection (2005-2015)

| No | LAND USE CLASS                          | AREA 2005 (ACRES) | AREA 2015 (ACRES) | MAGNITUDE OF CHANGES |
|----|----------------------------------------|-------------------|-------------------|----------------------|
|    | Built-Up Area                          |                   |                   |                      |
| 1. | Residential Area                       | 15,389.51         | 15,052.52         | -336.99              |
| 2. | Commercial Area                        | 2,691.46          | 2,756.92          | 65.46                |
| 3. | Industrial Area                        | 1,318.53          | 1,299.15          | -19.38               |
| 4. | Public Facilities and Institution      | 8,182.40          | 7,735.18          | -447.22              |
| 5. | Road Network                           | 13,247.84         | 10,717.83         | -2530.01             |
| 6. | Infrastructure and Utilities           | 33.91             | 1,806.66          | 1,772.75             |
| 7. | Transportation Hub and Terminal        | 462.28            | 3,469.60          | 3,007.32             |
|    | Unbuilt Area                           |                   |                   |                      |
| 8. | Barren Land                            | 11,515.57         | 9,121.17          | -2394.4              |
|    | Undevelopable Area                    |                   |                   |                      |
| 9. | Cemetery                               | 755.96            | 779.31            | 23.346               |
| 10.| Open Space Recreational & Forest Reserve | 4,348.89         | 4,996.56          | 647.67               |
|    | Natural Features                       |                   |                   |                      |
| 11.| Water Bodies                           | 1,934.30          | 2,145.75          | 211.45               |
|    | TOTAL                                  | 59,880.65         | 59,880.65         |                      |

*Source: Processed by ERDAS Imagine, and ArcGIS*
2.2.2. Leapfrog development sprawl measurement method. The leapfrog sprawl in Kuala Lumpur is measured by the distance of newly built residential area from the CBD for each Strategic Planning Zones (SPZ). The distance that is considered as smart growth, common development or leapfrog sprawl is specified in Table 2 below. The parameters presented is based on the study conducted by [25] where they grade urban sprawl occurrence based on accessibility. The area that is easily accessible by walking (which means the area are automatically approved as ideally accessible by another mode of mobility, i.e. bicycle and automobile) being considered as convenient thus smart growth. Based on the study by [43], the maximum distance of walkability for Malaysia’s urban areas is 600 metre and the most comfortable walking distance is 400 metre (5 minutes) for all age groups with consideration of several factors such as pedestrian age and health limits, safety, walkway facilities and environmental factors such as climate. Since the walking distance in the indicator is 500m which is still within the maximum and comfortable walking distance in Malaysia, the researcher decided to use the equivalent distance generated by [25].

| Grade | Distance from Central Business Area | Parameters | Annotation |
|-------|------------------------------------|------------|------------|
| A     | 0-500 metre                        | Walking Smart Growth | Smart Growth |
| B     | 501-1500 metre                     | Bicycle Smart Growth | Common Development |
| C     | >1500 metre                        | Suburban Sprawl | Leapfrog Sprawl |

Sources: Modified from Hasse & Kornbluh, (2004)

The second grade is the area that is moderately accessible by walking, but easily accessible by bicycle and automobile is considered as bicycle-smart growth in their research work or common development in this investigation. Lastly, the area that is poorly accessible by walking and cycling but only ideally accessible by automobile is considered as sprawling. In this research context, the accessibility is discussed the newly developed residential area and the CBD. This measurement method is expected to solve the problem of sprawl due to different boundary governed by various state and local authority as currently faced by many cities in Malaysia including Kuala Lumpur. The value of leapfrog development sprawl (LFGx) was calculated by using the formula modified from [44] as shown below:

\[
(LFGx) = \frac{\sum GC_{Gx} \times 100}{\sum GC_{Unit}}
\]

(3)

where:  
\(LFGx\) = Leapfrog development sprawl according to strategic planning zone  
\(GC_{Gx}\) = Number of grid cell according to CBD grade distance buffered area  
= (a) 0-500 metre from CBD  
= (b) 501-1500 metre from CBD  
= (c) >1500 metre from CBD  
\(GC_{Unit}\) = Number of grid cell units

2.2.3. Strip sprawl measurement method

This research adopted and modified [44] measurement method except for the selected road for this measurement is not highway or expressway. This is because the Highway and Expressway in Malaysia are not freely accessible as described in Kuala Lumpur Functional Road Hierarchy. Highway and expressway in Malaysia only can be accessed through the interchange. Therefore, it will not stimulate or have any direct impact towards development along its corridor. Accordingly, this research uses the arterial road that primarily distributes the traffic movement within Kuala Lumpur city and connects the collector road with arterial road and highways. The maximum road width of the arterial road is 30m...
with dual or single carriageway. By considering the actual road width, the length of the road buffer for strip sprawl measurement for this research is decided to be 130m. The new residential development was detected using land use change detection. Similar to the other LUGI sprawl measurement method, the measurement for strip sprawl in Kuala Lumpur was conducted in the newly developed residential area. The overlay analysis techniques are employed requiring a few data layers such as new residential grid, Kuala Lumpur existing land use 2015 and Kuala Lumpur Road Network 2015. A set of indicators for strip sprawl measurement is developed and shown in Table 3. Any new development that occurred inside the road buffer area (130m) is considered as sprawling.

### Table 3. Strip Sprawl Indicators

| Grid Cell Value | Parameters | Description | Annotation |
|-----------------|------------|-------------|------------|
| 0               | ≥130 m     | New development patches outside of 130 m buffer area | Non-Sprawl |
| 1               | <130m      | New development patches inside of 130 m buffer area | Strip Sprawl |

The value of strip sprawl (SS$_{spz}$) was calculated by using the formula modified from [44] as shown below:

$$SS_{spz} = \frac{\sum GC_x \times 100}{\sum GC_{Unit}}$$

(4)

where: (SS$_{spz}$) = Strip sprawl according to strategic planning zone

$GC_x$ = Number of grid cell value \{0, 1\}

$GC_{Unit}$ = Number of grid cell units

### 3. Research Results and Discussion

#### 3.1. Leapfrog sprawl

As shown in Table 4, the findings of leapfrog sprawl measurement identified that, of all new residential development in Kuala Lumpur, three out of six SPZ scored as common development (grade B), followed by the remaining three SPZ that scored leapfrog sprawl (grade C). Sentul-Menjalara scores the highest percentage of common development with (15.63%) followed by Damansara-Penchala (13.67%) and lastly the city centre with only 0.78%. The strategic zone that is currently facing the leapfrog sprawl problem includes Bandar Tun Razak-Sg.Besi (13.28%), Bukit Jalil-Seputeh (9.77%) and Wangsa Maju-Maluri (7.81%). Apparently, the percentage of leapfrog development sprawl of Wangsa Maju – Maluri SPZ is same with the leapfrog percentage of Damansara-Penchala SPZ.

Although only half of the Kuala Lumpur SPZ are regarded as leapfrog sprawl, the remaining SPZ did not score smart growth (grade A) either. As previously stated in this research, SPZ that scored that common development indicator is prone to sprawling as this area depended highly on the successful implementation of proper urban planning and management by the authority. As for now, the total findings from research measurement proves that Kuala Lumpur is facing a significant problem of leapfrog development sprawl with dominant percentage scores of 46.09% over smart growth that only scores 16.80% and common development (37.11%).

Leapfrog sprawl has brought negative effects not only in the rural area but the urban area as well. This is because leapfrog urban sprawl has led to massive loss of high-quality fertile lands in the suburbs and has encroached upon limited open space, such as forests, grassland and water area. Moreover, the leapfrog sprawl caused the growing traffic burden by increasing the distance between the newly developed land and city centres where job opportunities concentrate upon [45]. The spatial-
distance of human activities cause higher automobile-dependency. Hence, functional connectivity that provides adaptable, sustainable and robust transportation system is vital in ensuring an optimal mobility chain through comprehensive connections between the various networks of the mass-transportation system and close coordination of infrastructure and great spatial development strategy. Kuala Lumpur land use pattern had been the result of past practices and development trends, which were grounded on single land use zoning [46]. Thus, the past practice of urban planning in Kuala Lumpur has characterised the land use phenomena either as monocentric versus polycentric forms, centralised versus decentralised patterns and continuous versus discontinuous developments. As a result, Kuala Lumpur is experiencing population loss to surrounding the areas of the city due to decentralisation of economic development to other more industrialised zones and the availability of relatively cheaper housing development in other parts of Klang Valley. Wherefore, Kuala Lumpur has become clogged with the on-road vehicles making journeys to enter the city area where workplace and commercial centre are located. It is vital that transit-oriented development become a central consideration from the early stages of local planning – whether for infill development or new development.

Table 4. Findings of Leapfrog Development Sprawl Land Area by SPZ

| Kuala Lumpur Strategic Zone | Grade A (0-500m) % | Grade B (501-1500m) % | Grade C (1501-3000m) % | Total % | Annotations |
|----------------------------|--------------------|------------------------|------------------------|--------|------------|
| Sentul Menjalara           | 7.03               | 15.63                  | 7.42                   | 30.08  | Common Development |
| Wangsa Maju-Maluri         | 1.56               | 3.13                   | 7.81                   | 12.50  | Leapfrog Sprawl |
| City Centre                | 0.00               | 0.78                   | 0.00                   | 0.78   | Common Development |
| Bandar Tun Razak-Sg.Besi   | 3.52               | 3.91                   | 13.28                  | 20.70  | Leapfrog Sprawl |
| Bukit Jalil-Seputeh        | 0.00               | 0.00                   | 9.77                   | 9.77   | Leapfrog Sprawl |
| Damansara-Penchala         | 4.69               | 13.67                  | 7.81                   | 26.17  | Common Development |
| TOTAL                      | 16.80              | 37.11                  | 46.09                  | 100.00 | Leapfrog Sprawl |

In this research, the land use geospatial indices model of leapfrog development identifies one of the urban development categories namely the leapfrog development sprawl from infill and common land use expansion. The infill growth is characterised by a newly developed residential area in the year 2015 with an area less than 10 acres. It can also be defined as the residential development of a small tract of land mostly surrounded by a built-up land cover. While the common expansion development types are a newly developed residential area within the appropriate specified distance from the CBDs. Lastly, the outlying growth or leapfrog development is characterised by a change from non-residential to residential development occurring beyond the specified distance from the actual CBDs and likely approaching the urban fringe. The city of Kuala Lumpur shares boundaries with several districts that fall under different municipalities or local planning authorities within the state of Selangor, which is also regarded as Greater Kuala Lumpur. The pattern of leapfrog development growth in Kuala Lumpur tends to move towards the fringe of Wangsa Maju – Maluri SPZ that adjoined with Gombak district, Bandar Tun Razak – Sg.Besi SPZ with Hulu Langat District and Bukit Jalil – Seputeh SPZ with Petaling District. Undeniably, both change detection analysis and leapfrog analysis conducted in this research proved that the urban development in Kuala Lumpur is moving towards its fringe. Sentul-Menjalara SPZ, City centre SPZ and Damansara-Penchala SPZ are currently showing moderate leapfrog sprawl tendency. However, this situation might turn to be leapfrogging in the future if measures to control its growth is not efficiently executed. Historically, the Malaysian land use planning system has lack ability to monitor the sequencing of new development growth adequately.
either cause by natural topography factor, land ownership, the price of real estate, accessibility, infrastructure or policies by the government. This disorganised pattern of development has a domino effect on property functionality. The current trend in Kuala Lumpur is more development demand for residential land use in the fringe area due to lower property price, and there are a lot of access and modes of mobility towards the centre. Efficient transportation networks enable greater accessibility and higher density of developments, which in turn generates social and economic benefits. The conflict associated with urban sprawl activities could be solved by providing an efficient network of transportation that allow people and business to access the services and activities within the city.

3.2. Strip Sprawl

Next, Table 5 presented that findings from residential strip sprawl measurement. The outcomes of residential strip sprawl were presented in percentages value. The findings indicated that almost all of the SPZ in Kuala Lumpur scores high percentages of 0 value which mean that the new development area along the arterial road is not sprawling except for the city centre. The strip sprawl percentage in Kuala Lumpur city centre is 0.78% which occurred at the core city edges. Sentul-Menjalara scores the highest percentage of smart growth development (21.88%) followed by Damansara-Penchala (23.83%).

| Kuala Lumpur Strategic Zone       | Value 0 Percentage | Value 1 Percentage | Total Percentage | Annotations          |
|-----------------------------------|--------------------|--------------------|------------------|----------------------|
| 1. Sentul Menjalara               | 21.88              | 8.20               | 30.08            | Smart Growth         |
| 2. Wangsa Maju-Maluri             | 8.59               | 3.91               | 12.50            | Smart Growth         |
| 3. City Centre                    | 0.00               | 0.78               | 0.78             | Strip Sprawl         |
| 4. Bandar Tun Razak-Sg.Besi       | 16.80              | 3.91               | 20.70            | Smart Growth         |
| 5. Bukit Jalil-Seputeh            | 6.64               | 3.13               | 9.77             | Smart Growth         |
| 6. Damansara-Penchala             | 23.83              | 2.34               | 26.17            | Smart Growth         |
| **TOTAL**                         | **77.73**          | **22.27**          | **100.00**       |                      |

Characterization of highway strip development is challenging because the problematic qualities of strip development are a matter of urban design as well as location and configuration of land use. It is hard to determine from a land use map the configuration of parking, the existence of sidewalks, on-street parking, non-auto accessibility and other more aesthetic qualities associated with highway strip development. Therefore, a few researchers suggested that in-field observation is best to determine the highway strip characteristics at the site level. Automating the highway strip metrics at larger spatial extents necessitates preceding some of these design-specific characteristics of highway strip development [44], [47]. In this research, the land use geospatial indices model of strip sprawl development is utilised to distinguish the strip sprawl from typical development in Kuala Lumpur city. Unlike other research that uses the highway, this research uses the arterial road which also serves as the Federal route for Kuala Lumpur. This is because the private organisation operates all highways in Malaysia, and therefore all highways are gated and not freely accessible by the user. So this research focused on strip sprawl occurrence on the arterial road because pedestrian, workers, commuters should not have direct access toward the main road, cause it's ugly, cause congestion, the road should be linked by other smaller hierarchy to distribute traffic volume [48].

In theory, when the new development arose it will generate the trips and its distribution. Hence, the strip sprawl scenario within the city road networks will associate with increasing number of trips by motorcar and non-motorcar travellers as well as the travel behaviour that leads to a high volume of traffic flow and decrease the level of service of the existing road. Proper road geometry and street layout are needed to accommodate both non-motorised and motorcar traveller who daily commute to the suburb and city. In addressing the road congestion and high volume of public transportation
commuters from the strip sprawl along the arterial road of the city, a pleasant ‘liveable’ street with high safety, efficient network, excellent accessibility and convenient direct lines of access to facilities is vital. Based on the findings, Kuala Lumpur is not facing any severe issues in term of strip sprawl due to highways in Kuala Lumpur are not freely access and the guideline of the road network in Malaysia designed to distribute the traffic volume from the arterial road through other road hierarchy such as local and collector road. After measuring the strip sprawl for new residential along the arterial road as well as for both residential and commercial, the result shows that the ratio of common development is higher than the strip sprawl except for the city centre. This situation is considered as common since the city centre is the earliest location for development, and the road network is formed organically during the previous era. Thus, in the city centre, many commercial buildings stand along the main road and easily accessible by users such as in Jalan Tengku Abdul Rahman causing congestion and affecting the urban- scape. However, further understanding of the local context and pedestrian linkages and networks are necessary for accommodating the needs of shifting the short-distance trip with vehicles to walking and cycling modes.

4. Conclusion
The complex nature of land use pattern and transportation infrastructure installation in an urban area requires proper means to manage its planning and management. Thus, this paper examines two Land Use Geospatial Indices (LUGI) urban sprawl components pertinent to transportation sectors namely leapfrog development sprawl and strip sprawl using remote sensing imagery data and GIS approach in order to perceive how land use and transportation planning affecting each other, particularly in kerbing urban sprawl growth. These findings indicate that by integrating land use development pattern with proper transportation infrastructure, the growth of sprawl can be controlled. Moreover, the area that is already manifested by sprawl can be improved by installing the integrated transportation management approach to counter back the negative effect of urban sprawl. Both leapfrog development and strip sprawl index provides a significant method for identifying, comparing, and contrasting sprawl development in a more detailed manner for further investigation of the underlying process at play.

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