



# The Development and Distribution Pattern of Railway Network for Urban Public Transport Using GIS from 1990 Until 2019 in The Klang Valley and Kuala Lumpur, Malaysia

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**Abstract:** The development and distribution pattern of the railway network has significantly increased in urban public transport with the current situation to move fast towards the fourth industrial revolution (4IR). In Malaysia, the problem issues are related to traffic congestion and many user cars on the roadway in daily lives. One alternative mode of using a rail network is commuter, LRT, Monorail, MRT and ETS. Therefore, the Geographic Information System (GIS) technology is then used to map and produce the railway networks history and developments in urban public transportation (UPT). The goal of this research is to identify the heatmap trends of the Klang Valley railway stations which included Kuala Lumpur as urban public transport sectors. It was based on the OSM image layer from the year 1990 to 2019 and studied the growth of railway networks through a polyline pattern analysis. The results are Kuala Lumpur and Klang Valley more advanced and dominant places in the event of rail and variation patterns in the year 1995 until 2019. The final result is that heatmaps of railway stations in Klang Valley and Selangor help determine and visualize the user's attractive railway as the main public transport in daily routine and urban areas expand.

**Keywords:** Railway network, urban public transport, GIS, heatmap

## 1. Introduction

Urban Public Transport (UPT) becomes more critical with the changing demographic situation, economic growth and physical building pattern in urban areas over the years. It has substantially elevated the demand for environment friendly public transport in urban areas because it is an essential thing to get admission to sustainable transport. UPT is also a tool for solving problem cases related to traffic congestion, the essential issues of the human and time administration in daily lives [1]. Articles and news approve this situation in BERNAMA, Astro Awani and Mstar mentioned urban public transport issues according to the population of the Klang Valley and Kuala Lumpur area which is increasing to hit 10 million by 2020 and more significant stress on the railway system [2] [3] [4] [5]. The fact is that only 5 percent of public transportation in Malaysia has used. These have been more significant usage of public transportation interest such as rail transportation, taxis, and buses. [6]. Fewer people use public transport than non-public vehicles [6] [7] [8] [9].

Regional public transport networks and services are focused on rails and road transport. Types of road transport modes are taxi, grab and buses. The rail transport mode is LRT, train, Monorail, MRT and ETS. This railway is vital because urban public transport can be fast, efficient, convenient and low cost and can raise a higher potential than bus transport. One of the choice modes of transport is rail transport and has ended up become dominant for developing countries to upgrade the quality of urban life. APAD's Land Transport Mission Malaysia explained as achieving a safe,

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reliable, efficient, responsive, accessible, planned, integrated, less expensive and sustainable land public transport system to decorate socio-economic improvement and fantastic living conditions ([10] [11]).

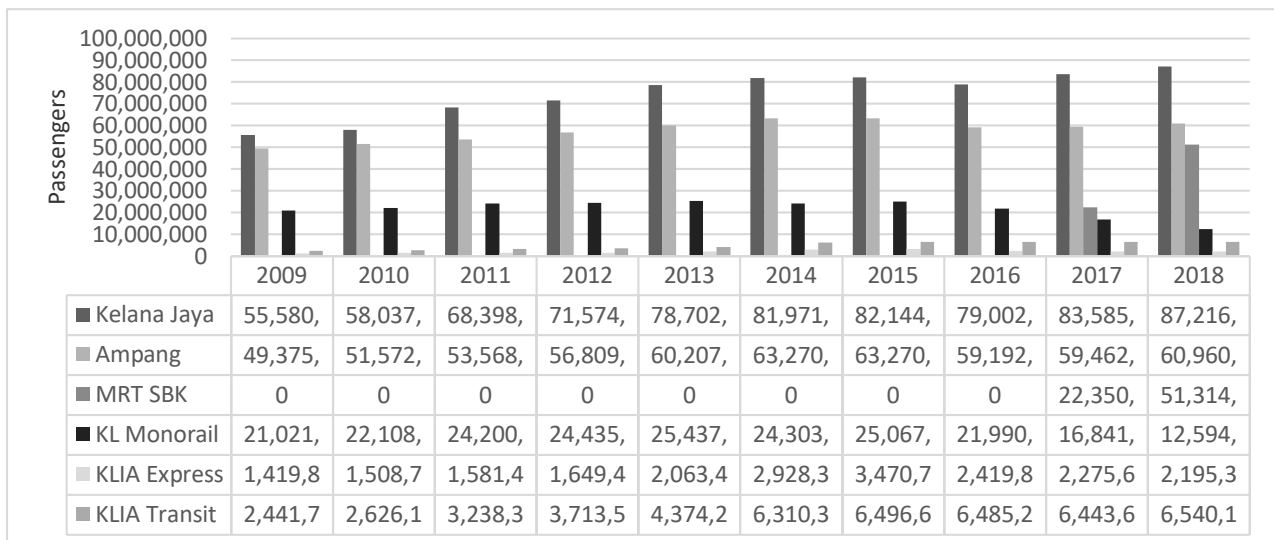
Therefore, as new technologies, geographic information systems (GIS) provide the spatial pattern of revolution of the urban public transportation system, especially the rail networks. For the kind of research for urban transport planning, GIS methods addressed and one of the decisions taken to implement new approaches. This knowledge of the objective is to select the railway network in the city public transportation system in the Klang valley and the Kuala Lumpur areas through the use of GIS technologies and ultimately analyze the improvement of the railway network system growth.

## 2. Railway Network Development and Evolution as Urban Public Transport

The railway network system is the earliest in Malaysia. The Malaysian transportation system has become better and advanced changes from traditional to modern style including the total length of railway lines and station numbers. The first evolution railway in Peninsular Malaysia was built by Keretapi Tanah Melayu Berhad (KTMB) from Taiping and Port Weld in 1 June 1885 and 1886 it extended towards Kuala Lumpur and Klang area, and a new line was built between Seremban and Port Dickson in 1891 [12]. Electrically powered rail transport is now one of the primary vehicles mode in Malaysia including KTM Komuter, Light Rapid Rail (LRT), Monorail KL, Express Rail-Link (ERL), Mass Rapid Transit One (MRT1) and Skypark Link to improve urban portability and lessen clogging and mishaps in urban areas.

Fig. 1 - Statistics of passengers for the principal railway link from 2009 until 2018

Source: [13]



Consequently, the study’s focus on the story of the beginning Malaysian railway system of evolved in 1995. KTMB used add the first train to connect Kuala Lumpur station-Rawang station and Kuala Lumpur station-Seremban station [14]. After one year, LRT is operated and consists of two STAR and PUTRA core systems. It continued the growth of the railway network by use of ERL between Kuala Lumpur and KLIA as recognised in 2002 as KLIA Express and the following year as Monorail. It is the first high-speed railway with a speed of more than 150km/hr. An efficient transportation device is wanted to attain Vision 2020. Malaysia is a rapidly developing country. After more than ten years, MRT and Skypark are the newest railway network system in Malaysia due to increased populations. Figure 1 shows the summary statistics of passengers for the main railway link from 2009 until 2018.

### 2.1 KTM Komuter

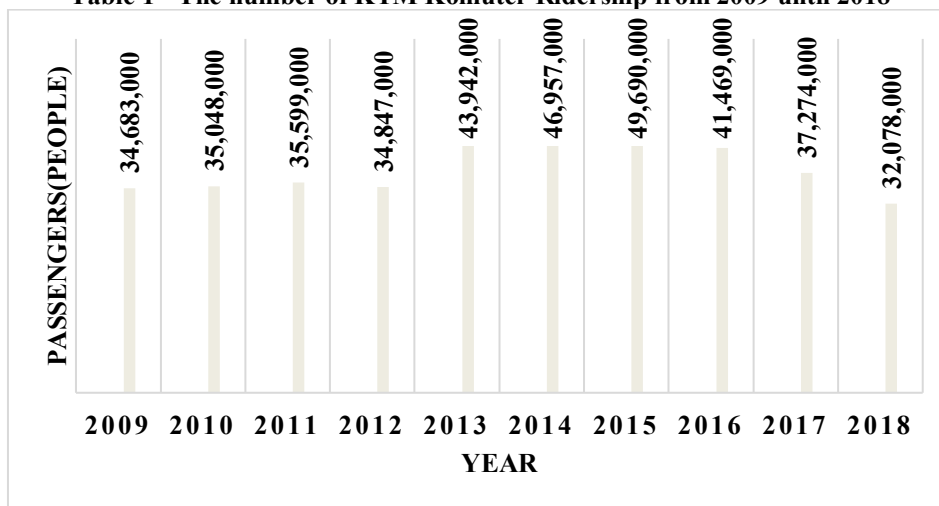
Malaysia has brilliant railway station and KTM is the first educated creation. KTM is a Malaysian electric commuter railway run by KTMB and added between the Kuala Lumpur and Klang Valley areas on August 14, 1995. KTM Komuter contributed RM146.2 million in income in 2017 carrying 37.274 million passengers [15]. This whole range was once lowering by way of 10.2% in 2017. The review of KTM Komuter has two line sectors: the Central and Northern lines [16].

In August 1995, the first service started at Seremban Line from Kuala Lumpur to Rawang, the Sentul and Shah Alam started second part operation on 28 August 1995 at the start-off station in Port Klang. This project extended to Klang on 29 September 1995 as a similar project in Salak Selatan station. 20 November 1995, the Seremban line had once been extended to Kajang and on 18 December 1995 to Seremban. This scenario would become the Komuter system for more than 100 years.

In 1995 the Seremban Line instructions were extended in 2007 to include Rasa and thus the line was maintained and expanded for the first time. KTM services were initially provided as a shuttle to the new stations north of Rawang. In January 2008 Kuala Kubu Bharu was expanded and Tanjung Malim was expanded on 1 June 2009. On 29 July 2010, Batu Caves also received the Port Klang Line. Four intermediate new stations have been opened in Batu Kentonmen, Kampung Batu and Taman Wahyu. On 14 May 2011 Seremban Line has been extended from Seremban in 2013 to Sungai Gadut by the Senawang and Rembau intermediate stations. On 11 July 2016, the shuttle carrier Rawang-Tanjung Malim was fusioned with the Port Klang main route.

The wide range of KTM Komuter riders generated in Excel between 1990 and 2018 was therefore shown in Table 1. KTM Komuter's absolute best passengers used approximately 49,957 million in 2015, compared with 32,078 million in 2018 [15]. The statistics show that from 2015 through 2018 the rate of passengers has declined.

**Table 1 - The number of KTM Komuter Ridership from 2009 until 2018**



Source: [15]

## 2.2 Light Rail Transit (LRT)

KL Starrail Sdn Bhd, the STAR-LRT, and (PUTRA-LRT) were used to own Rapid Rail Sdn Bhd and establish three rail conductors [17] [18]. All rail operators performed beneath important administrator management centre in Kuala Lumpur.

Prasarana Malaysia (Prasarana) opened the first of three railway, the Kelana Line, the Ampang Line and the Sri Petaling Line. A few years later, the Prasarana is running two new railways are KL Monorail and MRT 1 (Sungai Buloh-Kajang lines), which become five rail lanes currently. The known of Rapid KL consists of five rail lines operating on the preferred rail gauge, while the KL Monorail operates on the Alweg Monorail Company with the Hitachi Company. It begins at 6.00 a.m. Frequencies during peak experience for about three minutes.

Kelana Jaya and The Ampang lines were initially built and handled by various companies and began respectively in 1995 and 1998. All two LRT lines operational had been moved to Rapid Rail in 2004. Within the 2nd phase of Kuala Lumpur's reform of the public transportation system. From 2003 until 2007, the KL Starrail Sdn Bhd was the owner and operator of KL Monorail. The group finally declared bankruptcy. The fun response was to purchase the monorail and Rapid Rail for Prasarana Malaysia Berhad.

## 2.3 Express Rail Link (ERL)

ERL Sdn. Bhd (ERLSB) is the largest rail hyperlink for airport station service owned and operated company linking Kuala Lumpur International Airport (KLIA) with the 57 km long Kuala Lumpur Sentral station transport hub. The ERLSB provided two distinctive instruct facilities. On 14 April 2002, KLIA Express opened and this rail is a direct airport rail service from KLIA to KL Sentral station. This service is available directly at the airport. KLIA Transit station launched on 1 June 2002 with three additional stops between KLIA station and KL Sentral station.

On 25 August 1997, the government offered a 30 year concession to construct, maintain, finance, and operate the ERL railway service. The ERL service is a joint partner undertaking between YTL Corporation Berhad-YTLCB (45%), Lembaga Tabung Haji (TH) (36%), SIPP Rail Sdn. Bhd-SIPPRSB (10%) and Trisilco Equity Sdn. Bhd-TESB (9%) respectively [19].

ERL construct began in May 1997 and completed in 2002. Then this task was once passed on to the SYZ Consortium as a mutual relation between Siemens Electric Engineering Sdn. Bhd. from German and Malaysian companies by Syarikat Pembinaan Yeoh Tiong Lay Sdn. Bhd (SPYTL) and Siemens AG as an owned subsidiary of YTL Company Bhd [20].

Thus in 1999, ERL Maintenance and Support Sdn. Bhd. (E-MAS) was established and was responsible for train operations and renovations. E-MAS was initially a joint this project between ERLSB and Siemen Aktiengesellschaft (AG) have wholly owned since June 2005, with the aid of ERL Sdn. Bhd.

## 2.4 KL Monorail

On 31 August 2003, the city's monorail line opened once, with 11 stations are 9 km long rail line [16]. The South Central and north Titiwangsa Triangles, especially business area, entertainment areas and shopping such as Imbi Station, Sultan Ismail Station, Bukit Bintang Station, and Raja Chulan Station, have been connected to the Golden Triangle.

The KL monorail project was announced once through Kuala Lumpur City Hall (DBKL) in January 1990, after the government gave the go-ahead to the challenge at a cupboard meeting in the mid-closing year 1989 [21]. Its value was estimated at RM 143 million and 14 km with 22 station system is designed to raise more than 34,000 passengers a day over 20 minutes as a busy commercial core through Kuala Lumpur [22]. The design is to build it in two phases, the first phase of which consists of 16 stations, which will take 7.7 km and a further 6.5 km to be added at the later stage. The first section used to be predicted to be completed within two years.

In 2003, the line was opened and Monorail Line operated by KL Infrastructure Group Berhad (KIG) agreed to retain a 40 year concession to manage the KL Monorail [23]. The route and station numbers have remained unchanged since 2003. In addition, the Monorail Line is the eighth rail transit line and the only one in Malaysia's monorail gadget operating using Rapid Rail as a subsidiary of Prasarana Malaysia Berhad to be part of the Integrated Transit System in the Klang Valley. KL Monorail indicator is line the numbered eight and coloured light green inexperienced on the transit maps.

It consists of a single line and double way line that connects the inner of KL but not previously served by rail transport, namely Bukit Bintang station Chow Kit, and Brickfields with LRT, MRT phase 1 and KTM stations in Muzium Negara Hang Tuah, Bukit Bintang KL Sentral, Bukit Nanas, and Titiwangsa station.

The diagram of stations has constructions with ticketing facilities on the bottom level, comparable to KL Sentral station at the first floor. The platforms are situated at the very best floor and isolated by fencing from the monorail traces. In 2014, this station was once changed by way of aluminium zinc roofs after blanket by giant canvas roofs. Each station accustomed be specified with a route maps and a unique product brand for guidance. The most depot is between Tun Sambanthan station and KL Sentral station.

## 2.5 Mass Rapid Transit (MRT)

In June 2010, the former sixth Prime Minister (6<sup>th</sup>PM) announced the 10th Malaysia Plan (10MP) strategies 2011-2015 summarise that used to be implementing the MRT proposal for the Kuala Lumpur area [24]. The authentic idea was entitled to the KVITS and acquainted with Kuala Lumpur MRT (KLMRT) or Klang Valley MRT (KVMRT). This mission is beneath MRT Corp. Sdn. Bhd. It was wholly owned the Ministry of Finance (MOF) until September 2011, but Prasarana Malaysia by Rapid Rail Sdn. Bhd took over the undertaking in October 2011.

The MRT project represents one of the industrial tasks recognized for the Kuala Lumpur or Klang Valley (KV) as Economic Transformation Programme (ETP) and National Key Economic Area (NKEA) [25]. The new transport of the MRT system is artificial brain transport that radically improves and transforms Kuala Lumpur improvement in public rail transportation to the Kuala Lumpur area are the section with that of a developed city area. The mission generates proper economic balancing and investment returns to the next generation.

In 17 December 2010, the plan implementation of the MRT project was permitted by the government and strategy for the primary line as known Blue Colour Line, about 60 km from Sungai Buloh station-Kajang station [26]. This project consists of 35 stations and the railway bypass through the city core and suburban areas. Suburban area has a less dense population such as Kota Damansara (KD) station, Mutiara Damansara (MD) station, Bandar Utama (BU) station, Taman Tun Dr. Ismail (TTDI) station, Bukit Damansara (BD) station, Cheras station, Bandar Tun Hussein Onn station and Balakong station. This line began development in July 2011 and finished in 2016.

The MRT Circle Line (MRTCL) will serve as a quintessential function to hold and integrate the disjointed with monorail lines and LRT lines. The draft strategies of the Kuala Lumpur and Klang Valley using Public Land Transport Plan strategies mentioned that the MRTCL would cover to radius movement around the Kuala Lumpur area. This strategy

provides connections to current parts like the Mid Valley station, Mont Kiara station, Sentul Timur station and Ampang station, further proposed sizeable trends recognized within the DBKL City Strategies as MATRADE centre. The grasp format draft referred to the MRTCL developed in a minimal of two project phases. The first phase, conducting 29 km consists of northern and western divisions connecting Ampang station with Mid Valley station, MATRADE centre and Sentul station. The MRT segment persisted with 12 km jointed Ampang station-Sentul Timur station, finishing the southern area and jap sectors of the MRTCL. The master strategy, MRT phase 2 (MRT2) Sungai Buloh station to Serdang station and the last station in Putrajaya Line station as a northwest hall of Klang Valley. It is connecting with growth areas like Sungai Buloh station, Kepong station and Selayang station with the eastern area of half city centre which includes Kampung Baru station and Tun Razak Exchange (TRX). This plan used to be forecast to overload within the next generation.

Besides that, MRT could be a planned three-line mass public transit gadget inside Kuala Lumpur as a section of KV vicinity rapid development in Malaysia. The northwest and southeast transportation signs and one radius line around the Kuala Lumpur area due to the fact the notion and also the completion of MRT operation traces as components of the KVITS. The MRT improves this inadequate rail network, makes integration of the standard railway network the system more available, and alleviates the last visitor jams within the metropolitan Kuala Lumpur (KL) region. The idea was introduced on 23 June 2010 and was accepted by the government on 2 December 2010. The first MRT line project started on 8 July 2011 and MMC Gamuda and Land Public Transport Agency monitor the project as a project integrator for the Klang Valley MRT.

## 2.6 Skypark Link

In May 2018, the Skypark Link began operations as a new limited specific teach service in Kuala Lumpur. Skypark Link is the second airport rail hyperlink carrier and transports passengers from KL Sentral to the Subang Airport [27]. It performed by means of KTMB; the identical provider presently operates on the Port Klang Line of the KTM Komuter operation line. The distance between the track and the Subang Jaya Station is complete with track to Subang Airport closer. Today's route schedule of the Skypark Link consists of three major stations, the Skypark central, the Subang Jaya and the Skypark terminal. This provider is very convenient, time-saving, low-priced and an option for travelers as human beings residing and working at or close to the Skypark Terminal. Sets of three coaches with over 30 journeys per day at hour intervals. It brings up maximum top pace at a hundred km/h.

## 3. Research Method and Materials

This paper focuses on the railway network of Malaysia's most famous city of public transportation at the Klang Valley (KV) and the capital of Kuala Lumpur. The research study is selected based on the existing railways and metropolitan areas.

The Klang Valley Areas were developed in 1973 as a result of recommendations from a nearby regional planning study. It was once Malaysia's fastest-growing area, observed through the Iskandar Malaysia and Penang regions [28]. Klang Valley place located between  $3^{\circ}0' N - 3^{\circ}15' N$  latitudes and  $101^{\circ}51' E$  longitudes. The size KVR is 2831 square kilometers of land area and consists of Kuala Lumpur and districts Gombak, Klang, Petaling, Hulu Langat, and Putrajaya in the border of the state of Selangor.

Kuala Lumpur is the primary town of Malaysia and the most developed place in Peninsular Malaysia in the latitude of  $3^{\circ}8' North$  and longitude of  $101^{\circ}41' East$ . The dimension land place of Kuala Lumpur is 243.6 square kilometres with an excessive density of populace ability in city areas. The strategic vicinity of Kuala Lumpur (Klang Valley) area which is related via highways, roads and railways have intense enlargement and boom development dynamic alternate in railway network services.

The railway network stations can be determined using spatial analysis in GIS applications based on location in the research area. It is using the spatial tools in QGIS the results shown on the location data and spatial pattern variation that existed in the railway network. This situation can be creating heatmaps and access to primary public access because it helps to analyze the distribution of statistical data and show higher density areas. The identify each heatmap or spatial clusters for the rail station, which is green colors, indicates the clustered and has more concentration among the others.

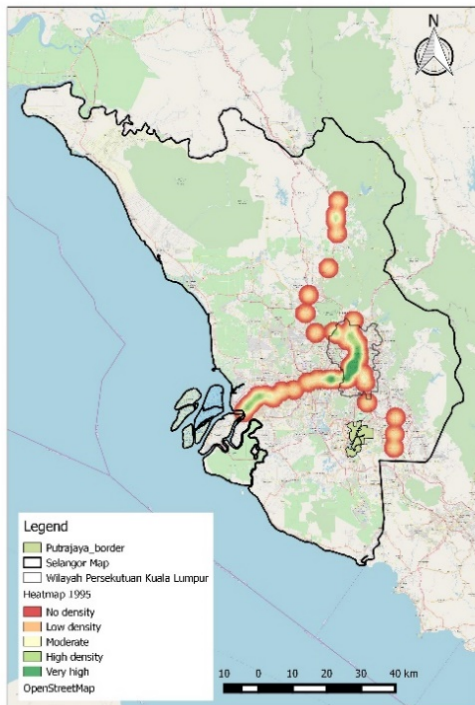
## 4. Results and Discussion

### *Heatmap of Railway Network System Distribution from 1990 until 2019*

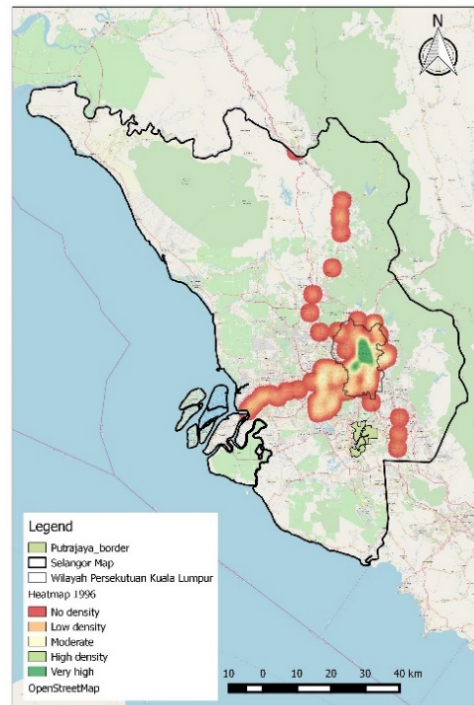
Heatmaps are one of the nice visualization and graphic representation tools for dense factor data. Heatmap is an interpolation approach that useful in finding out clusters and high concentration. QGIS has a heatmap renderer that can be used to fashion a factor layer and a Processing Algorithm Heatmap (Kernel Density Estimation) and changed to create a raster from a vector layer. Another method or technique than can be applied using ArcGIS software and geoprocessing tool in Point Pattern Analysis. The pattern distribution of train stations from 1990 until 2016 shown in figures 2, 3, 4, 5

and 7. Based on Figure 2 suggests the vogue of the train stations beginning to concentrate on Kuala Lumpur pass down to Port Klang. After one-year development of the railway network was constructed by the government and train station, it was dominant in the center of Kuala Lumpur which is dispersed out surrounding area to become more significant, as shown in Figure 3.

In starting 2002 and 2003, the evolution of train system change and additional train in Putrajaya station because it depends on focuses from on Kuala Lumpur area as Figure 4 and 5. After 13 years, in 2016, the new era development, Mass Rapid Transit (MRT), was introduced and the first launched starting from Sungai Buloh to Kajang Line (as shown in Figure 6). It is a more advanced train currently to improve urban public transport. The smart transport for urban public transport was introduced Skypark Link by KTMB in 2018. The changing pattern shows that in Figure 7. The heatmap expands out the left area into Port Klang Line. In conclusion, KL has the highest density for the urban railway system in Selangor between 1990 and 2019. By the year 2020, the total new stations are 91 included as a combination of MRT and LRT [11].



**Fig. 2 - Heatmap train station 1995**



**Fig. 3 - Heatmap train station 1996**

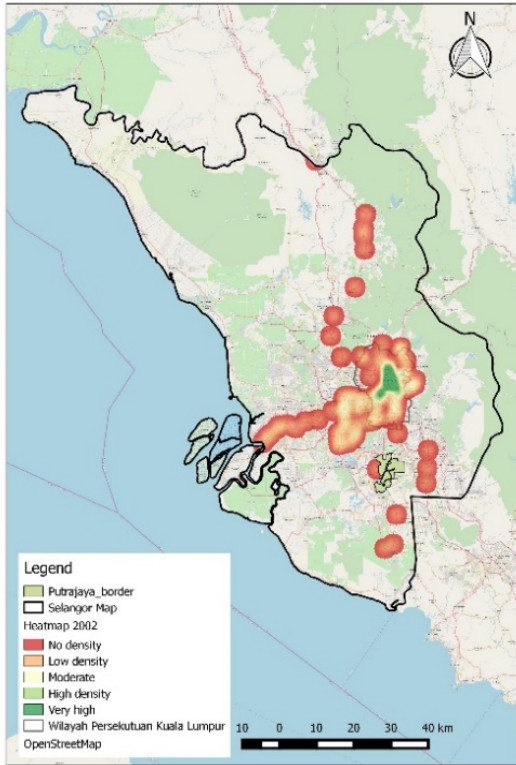


Fig. 4 - Heatmap train station 2002

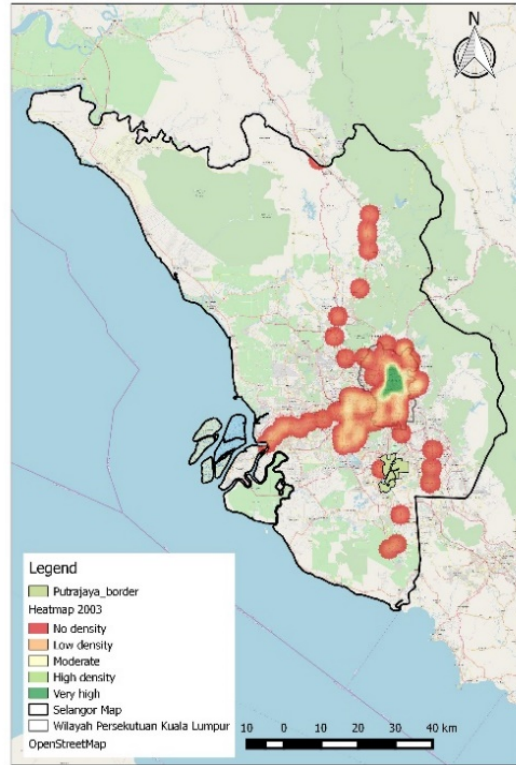


Fig. 5 - Heatmap train station 2003

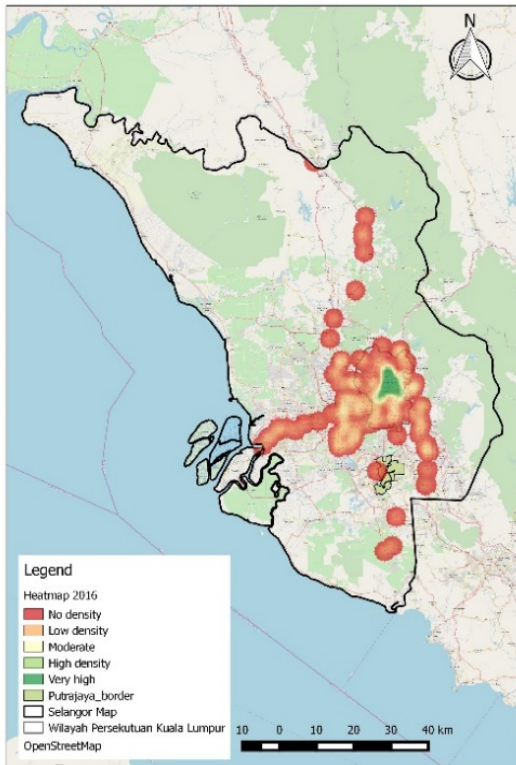


Fig. 6 - Heatmap train station 2016

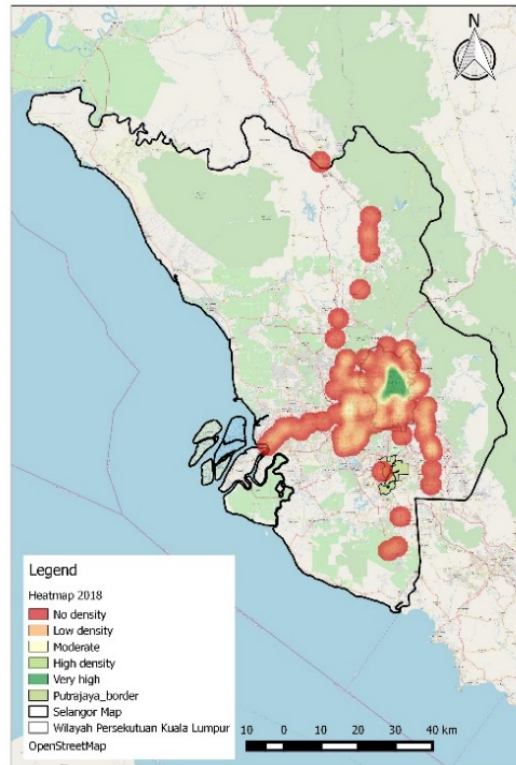
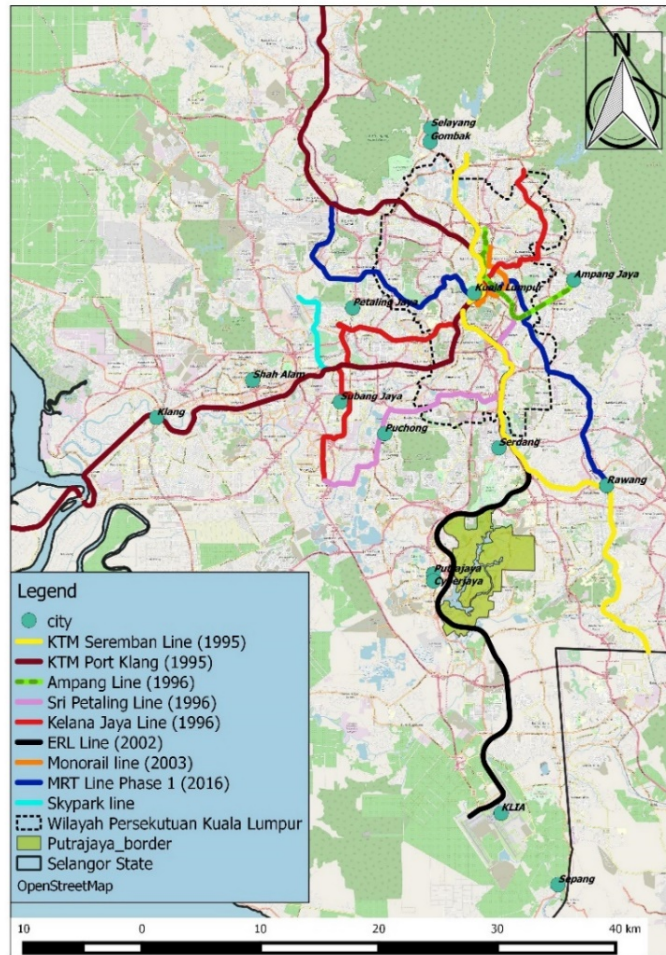


Fig. 7 - Heatmap train station 2018

From the visually analyzing the map, distribution and the cluster heatmap of train station focused at the Klang Valley (KV) area especially in Kuala Lumpur (KL) area because these areas have much access for public transport and variation of land use categories. Simultaneously, the heatmaps best location is a higher density population and congestion traffic problem.

**Expansion Development Railway Network from 1990 until 2019**

In Malaysia, the strategic locations are Klang Valley area included Kuala Lumpur (KL) as the capital city and Putrajaya to build and construct the railway network due to the fact of its new multi appropriate land use and developed area. In Figure 8 shows that the expansion development and construction network between 1990 until 2019.



**Fig. 8 - The division of railway network line from 1995 until 2019**

This division of railway from 1995 until 2019 is the transformation of public transportation system in Malaysia as a developing country to achieve mission green transport planning. The changes in land use patterns every year can influence the factors of the train network. In 1995, the train consisted of two primary traces: Rawang station to Seremban station and Sentul station to Port Klang station. On December 16, 1996, LRT opened from Sri Petaling Line Kelana Jaya Line and Ampang Line, [29]. Express Rail Link is constructed in 2002 between KL Sentral and KLIA and comprises less than ten stations over 75 km long. ERL is the best train and accessible to the airport center. For the best railway network facilities, the Monorail system developed in 2003 and it is 8.6 km between KL Sentral to Titiwangsa [30].

The launch of railway network building in 2016 as the flow path of the National Rail Industry Roadmap (NRIP) to achieve Vision 2030. The new train is introduced to a suitable facility and connectivity from the station to another station. Also, MRT phase 1 is operated from Sungai Buloh to Kajang with 31 stations combine existing rail lines. It is the first corridor by Urban Rail Development Plan (URDP) strategy [15]. It took a traveling time of about 86.3 minutes. After completed MRT phase 1, Skypark Line by KTM evolved with only three stations operation between KL Sentral and Subang Airport. This line just focused on the urban development area in the KL centre. The current development of the URDP is phase two MRT which connects Sungai Buloh Line to Serdang-Putrajaya and will be completed by Gamuda on 2022. This scenario concludes that due to many private vehicles in Klang Valley, the effects of mode transport by using UPT system will minimize the impact of the traffic jam and congestion problem on the route. Thus, the length of rail 699 km in 1995 and increase about 1,833 km in 2018. However, the urban railway in 1995 only 12 km, but it is an extension until 328 km long [16].



## 5. Conclusion

The increasing volume of vehicles on that road may lead to conflicting traffic problem in urban public transport system, in particular rail networks. In this scenario, the change from private cars to public transport is essential for reducing road traffic. Furthermore, the research demonstrates that the railway network and rail station can generate alternative visualization in mode choices in using urban public transport by analyzing the capability of GIS to be integrated with the temporary situation. In this study, train station heatmaps are the most suitable for demonstrating pattern distribution of rail networks in Klang Valley and Kuala Lumpur. Therefore, the spatial data on heatmap integration can be used by decision-makers to change their route plan or future development based on similar geographic and demographic conditions.

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