GREEN INITIATIVES FOR MASS RAPID TRANSIT PROJECT IN MALAYSIA

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KUALA LUMPUR

2018

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RESEARCH PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING (SAFETY, HEALTH AND ENVIRONMENT)

FACULTY OF ENGINEERING
UNIVERSITY OF MALAYA
KUALA LUMPUR

2018

UNIVERSITY OF MALAYA

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ABSTRACT

In this study the green initiatives taken in the Mass Rapid Transit project in Malaysia are evaluated during the inception, construction and operation stages. This evaluation was made based on the information collected from the one of the MRT construction company and some of the information gathered through the survey and further studies. During the initial stages, the major environmental damage caused by deforestation or drastic land clearing and tree cutting. This has been reduced by rerouting the alignment of the track with minimum clearance and impact to the environment and also replaced those affected trees with new landscaping. During the construction period, the environmental damage was reduced by having various prevention strategies such as sustainable environment, sustainable energy, sustainable material and waste reduction system. During the operation stage, the carbon footprint was reduced by appropriate selection of material and efficient public transportation system which contributed 47% increase in productivity comparatively to other transportation mode such as cars and buses. Overall the MRT project, which began operations on December 2016 reduced carbon footprints by 82,305 tonnes CO_2 per year in transporting a total of 146 million passengers. In addition, it is also expected to reduce 100,000 vehicles off the road and reduce traffic congestion in KL.

ABSTRAK

Dalam kajian ini, inisiatif penghijauan yang diambil dalam projek Mass Rapid Transit di Malaysia dinilai pada peringkat awal, pembinaan dan operasi. Penilaian ini dilakukan berdasarkan maklumat yang dikumpulkan dari salah satu syarikat pembinaan MRT dan beberapa maklumat yang dikumpulkan melalui kajian terperinci. Semasa peringkat awal, kebanyakan punca kemusnahan alam sekitar disebabkan oleh penebangan hutan atau pembersihah tanah dan pemotongan pokok yang drastik. Ini telah dikurangkan dengan mengalihkan penjajaran trek dimana memberi minimum kesan terhadap alam sekitar dan juga menggantikan pokok-pokok yang terjejas dengan landskap baru. Semasa tempoh pembinaan, kerosakan alam sekitar dapat dikurangkan dengan melaksanakan pelbagai strategi pencegahan seperti persekitaran mesra alam, kecekapan tenaga, kecekapan bahan dan sistem pengurangan sisa. Semasa peringkat operasi, pelepasan karbon dikurangkan dengan pemilihan bahan yang sesuai, dan sistem pengangkutan awam yang efisien yang menyumbang peningkatan produktiviti sebanyak 47% berbanding mod pengangkutan lain seperti kereta dan bas. Keseluruhan projek MRT yang beroperasi pada Disember 2016 dapat mengurangkan pelepasan karbon sebanyak 82,305 tan CO_2 setiap tahun dengan pengangkutan sebanyak 146 juta penumpang. Di samping itu, sebanyak 100,000 pengurangan kenderaan dijangka mengunakan jalan raya dan mengurangkan kesesakan lalu lintas di KL.

ACKNOWLEDGEMENTS

First of all, I would like to thank my supervisor, Professor Ir. Dr. Abdul Aziz Bin Abdul Raman for his encouragement, guidance and support in completing this research project successfully.

Moreover, I would like to thank the manager of the company which I have done the project, for allowing to use company data. Not to forget staffs and workers, which enroll with Mass Rapid Transit Project, whose has been cooperating to share knowledge and experiences throughout the project.

Besides that, I wish to express my gratitude to my beloved parents, Mr. Krishnasamy and Madam Indra who gave me consistent support and confidence all the time in order to complete this project. Special thanks to all my lovely friends who had given a lot of moral support and encouragement in completing this project.

Last but not least, I would like to offer my gratitude to all of those who had supported me directly or indirectly during the completion of this project

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LIST OF SYMBOLS AND ABBREVIATIONS

MRT	:	Mass Rapid Transit
CO_2	:	Carbon dioxide
GHGs	:	Greenhouse gases
H_2O	:	Water vapor
CH_4	:	Methane
N_2O	:	Nitrous oxide
PFCs	:	Perfluorocarbons
HFCs	:	Hydrofluorocarbons
LRT	:	Light Rail Transit
KTM	:	'Keretapi Tanah Melayu'
ERL	:	Express Rail Link
SBK	:	'Sungai Buloh-Kajang'
SSP	:	'Sungai Buloh-Serdang-Putrajaya'
KVMRT	:	Klang Valley Mass Rapid Transit

CHAPTER 1: INTRODUCTION

1.1 Background of Study

Even though initially the Mass Rapid Transit project was introduced into Malaysia to reduce congestion in KL but it also to reduce environmental pollution. However, till today no systematic evaluation is conducted on green initiatives, implementation in Mass Rapid Transit. Hence this study will evaluate green initiatives during the inception, construction and operation stages.

Green initiatives can be defined as an environmental friendly approach which can overcome climate change and global warming issues. Those green features used for this technology to define as green technology.

Currently natural environment is badly affected due to poor transportation system and irresponsible human activities. In Malaysia, GHG emissions produced by numerous human activities, but approximately 28% of total CO_2 emissions caused from the transportation sector which 85% arises from road transport.

The amount of carbon dioxide found to be to increase drastically each year due to high demand of transportation service. It leads to climate change and increase to global warming. The amount of carbon emission released from transportation pollutes the atmosphere and has great damaging effects on the environment.

Therefore, this work evaluated the green initiatives implemented in MRT project and summarize the carbon reduction. This work also discussed impact on the green technology. Recommendations are also made to ensure the operation in the future will

remain an environmentally friendly one. This work can assist other similar project elsewhere in Malaysia and reduced environmental impact.

1.2 Problem Statement

If planning and proper implementations are carried out, development projects can be constructed and operated in an environmentally friendly manner. MRT is a large project and a similar approach was adopted. In this work the initiatives to reduce the environmental degradation and impact are explored. The research questions related to this project are:

1. What are the green initiatives implemented in MRT projects during inception, construction and operation stages?
2. What are the impacts of these initiatives to environmental friendliness?
3. What are the steps need to be taken to maintain an environmentally friendly operation?

1.3 Aim and Objectives

The study aims to evaluate overall green initiatives implemented in Mass Rapid Transit Project.

To achieve the aim, the following objectives were defined:

a. To identify and evaluate green initiatives implemented throughout the MRT project implementation.

b. To determine the impact of green technology.

c. To recommend possible green initiatives that can be taken to reduce environmental impact in the future

1.4 Scope of the Study

The study was carried out in a Mass Rapid Transit project located in Klang Valley. All the green initiatives concept implemented in the MRT project during inception, construction and operation stages was included in the scope. The green initiatives concept is to strengthen the role of green economy and green technology as a catalyst to drive Malaysia's aspirations for sustainable growth.

1.5 Report Outline

This research report consists of five main chapters. The chapters are elaborated as per following:

a. Chapter 1: Introduction

Introduction sections which covers the initial process of conducting research studies which include project background, problem statement, objective, scope of the project and report outline.

b. Chapter 2: Literature Review

Literature Review is mainly about previous study and detailed information on topics related green initiatives of rail transit. In this chapter, detailed information on global warming, contribution of global warming due to transportation, transportation status in Malaysia, rail transit status in Malaysia, possible environment implication, green strategies in rail transport and case studies on green transportation are clearly discussed.

c. Chapter 3: Methodology

Methodology covers all the methods conducted during this research. It also indicated the flow of the steps in completing this project. The methodology is ensured to enable identification and evaluation of green initiatives implemented throughout the MRT project. The methodology was conducted to achieve objectives of the study.

d. Chapter 4: Results and Discussion

The results obtained are presented and discussed systematically. The conclusion is made on carbon footprints reduced for MRT compare to another mode of transportation using fossil fuel. The results are further discussed in this section.

e. Chapter 5: Conclusion and Recommendation

This chapter concluded the project results based on the findings obtained and gave a few recommendations on the improvement that can be done in future studies.

CHAPTER 2: LITERATURE REVIEW

2.1 Global Warming

Global warming defines as increasing of average temperature of the earth's surface. The drastic increase in greenhouse gas emissions is the main reason cause of global warming. Based on the current amount of population growth, emission of greenhouse gas into the earth surface temperatures is estimated to increase from a range of 1.6 up to 5.8°C by the end of this century. These extreme increases in carbon dioxide (CO_2) concentration and drastic temperature changes will indirectly affect crop plants and the environment. (Prasad, Thomas, & Narayanan, 2017)

The ozone depletions and climate change are mostly contributing by greenhouse gasses (GHGs) which include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor (H_2O) and fluorinated gases including hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). The danger of global warming is amongst the most essential and critical issues of the world (Freije, Hussain, & Salman, 2017). The CO_2 level in atmospheric has expanded from 280 ppm in the late 1700 s to 407 ppm in July of 2017 due to a great extent of the consuming of petroleum products and change into land utilization. (Gao et al., 2018)

Commonly CO_2 and other gases emerge from the burning of fossil fuels, energy use, industrial, agricultural activities and fertilizers. The greenhouse impact mostly contributes by CO_2 emission representing 80% of the effect.

It is expected that global warming will influence the world, regardless of significant action taken to reduce discharges of GHGs today. Such patterns would proceed with a long stretch, could be decades or hundreds of years to come.

In this manner, cutting GHGs must be given top priority in order to reduce future environmental changes. The Emission Gap reports arranged by the United Nations Environment Program (UNEP) advocate that the synergistic push to decrease carbon footprints is the best way to minimize the impact on global warming and avoid the greenhouse effect.

Commitments for example, travelling using public transport, using renewable energy and sustainable material to help reduce global warming, but most important all began with raising awareness of global warming. (Freije et al., 2017)

2.2 Contribution of global warming due to transportation

The main cause of global warming is due to global greenhouse gas emission. The fundamental reason for environmental change is especially credited to power generation and transportation in the world.

Transportation is the main factor contributing to greenhouse gases (GHG) emissions and climate change. The combustion of fossil fuels from transportation result increase in CO_2 emissions of the world.(Bicer & Dincer, 2018). The continuing rise of GHG emissions would result extreme warming and harm to the climate system.(Ülengin et al., 2018)

The essential division of GHG mitigation in Asian countries is the transportation sector. In 2010, 13% of CO_2 emission related to energy contribute from the transportation

sector. The transportation demands expected based on expanding on capital incomes in the future, which cause greater CO_2 emissions and energy demand from the transportation sector.

The strength of current and future fossil fuels will pose remarkable sustainability challenges other than air pollution and climate change-for energy security. Air pollution is a critical issue in most of the cities and major causes of air pollution are road dust and vehicular emissions. Transportation sector consumed large amount of oil and its high reliance on imports raises significant concern for energy security.(Dhar, Pathak, & Shukla, 2018).

Transportation infrastructure influences urban carbon emissions via three mechanisms, as shown in Figure 2.1.

a) population scale
b) economic growth
c) technological innovation

First, transportation infrastructure able to minimize travel costs, improve population mobility and enhance regional accessibility. Hence it can expand a city’s growth, which thus influences urban carbon emissions and probably going to influence the city's carbon emissions.(Xie, Fang, & Liu, 2017)

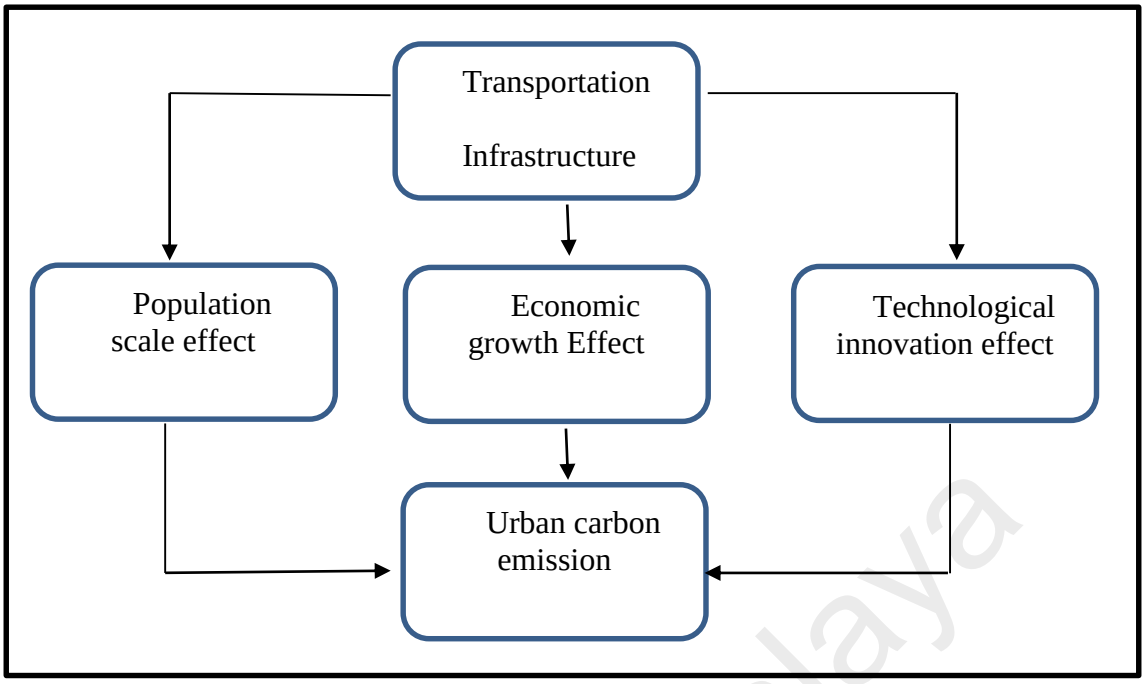

Figure 2.1 : Transportation Infrastructure Effect

Secondly the geographical commuter travel distances and the costs of transportation reduce based on the construction of transportation infrastructure resulting regional accessibility are improved. Improvement of transportation infrastructure similarly growths inter-regional trade and contributes to market expansion. These results regional economic development, which influence carbon emissions. Numerous observational studies have demonstrated that transportation infrastructure can encourage regional economic development through spillover and direct effects. Furthermore, numerous researchers have verified that carbon emissions influence significantly by economic growth. (Xie et al., 2017). The exchange of goods and people, thus advancing the spread of technology and knowledge encouraged by the development of transportation infrastructure. This is beneficial for improving technological innovation. The carbon emission will be further impacted by increasing of technological capacities. The carbon emissions can directly and adversely affect by technological innovation, however the

economic development that outcomes from the technological innovation can have a positive effect. (Xie et al., 2017)

2.3 Transportation status in Malaysia

Transportation has controlled global fuel consumption and greenhouse gas emissions have increased at a critical rate. Road transportation consumed more gasoline and diesel than other sector with the fastest growing rate. This has produced much anxiety in numerous nations, including Malaysia to enhance the sustainable energy of this area. Currently, 13.5% of global warming occurred from the transportation sector with the fastest growing carbon emissions rate than any other economic sector. The main reason mainly due to increasing numbers of automobiles as more than 600 million cars is on roads around the world.

In Malaysia, over the last 20 years the gross domestic product (GDP) grew at an average 6% with the population approximately 27.73 million. Transportation plays a critical role in daily activities by providing an important contribution to the economy resulting in rise of motor vehicle ownership. Each year the motor vehicle ownership increased drastically and for every 10 years the quantity reached double. The road transport vehicles have developed to grow almost 4 times of the annual growth rate of 8%, which have increased significantly from 4.5 million vehicles in 1990 to 18 million vehicles in 2008 as shown in Figure 2.2. The maximum development rate is in year 1996 and 1997 at 11.43% and 11.25% individually (Ong, Mahlia, & Masjuki, 2012).

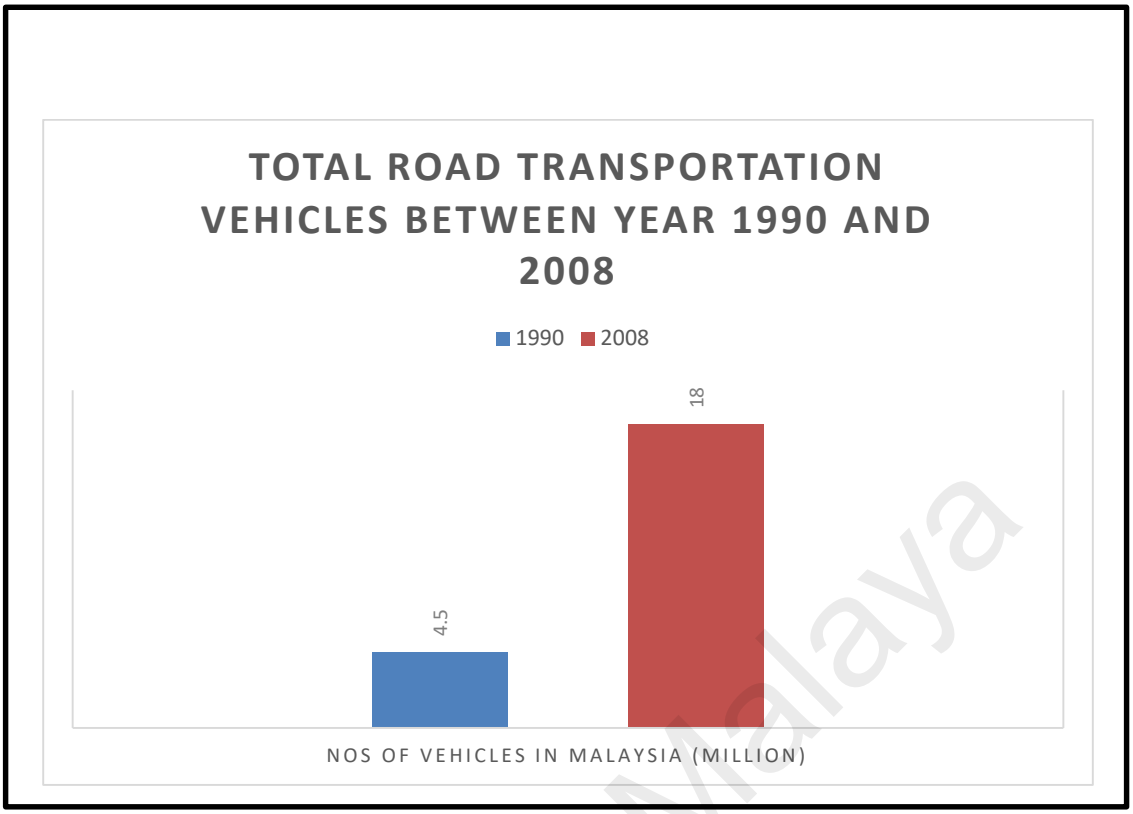

Figure 2.2: **Total Road Transportation Vehicles between Year 1990 and 2008**

In Malaysia, the number of motor vehicles increased by 7.4% per annum from around 5 million in 1990 to 23.7 million in 2013. In addition, increasing motor vehicle population also caused due inadequate public transportation infrastructure. In 2013, around 92% of the vehicles in the country accounted motor cars and motorcycles. Besides that, in Malaysia only 8% share of the total registered vehicles is in public transportation modes. The public transport share in urban has dropped continuously from 34% in 1985 to 20% in 1997 and is now close to 10–12% resulting drastic increase in private vehicles. In addition, the drastic growth of vehicles quantity also contributed by rapid population and urbanization. It was found that, the growth of vehicles quantity is much faster than the growth of population. The growth of total population is 2.5% per annum for the period 1990–2013 however, the growth of the vehicles quantity in the country rise by 8.6% per annum in the same period. The increased in the vehicles quantities have resulted in a

drastic increase in fuel demand and CO_2 emissions as over 80% of vehicles still operate on petroleum fuels (Mustapa & Bekhet, 2016). As for now, the quality of public transportation is one of the most prevalent issues faced by government and city planners in Malaysia and other developing countries. Fulfill consistent growth of urban population and generate high-quality public transportation is a major challenge in Malaysia. The country has endeavored to meet the fundamental requirements of transportation to maintain its economy and also to encourage investment. Malaysia development has reduced the number of private vehicles and enhanced the public transportation system. Hence, the nation has contributed towards reduction of traffic congestion, sound and air pollution. As in developing country demand for public transportation services (e.g., buses and trains) had been increased and demand of personal vehicle ownership is reduced. Since by encouraging more travelers to use public transportation, the current traffic problems in Malaysia can be moderated (Almselati, Rahmat, Jaafar, & Yahia, 2015).

One of the main purpose public not rely on public transportation or by travelling via private vehicles will be more privacy, time saving, cost expenses can be avoided and better possibilities of point-to-point travel. Currently in public transportation has low services which cause overcrowding, especially in buses and train travel with low speed, low arrival and departure time reliability (long waiting time), low frequency and high level of discomfort.

Approximately 15 million vehicles, end of 2005 found have plied Malaysian roads which include cars, freight trucks, taxis, motorcycles and buses. At present, approximately 15.1 million populations of the country consisted of adults. Motor vehicles in Malaysia, ninety percent are privately owned. Based on the Department of Statistics in Malaysia, motorcycles consist of 47% (7 million) of the total number of vehicles, followed by passenger cars consist of 43% (6.5 million). The total quantity of private

passenger cars expanded from year 2000 to 2005 at an average rate of 4.5–10% (Almselati et al., 2015). This drastic increase of private vehicles on the road caused congestion in KL and produced a lot of pollution. Therefore, rail transit is introduced to mitigate congestion and pollution issues. Rail status in Malaysia had been further discussed in Chapter 2.4.

2.4 Rail Transit status in Malaysia

The main public transport rail transit services in Kuala Lumpur are LRT, KTM Commuter, KL Monorail and Mass rapid transit. Currently to avoid road traffic congestion, most of the riders in Kuala Lumpur start to depend on this this public transport to travel from one destination to another destination within the city. Since public transit can accommodate better travel demand than cars, it should be encouraged. Expanding the awareness of public transit may protect the environment, enhance the personal satisfaction, decrease traffic congestion, energy consumption and reduce the quantity of accidents (Din, Paramasivam, Tarmizi, & Samad, 2016).

In urban cities, mass transit systems are becoming prevalent. One of the most famous transit systems in Kuala Lumpur is Light Rail Transit (LRT) systems which also known as a modern version of street cars. Since LRT able to transport high capacity of passengers comfortably, proficiently and rapidly, LRT is known as an essential part of a modern transit system in Kuala Lumpur. Besides that, the Monorail is also one of vital modes of public transportation in Kuala Lumpur. This system is commonly placed in the middle of congested town since the tracks of monorail system only required minimal space horizontally and vertically.

There are total six transit systems in a modern transit system in Kuala Lumpur which consist of the Sri Petaling Line, Ampang Line, Kelana Jaya Line, Express Rail Link (ERL), KTM Commuter and Rapid KL bus system as shown in Figure 2.3. LRT systems operating under one main operator that is the 'Rangkaian Pengangkutan Integrasi Deras Sdn Bhd' (RAPID KL) consist of the Sri Petaling Line, Ampang Line and Kelana Jaya Line. This three system mainly covered routes around Kuala Lumpur and Selangor. Meanwhile KL Monorail covered the routes through the central areas of commercial buildings, shopping arenas and hotels in the Kuala Lumpur district which operated by KL Monorail System Sdn Bhd. KTM Commuter operated by KTMB Berhad which is the first electrified rail system in Malaysia and cover certain areas in Kuala Lumpur and Selangor. ERL is a high-speed air-rail system between Kuala Lumpur City Air Terminal at KL Central Station and Kuala Lumpur International Airport (KLIA) (Phang, 2007).

MRT is one of rail transit recently constructed in Malaysia on December 2016. MRT believes in reducing congestion in KL by transporting 1.4 million passengers per year, which can reduce 100,000 cars on the road and reduce carbon emission.

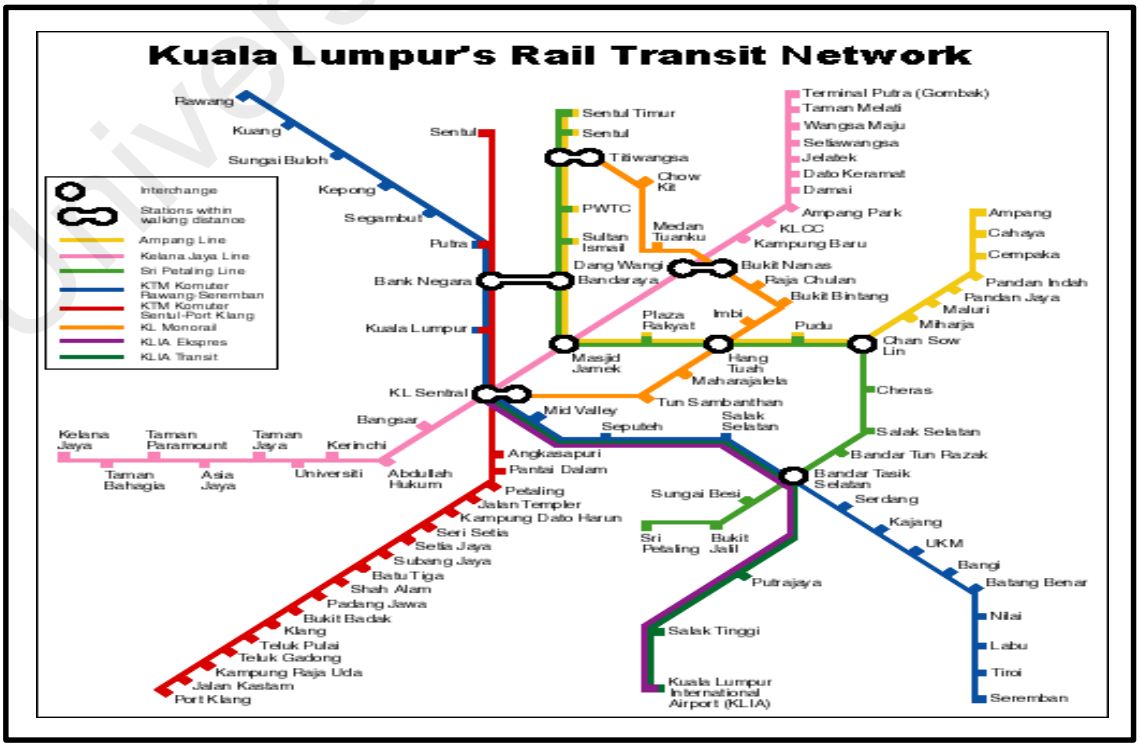

Figure 2.3: Kuala Lumpur's Rail Transit Network

2.5 Possible Environment Implication Method Overcome Pollution Mitigation

Poor green transportation systems adversely affect the environment including pollution, traffic congestion, energy depletion and climate change. Poor transportation will increase high living cost and unhealthy life. Environment pollution impacts human health in multiple ways. Air pollution related to transportation will contribute most health problems such as cardiovascular, lung cancer and respiratory diseases. Other than that, impacts of poor green transportation systems include deterioration of ecology characteristic, uncontrolled waste generation and natural resource depletion from unlimited deforestation.

Poor green transportation also will affect biodiversity. Continued deforestation for construction, development of land based transportation will impact growth of plants and endanger animal species due to changes on the natural habitats.

Soil erosion and soil contamination from poor green transportation also will affect soil quality. Those toxic materials of fuel and oil spills release from transportation industry may cause soil contamination and impact the environment.(Zutshi & Creed, 2015)

MRT is one of the solution to create green environment and also to reduce congestion, but there is issue with initial project where a lot of trees require to be cut down and there is also issue on introducing of new pollution such as usage of electricity. However, things can be done to reduce pollution. There are lots of green aspect can be done during all stages and this will be further discussed in Chapter 2.6 and Chapter 2.7.

2.6 Green Strategies in Rail Transport System

Green strategies in rail transport can be defined as an environmental travelling mode by implementing green features of low carbon. Advantage of green transportation is an environment friendly system which will protect our environment, decrease traffic congestion, safe, convenient, reduces energy consumption and create a healthy lifestyle (H.-r. Li, 2016). Currently, Malaysia is growing rapidly towards the green technology era. Sustainable transport has become an important worldwide and grab everyone's attention globally (Geng, Long, Chen, & Li, 2017).

Nowadays, various companies promoting sustainable development by using greener production that environmentally friendly (Fernando & Wah, 2017). Green transportation is the most cost saving way to protect the environment. It applies greener technology to achieve sustainable development in the transportation system without harming the environment (Costantini, Crespi, Marin, & Paglialunga, 2017).

Rail transport, public transport and electrified transportation vehicles such as mass rapid transit are those examples of the green transportation system. Green transportation like solar energy vehicle, natural gas vehicle and electric vehicle found to release less carbon emission and reduce pollution to the environment (D. Li, Zhao, Zhang, Chen, & Cao, 2018).

Normally green transportation concept more efficient, convenient, safe and environmental friendly suitable for all kinds of travelers (H.-r. Li, 2016). Efficient green transportation can avoid environmental harm and reduce transportation cost by decreasing greenhouse gas emission and fuel consumption (Salehi, Jalalian, & Vali Siar, 2017).The growth of urban green transportation is essential for improving the environment, decreasing carbon emission and saving energy (H.-r. Li, 2016)

2.7 Case Studies on Green Transportation

Today, the construction of "green" initiatives in Malaysia is becoming popular. In previous year ago, most of the people not aware of the green initiatives. However, nowadays more information available to promote green initiatives to get a better understanding. Green transportation targeted to provide sustainable development to reduce negative impact on nature. Those green initiatives implemented are as follows: (Izvekova, Roy, & Murgul, 2016)

2.7.1 Design efficiency

In Mass Rapid Transit, green designs have been developed to reduce adverse impact on the environment and human health. Normally green designs will be implemented in the inception stage of a project. All the material used for construction phase will be based on eco-friendly materials to protect air, water and earth surrounding the environment (Ragheb, El-Shimy, & Ragheb, 2016).

When constructing a building, design stage and concept play an important role as it will influence the building cost and performance. The performance of the building will be affected if the building design not done efficiently. For example, based on an efficient green design of a building, energy, water, land and material conservation can be achieved based on the utilization of heat from the sun rises and sets which will impact the occupants comfort inside the building. Building occupants can enjoy a healthy and comfortable working and living environment parallel with nature with efficient green design implementation. Basically concept of “green building,” is also known as concept of buildings designed and constructed based on environmentally friendly values (Yuan et al., 2017).

One of the green designs implemented in the MRT can be found in MRT elevated stations along Sungai Buloh-Kajang Line, which the station was designed based on open-

sided concept which will allow natural lighting and ventilation based on environment friendly concepts.

2.7.2 Building Sector

Green building known as operations that include sustainable practices and environmentally friendly procedures. Implementation of green building system will reduce maintenance and operation cost of a project. This will create a healthy and safe environment by increase efficiency of resource use by using renewable energy and material that reduced carbon footprint, reduced waste consumption in construction, used clean technologies and water conservation (Kubba, 2010). Building that constructed and designed to improve environmental, productivity and health also known as green building. The overall influence on the environment and human health can be minimized by implementing efficient green design which consists of a building's lifecycle through better design, construction, operation and disposal (Nguyen, Skitmore, Gray, Zhang, & Olanipekun, 2017). Green buildings today are designed to decrease impacts of the building stock on the environment, society and economy by providing sustainable solutions (Medl, Stangl, & Florineth, 2017).

2.7.3 Energy efficiency

Green energy efficiency is one of the green initiatives implementation that used to minimize energy waste and mostly depends on natural resources such as solar, wind, biodiesel and hydropower which will prevent pollution, cost effective and create an environment friendly concept (Q. Zhang, Tang, & Zhang, 2018).

In Malaysia, Mass rapid Transit is one of the green transportation infrastructures that optimizing energy-saving and implements carbon-reducing measures. MRT has fully implemented energy efficiency and sustainability. Hence. to improve energy efficiency

in MRT, lighting, electrical, air conditioning, escalator and lift systems have been upgraded.

One of the examples of using green energy concept is placing window at right position which exposed to natural daylight and ventilation. This will reduce energy consumption and cost saving. Most of the mass rapid transit system started implements this green, energy efficient method to achieve a holistic approach towards the design of the system (Lu, 2016).

2.7.4 Water efficiency

Efficient conservation of water is another green initiative that can be implemented to save the environment. Most of the cities in the world have constructed efficient water management based on terrain, climate and green space development plans. In addition, the main factors in green transportation are reduction in water wastage, maintain good quality of water and efficient use of water.

Water can be used wisely by recycling the used or collected water at the site. To reduce the usage of water, train washing plants can use a recycling feature by pre-washing the next train by using collected water from recycling tanks.

Besides that, water can be conserved and water wastage can be minimized by designing a dual plumbing system in a building which water in the toilet will be recycled (X. Zhang et al., 2017).

2.7.5 Materials efficiency

Green transportation materials normally use from renewable resources which source from environmentally friendly product. This green material saved energy, cost, time and increase productivity (Ragheb et al., 2016).

Green material can be used efficiently by reusing and utilize renewable resources rather than choosing non-renewable resources in material components. In sustainable design and manufacturing, green material has been enhanced by reducing the total requirement for material production and processing which includes reused and recycled material, construction material and also waste material. Implementation of material efficiency in MRT system such as designing light-weight product, re-using components, use long-life product able to reduce the extraction of natural resources, reduced energy demands and impact to the environment (Ji, Jiao, Chen, & Wu, 2013).

2.7.6 Indoor environment quality

Indoor Environmental Quality (EQ) is also one of green initiative method practiced which defined as the quality of environment in the building. The Indoor Environment Quality provided sufficient ventilation, lighting, thermal quality, heating and good indoor quality elements. This will involve usage of air and humidity control, artificial light, the application of sound absorption material and quality air filtration to achieve good indoor environmental quality. The advantage of IEQ is it affect the indoor environment where it can specify areas which need upgrading measures of the parameters (Mihai & Iordache, 2016).

2.7.7 Operation and maintenance

Basically green transportation required to be operated and preserved accordingly to maintain the sustainability of a transportation with its design and construction. The operation and maintenance stages of a transportation's life rely on the aspect of green transportation in a building to avoid any negative impact to health and the environment. Operations and maintenance must be given priority in the project's planning and development process in order to preserve the green criteria designed for the project. Green transportation should be designed, operate and will maintain to sustain the long term

project with effective cost. In MRT project, an example of green operation and maintenance that have been implemented are providing regular maintenance and competent personnel to conduct maintenance and operation and also allocate sufficient funds to cover cost of replacement component. Good operation and maintenance system can sustain the green transportation for longer period and reduced the impact to the environment (Ragheb et al., 2016).

2.7.8 Waste reduction

Finally, waste reduction is another green initiative commonly applied in green transportation. Normally environment will be polluted from the wastage contribute from construction of a project. Green transportation will reduce waste consumption and will fully utilize the use of the materials in the sustainable waste management. The waste also can be eliminated by implementing 3R" hierarchy which includes (Reduction, Reuse, Recovery). 3R practices able to minimize the waste volume and prevent environment impact. The waste management hierarchy created green initiatives by reducing waste at the source. In MRT project, waste reduction has been given priority by giving sufficient training and campaign to create awareness on the green initiatives and wastage reduction measures (Fercoq, Lamouri, & Carbone, 2016).

2.8 Summary of literature review

Many researches have been carried out to find a green initiative implementation in the green transportation system. The green transportation system refers to the environmental travelling concept which produced low carbon emission, less energy consumption and low pollution.

Based on the previous study done, global warming, contribution of global warming due to transportation, transportation status in Malaysia, rail transit status in Malaysia, possible environment implication, green strategies in rail transport systems and case studies on green transportation in Mass Rapid Transit have been explored.

Since Mass Rapid Transit is the first project constructed in Malaysia, detailed study on the green initiative implemented in the Mass Rapid Transit project have been studied and explored to ensure the operation in the future will remain an environmental friendly and assist other similar projects elsewhere in Malaysia and reduced environmental impact.

Based on the study done, it is found that green transportation implementation is really essential to created healthy life and protected our environment from further deterioration.

CHAPTER 3: METHODOLOGY

In this chapter, the methodology of the project will be explored. This report evaluated implementation of green initiatives in the MRT project during inception, construction and operation stages. This chapter highlights the location of study, sample selection, data collection and data analysis method to be applied in this study.

3.1 Overall methodology Flow Chart

Figure 3.1 below shows the flow chart of the overall methodology involved in the study:

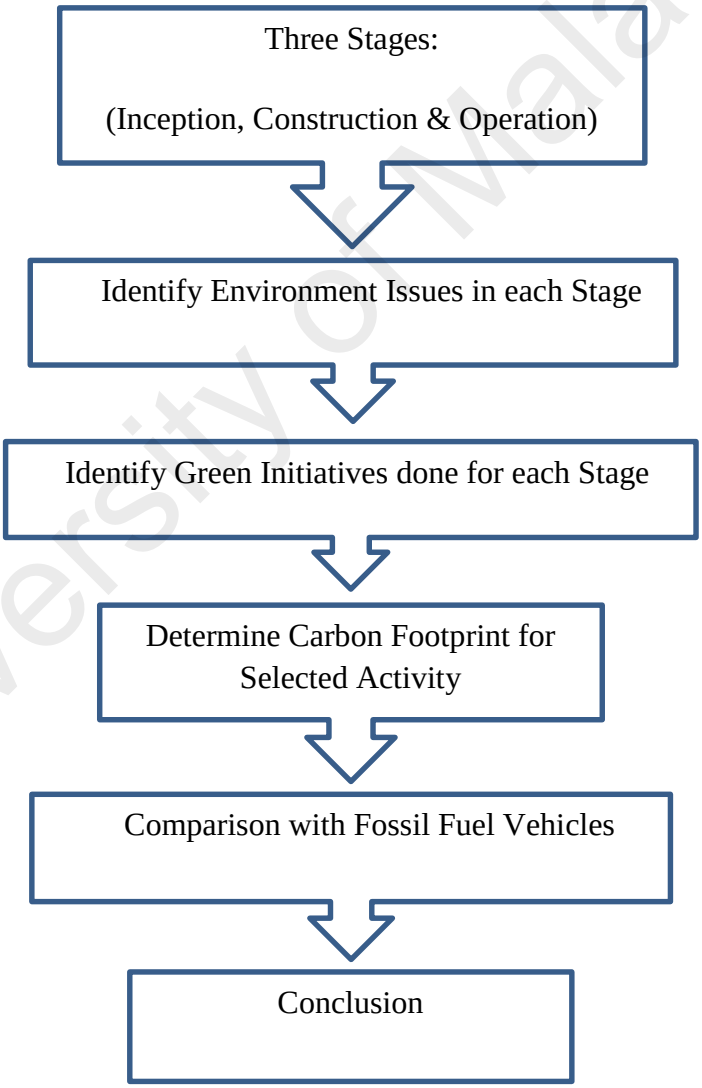

Figure 3.1: Methodology flow chart

3.2 Location of Study

Construction of MRT line 2 currently in progress and involves few packages which have been nominated as work package contractor. The study focus on the green initiatives implemented during the inception, construction and operation stages of MRT project. One of the MRT packages has been chosen to conduct as case studies on green initiative implemented in MRT project. A letter of permission was sent to the company management in order to enter the work site and obtained necessary data. Although verbal approval has been obtained to conduct this research study, however company information will be kept confidential. Data during construction stages of MRT mainly took from this particular company and data during inception and operation stages also have been discussed and shared. Basic information of the company that involve in this project shown as per table below.

Table 3.1: Information of Selected Project

No	Item	Description
1	Company Name	XYZ Sdn Bhd
2	Project	Projek Mass Rapid Transit Laluan 2: Sungai Buloh - Serdang – Putrajaya
3	Work Package Coverage	5km
4	Total Employees	200-250 employees
5	Working Hours	Site Operation: Shift 1: 8am-8pm Shift 2: 8pm -8am Office : 8am-5pm
6	Site Location	Kuala Lumpur

3.3 Sample Selection

In this project the samples are selected randomly among workers and staff of MRT construction. This research is based on non-probability sampling which is a convenience sampling technique. The member of sampling selected based on their experiences, expertise and knowledge on related field for the purpose of the study.

3.4 Data collection

In the MRT construction project, carbon emission is a major issue that needs to be tackled to protect our environment. The data collection was required in this methodology to further understand the green initiatives implemented during inception, construction and operation stages of MRT project. The data collection was obtained through several methods which through observation and informal interviews.

3.4.1 Observation

The observation was carried out during a site visit of the selected MRT work package. The company management allowed to walk around the site to collect info related green initiatives which have been implemented. There was also a representative site engineer from company followed together during the visit section around the site in order to explain in detail regarding green initiatives has been practiced at the MRT construction site. In addition, drawing, design related to green concept also had been explained and discussed during the site visit. Meanwhile, for the MRT operation stages, current MRT line 1 which has been started operating from the Sungai Buloh station to Kajang Station had been observed on the green initiatives that has been implemented. Photos and any green initiatives concept that had been practiced related to the research have been observed and captured as evidence for the result obtained.

3.4.2 Interview

Interviews conducted among site personnel involved the project manager, engineer, safety officer, supervisor and workers that related to MRT project. The entire process involved with green concept in the MRT had been discussed and reviewed over the interview session. Those interview questions that were asking are on the current green initiatives that have been implemented, awareness of green concept and challenges. The interview was carried out informally and the sample questions were shared in Appendix 1. All the information obtained is documented, however some sensitive information includes names are not revealed due to confidentiality.

3.5 Methodology used for identifying greening initiatives

In this research, green initiatives are identified by following methodology:

a) Identify Stages

Green Initiatives implemented in MRT project was identified by following three stages:

1) Inception Stages
2) Construction Stages
3) Operation Stages

b) Identify Environment Issues in each Stage

Those environments issue at each stage during the inception, construction and operation stages were highlighted and reviewed in the literature review. One of the major environmental issues identified are global warming. Contribution of global warming due to transportation and possible environment implication caused by the poor green transportation system was discussed further in the literature review.

c) Identify Green Initiatives done for each Stages

Green initiatives conducted during each stage of the inception, construction and operation stages of the MRT project were identified and further discussed in Chapter 4. Those green criteria that were focused are sustainable energy, sustainable material, waste reduction and sustainable environment implementation.

3.6 Methodology of Carbon Footprints Calculation

Transportation contributed high carbon emission to the environment. The carbon footprints emission can be calculated as per following formula shown in Figure 3.2 below.

$$CO_2 = X\ (km) \times \theta_{mode}\ (g/km)$$

Figure 3.2: Carbon Footprints Calculation

The Carbon Emissions factor θ is calculated in government laboratories where vehicles are rigorously tested. For the vehicle mode, the values are calculated as shown in below Table 3.2:

Table 3.2: Carbon Footprints Emission

Mode	CO_2 Emission Factor θ	Notes
MRT	854 g/km	-Assuming an average loading of 1,200 passengers per train, total electricity consumed and CO_2 produced when generating electricity and convert to gasoline unit.
Bus	660 g/km	-Assuming an average loading of 40 passengers per bus, total diesel fuel consumed and CO_2 produced when generating fossil fuel.
Car	120 g/km	-Assuming an average loading of 4 passengers per car, total petrol fuel consumed and CO_2 produced when generating fossil fuel.

Table 3.3: Carbon Footprints Calculation

Fuel Consumption	**CO_2 Emission**
1 Liter Diesel	2640 gCO_2/Liter
1 Liter Petrol / Gasoline	2392 gCO_2/Liter
Vehicles Mode	**Fuel Consumption**
Car (Petrol)	= 5Liter/100km = 20 km/Liter Petrol
Bus (Diesel)	= 25Liter/100km = 4 km/Liter Diesel
MRT Train (Electricity)	Power supply =750 V DC /third rail = 3.18 kWh/km (1 Liter of gasoline = 8.9kWh) =3.18kWh/km / 8.9 kWh =0.36 L_e/km =2.8km/Liter Gasoline

Vehicles Mode	CO_2 Emission Factor
Car	2392gCO_2/L x 1/20km/L **=120 gCO_2/km**
Bus	2640 gCO_2/Liter x 1/4km/L **= 660 gCO_2/km**
MRT Train	2392 gCO_2/Liter x 1/2.8km/L **= 854 gCO_2/km**

Source: ecoscore.be/en/info/ecoscore/CO_2, Urban Transit Statistics in Ontario & Metro Klang Valley Kuala Lumpur

3.7 Data analysis

All the data obtained from data collection will be analysis and evaluated. In data analysis, quantitative and qualitative approaches will be used. Tables and graphs will be used to present the quantitative data based on the main research questions. Open-ended questions created from the qualitative data and will be categorized in themes in accordance with research objectives and described in narrative form along with the quantitative presentation. Overall green achievement in the MRT project would be analysis in detail.

3.8 Safety and confidentially of the project

The construction project is exposed to various risks and high safety requirement. In order to conduct this research, prior permission was obtained from the MRT construction project XYZ Sdn Bhd. Safety and security measures such as safety induction and temporary visitor pass provided. A letter of non-disclosure of sensitive information is signed prior to conducting this study. An assurance is given by the researcher that the study is meant for academic research purely and not intended for publication.

CHAPTER 4: RESULT AND DISCUSSION

4.1 Current status of the project

Currently MRT project phase 1 has been started operation from Sungai Buloh to Kajang with a total length 51km as shown in Figure 4.1. The MRT Sungai Buloh-Kajang (SBK) line to consist of 9.5km distance underground runs at the centre of Kula Lumpur and balance of the alignment is elevated. There are 31 stations along the line and seven stations are underground.

MRT Sungai Buloh-Kajang Line from Sungai Buloh to Semantan phases one started operations on 16 December 2016. Meanwhile phases two, from Semantan Station to Kajang Station began its operations on 17 July 2017 which cover entire alignment. There are four cars in each train set serving the line with total capacity of 1,200 passengers. The frequency of trains run at every 3.5minutes with daily ridership is about 400,000 passengers.

Meanwhile MRT phases 2 from Sungai Buloh to Putrajaya still under construction which had been started construction in 2016 and estimated to complete by the year 2020. The total length of MRT Sungai Buloh-Serdang-Putrajaya (SSP) Line alignment is 52.2km, involving 13.5km underground tunnels and 38.7km elevated tracks and consists of total 35 stations with 24 are elevated and 11 are underground.

Besides that, to provide convenience for commuters to transfer from the SSP Line to existing and future rail lines, including the future Kuala Lumpur-Singapore High Speed Rail, there will be 11 interchange stations to be provided.

Meanwhile MRT line 3 or MRT Circle Line still under feasibility study with a total length 40km consist of 26 stations which 7 are elevated and 19 underground. The MRT Circle Line is expected to cover the hot spots surrounding the Ampang Jaya, Bandar Malaysia, KL Eco City, Bukit Kiara, Sentul, Setapak and Ampang. Figure 4.2 shows Malaysia Klang Valley MRT lines.

Basically based on study both MRT phase 1 and phase 2 implement green initiatives during the inception, construction and operation stages. This green transportation concept will definitely help reduce GHG emissions in Malaysia by developed awareness of ridership on public transport, minimize the number of private vehicles and most importantly moving away from fossil fuel based transportation.

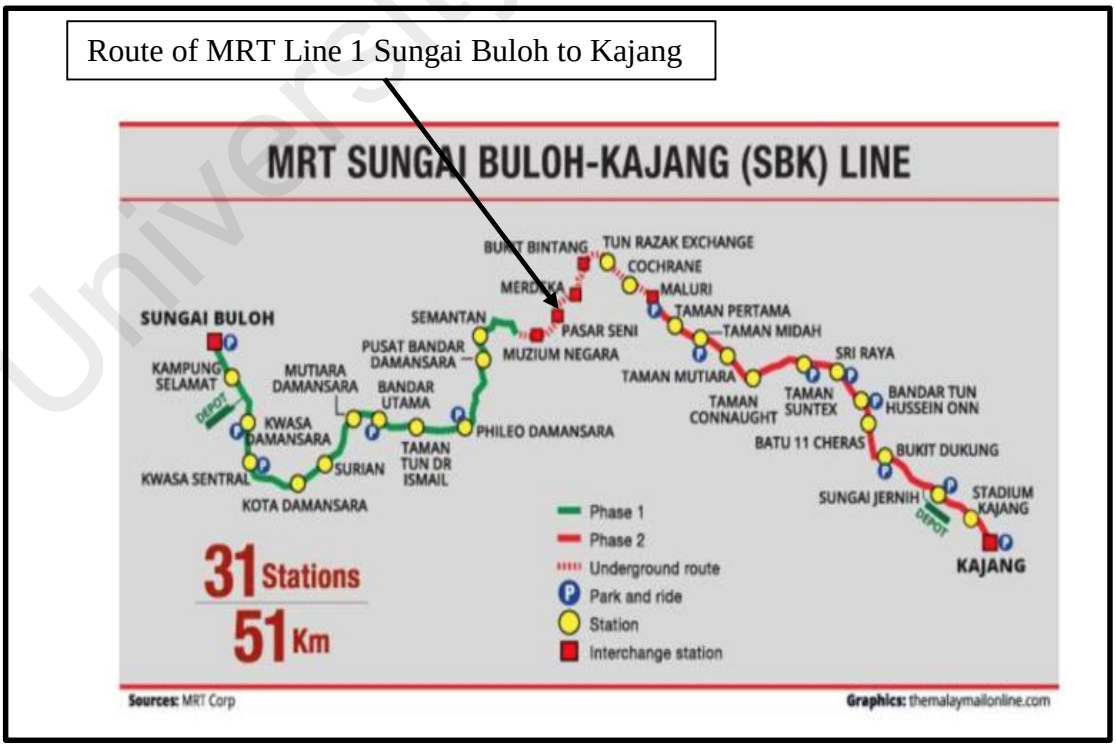

Figure 4.1: MRT Line 1 Sungai Buloh to Kajang

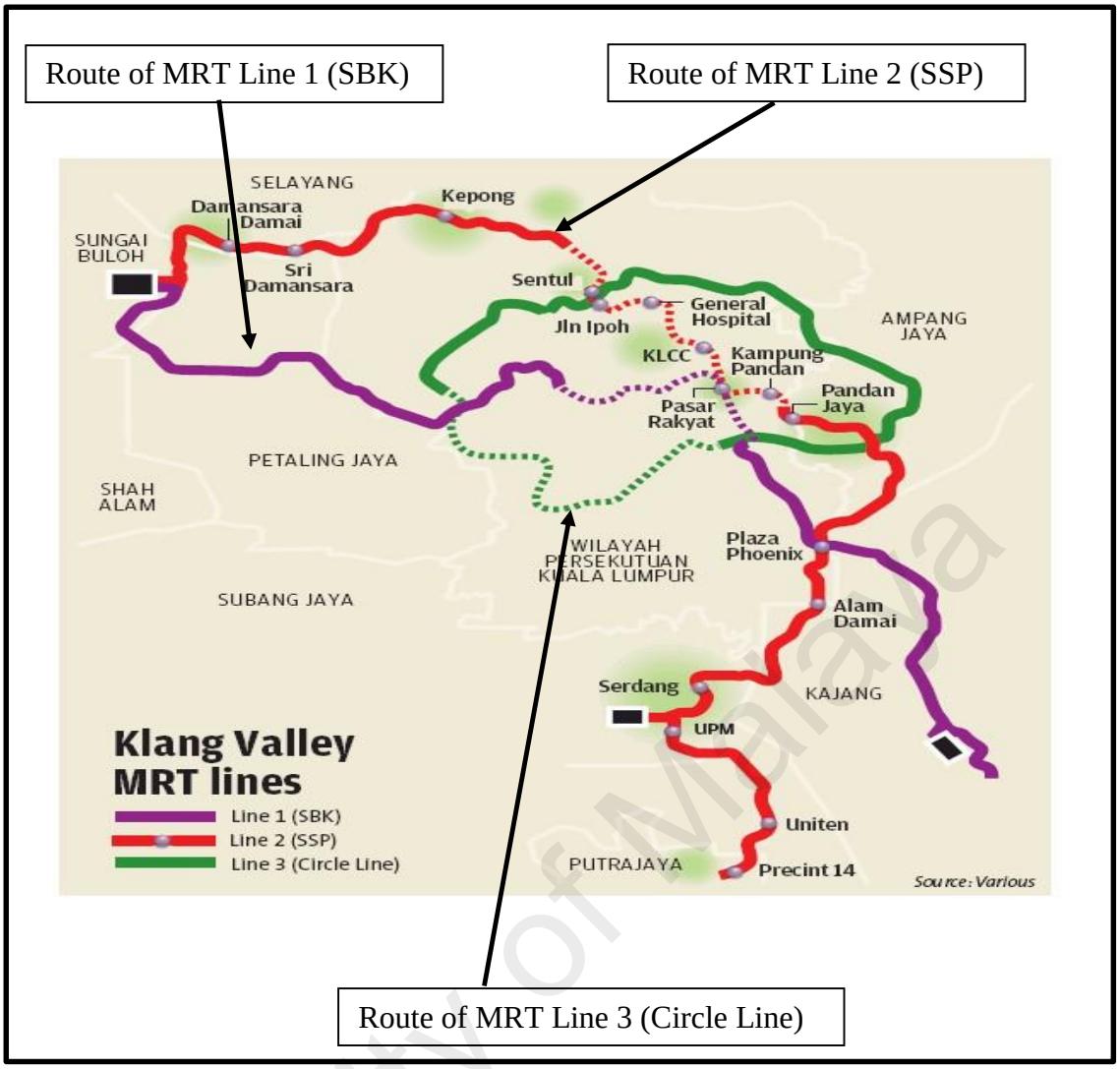

Figure 4.2: Malaysia Klang Valley MRT Lines

4.2 Assessment of Greening initiatives during inception

The Mass Rapid Transit (MRT) implemented **'green design' transportation concept.** This concept applied during inception stages by using **sustainable energy** combined with eco-friendly green design. The interior design of MRT trains is based on an open environment concept that is attractive by providing light, tinted windows and doors to allow natural lighting. In addition, the coaches provided are very spacious, fresh and light with cool blue tone colours. MRT coaches offer a very fresh feeling with cool colors and are environment friendly as shown in Figure 4.3.

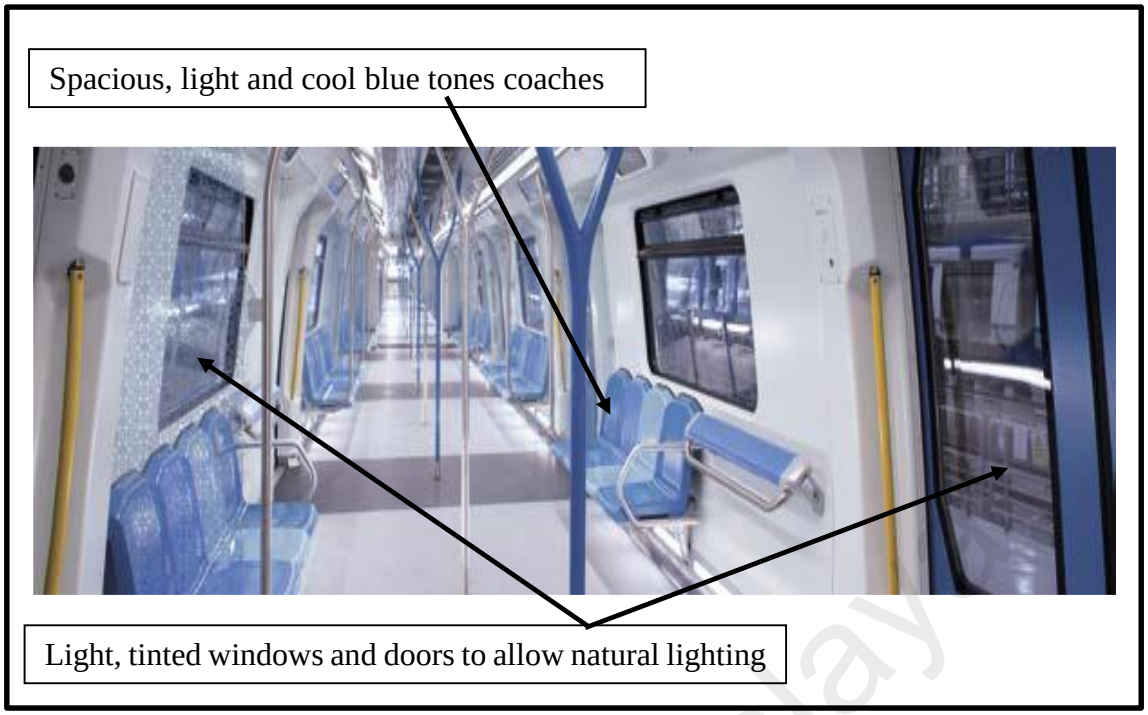

Figure 4.3: Interior Design of MRT

MRT train was designed with greener concept which the train service powered by electricity rather than fossil fuels to reduce greenhouse gas emissions. MRT train designed with power supply 750 VDC which offering high efficiency with a power supply transmission efficiency average of 92-94% which can reduce energy loss and carbon emission. This also reduced maintenance costs because the power supply equipment is virtually maintenance-free with only regular inspections and cleaning required, thus reduced air pollution and carbon emission.

In a green transportation of MRT, natural environment feels shall be created to the occupants. Exterior and interior design shall go hand in hand by combination natural and artificial lighting. It employs highly efficient air conditioning and lighting systems such as LEDs lights. The cladding was installed in white cooling color to reduce heat and energy consumption. In addition, MRT station was designed based on green environment with an open-sided concept which allowed natural lighting and ventilation based on environment friendly concepts which duration from 7am till 7pm not lights required and reduction of air conditioning usage as shown in Figure 4.4 and Figure 4.5. This reduced

30% of energy consumption compares to closed building This new green environment such as landscaping and close turfing also reduced the carbon footprint.

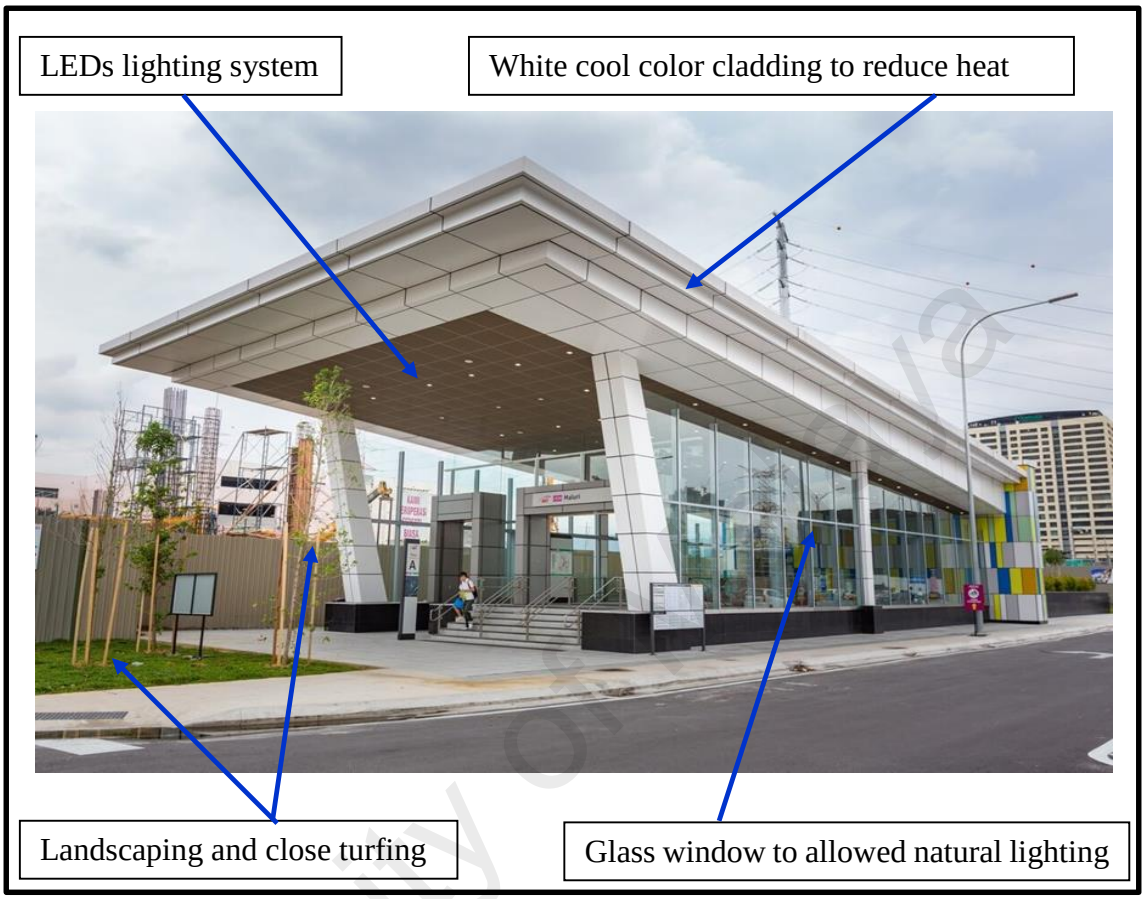

Figure 4.4: MRT station allowed natural lighting and ventilation

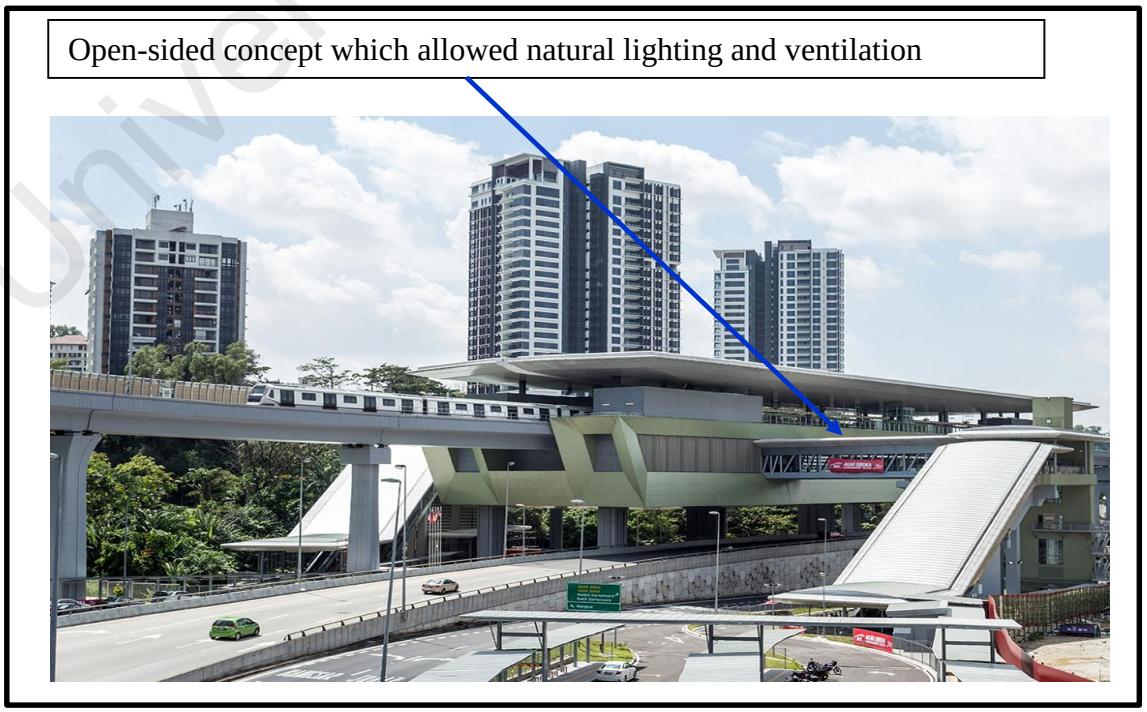

Figure 4.5: MRT station allowed natural lighting and ventilation

The trains used for the Sungai Buloh-Kajang (SBK) Line is designed with **sustainable and non-flammable materials,** lightweight, quieter and has high recyclability at the end of their service life. For the MRT train, 90 per cents of trains consist of sustainable material such as aluminum, copper and steel parts which trains' designed to be easily recycled and removed

MRT alignment was studied during inception stages, the **sustainable environment** was given priority with the green alignment concept has designed by taking into consideration the preservation of wildlife, local vegetation and natural resources. The MRT track alignment was designed along the main road and highway to reduce minimum impact and minimum clearance to the environment. Specially a site with biodiversity has been avoided and construction be planned to reduce site disturbances. Those site constraint areas, tunneling method have been designed to reduce minimum impact to the environment.

In addition, for added convenience selected **MRT stations** are **designed connected** to other Kuala Lumpur transit services such as monorail, LRT, KTM, and airport trains. Figure 4.6 shows one example view of the LRT to MRT link way at Maluri Station. The majority of MRT station is connected to taxi layby and main bus services. In fact, there are also feeder buses servicing at each MRT station that stops at neighboring landmarks and neighborhoods, with fares priced at RM1. Thus concept allowed more people to travel from one mode transport to another mode transport within 200m distance as shown in Figure 4.7. It provides a safe and convenient way of interchange between public transport and also provide OKU facilities such as tactile tiles. In addition, windows along walkway also made of glass to allow natural lighting and help to reduce carbon emission

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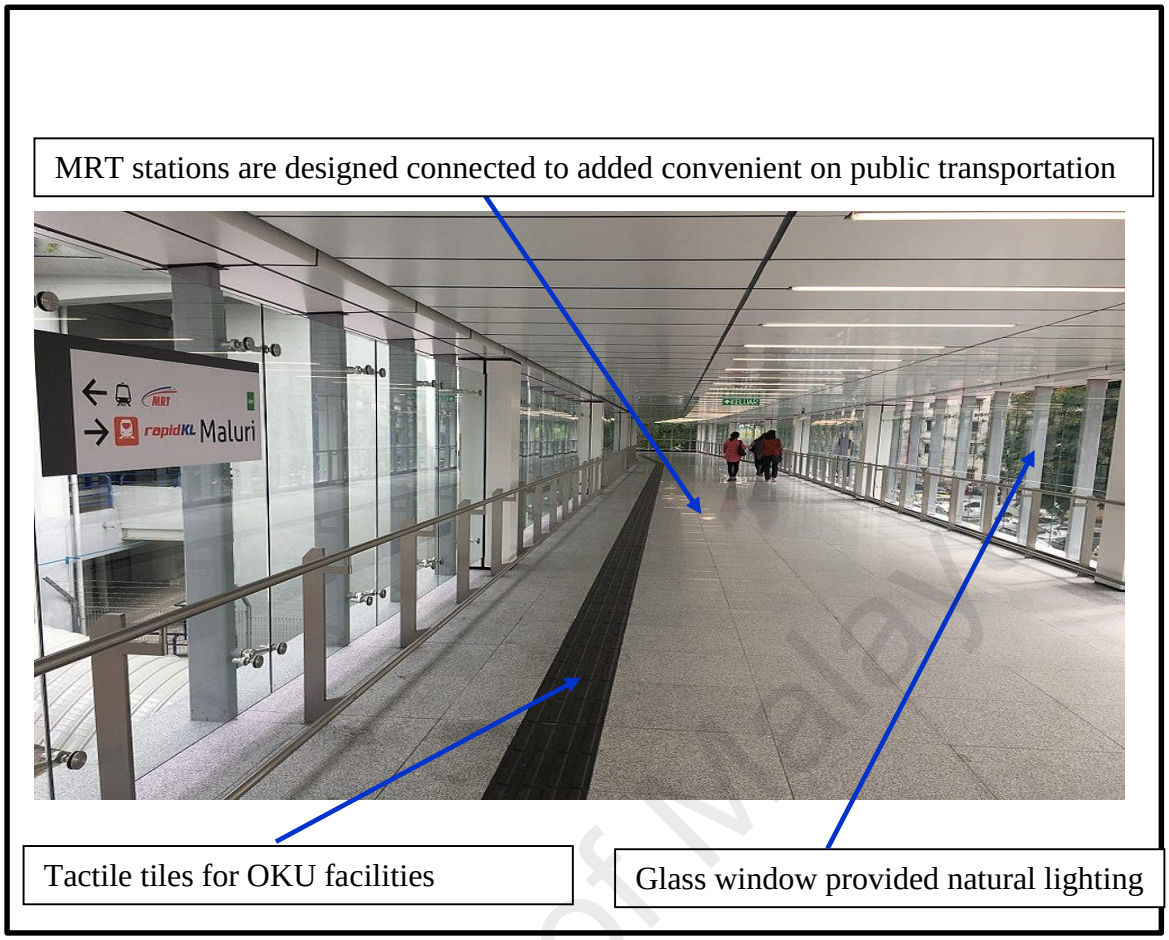

Figure 4.6: View of the LRT to MRT linkway at Maluri Station

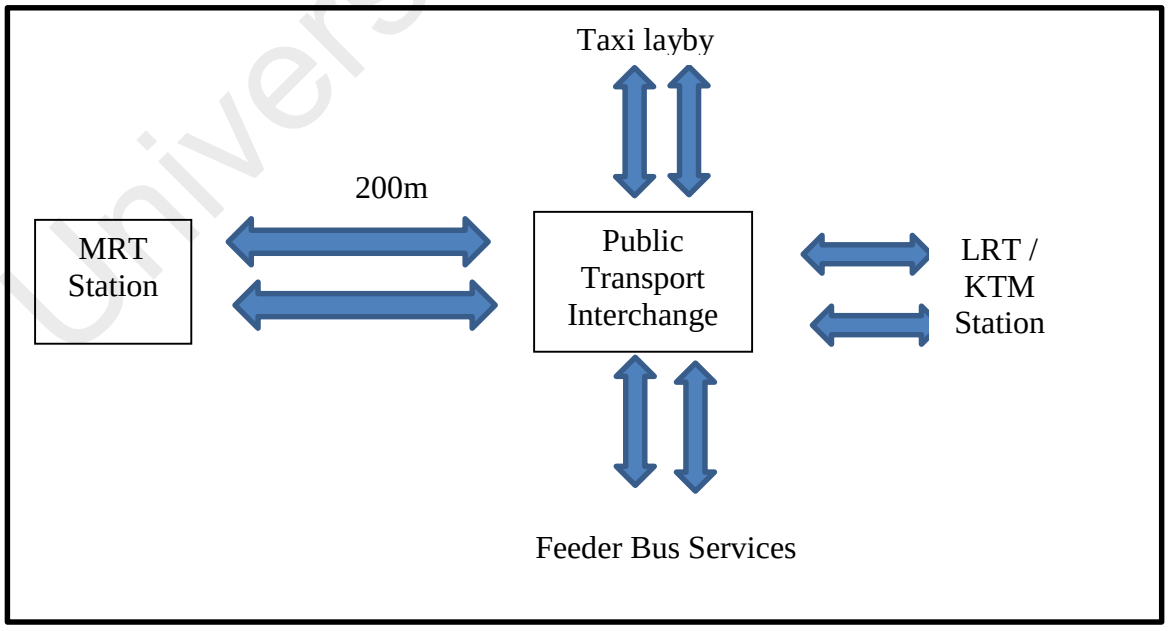

Figure 4.7: Public Transport Interchange at MRT Station

4.3 Assessment of Greening initiatives during construction

The green concept of MRT construction emphasizes the **sustainable environment, sustainable energy, sustainable material and waste reduction** that can minimize or eliminated the adverse impact on the environment.

MRT construction implemented **sustainable environment,** by reducing minimum impact to the surrounding environment Those affected trees that have to be fell for the MRT construction work have been replaced with new landscaping trees with ratio 1:2 to maintain green environment. All the exposed slope has been covered with close turfing to maintain the green of the area. Green concept landscaping and exterior design shall be done to ensure more landscape plants surrounding MRT alignment as a greening element, to filter the dirty air and also bring more shaded area.

Guideways has been built supported by pillars for the elevated alignment of the SSP Line by single and double track as shown in Figure 4.8. There are numerous factors influenced the height of the guideways such as the terrain on which it is built and whether it has to span over roads. Basically MRT construction was performed in modular based with optimizing place where only affected MRT alignment will be clear and replaced with landscape trees while the rest will be maintained undisturbed and upgrade.

Meanwhile to give minimal impact to the environment, tunnels have been built for the underground alignment of the MRT line as shown in (Figure 4.9). Tunnel boring machines and the cut-and-cover method has been used to build tunnels at MRT. The geology and underground structures are the factors that need to be considered when determine the depth of the tunnels. The tunneling construction method reduced land clearance and impact to the environment which in line with the green concept.

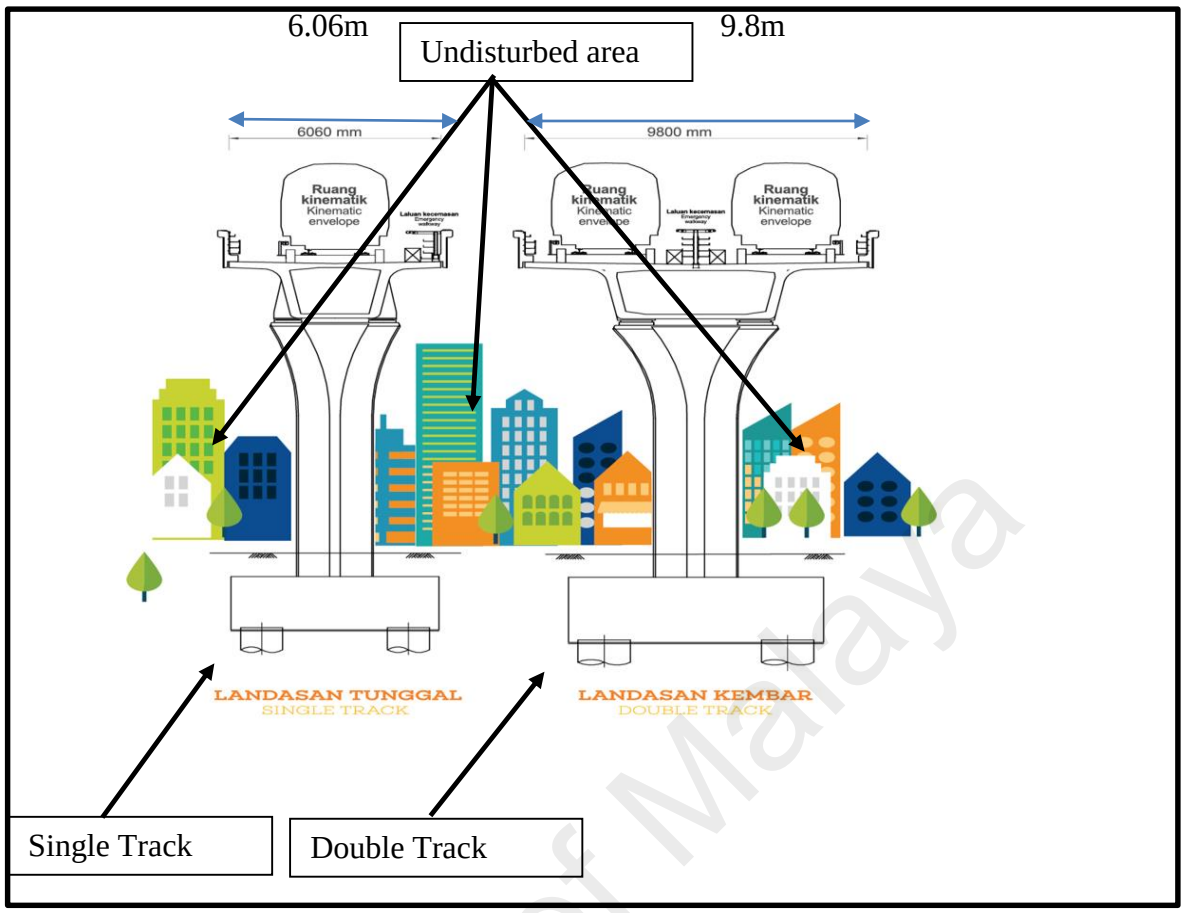

Figure 4.8: Elevated Guideway

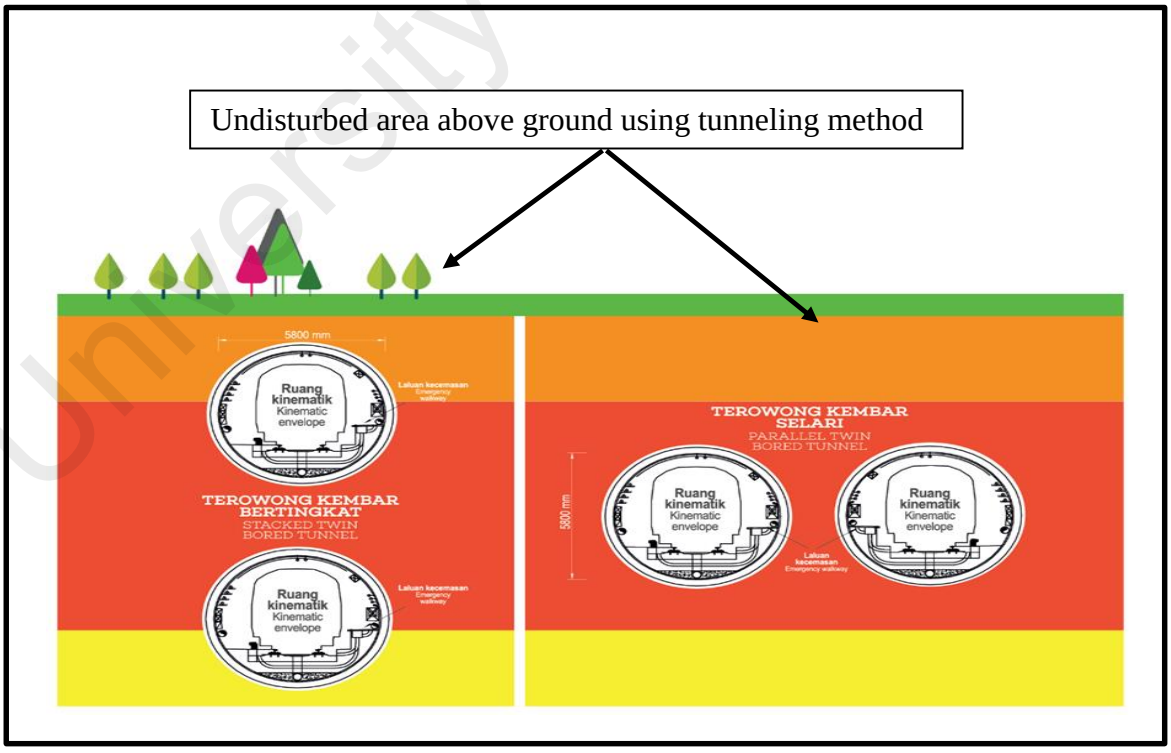

Figure 4.9: Tunneling Method

Besides that, MRT construction implemented **sustainable energy** to support green technology. Energy efficiency measured will reduce carbon footprints, saved energy and cost and also produced cleaner air. One of energy efficiency have been practiced at MRT construction are used low-energy sources such as solid state lighting with light emitting diode bulbs (LED) lamps and compact fluorescent lamps at the construction site to reduced energy consumption. In addition, solar panel CCTV has been installed at site to monitor site progress and for security purpose as shown in Figure 4.10. This method reduced energy consumption from electricity. These efforts include promotion of energy-efficient machinery such as used electric water pump instead of diesel water pump which more efficient, low maintenance and reduced carbon emission.

Figure 4.10: Solar Panel CCTV

Sustainable material also has been given priority in MRT construction by purchasing green and eco-friendly product. Eco-friendly material and techniques has been used in MRT construction as shown in Figure 4.11. Those materials used in MRT construction were ensuring **durability and have a long life span** such as purchase high quality cement, concrete, bricks, durable PVC pipes and timber which have tested and certified by SIRIM to decrease production cost by reduced of raw materials utilized in the production process with maximum lifetime. Besides that, eco-friendly material that required **low energy** during construction also has been used in MRT such as columns, beams, slabs and drain of precast components, cellular lightweight precast concrete blocks, ready mix cement concrete and materials with low VOC emissions example cement paints.

Biodegradable material also used in MRT construction such as those materials that decompose easily example clay brick, biodegradable mat for erosion control, wood or earthen materials which can reduce the harm to the environment and reduced the amount of material required.

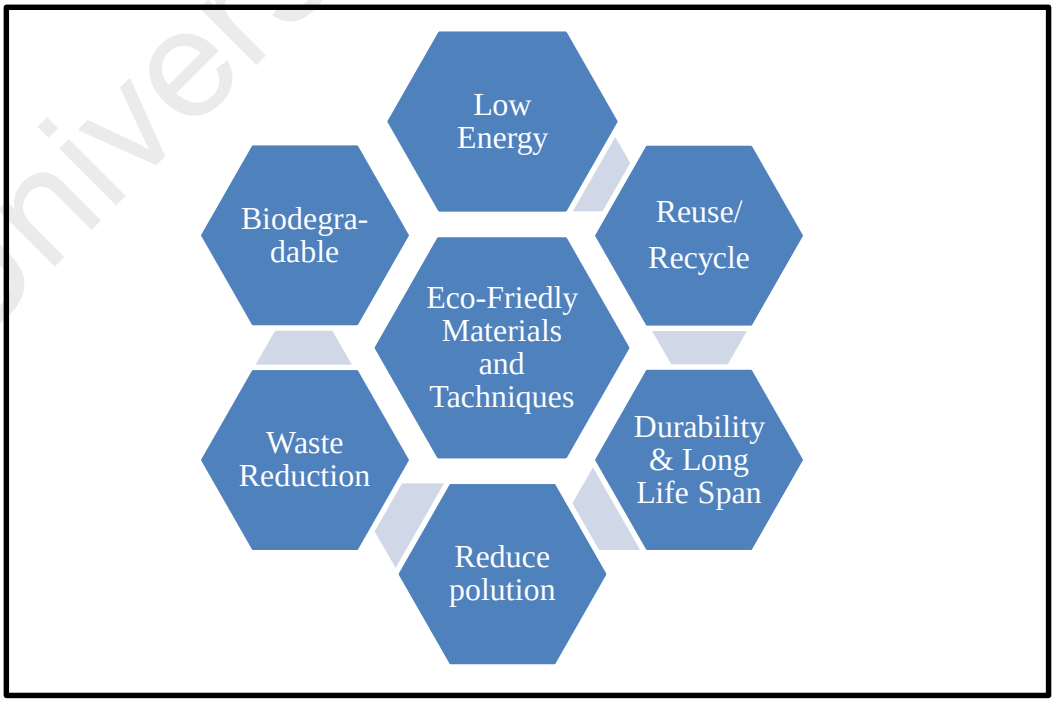

Figure 4.11: Eco-Friendly Materials & Techniques

In addition, the green MRT construction implemented a waste management system by encouraging **waste reduction.** Basically, in MRT construction before disposing any waste to the proper dumpsite such as landfill, the waste management hierarchy will have been gone through to decide the waste shall be reduced, reused or recycled. All the wastes have been segregated by prioritizing the 3R method, that is in view of extending its life-cycle as much as possible before use for another purpose or disposal. The purpose of waste reduction is to avoid any impact to human health and on the environment.

Construction solid waste material such as plastic, brick, wood, paint and concrete may contribute problem if not properly managed such as caused water pollution if the direct discharge of waste into rivers, land pollution if chemical leaking on ground surface and air pollution if open burning of this solid waste material. Therefore, construction waste management is one of the sustainable development approached to minimize waste and **reduced pollution** such as air, water and land pollution to avoid negative impacts on the environment.

Current MRT site construction implemented 3R method by reduced construction waste by using highly efficient material and ensured proper handling material to reduce concrete, steel and timber waste during construction work. Besides that, construction waste such as broken brick, concrete waste and premix waste has been **reused or recycled** to create the temporary platform and access road for construction sites. In addition, certain construction waste such as scrap steel has been recycled to construct wash through and other steel material on site to reduce energy consumption on purchasing new product. These efforts assist to decrease the disposal quantity of construction wastes to landfill. Hence, it will reduce carbon emission and maintained green environment.

4.4 Assessment of Greening initiatives during initial stages of operation

The transportation sector contributed a major quantity of energy used and carbon emission in Malaysia. Thus, in order to reduce carbon footprints and to minimize private vehicles on the roads, MRT was constructed as one of public transportation in Malaysia which implement green initiatives. The KVMRT Sungai Buloh-Kajang Line, which has to start operation emphasized the green concept by implementing **sustainable energy, sustainable environment, sustainable material** and **efficient public transportation system** to maintain green environment.

MRT implemented **sustainable energy** during the operation stage by running the rails with energy-efficient vehicles (EEVs) which fully powered by electricity rather than fossil fuels to reduce greenhouse gas emissions. Besides that, MRT operated remotely from the Operations Control Centre (OCC) in Sungai Buloh Depot and a Backup Control Centre (BCC) in Kajang Depot. which have been fully operated in a green manner.

The KVMRT Sungai Buloh-Kajang Line stations are incorporated with green technology to boost energy efficiency. Installation of escalators in MRT stations applied energy efficiency concept by re-using energy produced by installing escalators with motion sensor that auto stops when not in use to reduce energy loss. In addition, staircase also provided to reduced energy consumption of escalator usage as shown in Figure 4:12. In addition, the energy regenerative lift also applied in MRT stations which power obtained from the electrical supply network. The regenerative lifts are 20% to 30% more energy efficient compared to conventional lifts which reduce energy loss.

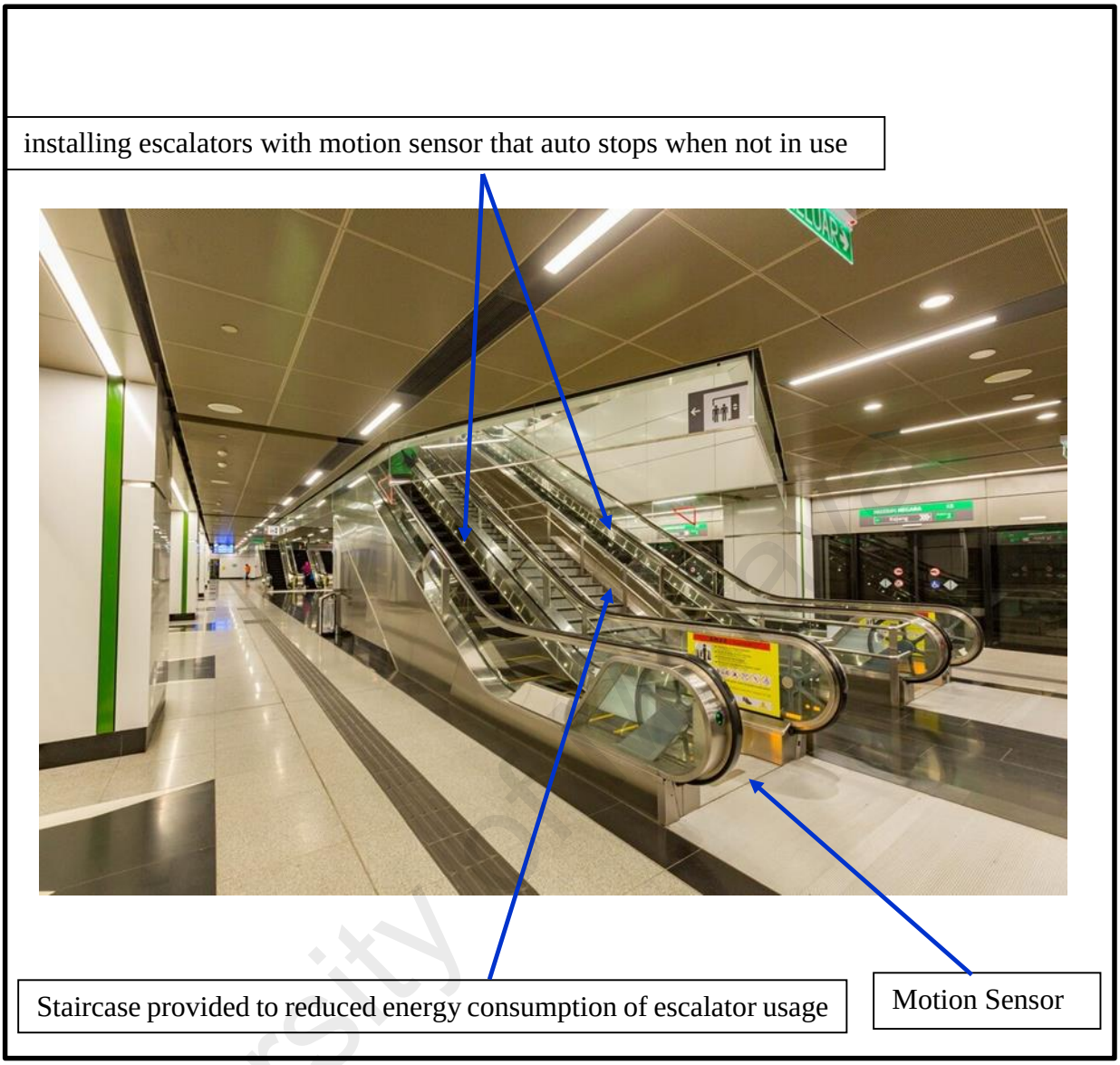

Figure 4.12: Energy Efficient Escalators

As part of the green initiative to reduced energy consumption, MRT train and station interiors and exterior are equipped with glass window and LED lighting system as shown in Figure 4.13. The glass window allowed natural lighting and reduced energy consumption. LEDs lights have a long lifespan which can save maintenance cost and reduced carbon emission. LEDs have a lifespan of up to 60,000 hours compared to 1,500 hours for incandescent bulbs resulting 90% energy savings.

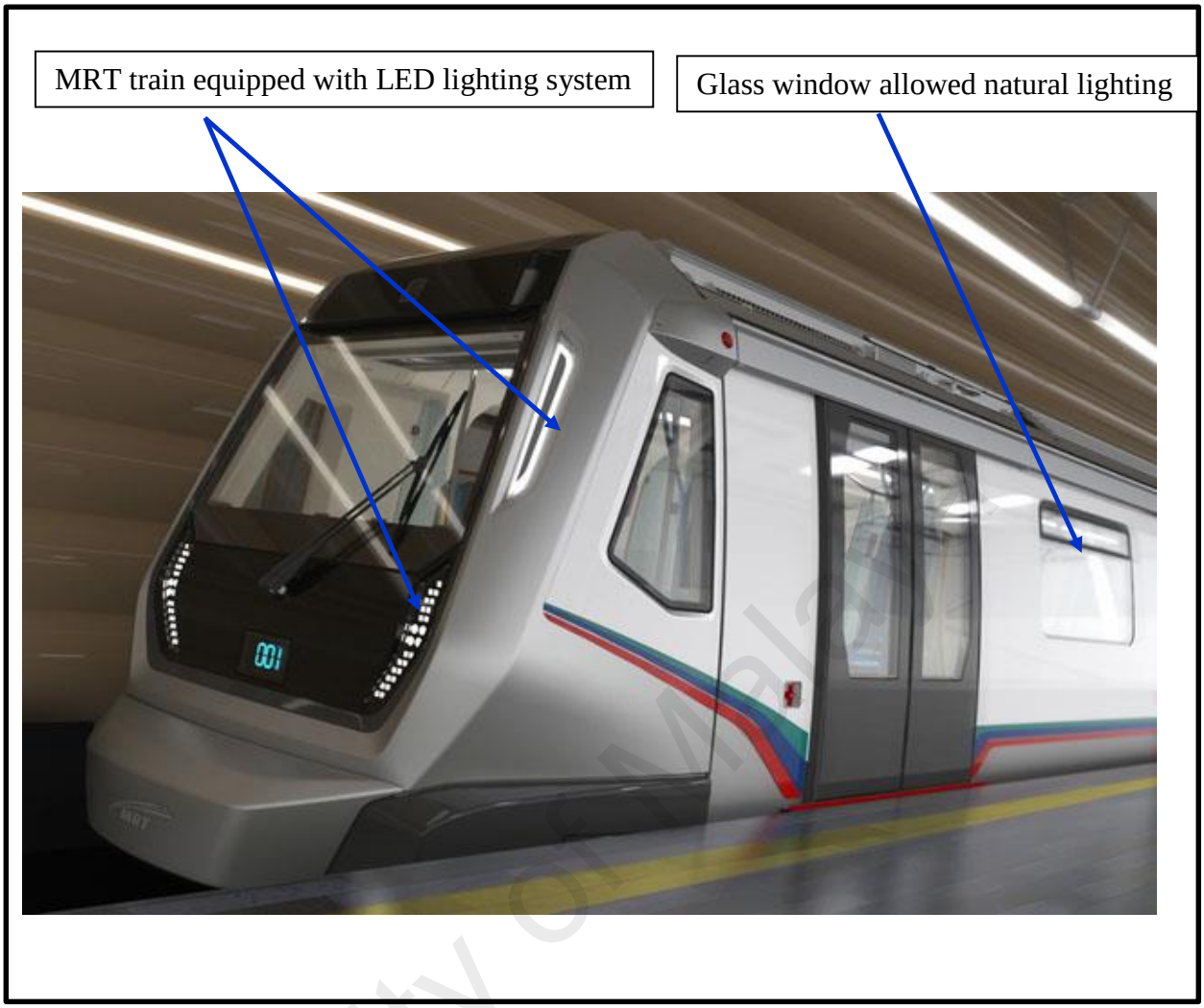

Figure 4.13: LED Lighting System & Glass Window to Reduced Energy Consumption

KVMRT also implemented **sustainable environment** during operation stages by planting beautiful landscaping and close turfing surrounding MRT alignment and station to give a pleasant and green view as shown in Figure 4.14 and Figure 4.15. The whole 51km alignment landscaping trees have been maintained well to bring attractive and sustainable landscaping environment. All the regulations and requirements set by the authorities such as local councils and Keretapi Tanah Melayu Bhd have been implemented accordingly for the proposed landscape area along elevated and underground tracks. Thus, in order to create a greenery theme for MRT commuters, the greatest landscape plans had been implemented. The plants used for MRT landscaping

mostly selected from local species which need less maintenance and suitable for tropical weather. Those landscaping trees planted at all station ranges from trees to shrubs and turfing types to cover the ground. Those shady trees and local flowers planted along the MRT alignment provided lively and pleasant green environment.

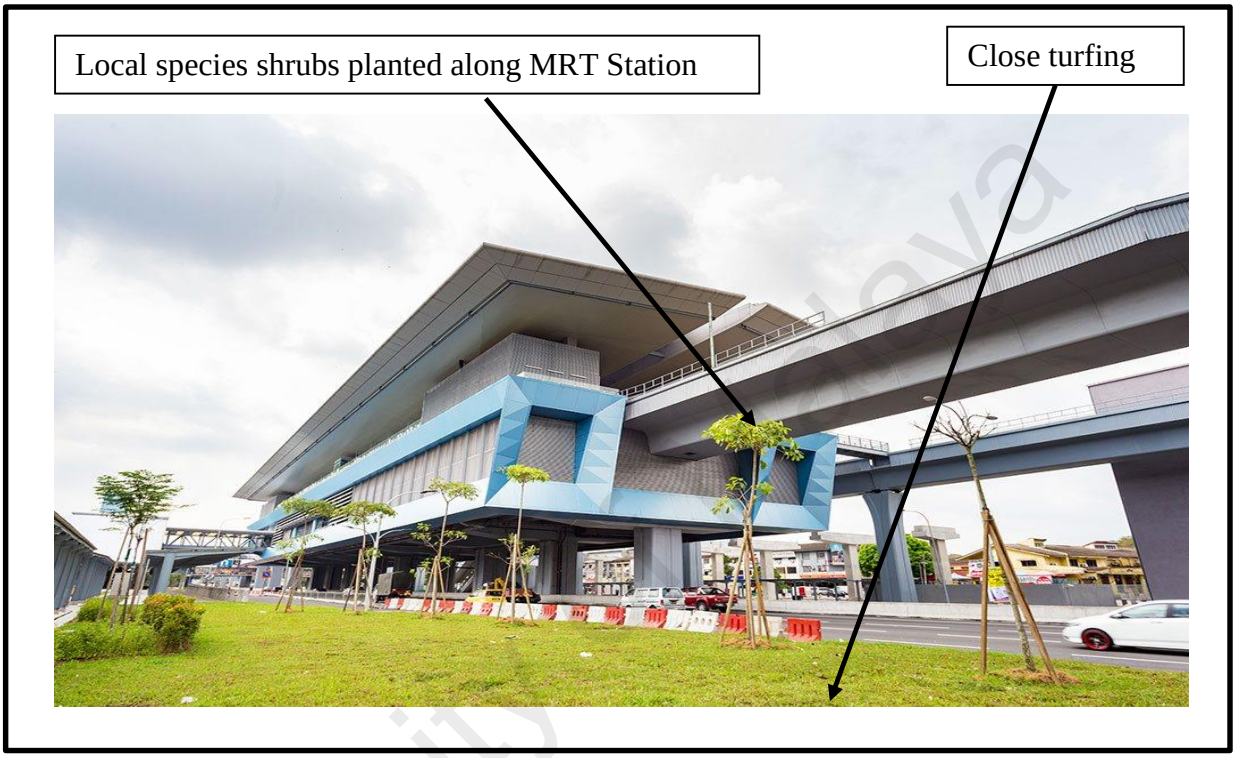

Figure 4.14: Landscaping at Klang Valley Mass Rapid Transit (KVMRT)

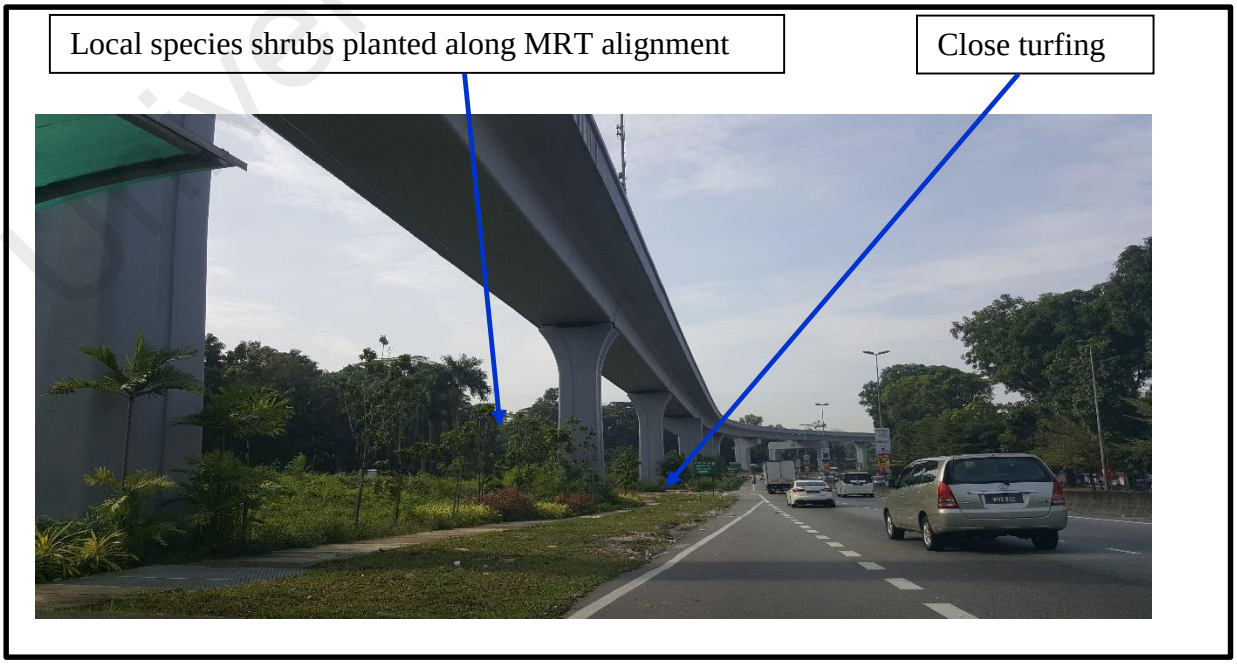

Figure 4.15: Landscaping at Klang Valley Mass Rapid Transit (KVMRT)

The MRT exterior image takes into consideration the specific view of the train when entering the station and along the platform. The colour livery strongly emphasizes the powerful expression of the front-end style. The front-end mask is made of strongly structured shapes and volumes, expressing decision, safety and confidence. Besides looking aesthetically pleasing on the outside, the MRT train's interior design also keeps the people in mind by prioritizing comfort, practicality and user-friendliness.

The interior design of trains equipped with 174 passenger seats in each train with seats in cool blue tones that are light on the eyes, easy to maintain colours and using light long lasting material which bring fresh and sustainable mode. The light, solid grab poles also was provided to optimized traveler protection and their lightly tinted glass are of contrasting clear pattern for subtlety. The ceiling pattern makes use of subtle graphic effects of matte and shine. The grab poles and rails bear a sharply contrasting yet matching colour for better visibility as shown in Figure 4.16. All this indirectly support sustainable environment during MRT operation stages.

Figure 4.16: MRT Interior Design Comfort, Practicality and User-Friendliness

Besides that, MRT also emphasized the importance of **sustainable material** during operation stages by selecting and used eco-friendly product for example provide eco-friendly restrooms that are comfortable for the end-user while also easing maintenance and reducing related costs for the facility to reduce adverse impact to the environment. All the MRT station restrooms as shown in Figure 4.17 used sustainable material by installing motion sensors lighting to turn off lights when the restroom is not in used and no movement detected, replace conventional light bulbs with energy-efficient lighting in restroom areas, using green cleaning chemicals and products, installed sensor taps that turn water on only when needed which can reduce water consumption by as much as 70% and provided recycling bins in restrooms to recycled paper products used in restrooms. This green sustainable material restroom provides energy efficiency, water consumption, and waste reduction which reduced carbon emission to the environment.

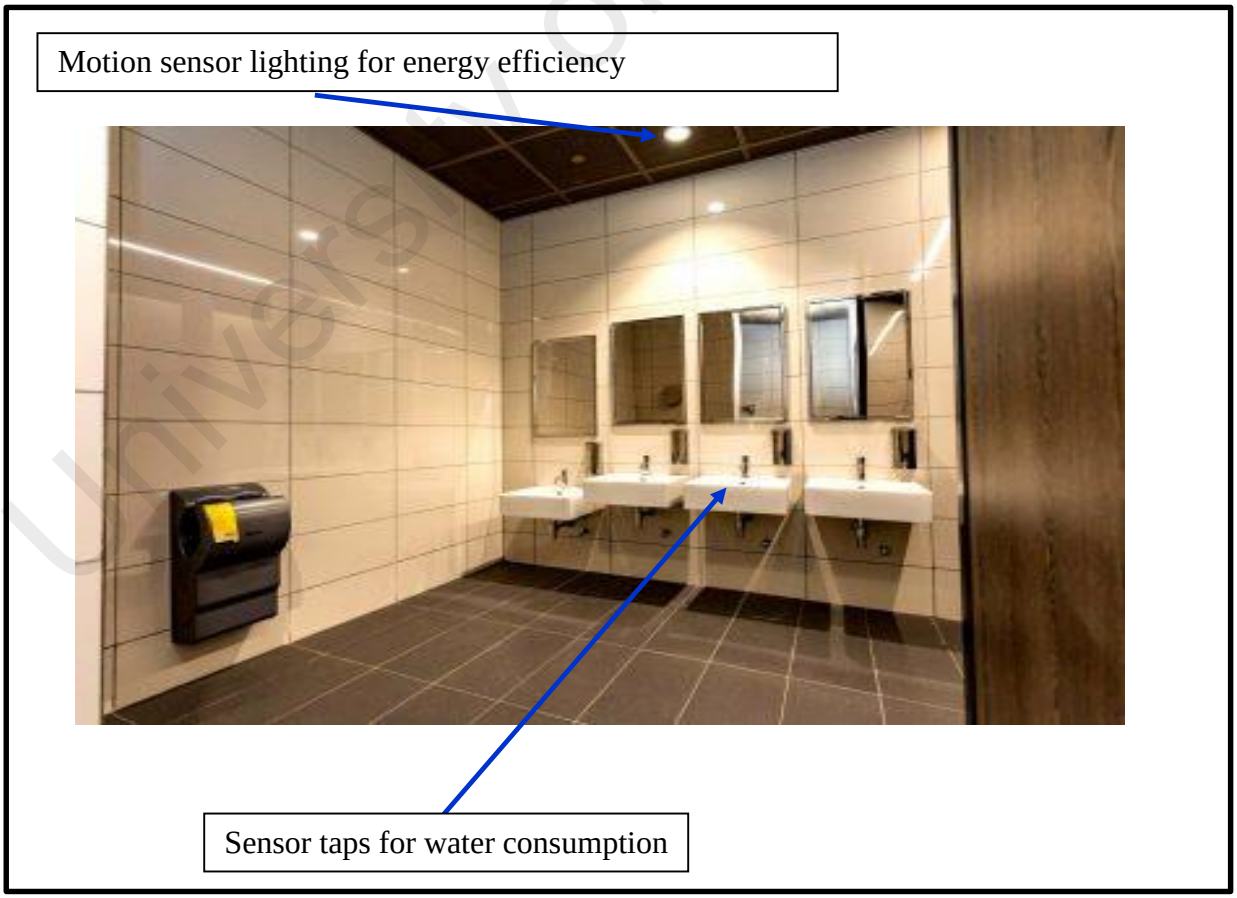

Figure 4.17: MRT Station Environmental Friendliness Restroom

Malaysia's transportation industry has introduced a new era for a more efficient transportation network. The KVMRT Sungai Buloh-Kajang Line has implemented **efficient public transportation system** during operation stages. The KVMRT has provided Park & Ride (P&R) facilities which convenient to people to park the vehicles and continue travelling by MRT train and link to bus and taxi layby interchange for easy travelling mode. Besides that, this park and ride service at MRT station also provided reasonable season parking rates and eliminated high parking service charge during peak hours. Thus, indirectly minimize traffic congestion, reduced carbon emission and fuel and also money saving as shown in Figure 4.18.

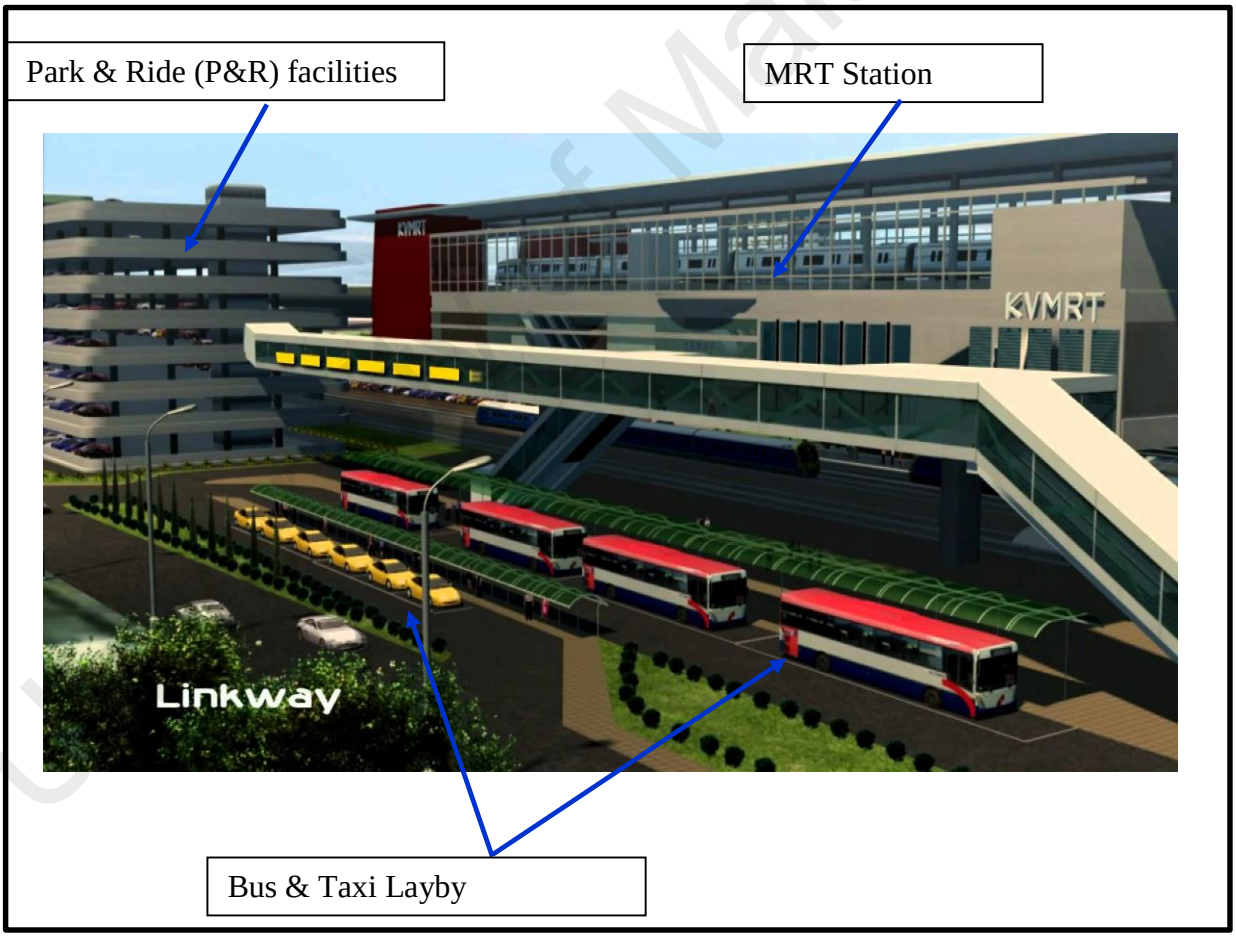

Figure 4.18: KVMRT Park & Ride (P&R), Bus & Taxi Layby Facilities

Besides that, efficient public transportation system from KVMRT also contributed in time savings which hours spend from being stuck in traffic jams can be avoided and saved. The speed of the trains can go up to 100km/h. However, the average speed the trains operated at is 70km/h, which is good enough to end journey (Sungai Buloh to Kajang) which only will take 80 minutes compare to private car which will take 2hours and by public bus around 2.5hours. This will encourage more people to choose MRT as traveling mode in the city which indirectly will reduce traffic congestion and reduce carbon emission as shown in Figure 4.19.

Figure 4.19: Public travel by MRT to avoid traffic congestion in the city

4.5 Carbon Footprints from KVMRT Transportation

Transportation contributed high carbon emission to the environment. The carbon footprints emission has been calculated as per equation stated in Figure 3.2 in Chapter 3. The total length of MRT project phase 1 which has been started operation from Sungai Buloh to Kajang involved total length 51km. The result of calculation contributed to the carbon emission shown in below Table 4.1.

Table 4.1: Carbon Footprint from KVMRT Transportation

Nos	Description	Results
1	Numbers of Trees chopped for KVMRT project (51km)	9700 nos trees (local species)
2	Numbers of Trees planted for KVMRT project	19400 nos tress (local species)
3	Ratio of trees planted for KVMRT project	**= 1:2** Each trees felled for MRT project will be replaced with 2nos trees with ratio 1:2 to maintain the green environment
4	Total km travelled per year by KVMRT	=333 trips per day x 51km length x 365days **≈ 6.2 million km per year** Distance earth to moon = 384,400km Total km traveled per year by KVMRT is =6.2 million km / 0.384million **≈ equal to 16 times distance going to moon**

Nos	Description	Results
5	Total passenger travel by year via KVMRT	= 400 000 passengers per day x 365days =**146 million passenger per year**
6	Total Carbon Footprint per km travel by year through KVMRT	= 6.2 million km x 854 gCO_2/km **= 5,295 tonnes CO_2 per year**

The total numbers of trees have been chopped for KVMRT project are 9700 nos trees along 51km alignment. However, 19400 nos trees had been replaced with new landscaping with ratio 1:2 to maintain the green environment. Total km travelled annually by KVMRT is 6.2 million km per year which equal to 16 times distance going to the moon. Meanwhile the total passenger travelled by year via KVMRT is 146 million passengers per year which equal to 5,295 tonnes CO_2 emission per year.

4.6 Comparison of Carbon Footprints between MRT, Bus and Car in Malaysia

The Carbon Emissions factor θ is calculated in government laboratories where vehicles are rigorously tested. Comparison of Carbon Footprints between MRT, Bus and Car in Malaysia is shown in below Table 4.2:

Table 4.2: Comparison of Carbon Footprints

Transport Mode		
MRT	**BUS**	**CAR**
CO_2 Emission Factor θ		
854 g/km	660 g/km	120 g/km
Total Trips per Day		
= 400 000 passenger /1200 **=333 trips**	= 400 000 passenger / 40 **=10,000 trips**	= 400 000 passenger /4 **=100,000 trips**
Total km travel per year		
=333 trips per day x 51km length x 365days **≈ 6.2 million km per year**	=10,000 trips per day x 20km length x 365days **≈ 73 million km per year**	=100,000 trips per day x 20km length x 365days **≈ 730 million km per year**
Total Carbon Emission per year		
CO_2 = 6.2 million km x 854 gCO_2/km = **5,295 tonnes CO_2 per year**	CO_2 = 73 million km x 660 gCO_2/km = **48,180 tonnes CO_2 per year**	CO_2 = 730 million km x 120 gCO_2/km = **87,600 tonnes CO_2 per year**
Total Carbon Emission per day		
= 15 tonnes CO_2 per day	**=132 tonnes CO_2 per day**	**= 240 tonnes CO_2 per day**
Total Carbon Emission per passenger		
=37.5 gCO_2 per passenger	**=330gCO_2 per passenger**	**=600 gCO_2 per passenger**

Note* Assuming an average loading of 1,200 passengers per train, 40 passengers per bus and 4 passengers per car with average total length km traveled from Sungai Buloh to Kajang 51km by train, 20km by bus and 20km by car.

(1 MRT train set = 30 buses = 300 cars)

Based on the carbon footprint calculation, travel by transport mode MRT release 5,295 tonnes CO_2 per year, travel by transport mode bus released 48,180 tonnes CO_2 per year and travel by transport mode car release 87,600 tonnes CO_2 per year as shown in Table 4.2. Anyway travelling by transport mode MRT is still greener and environment friendly since its release less carbon compare to bus and car.

Table 4.3: Total Saving Travelling by MRT

Mode of Transport	Total Carbon Emission per year (tonnes)	Additional Carbon Emission Compare to MRT (tonnes) Yearly
MRT (replaced by MRT)	5295	-
Bus (All 100% Bus)	48180	42,885
Car (All 100% Car)	87600	82,305
(Bus & Car) (50% Bus +50% Car)	67,890	62,595

Total saving travelling by MRT as shown in Table 4.3 able to reduced additional carbon emission yearly 42,885 tonnes from bus, 82,305 tonnes from car and 62,595 tonnes from bus and car. It was estimated that if 400,000 people were to take MRT as mode of transport every day, it was predicted that the number of cars entering the Klang Valley will drop by 100,000 and able to reduced 82,305 tonnes CO_2 per year which equal to 411,525 trees saving or 9.3 million gallon gasoline saving each year as shown in Table 4.4 below:

Table 4.4: Total Trees and Gasoline Saving from Carbon Reduction

Total Carbon Reduction CO_2 (tonnes) per year	Total Trees Saving (Nos) per year	Total Gasoline Saving (Gallons) per year
82,305 tonnes CO_2	411,525 trees	9.3 million gallons gasoline

Notes: 1000 tonnes CO_2 = 5000 trees saving yearly source (global warming resource carbonify.com)

1000 tonnes CO_2 = 113000 gallon gasoline saving yearly source (Greenhouse Gas Equivalencies Calculator)

4.7 Overall achievement in terms of greening

The MRT SBK Line line from Sungai Buloh to Kajang has been fully operation since July 2017 with approximately travelling time 80 minutes and daily ridership is 400,000 passengers.

Thus, to inspire more people to travel by MRT, 14 multi-storey car parks which can accommodate 8000 parking bays have been provided entire 51km alignment. In addition, 300 feeder buses also have been provided with a capacity of 62 passengers and 10minutes frequency to transport people to the nearby station.

The MRT SBK Line 1 expected to reduce 100,000 vehicles off the road, which translates to a significant reduction in carbon emission. The MRT will achieve greener transportation concept compared to other transportation and also will be more beneficial in terms of productivity, cost saving, and safety.

The next chapter will discuss more details in terms of productivity, cost saving, and safety which contribute on the greening achievement.

4.7.1 Productivity

The Mass Rapid Transit (MRT) services provided greater productivity, which reduced traffic congestion, especially during peak hours and the rainy season and indirectly eliminated hours wasted in heavy traffic. Basically, it takes about 2 hours and 30 minutes (travel by bus) and 2 hours (travel by personal car) during peak hours from Sungai Buloh to Kajang, whereas it only takes 80 minutes' travel via the MRT as shown in Figure 4.20.

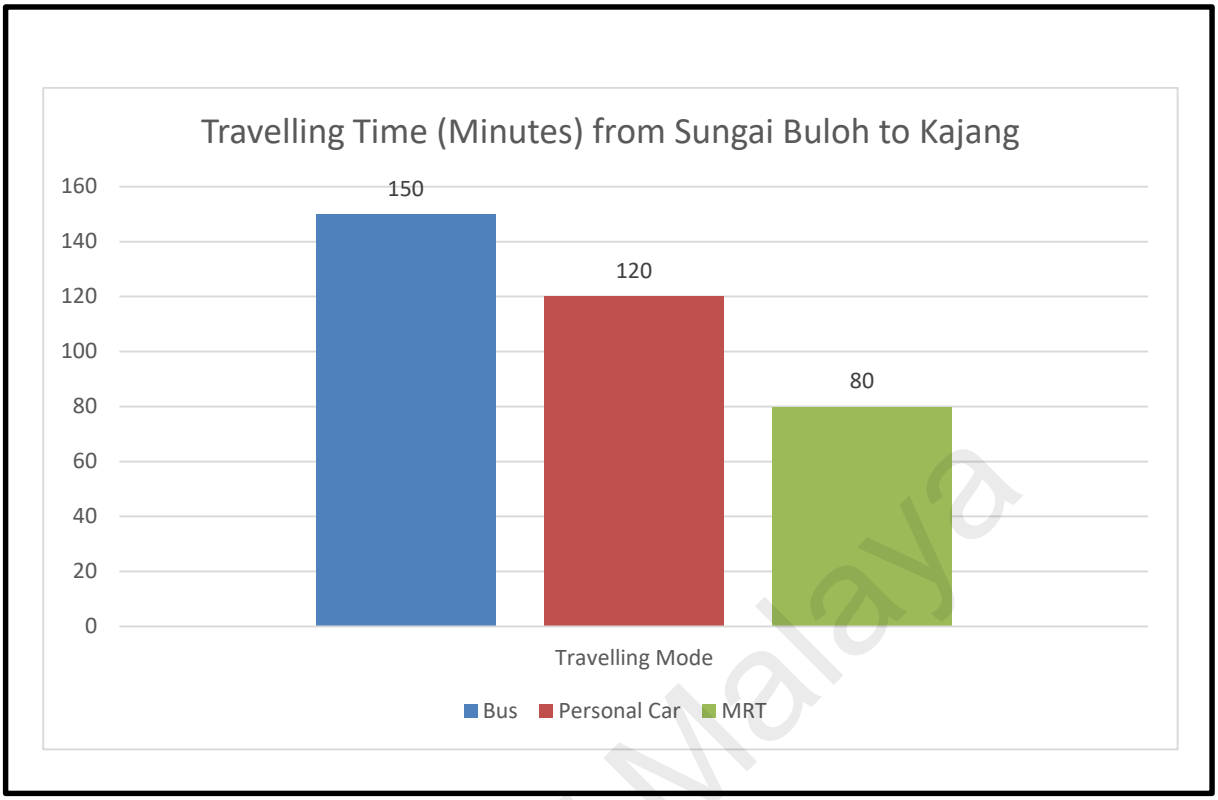

Figure 4.20: Travelling Time (Minutes) from Sungai Buloh to Kajang

Traveling via MRT is expected to shorten travel time from the current approximately 2.5 hours on the road to 80 minutes which contributed 47% increase in productivity.

This efficient public transportation also reduced greenhouse gas emissions by allowing more cars to be off the road which creating a healthier environment and encouraging healthier lifestyles which create greater productivity and better quality of life.

4.7.2 Cost Saving

MRT provided affordable and reasonable fares of the service. Currently travelling from Sungai Buloh to Kajang by taxi will cost RM80, by Uber RM55 and by personal car approximately RM20. However, travelling by MRT will only cost RM5.50 by Touch N' Go or RM6.40 by cash which will be more cost saving compare to other travelling mode as shown in Figure 4.21.

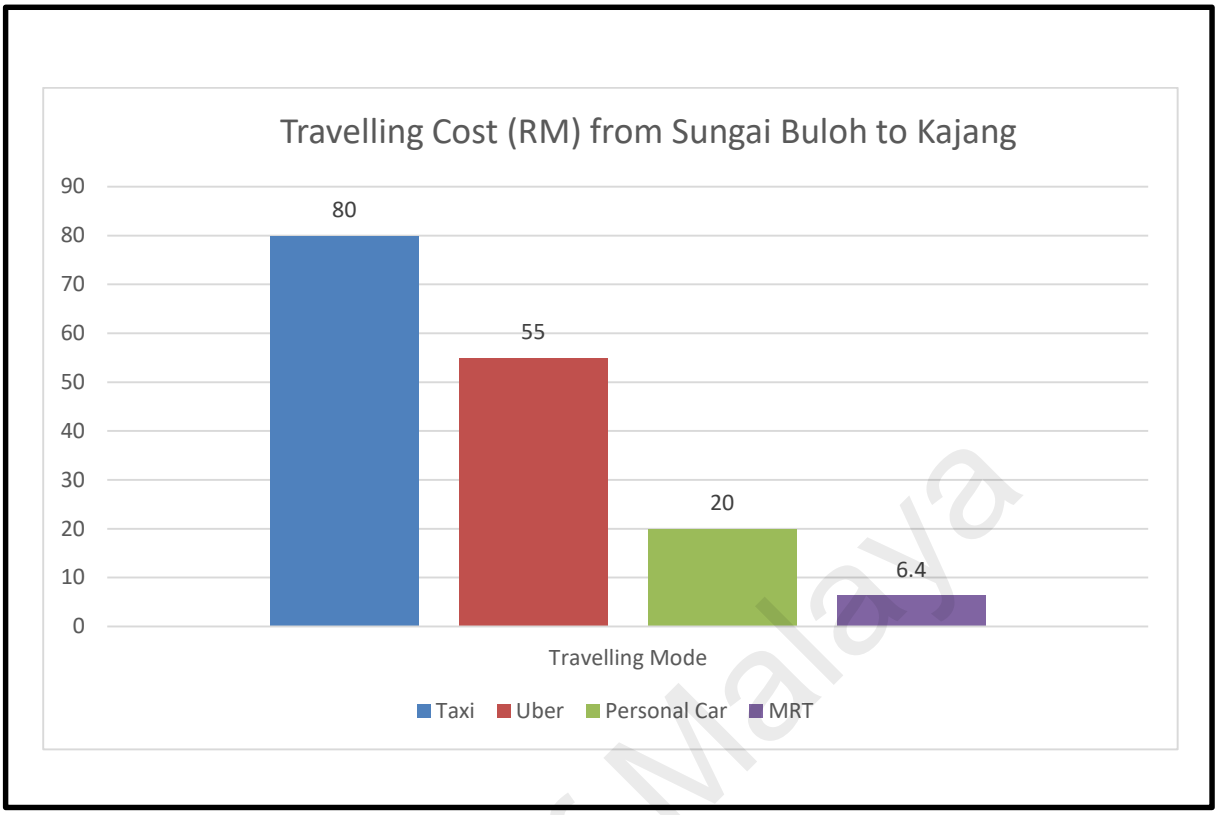

Figure 4.21: Travelling Cost (RM) from Sungai Buloh to Kajang

Besides that, fuel consumption of MRT is much cheaper and economical compare to bus and car as shown in Figure 4.22. Total fuel cost yearly travelled by MRT only took RM4.9million of gasoline compared to bus RM40 millions of diesel and car RM80 millions of petrol with RON95 price RM2.20/L and diesel RM2.18/L.

The cost of tolls and parking also can be saved by travelling via MRT compare to other travelling mode. Travelling by MRT will be more convenient and cost saving since MRT provided reasonable fares with ample facilities such as feeder bus and parking facilities with the green environment mode which encourage more public to choose MRT as their favorite travelling mode.

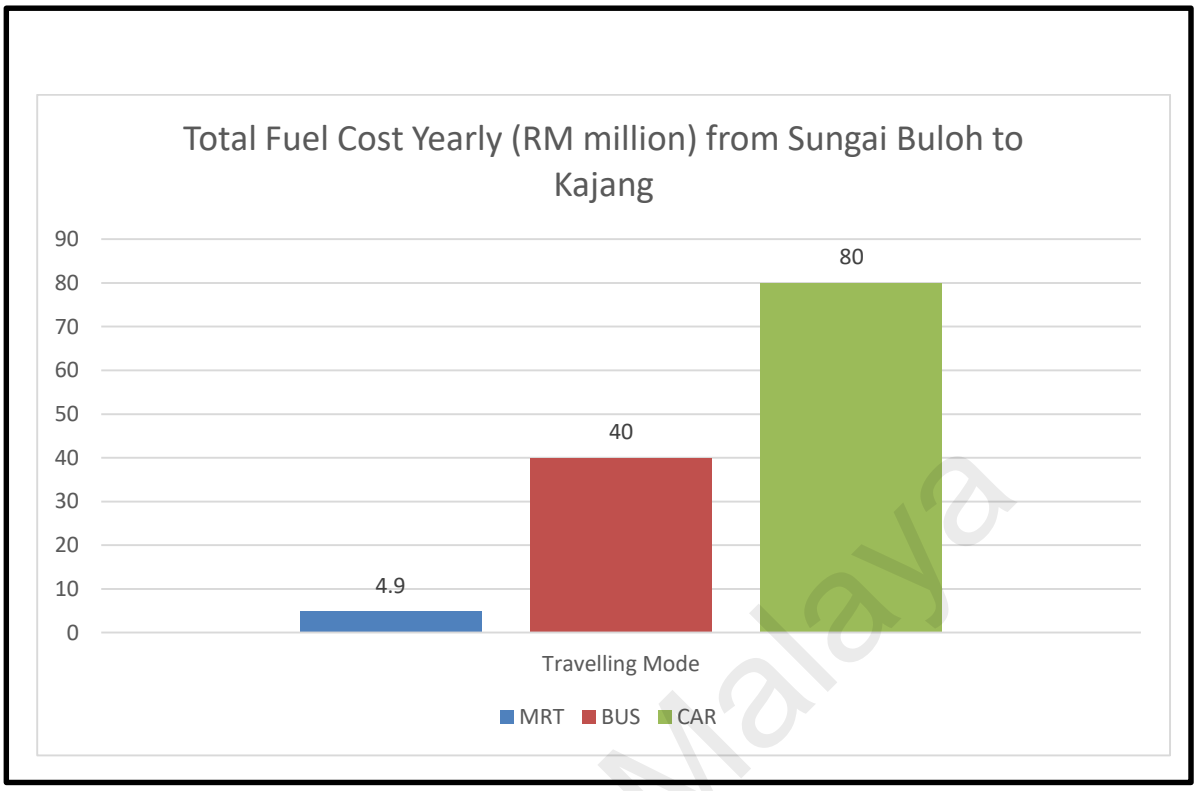

Figure 4.22 : Total Fuel Cost Yearly (RM million) from Sungai Buloh to Kajang

4.7.3 Safety

Safe travelling mode and low accident incident risk can be expected by travelling by MRT compare to other transportation mode. Those employees travelling to and from their workplace, the MRT will be the best choice which offers efficient service and most important assist to lower the quantity of road accidents by creating safe journey transportation mode.

Most of the accidents reported occurred during the early morning peak hour involving workers travelling to and from work. It was found that 88% of accidents happen while travelling to and from work, 68.8% of reported involved workers work in the morning session and 55% of accidents happened within less than 5km from their workplace as per studies conducted by the Social Security Organization (SOCSO) in collaboration with local universities. Moreover, the quantity of road fatalities in Malaysia is upsetting which encountered 6,000 deaths each year equivalent into 18 to 20 people killed daily.

It was expected about 200 fatalities from road accidents can be prevented each year based on KVMRT save travelling system. Hence MRT found to be one of convenient transportation which not only reduce road traffics accidents and carbon dioxide but also create a safe and healthy lifestyle among passengers.

4.8 Summary of Carbon Footprints Reduction

Table 4.5: Carbon Footprints Reduction

Inception Stages	**Construction Stages**	**Operation Stages**
Green Initiatives Option		
Sustainable Energy (train service powered by electricity rather than fossil fuel)	Sustainable Energy (used low- energy sources such as LED lights)	Sustainable Energy (used energy efficiency product such as escalators and regenerative lift)
Sustainable Material (designed lightweight material, durable with long life span)	Sustainable Material (purchased green and eco-friendly product)	Sustainable Material (used green and eco-friendly product
Sustainable Environment (rerouting the alignment of track with minimum clearance and impact to the environment)	Sustainable Environment (affected trees was replaced with landscaping trees with ratio 1:2)	Sustainable Environment (planting beautiful landscaping with good maintenance)
MRT Station Design Connected (transit service with monorail, LRT,KTM and airport trains)	Waste Reduction (practice 3R method in construction)	Efficient Public Transportation System (provide park and ride facilities, time and cost saving)
Possible Reduction		
Reduce energy		
Reduce material wastage		
Reduce deforestation		
Reduce traffic congestion and carbon emission	Reduce wastage	Reduce traffic congestion and carbon emission
Reduction of Carbon Footprint/tonnes per year		
82,305 tonnes CO_2 per year		

4.9 Overall Summary

The green transportation system is an important measure to maintain the environment. In order to achieve green initiatives, all the citizens shall encourage and give priority on choosing a green travelling mode instead of relying on fossil-fueled vehicle. The awareness of low carbon living styles and promotes green travelling needs to be further encouraged and raised. It is vital to reduce energy consumption in transportation activity to achieve sustainable goals through the use of efficient energy vehicle, effective trip management, develop alternative energy by use clean renewable energy and solve environmental and resource effect due to energy consumption. Green initiative implementation in MRT is encouraged in the transportation industry by using sustainable energy, sustainable material, green alignment concept, waste reduction, efficient public transportation system, sustainable environment and conserve water and natural resources. The green public transport system idea is not only to replace immediately personal vehicles yet to give an alternative commute which would encourage a greener future for the environment, improved traffic congestion, time and cost saving.

CHAPTER 5: CONCLUSION AND RECOMMENDATION FOR FUTURE WORK

5.1 Conclusion

Implementation of green initiatives has become important in everyone's lifestyles as it will reduce environmental impact and protect human health. Mass Rapid Transit is considered as one of the green transportation system implemented successfully during inception, construction and operation stages. This green transportation became one of the effective methods to mitigate problems in urban development which found to be efficient, convenient, cost and time effective and environmental friendly. The impact of this green initiative manages to reduce 82,305 tonnes CO_2 per year which equivalent to 411,525 trees saving and 9.3 million gallons gasoline saving each year. This study mainly evaluated overall greening initiatives implemented for Mass rapid Transit Project in Malaysia. The conclusions were captured based on objectives, as per following information:

1) The green initiatives implemented throughout the MRT project in Malaysia was identified and evaluated in three stages during the inception, construction and operation stages. The green initiatives contributed in each stage were discussed and presented briefly in this study.
2) The impact of green technology based on the green transportation concept of the MRT was determined and discussed further in this study. The comparison of carbon reduction between MRT, bus and car was shown and the overall greening achievement in term of productivity, cost saving, safety and environmental benefits were highlighted and presented. In addition, total trees

and gasoline saving based on the carbon reduction was concluded in table form to emphasis on the significance of green technology to the environment.

3) Finally, recommendation on possible green initiatives that can be taken to reduce environmental impact in the future had been presented. Based on the evaluation done, it creates awareness on the importance of green transportation to the environment and human health.

5.2 Recommendation for Future Work

Based on research done, for continuous green initiatives implementation in public transportation, several recommendations can be made to improve future research work.

1. It is recommended that future studies are carried out on green initiatives implementation on all the rail transportation such as LRT, KTM ETS, KTM Komuter, Ekspres Rail Link (ERL) and Monorails rather than focus only on MRT rails to improve and upgrade the green initiatives in rail transportation.
2. Expand the area of study to multiple type of public transportation around Malaysia such as taxis and buses to implement green initiatives into different types of public transportation to reduce carbon emission and maintain a sustainable environment.

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