Towards Smart Cities Development: A Study of Public Transport System and Traffic-related Air Pollutants in Malaysia

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Abstract. Increasing number of privately owned vehicles are depicting Malaysians preferred mode of mobility and lack of interest in the public transport system. In most developing countries such as Malaysia, motorized vehicles are the major contributors to air pollution in urban zones. Air pollution is a silent killer as it infiltrates the vital organs, leading to serious diseases and death. This research critically analyses the emissions of air pollutants such as CO, NO_2, SO_2, hydrocarbon, and PM from various sources in Malaysia with emphasis mainly on the emission of pollutants from motor vehicles. This research also discusses the public transport initiatives undertaken by the government of Malaysia such as enhancing the bus and rail system, transforming Malaysia's taxi system, managing travel demand and enhancing the integration of urban public transport system. Furthermore, considering the smart cities initiatives, this research identified that weather, safety, security and inappropriate infrastructure are major barriers in Malaysia's move towards the implementation of smart and eco-friendly mobility practices such as cycling, carpooling and car sharing.

1. Introduction

Malaysian citizens are less interested in non-motorized modes of mobility such as walking or cycling and not fully aware of the harmful effects of motorized transportation [1]. There is no doubt that transport sector is fulfilling the mobility requirements and contributing to strengthening the economy but pollution from transport is also an emerging concern that needs to be addressed [2], [3]. Public Transport System (PTS) in Malaysia is not advanced yet as in well-developed European countries. Therefore, there is massive use of privately owned vehicles. According to Malaysian Institute of Road Safety Research (MIROS), the registration of vehicles in Malaysia is significantly growing every year, as of 2016, over 27 million vehicles have been registered. The increase in the number of vehicles registration leads to accidents and crashes causing deaths, serious and slight injuries as shown in table 1 [4]. Apart from accident and crashes, air pollution is one of the major problems that is caused by growing number of vehicles on the road. Traffic congestion pollutes the environment, health, and lifestyle of the citizens. Most of the Carbon Monoxide (CO) emissions in Malaysian atmosphere are generated from motor vehicles. Malaysia is second biggest per capital Greenhouse Gas (GHG) emitter among the ASEAN nations [5]. In spite of the fact that, Malaysia shares just 0.3% of worldwide GHG emission [6]. The real concern lies in the regularly expanding pattern of GHG emission. At the point when many developed nations have effectively reduced the GHG discharge, in Malaysia emission level keeps expanding [7].

Table 1. MIROS: Vehicle Statistics and Accidents in Malaysia (1997 – 2016).

Year	Registered Vehicles	Population	Road Crashes	Road Deaths	Serious Injury	Slight Injury
1997	8,550,469.00	21,665,600.00	215,632.00	6,302.00	14,105.00	36,167.00
1998	9,141,357.00	22,179,500.00	211,037.00	5,740.00	12,068.00	37,896.00
1999	9,929,951.00	22,711,900.00	223,166.00	5,794.00	10,366.00	36,777.00
2000	10,598,804.00	23,263,600.00	250,429.00	6,035.00	9,790.00	34,375.00
2001	11,302,545.00	23,795,300.00	265,175.00	5,849.00	8,680.00	35,944.00
2002	12,068,144.00	24,526,500.00	279,711.00	5,891.00	8,425.00	35,236.00
2003	12,819,248.00	25,048,300.00	298,653.00	6,286.00	9,040.00	37,415.00
2004	13,828,889.00	25,580,000.00	326,815.00	6,228.00	9,218.00	38,645.00
2005	15,026,660.00	26,130,000.00	328,264.00	6,200.00	9,395.00	31,417.00
2006	15,790,732.00	26,640,000.00	341,252.00	6,287.00	9,253.00	19,885.00
2007	16,813,943.00	27,170,000.00	363,319.00	6,282.00	9,273.00	18,444.00
2008	17,971,907.00	27,730,000.00	373,071.00	6,527.00	8,868.00	16,879.00
2009	19,016,782.00	28,310,000.00	397,330.00	6,745.00	8,849.00	15,823.00
2010	20,188,565.00	28,910,000.00	414,421.00	6,872.00	7,781.00	13,616.00
2011	21,401,269.00	29,000,000.00	449,040.00	6,877.00	6,328.00	12,365.00
2012	22,702,221.00	29,300,000.00	462,423.00	6,917.00	5,868.00	11,654.00
2013	23,819,256.00	29,947,600.00	477,204.00	6,915.00	4,597.00	8,388.00
2014	25,101,192.00	30,300,000.00	476,196.00	6,674.00	4,432.00	8,598.00
2015	26,301,952	31,190,000	489,606	6,706	4,120	7,432
2016	27,613,120	31,660,000[e]	521466[a]	7152[a]	NA	NA

[e] Estimated value from Department of Statistics Malaysia.

[a] Media statement.

[NA] Not available (The official figures are not available yet).

The high demands of mobility and ineffective PTS resulted in an increase of cars in contrast to growth In 1995, approximately three individuals had one vehicle that reduced to 1.4 people having one vehicle in 2010 [8]. With the increasing number of vehicles, the consumption of diesel and petrol has rapidly increased. Consequently, 36% of the national energy is consumed by the transport sector. Therefore the sector is the major emitter of Carbon Dioxide ($CO_{2)}$ and other air pollutants [9], [10]. The rest of this research paper is organized as follows: the emission of air pollutants from traffic are discussed in Section 2. The reasons behind Malaysian citizens not using public transport are explained in Section 3. Section 4 contains discussion on the initiatives of the Malaysian government to improve PTS by 2020. The era of smart mobility and its implementation challenges in Malaysia are discussed in Section 5, and the research is concluded in Section 6 with the discussion of its future direction.

2. Emissions of Traffic-related Air Pollutants

It was estimated that in 2015, the combined air pollutant emission load accumulated to 2,001,195 metric tonnes of CO, 835,927 metric tonnes of Nitrogen Oxides (NO_2), 209,156 metric tonnes of Sulphur Dioxide (SO_2) and 23,904 metric tonnes of Particulate Matter (PM). Emission load for CO had increased in 2015 compared to 2014 due to high consumptions of fuel oil and coke which were used as fuels in industries and, power and heat generation plants. The declination of 0.10% in CO emission load, 5.56% in SO_2 emission load and 6.89% in PM emission load compared to 2014 could

be due to lower fuel consumption in agricultural activities. Power plants contributed to the highest SO_2 emission load (54%), followed by others (32%), industries (7%) and motor vehicles (7%). The highest contributor of PM was industries (32%) followed by power plants (31%), others (20%) and motor vehicles (17%). The highest contributor of NO_2 was power plants (65%) followed by motor vehicles (27%), others (6%) and industries (2%). However, motor vehicles remain the highest contributor of CO (95%) as shown in Figure 1 [11]. Others in Figure 1 represents air pollutant sources from residential, commercial, non-energy use and agriculture.

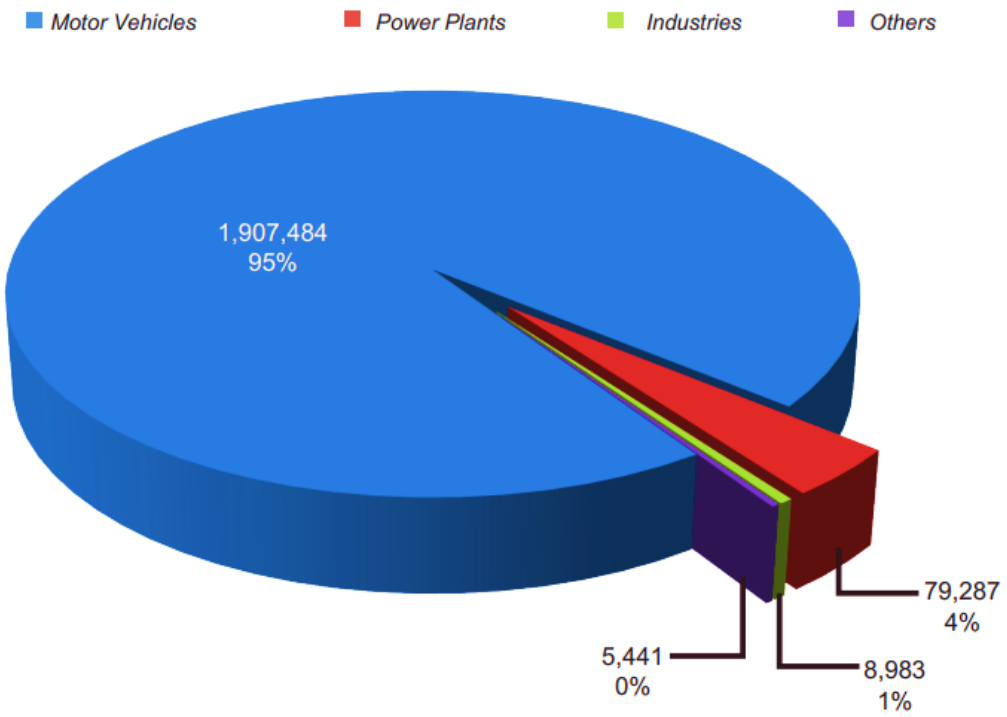

Figure 1. CO Emission from Various Sources (Metric Tonnes) – 2015.

In 2015, like the past years, emission from motor vehicles remained the major source of air pollution, especially in urban areas. There was an overall increase in the number of motor vehicles registered. The number of registered passenger cars, motorcycles, goods vehicles, taxis and buses increased by 4.40%, 3.10%, 2.47%, 1.68% and 2.39% respectively as compared to 2014. The number of in-use vehicles has also shown an ascending trend in which the number of passenger vehicles, motorcycles, goods vehicles, and taxis increased by 4.90%, 0.86%, 0.54% and 0.57% respectively as compared to 2014. Meanwhile, for the buses, it is still a descending trend of 7.13% compared to 2014. The overall statistics of vehicles in-use in Malaysia as reported by the Road Transport Department for 2014 and 2015 is shown in Figure 2 [11].

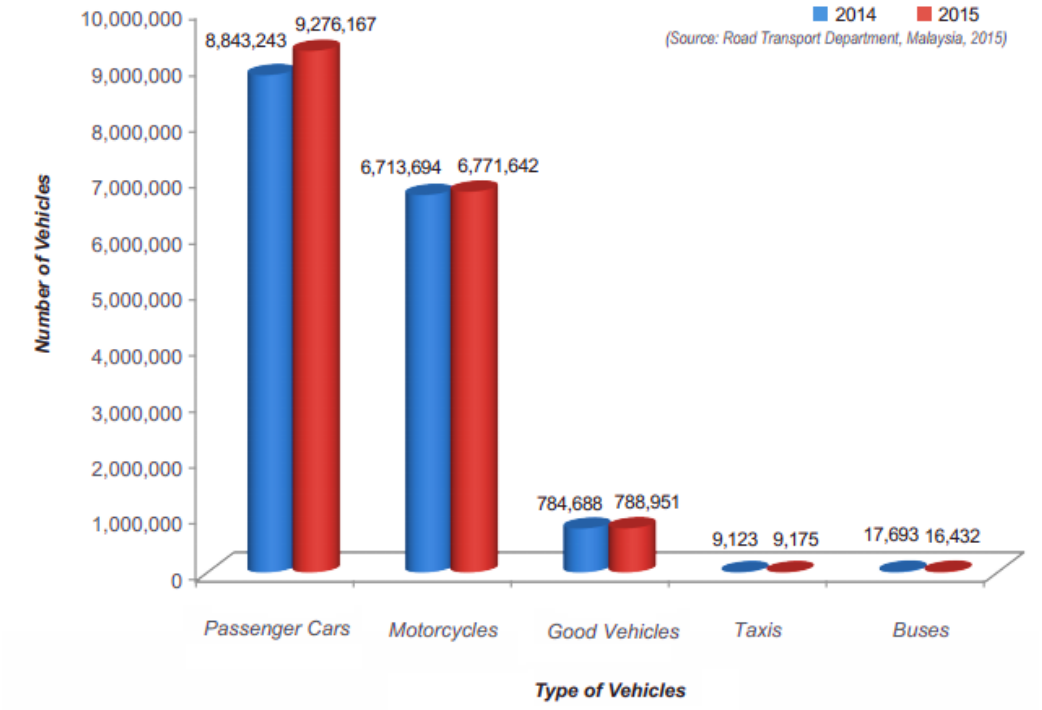

Figure 2. Number of In-use Vehicles in Malaysia: 2014 – 2015.

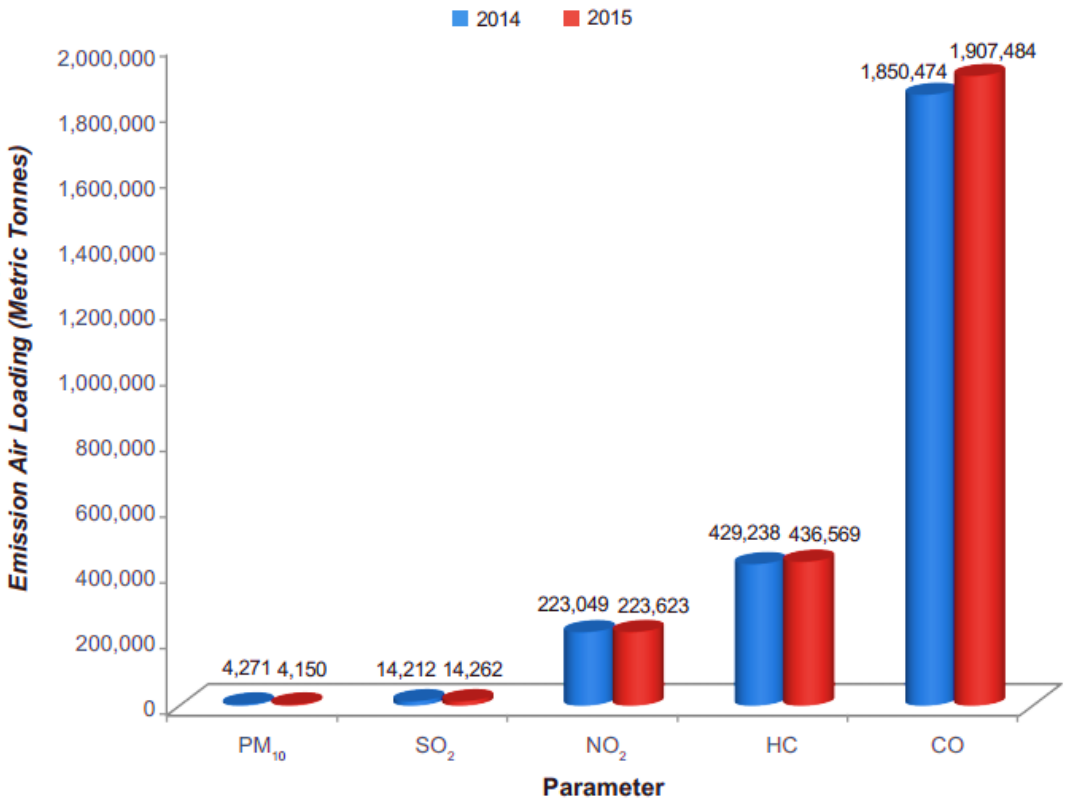

Figure 3. Air Pollutant Emission Load from Motor Vehicles in Malaysia: 2014 – 2015.

The estimated annual air pollutant emission load of Hydrocarbon (HC), CO, PM, NO_2, and SO_2 from motor vehicles for 2014 and 2015 is shown in Figure 3 [11]. In 2015, the emission load of HC and CO was estimated to be 436,569 metric tonnes and 1,907,484 metric tonnes respectively. There was an increase of 3.08% of CO emission load compared to 2014. A similar increasing trend was also observed for the emission load of SO_2, NO_2 and HC from motor vehicles in 2014. SO_2 was 14,262 metric tonnes in 2015 as compared to 14,212 metric tonnes in 2014 (0.35% increased), and NO_2 was 223,623 metric tonnes as compared to 223,049 metric tonnes in 2014 (0.26% increased). However, for the emission load of HC, 436,569 metric tonnes (increased by 1.70%). Emission load of PM was 4,150 metric tonnes in 2015 as compared to 4,271 metric tonnes in 2014 (decreased by 2.83%). CO emission is dangerous as it decreases the flow of oxygen into the bloodstream and it is severely threatening for people having heart disease. The NO_2 and Nitric Oxide (NO) increase exponentially with highest flame temperatures if endured long enough with the concurrent availability of oxygen. In the existence of sunlight and nitrogen oxides, HC reacts to form ground-level ozone that is a main element of pollution. Hydrocarbons are toxic and have the probability to cause cancer whereas ozone damages the lungs, aggravate respiratory problems and irritates the eyes [12].

3. Malaysians Lack of Interest in Public Transport

It has become imperative research activity for the responsible authorities in Malaysia to control the level of pollutants produced by the transport sector mainly in urban zones. One of the key steps in reducing pollution is to reduce the number of vehicles by improving the PTS that could be shared by many commuters as compared to private vehicles. However, in the perception of community, the PTS in Malaysia has been declining over the years. It is a key challenge for the government to make public transport a preferred choice for the citizens of Malaysia by undertaking significant transformations. Several improvements are required such as increasing capacity, infrastructure, integration, cost-effectiveness, technology, etc. By reviewing the existing research, this section critically discusses the limitations of the PTS which are core reasons for the public to use privately owned vehicles as their preferred mode of mobility.

3.1. Infrastructure

The government of Malaysia has spent tremendous amounts of money especially in the development of rails such as Light Rail Transit (LRT), monorail and Keretapi Tanah Melayu (KTM) in an attempt to make the railway service the preferred mode of transportation for citizens and to overcome the problems of traffic congestion in urban areas such as Kuala Lumpur. However, the majority of citizens interested in using rail service as their preferred mode of mobility are still unsatisfied with the service [13]. Lack of integration represents the limitations of the infrastructure. The buses from different companies are not coordinating with each other, which makes the transfers very difficult. Moreover, schedules of buses are not fixed, as they have to complete trip cycles, some travelers find it difficult to manage transit from trains to buses. Connectivity is also a major concern as some train stations are not directly connected to bus stations via facilities such as air-conditioned bridges. People find it difficult to walk across the road to continue their journey due to factors such as time-consumption, hot and rainy weather, safety and security.

3.2. Quality of Service

Usually, three attractive words cheap, convenient and comfort are used to describe the PTS in Malaysia. Commuters are expecting comfortable and convenient services at affordable cost. Although the 3Cs sound attractive to represent the public transport, however quality and efficiency of the service have not been up to the expectations of commuters [14]. [13] conducted a study to analyze the people's satisfaction and perception regarding service quality attributes of public transport. The study was based on a set of questionnaires using statistical models by including variables such as comfort, quality of service and facilities to examine the overall satisfaction of the commuters and the factors that influence their satisfaction. Various analytics methods such as descriptive, factor analysis, correlation and multiple regression were used for analysis. The results depict that PTS mainly buses need to improve their quality of service to achieve customer satisfaction.

3.3. Technology

To improve commuters' mobility and to address the major issues of public transport in Kuala Lumpur, [15] studied the level of Urban Public Transport (UPT) institutional framework. The research identified that mobility in Kuala Lumpur could be easier if traffic flow runs smoothly. However, it requires smart planning with major transformations and improvements to reduce congestion on Kuala Lumpur roads. Currently, people avoid public transport due to heavy congestion on roads and lack of accurate as well as up-to-date information on arrivals and departures. There is a need for implementing journey planning and vehicle tracking applications. It will greatly motivate people to use public transport if they could plan their journey, record their mobility patterns, undertake real-time mobility decisions, and determine effective and efficient modes as well as routes of mobility as per their preference. Technology plays an integral role in making mobility via public transport easier, and it could be used as an approach to encourage people to use public transport. The government needs to consider facilitating citizens with the smart applications such as journey planners using modern technology.

3.4. Cost and Comfort

Cost is one of the most critical factors in selecting mobility methods. Many people want to travel via public transport such as bus and train due to low cost and efficiency of service [16]. Higher cost and less comfort in public transport enforce people to own private vehicles such as cars or motorcycles. Public Bus Transport (PBT) in Malaysia is underutilized, and there is an opportunity to improve the service provided. [17] conducted a study to explore the aspects that impact the usage of PBT in Malaysia. The results showed that ticket price was a great contributing factor in commuters' decision to use public transport. Efficiency and accuracy of schedule also play an integral role in attracting commuters. Therefore, stakeholders must consider these factors to increase the use of PTS. For instance, for the commuters who are using public transport for long-journey, they should have comfortable journeys with basic facilities such as wider seats, user-friendly interchanges, air condition and toilets for disabled, etc.

3.5. Safety and Security

[18] and [19] found in their research that safety and security is a serious issue in convincing citizens to choose public transport as their method of mobility. In Malaysia, safety has been a major concern for people to use private vehicles for mobility due to the alarming rate of street crime. A study conducted by [20] discovered that in Klang Valley, safety is a major concern for the public to avoid PTS. Furthermore, [21] conducted a study that revealed that in Petaling Jaya, only 2.7% of the respondents agreed that public transport in their region is safe. Factors such as robbery, sexual harassment of female passengers and snatch-thieves were cited as the serious concerns in mobility via PTS. Apart from that, drivers of the public transport drive recklessly in a bid to meet schedule. It can be seen from the studies that government authorities need to increase the level of security standards to eradicate crime from streets of Malaysia. Insufficient security will remain a barrier to using the PTS. Therefore, responsible authorities must undertake measures to overcome the safety and security issues.

4. Government Initiatives

With the growth of population, the number of private vehicles is increasing. By 2020, the population of greater Kuala Lumpur (KL) is projected to be 10 million [22]. Government is undertaking precautions to improve the PTS in a bid to reduce private vehicle ownership that would eventually lead to reduced traffic congestion and air-pollution. The government of Malaysia has recognized the current problems related to the PTS and increased emission of traffic-related pollutions that are affecting the health and lifestyle of Malaysian citizens. Therefore, the government is addressing these concerns, and planning improvements as well as enhancements in Government Transformation Programme (GTP) 2.0. From transport sector, GTP 2.0 is mainly based on the goals discussed in the following sub-section.

4.1. Enhancement of Bus System

Bus service is still an important source of mobility for the citizens of Malaysia. However, their inefficiency has been proved as an obstacle to their adoption. In greater KL/Klang Valley, UPT-National Key Resul Area (NKRA) has implemented new initiatives to improve bus service. At present, several bus companies are operating via the same routes that create congestion in Central Business District (CBD) due to overlapping services and unhealthy competition. The first initiative is to implement a systematic bus network by downsizing the number of operators per route and by requiring the buses to stop at dedicated Inter-Urban Transport Terminals (IUTT) located at the periphery of the CBD. In an objective to provide express service in Klang Valley, the government also implemented Bus Rapid Transit (BRT). It is more convenient and covers many regions [22].

4.2. Enhancement of Rail System

The improvement of train service will keep on being a state of accentuation in the GTP 2.0 as it is the most highly used method of public transport in the nation. Three noteworthy activities will be propelled under this work stream influencing each of the systems serving the greater KL/Klang valley territory, in particular, the inter-city KTM trains, RapidKL Light Rail Transit and KL Monorail. The GTP 2.0 lab has recognized a few areas of an upgrade to enhance the service of KTM. These are track power upgrades of KTMB's networks, rehabilitation programmes and updating of the communication and electrification system. The objective here is to enhance the efficiency, effectiveness, and reliability of KTM. Moreover, GTP 2.0 plans to expand the Kelana Jaya and Ampang LRT lines. This activity will address the linkages of the high-volume Kelana Jaya and Ampang LRT lines to many areas. The multi-billion ringgit line expansion project will interface the current Sri Petaling LRT station to the Ampang line, and also the Kelana Jaya station on the Kelana Jaya line to Putra Heights. The capacity of monorail has been expanded to diminish bottlenecking in specific stations, for example, Hang Tuah and KL Sentral [22]. Furthermore, the government built Mass Rapid Transit (MRT) system in the Klang Valley that is capable of increasing the use of public transport and help to reduce traffic congestion in the area [23].

4.3. Transformation of Taxi System

The inclusion of taxi work stream into the Urban Public Transport NKRA of the GTP 2.0 is targeted to enhance the quality of service offered by taxis in Malaysia, particularly in urban zones. Specifically, the main objective of NKRA is to enable the taxis in Malaysia to provide services of similar quality as in other ASEAN nations. The initiatives of this program incorporate the implementation of a centralized taxi system and presenting a new business model for taxi business. This extensive system is anticipated to increase the enforcement and monitoring capabilities of the industry regulators and operators of taxi fleets. The initiative is based on best international practices, and it provides an end-to-end process from guidelines to the penalty system to an effective public communications plan. Additionally, Suruhanjaya Pengangkutan Awam Darat (SPAD) will engage with car manufacturers for a leasing option to decrease the amount of down payment for car loans upon renewal of vehicle permits and continue to assist with maintenance and repair facilities [22].

4.4. Enhancing the Integration of the Urban Public Transport System

The most integrated transport systems are considered as the best ones. Integration of work stream undertakes several initiatives to integrate existing public transport facilities. The approach considers the integrated routes and transport facilities such as the mobility of commuters from source to destination and returning to the source. The integration of bus and rail services will encourage people to use public transport if stations are nearby or connected by bridges. Similarly, facilities such as Park-n-Ride will motivate the travelers to use trains or buses for long distances while parking their privately owned vehicle at the station. Such practices will result in less congestion on the roads [22].

4.5. Management of Travel Demand

About three million cars enter the Kuala Lumpur city centre every day causing congestion due to over-capacity. To overcome congestion, initiatives are to implement journey planners for public transport users and to enhance parking control and management. A journey planner will provide commuters an

opportunity to plan their journey based on routes with the least amount of interchanges, fastest routes and routes with lesser walking distances. This initiative will be implemented by setting up an integrated one-stop journey planner across all modes by providing information such as routes, travel fare and schedule from the beginning of the proposed journey to the destination. The parking control and management initiative will review the parking rates in the Kuala Lumpur city centre to ensure a more competitive rate and to build effective pedestrian walkways [22].

5. The Era of Smart Mobility: Implementation in Malaysia

Smart mobility is a crucial component of smart cities implementation [24]. It encompasses several dimensions of the smart cities on numerous aspects comprising the citizens' quality of life [25]. The most imperative goals of smart mobility include reducing air pollution, traffic congestion, and noise pollution, increasing people safety, improving mobility speed and reducing cost. Nowadays, smart mobility is practiced via various methods such as carpooling, car sharing and cycling. Through carpooling also known as ridesharing, rides are shared with other to fill out the empty seats and to reduce the use of extra vehicles on roads. This facility helps in reducing traffic congestion and air pollution and improves mobility without adding new vehicles to the system. Cycling is considered as an eco-friendly method of mobility and use of it has been on the rise in Europe mainly in the cities with flat land and appropriate cycling infrastructure. For shorter distances such as few miles or less, cycling is often considered as the fastest mode of mobility to get to the workplace. Recently, car sharing has transformed the mobility. Companies such as Uber and Lyft have facilitated the commuters and drivers with smart technology that could be used to reserve transport services on individual or sharing basis. Using the applications drivers can access locations and customers using Global Positioning System (GPS) technology [26].

When it comes to the implementation of smart mobility facilities, there are significant barriers. For example, people are not willing to ride using carpool and car share due to emerging safety and security concerns. However, with the introduction of companies such as Grab and Uber, people are practicing carpooling as they feel safe since the companies can track the driver and travelers response in real-time. Cycling is not very common yet due to various reasons such as weather as the country stays hot throughout the year and another reason is lack of dedicated safe cycling lanes. However, the government is steadily working to make cycling as one of the mobility methods in Malaysia, Kuala Lumpur City Council went on to approve funds for two more cycling lanes in some parts of the city with a total budget of £765,000 [27]. oBike started a station-less smart cycle share system in Malaysia to promote cycling. From the current status, it could be said that Malaysia is steadily moving towards smart and eco-friendly mobility methods. With the improvements and developments, adoption could be further increased that would lead to the sustainable environment with reduced emission of air pollutants and improved health as well as lifestyle.

6. Conclusion and Future Work

European cities such as Bristol, Helsinki, and Stockholm have implemented green mobility patterns as discussed in Section 5. Malaysia is steadily adopting those practices, but there are significant barriers to overcome before full implementation. Currently, the biggest problem faced is a generation of traffic-related air pollutants that can be reduced mainly with reduction of privately owned vehicles. The increase in the use of public transport such as bus, train, taxi and carpooling services can result in lesser number of vehicles that means lower emissions of pollutants. The government has undertaken several initiatives to improve public transport, for example, nowadays infrastructure is connected using air-conditioned bridges, people have facilities such as Park-n-Ride, carpooling using Grab and Uber. However, there are still several improvements required regarding security, safety, journey planning applications and pricing policies. Efficient implementations are required from the government to compete with the smart mobility facilities of European cities with less traffic-pollution index. Apart from government efforts and initiatives, people must be educated via community engagement activities and gamification to realize the impact of their mobility method so that they could practice smart mobility by preference. This research mainly focused on data analysis of years

2014 and 2015, the next phase of this research would include an in-depth study with broad coverage of the past few years' data with emphasis on air pollution and healthcare.

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