The impact of UiTM Cawangan Pulau Pinang Permatang Pauh campus on urban development in Central Seberang Perai District

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Abstract. Universiti Teknologi MARA (UiTM) is regarded as one of the largest higher education institutions (HEIs) in Malaysia. Significantly, HEIs are increasingly seen as catalysts for development, with substantial contribution not only as providers of education and research but also as an active role in developing their economic, social and cultural surroundings. Thus, it is thought the existence of HEIs particularly UiTM as key players in global development, alongside being significant contributors to local urban areas’ development. UiTM Cawangan Pulau Pinang (UiTMCPP) was first established in June 1996 at a temporary site in Permatang Pasir as the university's eleventh campus. In August 2003, UiTMCPP relocates to a permanent campus in Jalan Permatang Pauh. The main purpose of this study is to determine the influence of the UiTMCPP Permatang Pauh campus on the local area's urban expansion. In this study, multi-temporal satellite imageries, Landsat Thematic Mapper (TM) in three different years (1999, 2009, and 2019) was processed by Geographic Information System (GIS) and remote sensing techniques to distinguish the spatial expansion of urbanisation in Central Seberang Perai District. Further analysis on data collection using the quantitative and qualitative approach were performed to determine the actual impact of urbanisation on the communities. Results show that the percentage of developed area increased from 51.2% (1999) to 68.6% (2019) within a 5 km radius, and from 29.0% (1999) to 45.6% (2019) within a 10 km radius, according to the urban development map. Although the establishment and existence of the UiTMCPP Permatang Pauh campus can be considered one of the area's development catalysts, several adjacent educational institutions also contribute to the growth of the region near the UiTM campus.

Keywords. Urban development, University, Central Seberang Perai, Remote Sensing, Geospatial Analysis
1. Introduction
To date, Malaysia's urbanisation rate has been increasing. A study shows that urbanisation will hasten changes in specific aspects like people, geography, physical and social technology [1]. Malaysia was among the most urbanised countries in East Asia [2]. Statistics show that Malaysia's urban population has gradually increased from 70.08% in 2009 to 74.21% in 2015 and further to 76.61% in 2019 [3]. The Malaysia's urban population growth has been recognised as one of the quickest in the area, with a noteworthy growth rate of 6% during the last 10 years. Penang, in particular, is one of Malaysia's most urbanised states, having a level of urbanisation of 90.8% among the country's 13 states [1]. Despite being the country's second smallest state by landmass, Penang is one of Malaysia's most populous states. Penang's rapidly changing population demographics are both fascinating and perplexing. Penang ranked second in population density in 2010, just behind the country's capital, Kuala Lumpur, with 1,490 people per square kilometer [4]. In 2021, the population has increased to 1,691 people per square kilometer [5]. The rapid rate of urbanisation, expanding population, and growing property prices, combined with political antagonism between the federal and state governments at the time, have exacerbated the problem of affordable housing in Penang [1].

The Central Seberang Perai District is the third-largest district in Penang, Malaysia, with an area of 238 square kilometres with the latest population of 438,200 people [4]. The Central Seberang Perai has four (4) cities: Bandar Bukit Mertajam, Bandar Perai, Bandar Perda, and Bandar Seberang Jaya. The district consists of various races and backgrounds inhabiting 21 Mukims. One of the Mukims is Permatang Pauh. There are two recognisable higher learning institutions located in Permatang Pauh, namely a campus of Universiti Teknologi MARA (UiTM) and Politeknik Seberang Perai. Universiti Teknologi MARA Cawangan Pulau Pinang (UiTMCP), the eleventh campus of Universiti Teknologi MARA (UiTM), was established on 16 June 1996 at a temporary site in Permatang Pauh. In August 2003, UiTMCP moves to a permanent campus in Jalan Permatang Pauh. UiTMCP Bertam campus is UiTMCP’s second campus, having a total area of 100.4 hectares that includes phase 1’s initial development of 13.2 hectares. The second campus development is to accommodate the increase in students at the UiTMCP Permatang Pauh campus. Previous study has been carried out on the impact studies related to the social and urbanisation impact at Penang state [6]. However, the impact of establishing the UiTMCP on urbanisation within 5 to 10 km has not been evaluated, especially using the latest geospatial technologies.

Urban growth shows a rapid increase in urban population, city and economic expansion [3]. Geospatial technologies such as GIS and remote sensing techniques are popular approaches in determining urban growth or land-use changes [7-9]. Studies by [10-13] used multi-temporal Landsat images with integration the GIS, spatial metrics and indications to determine the land-use and land-cover changes where urban as well as forest lands have replaced agricultural lands substantially and also for future planning. Furthermore, [8, 14] discriminated the built-up and vegetation area using Normalised Difference Vegetation Index (NDVI) and Normalized Difference Built-up Index (NDBI).

Theoretically, the Seberang Perai district's economic and human capital development would benefit from the presence of the UiTMCP Permatang Pauh campus. More succinctly, previous studies have
demonstrated that educational institutions such as universities play a significant part in the development of human capital and innovation systems in their cities and regions [15-17]. Furthermore, universities are well-known for providing cutting-edge research, high-quality education, and innovation, all of which contribute to Sustainable Development Goals (SDG) 4 and 9 of the United Nations Sustainable Development Goals [18]. Universities are also known to be significant employers, contributing significantly to the growth of local economy (SDG 8) [19]. Thus, this study attempts to highlight the impact of UiTMCPP Permatang Pauh campus towards the urban expansion of the local area using an integration of GIS and remote sensing techniques. This study can also be used to demonstrate and justify the importance of UiTMCPP to the local economy, particularly in the Central Seberang Perai District. Furthermore, the findings obtained from this study can further be used to determine the contribution of the economic coefficients to the measuring of UiTMCPP's economic impact.

2. Materials and Methods
The study area is UiTMCPP Permatang Pauh campus is with a land area about 48 hectares at coordinate 5°22'59.29"U dan 100°24'55.36"T. The focus was given on the stages that involved digital image processing and interpretation with GIS integration to produce a map of land-cover changes surrounding the UiTMCPP Permatang Pauh campus. This study's data is Landsat Thematic Mapper (TM) in 30m spatial resolution in three (3) different years of 1999, 2009, and 2019 as shown in Figure 1.

![Figure 1. Landsat imageries (a) 27 December 1999, (b) 14 December 2009 and (c) 25 February 2019.](image)

Figure 2 shows the overall methodology involved in this study. The digitising process was applied to establish the boundary of the campus and buffer operation in ArcMAP software used to delineate the zone in radius 5 km and 10 km away from the campus. The data were downloaded from the U.S. Geological Survey (USGS) website, https://earthexplorer.usgs.gov/ in the WGS84 coordinate system, and all the bands were combined using a layer stacking method in ERDAS Imagine software. Later,
the processing of images was carried out by applying image enhancement, geometric correction, vectorisation, classification, and information extraction. A supervised maximum likelihood classification technique was used [14, 20-22] to classify the land cover area surrounding the campus. The satellite imageries were subset and classified into nine (9) types of land-cover within 5 km and 10 km offset from the boundary of UiTMCPP Permatang Pauh campus.

Accuracy assessment was carried out to ensure that the images from supervised classification technique were highly accurate. Results showed an overall accuracy of the classification was 88% (Kappa = 0.846), 86% (Kappa = 0.809) and 91% (Kappa: 0.862) for 1999, 2009 and 2019, respectively. Furthermore, by referring to google earth, a total of 30 points were employed in different locations for this study. Moreover, a ground observation was manually performed to check and verify the accuracy of the classified land-cover items. It was found that 26 out of 30 (87%) points determine the same land-cover type compared to the classified classes. Therefore, the classification of the Landsat TM successfully and accurately classifies the land-cover area, which is indicates more than 80%. To be specific for developed area, the accuracy assessment based on producers and user’s accuracy was more than 90% in years of 1999, 2009 and 2019.

3. Result and Discussion

3.1. Land-cover changes surrounding the UiTMCPP Permatang Pauh Campus

As tabulated in Table 1, a classification scheme was established based on the characteristics of the area. The Landsat TM imagery was classified into nine classes in Table 1 within two different radius, five and ten km. It consists of bare soil, developed area, forest, vegetation and mixed vegetation, water bodies, agriculture (oil palm and paddy field) and cloud.
Table 1. Detail Classification Scheme Used for Supervised Classification

| Code | Land-cover Type   | Description                                                                 |
|------|-------------------|-----------------------------------------------------------------------------|
| 1    | Bare Soil         | Land without greens and buildings                                           |
| 2    | Developed Area    | Temporary and permanent buildings, houses, villages and artificial infrastructures |
| 3    | Forest            | Area covered with trees and undergrowth                                     |
| 4    | Vegetation        | Area covered with grasslands or green area                                  |
| 5    | Mixed Vegetation  | Agriculture, shrublands, etc.                                              |
| 6    | Water Bodies      | River, permanent open water, lakes and reservoirs                          |
| 7    | Oil palm          | Agriculture crop of oil palm                                               |
| 8    | Paddy field       | Agriculture crop of paddy                                                  |
| 9    | Cloud             | White upper atmospheric substances                                          |

3.1.1. Five (5) Kilometer Radius

Figure 3 shows the land-cover maps in three different years in 1999, 2009 and 2019. The land-cover maps consist of seven classes in 1999 and eight classes in 2009 and 2019. Table 2 illustrates the land-cover area of UiTMCPP Permatang Pauh campus with an offset of 5 km within the 20 years at the ten-year interval: 1999, 2009 and 2019. Developed areas monopolize the study area which occupy more than half of the area (> 50%) in 1999 and increase to 70% in 2019. Less than 2% of the total area is mixed agriculture, oil palm, bare soil, and forest within 20 years. Since the research area is located in a city, it has a high rate of the developing areas. Paddy fields and water bodies account for less than 25% and 14% of the total area, respectively. Figure 4 depicts a paddy field that has shrunk by almost half, from 2729.3 hectares in 1999 to 1413.6 hectares today (2019). In addition, the size of the water bodies has shrunk from 1731.1 to 1552.9 hectares.

Table 2. Summary of Land-cover area for the year 1999, 2009 and 2019 (5 km)

| Land-cover Type | 1999 Area (hectare) | 2009 Area (hectare) | 2019 Area (hectare) |
|-----------------|---------------------|---------------------|---------------------|
|                 | %                   | %                   | %                   |
| Water bodies    | 1731.1              | 14.7                | 1772.3              | 14.9                | 1552.9              | 13.2                |
| Forest          | 164.0               | 1.4                 | 58.1                | 0.5                 | 41.5                | 0.4                 |
| Developed area  | 6040.2              | 51.2                | 6309.1              | 53.2                | 8094.1              | 68.6                |
| Bare soil       | 423.9               | 3.6                 | 134.5               | 1.1                 | 94.0                | 0.8                 |
| Paddy field     | 2729.3              | 23.1                | 2102.5              | 17.7                | 1413.6              | 12.0                |
| Oil palm        | 229.6               | 1.9                 | 314.2               | 2.6                 | 166.5               | 1.4                 |
| Vegetation      | 474.1               | 4.0                 | 1002.6              | 8.5                 | 277.1               | 2.3                 |
| Mixed vegetation| 0.0                 | 0.0                 | 164.6               | 1.4                 | 0.0                 | 0.0                 |
| Cloud           | 0.0                 | 0.0                 | 0.0                 | 0.0                 | 152.5               | 1.3                 |
| **Total**       | **11792.1**         | **11857.8**         | **11792.1**         |

3.1.2. Ten (10) Kilometers Radius

Figure 5 shows the type of land-cover for the radius of ten (10) kilometres. The land-cover map for the year of 2009 was classified into seven categories while the land-cover maps of 1999 and 2019 have eight land-cover categories, including cloud cover. This study area (Permatang Pauh) consists of
developing areas, paddy fields, water bodies, forests, oil palm, bare soil, vegetation and cloud cover. Grossly, there has been an increase for developed area and a sharp decline in paddy fields and vegetation. These changes are due to the rapid urbanisation in the district area.

Table 3 tabulates a summary of the land-cover for a 10 km radius in area and percentage. Developing areas and water bodies have the highest area and percentage of the study area where the developed area covers ~40% and water bodies make up almost ~34% of the total area. Developing areas rose sharply from 1999 to 2019, with about 7192.3 hectares (17.2%). Also, there are three types of land-cover classes: vegetation, oil palm and water bodies that rose from 1999 to 2009 and then dropped significantly in 2019. Between 1999 and 2009, the vegetation and oil palm classes increased by 2.7% (1197.5 hectares) and 1% (455.6 hectares). However, from 2009 to 2019, it decreased by 5.6% (2435.2 hectares) for vegetation while 2% (927.3 hectares) for oil palm. The same pattern can be seen for the water bodies where it increased by 347.2 hectares (0.5%) and declined to 854 hectares (1.2%). It can be seen that the area decreases over the years for paddy fields and forest. This is due to the development of housing project and commercial buildings on these areas. Previously, in 1999, the paddy field had an area of 7349.9 hectares (16.9%) but started decreased in 2009 to 4939.8 hectares (11.3%) and 3364.2 hectares (7.8%) in 2019. The decline from 1999 to 2019 was almost half of its original 1999 which is in total of 3985.7 hectares (9.1%). Forest area types also decreased from 4.4% (1999) to 3.0% (2019) by 640.2 hectares.

| Land-cover Type | 1999  | 2009  | 2019  |
|-----------------|-------|-------|-------|
|                 | hectare | %     | hectare | %     | hectare | %     |
| Water bodies    | 14830.5 | 34.1  | 15177.7 | 34.6  | 14323.7 | 33.0  |
| Forest          | 1926.6  | 4.4   | 1423.3  | 3.2   | 1286.4  | 3.0   |
| Developed area  | 12616.4 | 29.0  | 14000.4 | 31.9  | 19808.7 | 45.6  |
| Bare soil       | 1836.8  | 4.2   | 517.5   | 1.2   | 911.2   | 2.1   |
| Paddy field     | 7349.9  | 16.9  | 4939.8  | 11.3  | 3364.2  | 7.7   |
| Oil palm        | 2882.5  | 6.6   | 3338.1  | 7.6   | 2410.8  | 5.6   |
| Vegetation      | 2028.6  | 4.7   | 3226.1  | 7.4   | 790.9   | 1.8   |
| Mixed vegetation| 0.0    | 0.0   | 1225.1  | 2.8   | 0.0     | 0.0   |
| Cloud           | 0.0    | 0.0   | 0.0     | 0.0   | 541.5   | 1.2   |
| **Total**       | **43471.2** | **43848.0** | **43437.4** |     |

3.2. Developed Area for Year 1999, 2009 and 2019

Penang is one of the highest industrial areas which can compete with Kuala Lumpur, Selangor and Johor. It serves in various aspects such as manufacturing and tourism, and each element consists of its part of the developed area. Since 2017, there is an ongoing affordable housing project nearby UiTMCPP Permatang Pauh campus, known as Residensi Permatang Pauh. The proposed development consists of two 34-story condominium buildings that will include 1,017 affordable apartments with a standard unit size of 900 square feet.
3.2.1. Five (5) Kilometers Radius
Figure 7 illustrates the urban development map with an offset of five kilometres within the 20 years at 10-year interval; the year 1999, 2009 and 2019. As depicted on the maps, the red colour represents the developed area identified within the study area, and the shaded region is the boundary of UiTMCPP Permatang Pauh campus. We can conclude that there is a slight increase in the developed area in UiTMCPP Permatang Pauh campus. It shows a three (3) years urban development map and a combined land-cover map (three (3) areas) for three (3) years. The area of development in 1999 was 6040.2 hectares, 6309.1 hectares for 2009 and 8094.1 hectares for 2019. It is slightly increased from 1999 to 2009 and a sharp increase over the next year. In 1999, the percentage was 51.2% and improved in 2019 by 69.5%. The growth rate of developing areas was 17.4%. UiTMCPP Permatang Pauh campus located at the centre of the district covered by urban areas. Many factors influenced the urban development of Permatang Pauh, which depends on the locality of that particular area. Different locality factors support most of the area's growth along the main road, providing access to the main area.

3.2.2. Ten (10) Kilometers Radius
Figure 8 illustrates the urban development map with an offset of 10 kilometres radius within 20 years at ten years, 1999, 2009 and 2019. Red colour represents the developed area, and the shaded region is the boundary of UiTMCPP Permatang Pauh campus. The developed area increases in 1999 with 12616.4 hectares, 14000.4 hectares for 2009 and 19808.7 hectares for 2019. The changes in the expansion of the developed area within 20 years were 7192.3 hectares.

3.3. Ratio of Development per area of UiTM

3.3.1 Five (5) Kilometers Radius
Table 4 tabulates the ratio of UiTMCPP’s contribution to the development area within a five (5) kilometre radius for three consecutive years: 1999, 2009, and 2019. It found that no further development occurred in the UiTMCPP Permatang Pauh campus. However, within the five kilometres, the development area increases to 125.94 hectares in 1999, 131.55 hectares in 2009 and 168.77 hectares in 2019.

3.3.2 Ten (10) Kilometers Radius
Table 4 tabulates the ratio of UiTMCPP’s contribution to the development area within a ten (10) kilometre radius for three consecutive years: 1999, 2009, and 2019. However, within 10 kilometres from the campus, the development area increasing within 20 years with every one (1) hectare area of UiTM contributes to 263.06 hectares of developed land in 1999. Meanwhile, in 2009, every one (1) hectare area of UiTM contributed to 291.92 hectares of developed land. In 2019, every one (1) hectare area of UiTM contributed to 413.03 hectares of developed land in its surrounding ten (10) kilometres radius.
Figure 3. Land-cover Map of the Three-Years (1999, 2009 & 2019) for 5 km radius.

Figure 4. Bar chart of Land-cover Map of the Three-Years (1999, 2009 & 2019) for 5 km radius; (Right) Land-cover in hectare and (Left) in percentage.
Figure 5. Land-cover Map of the Three-Years (1999, 2009 & 2019) for 10 km radius.

Figure 6. Bar chart of Land-cover Map of the Three-Years (1999, 2009 & 2019) for 10 km radius; (Right) Land-cover in hectare and (Left) in percentage
**Figure 7.** Urban development map of the year 1999, 2009 & 2019 for 5 km radius from UiTMCPP Permatang Pauh campus.

**Figure 8.** Urban development map of the year 1999, 2009 & 2019 for 10 km radius from UiTMCPP Permatang Pauh campus.
Table 4. Ratio of development per area of UiTM CPP Permatang Pauh campus for 5 km and 10 km radius (1999, 2009 & 2019)

| Year | Development Area (hectare) | 5 km radius Area of UiTM CPP (hectare) | Contribution per hectare (ratio) | Development Area (hectare) | 10 km radius Area of UiTM CPP (hectare) | Contribution per hectare (ratio) |
|------|-----------------------------|----------------------------------------|----------------------------------|-----------------------------|----------------------------------------|----------------------------------|
| 1999 | 6040.0                      | 48.0                                    | 125.9                            | 12616.0                     | 48.0                                    | 263.1                            |
| 2009 | 6309.0                      | 48.0                                    | 131.6                            | 14000.0                     | 48.0                                    | 291.9                            |
| 2019 | 8094.0                      | 168.8                                   | 482.4                            | 19809.0                     | 413.0                                   | 413.0                            |

4. Conclusion

It is well understood that the establishment of universities and other higher education institutions (HEIs) in urban areas has a substantial impact on the development of human capital. Although universities and HEIs have the means and access to knowledge networks, they may promote fast urbanisation by creating opportunities for a broad cross-section of society, not just academics and students. The percentage of developed area increased from 51.2 percent (1999) to 68.6 percent (2019) within a 5 km radius, and from 29.0 percent (1999) to 45.6 percent (2019) within a 10 km radius, according to the urban development map. As a result, the presence of the UiTM CPP Permatang Pauh campus enhances the development of the local neighbourhood. It is thought that the campus plays a significant role in improving the well-being of local community surrounding the campus by the development of affordable housing and creating job as well as business opportunity. This is in-line with SDG 4 (quality education) and 8 (decent work and economic growth). However, it is safe to acknowledge that other surrounding educational institutions also contribute to the development of land near the UiTM campus. Furthermore, results from land-cover map shows that paddy field reduced almost half from 23.1% (1999) to 12.0% (2019) within 5 km radius and 16.9% (1999) to 7.7% (2019) within 10km radius. With the current technologies using GIS and remote sensing, the land-use changes can be determined efficiently from satellite images within 20 years of the UiTM CPP Permatang Pauh campus development to support economic growth.

Acknowledgements

We would like to thank Universiti Teknologi MARA (UiTM) for granting Bestari Research Grant (600-RMC/DANA 5/3/BESTARI (TD) (003/2019)) on Kajian Impak 20 Tahun UiTM, Universiti Teknologi MARA Cawangan Pulau Pinang for providing research facilities and The Landsat data that was available from the U.S. Geological Survey (USGS) website (https://earthexplorer.usgs.gov/).

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