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TOWARDS CAMPUS SUSTAINABILITY: ESTIMATING ON-CAMPUS VEHICLE CO_2 EMISSIONS IN UNIMAS

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Abstract: Carbon dioxide (CO_2) emission from motor vehicles is a one of major contributing factors to global warming. Efforts to reduce CO_2 emissions should involve all parties including universities. In 2017, Universiti Malaysia Sarawak (UNIMAS) has committed to reduce CO_2 emissions from its campus upon joining the low-carbon campus initiative. Thus, the current study aims to estimate the baseline of on-campus vehicle CO_2 emissions by using mobility analysis of 5,294 entry vehicle data from two main gates (West and East) and 15 parking zones in the campus. Parking volume observations and traffic assignment analysis using the Bureau of Public Roads functions were undertaken to determine the links' volumes. Subsequently, vehicle CO_2 emissions were derived from the estimated vehicle fuel consumption. The results reveal that a total of 1,333.4 kg of CO_2 emissions were expelled by on-campus motorised vehicle movements (which were predominantly petrol cars that comprised 80% of the observed vehicle trips). Additionally, the study discovered that the average on-campus vehicle CO_2 emission was 12.4 kg per kilometre which far exceeds the European Standard for road traffic CO_2 emissions. Thus, to achieve the status of a low-carbon campus, it is imperative for the university management to properly address Sector 3 CO_2 emissions from the transportation segment by employing effective strategies and policies to significantly reduce private vehicle dependency among university staff and students.

Keywords: Sustainability, low carbon campus, fuel consumption, vehicle CO_2 emissions, transportation.

Introduction

CO_2 emissions have continued to increase as human energy consumption has intensified over the years in which the burning of fossil fuels has been the primary source for energy. In 2020, Malaysian CO_2 emissions were estimated to be 256 million tonnes which have increased by an average of 3.1% per annum since 2009 (BP Plc, 2021). The biggest contributor to CO_2 emissions in the country is the electricity energy sector, followed by transportation and waste management (handling and disposal) sectors. In the 10th Malaysian Plan, the government of Malaysia has committed to reducing its carbon dioxide emission intensity to the gross domestic product (GDP) by 40% per GDP by 2020 to reduce the country's carbon footprint (Ho *et al.*, 2013). Consequently, the Ministry of Energy, Green Technology and Water has developed a framework for low-carbon cities that guides the implementation on reducing carbon emissions in the country.

As far as upholding sustainability is concerned, universities are expected to practise significant responsibilities to resolve issues pertaining to sustainability and serve as a role model to society. The institutions should embark on sustainable plans that facilitate and monitor negative environmental impacts by campus facilities and activities that highly consume energy, particularly from electricity-driven infrastructures and on-campus transportation activities. In addition, implementation of good sustainability practices in the university's policies and curricula would then influence the industry's commitment towards reducing CO_2

emissions when the university's graduates are employed by the industry.

In 2017, Universiti Malaysia Sarawak (UNIMAS) has decided to join the low-carbon campus (LCC) initiative. As such, a local sustainability plan should be devised and implemented to reduce CO_2 emissions in the campus. A baseline study is therefore required to measure the campus CO_2 emissions, in which this study aims to estimate the level of on-campus CO_2 emissions from motorised vehicles. From the results of the baseline study, the university's management could then devise proper strategies and policies to become a more energy-sustainable campus.

Literature Review

Energy contributes the highest number of CO_2 emissions to the atmosphere. Since the industrial revolution, human sources of CO_2 emissions have grown. Generally, CO_2 emissions are proportionate to the amount of fuel consumption. The combustion of fossil fuels is the largest human source of CO_2 emissions, making up 87% of the total emissions. Burning these fuels releases energy, which is mostly turned into heat, electricity or power for transportation. They are used in power plants, cars, planes and industrial facilities. In 2011, fossil fuel use created 33.2 billion tonnes of CO_2 emissions worldwide (Le Quéré *et al.,* 2012). The three types of fossil fuels that are used the most are coal, natural gas and oil. Coal generates 43%, oil (36%) and natural gas (20%) of CO_2 emissions from fuel combustion (Quadrelli & Peterson, 2007).

Transportation emits several other gases, including N_2O, CH4 and NH_4 but it is also one of the major contributors of CO_2. It is well known that the transportation sector is the second largest source of anthropogenic CO_2 emissions. About 22% of fossil fuel-related CO_2 emissions in 2010 were produced in transporting goods and people around the world (Quadrelli & Peterson, 2007). The study added that the transportation sector is very energy intensive and it uses petroleum-based fuels, such as gasoline, diesel and kerosene. Since the 1990s, transport-related emissions have grown rapidly, increasing by 45% in less than two decades. The industrial and construction sectors rank third in terms of releasing CO_2 to the atmosphere. The four main types of industrial processes that are significant sources of CO_2 emissions are the production and consumption of mineral products such as cement, the production of metals such as iron and steel and the production of chemicals and petrochemical products.

The emissions caused by the transportation have grown so rapidly that the amount has surpassed the emissions from the industrial sector. This trend started in the 1990s and has continued ever since, causing an increase in indirect emissions. Since the distance travelled by goods during production is continuing to grow, more pressure on the transportation sector leads to the creation of more indirect emissions. The rapid growth of the economy, well developed urbanisation and the rise in stable incomes have caused a rapid increase in the demand for passenger transport services (Kasipillai *et al.,* 2008). Conclusive evidence proves that as people gain stabilised income, they make use of faster modes of transport which could contribute to another way in terms of effects on the environment (Profillidis *et al.,* 2014). In Malaysia, with 85.2 % of the total CO_2 emissions, total road transportation makes up the largest share, followed by aviation, maritime and railways. Private vehicles such as motorcars and motorcycles are the most common components of road transportation.

Rapid growth in the prevalence of private car ownership has made the road transportation sector a stopping way in the fulfilment of the goals of CO_2 emissions reduction (Cheng & Lu, 2015). A negative impact on national economic growth will come from the CO_2 emissions reduction efforts in the transportation sector. However, increasing fuel efficiency without affecting economic growth can be achieved by advances in vehicle technology, which could decelerate the growth in CO_2 emission level and intensity (Aizura *et al.,* 2010; Khalid, 2014). In determining the emission factors per vehicle class, the type of engine and fuel type can be identified and classed for further emission calculation (Klien *et al.,* 2012). The types of engines and type contribute to the combustion of motor fuels that leads to the emission of gases. The increase in fuel consumption results in an increase in the distance travelled by a vehicle, thus created an increasing level of CO_2 emissions (Zanni & Bristow, 2010). The option of having more efficient cars will increase the distance travelled but reduce fuel consumption and CO_2 emissions.

In Malaysia, the highest amount of CO_2 emissions among all the sectors in the country based on energy consumption is the transport sector (Mustapha & Bekhet, 2016). Based on fossil fuel consumption, the transportation sector accounts for almost 39% of the national greenhouse gas emissions (Ong *et al.,* 2012).

Under the GHG Protocol, the World Business Council for Sustainable Development and World Resources Institute (2021) categorises an organisation's CO_2 emissions into three major scopes. Scope 1 covers direct emissions that comprise emission sources operated by the organisation, Scope 2 is indirect emissions which includes emissions from the electrical energy consumption by the organisation while Scope 3 covers other indirect emissions from sources or activities which are not controlled by the organisation such as staff and students commuting in and out of the campus. In the case of universities, CO_2 emissions are generated by different major energy consuming sectors or activities, namely heating, waste and transportation (Altintasi & Tuydes-Yaman, 2016). Indirect emissions from Sector 3, which is primarily generated by transportation trips to the university campus, contributed the highest quantity of a university's total CO_2 emissions (Yanez *et al.,* 2019).

Several studies have been undertaken to measure on-campus CO_2 emissions considering different production categories. For example, Larsen *et al.* (2011) found that the carbon footprint of the Norwegian University of Technology and Science was 4.6 tonnes per student by using the Environmentally Extended Input-Output (EEIO) model to calculate CO_2 emissions. Yanez *et al.* (2019) discovered that transportation activities was the highest contributor of carbon emissions (0.41 tCO_2e per person) in the University of Talca, Chile in 2016 where the transportation of students within and out of the campus was identified as the primary source of emission contributor. In another study, Adenle and Alshuwaikhat (2017) estimated that the total campus CO_2 emissions for the King Abdullah University of Science and Technology in Saudi Arabia were 127.7 tCO_2e. In Portugal, Veludo *et al.* (2021) found that commuting trips to the Maiêutica Academic Campus produced CO_2 emissions of 2,937 tCO_2/year.

In Malaysia, a study undertaken by Abdul Azeez (2018) estimated that the Universiti Teknologi Malaysia (UTM) campus in Johor generated a total of 46,000 $MtCO_2$ emissions in 2011. The study revealed that the electricity energy sector accounted for the highest CO_2 emissions at 74% while transportation activities contributed to 26% of the total campus CO_2 emissions. In 2019, Zakaria *et al.* (2019) investigated on-campus CO_2 emissions from the transportation sector at the Universiti Kebangsaan Malaysia (UKM) main campus. The study discovered that the total on-campus vehicle CO_2 emissions was 7,900 kg CO_2/year/capita.

Materials and Methods

Past studies have employed different methods for estimating vehicle CO_2 emissions (Faiz *et al.,* 1996; Ribeiro & Balassiano, 1997; Asian Development Bank, 2010; Gharineiat & Khalfan, 2011; Larsen *et al*., 2011; Kakouei *et al.,* 2012; Mathez *et al.,* 2013; Lui *et al*., 2015; Kan *et al.,* 2018; Veludo *et al*., 2021). The application of these methods would depend on the study's required data types, amount of time given and the costs involved for data collection. Of these methods, the estimation of vehicle CO_2 emissions is primarily governed by the total fuel consumption by the motorised vehicles.

Motor vehicle fuel consumption is dependent on the vehicle's engine type, speed and the amount of distance travelled (Faiz *et al.,* 1996; Asian Development Bank, 2010; Gharineiat & Khalfan, 2011; Lui *et al*., 2015; Kan *et al.*, 2018). In research, obtaining enough and accurate data for fuel consumption parameters from transportation trips are very challenging. To obtain a large amount of transportation trip-related information, some previous studies (Larsen *et al.,* 2011; Kakouei *et al.,* 2012; Mathez *et al.,* 2013; Veludo *et al.,* 2021) used surveys in their investigation to estimate vehicle fuel consumption. Henceforth, CO_2 emissions quantification can then be undertaken which generally increases proportionately with the amount of fuel consumed (Ribeiro & Balassiano, 1997).

Study Location

The UNIMAS main campus spans an area 250,00 m^3 in which there are 11 main faculties and buildings, 15 major parking zones (with a total parking space of 11,631, 6,998 for cars and 4,633 for motorcycles) and 6 student colleges. The campus is divided into the main campus (West) and the old campus (East). There are two entry and exit points which are shown in Figure 1, the West Campus Gate (G1) and East Campus Gate (G2). Note that the southern gate has been closed for safety reasons.

Traffic Volume Estimation

In their study on vehicle emission, Wang *et al.* (2020) used daily traffic data to estimate vehicle emissions at the Jingfu National Highway in Hebei, China. For this study, the traffic volume survey was observed on Wednesday from 7.00 am until 6.00 pm in 2019 (Semester 2, 2018-2019 session) based on video footage captured at the West entrance and East entrance. A summary of the observed daily entry traffic flows is provided in Table 1.

Parking observations were also conducted on the same day and consequently the proportions of the campus parking turnover were used to distribute the entry traffic volumes to the respective parking zones in the west campus. There are five potential routes to gain access to the parking zones in the main campus (Appendix A). In addition, free-flow travel time for the identified routes was estimated based on the campus posted speed limit of 40 km/h. For mobility analysis, origin and destination (OD) estimated routes lengths and their respective travel times are attached in Appendix B.

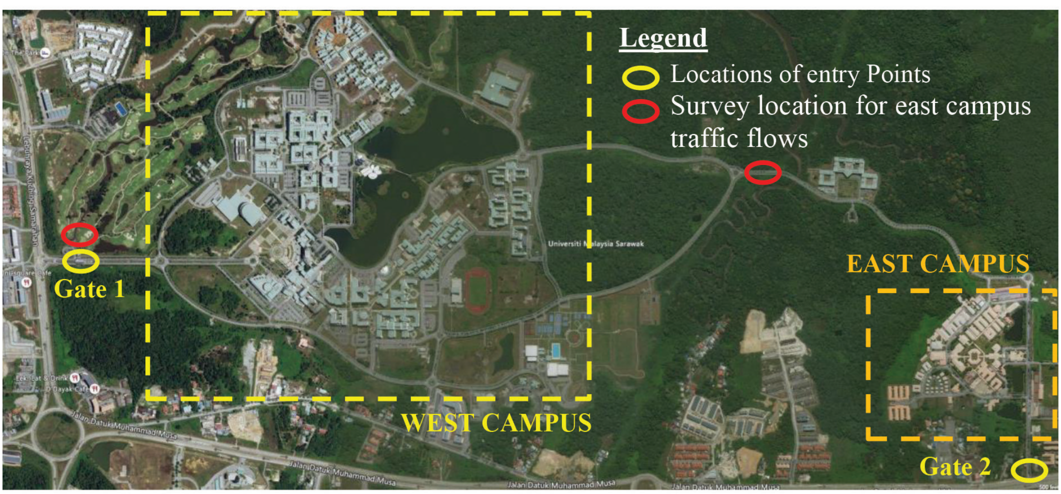

Figure 1: Location of UNIMAS main entry gates

Table 1: Observed daily traffic volume entering UNIMAS from the West and East gates

Vehicle Type	Entering from the West Campus	Entering from the East Campus
V_1 Motorcycle	478	242
V_2 Private car (diesel)	146	25
V_3 Private car (petrol), cc < 1,000	808	56
V_4 Private car (petrol), cc 1,001 – 1,500	1,111	704
V_5 Private car (petrol), cc 1,501 – 2,500	1,288	311
V_{15} Private light bus (diesel)	45	36
V_{31} Light goods vehicle (petrol), weight < 1.9 T	27	6
V_{32} Light good vehicle (petrol), weight > 1.9 T	9	2
Total	**3,912**	**1,382**

Traffic Assignment

Henceforth, traffic assignment (for each of the parking zones) was undertaken using the capacity restraint method, (The United States Bureau of Public Roads [BPR], 1964) to estimate and distribute the zone's traffic volume on the potential access routes. As far as the suitability of the BPR model application in the Malaysian context, Leong and Tan (2015) suggested that for traffic assignment modelling, by using EMME software, the BPR function can be used to estimate the link travel time upon software calibration. According to the US Highway Capacity Manual (2000), the typical values for α and β are 0.15 and 4, respectively. As for the lane capacity, the Malaysian Highway Planning Unit (2006) recommended 1,800 vehicles per hour per lane for the basic lane capacity.

The BPR formula for a link travel time can be expressed as:

$$T = t_0\ (1 + \alpha\ (\frac{V}{C})^{\beta} \qquad (1)$$

where T = link travel time, t_0 = free-flow travel time, V = assigned traffic volume, C= the link capacity, α = coefficient (set at 0.15) and β = exponent (set at 4.0).

Fuel Consumption Estimation

For fuel consumption estimation, this study used the mathematical model approach introduced by Ribeiro and Balassiano (1997). In general, the model applies average fuel consumption for the observed vehicles as claimed by their manufacturer. Briefly, the model is specified as follows:

$$F_c = A_c\ x\ V\ x\ R_D \qquad (2)$$

where F_C = fuel consumption by types (diesel or petrol) (L), A_c = average fuel consumption by the vehicle per kilometre (L/km), V = volume of vehicle and R_D = vehicle distance travelled (km).

The Energy Efficiency Office of Electrical and Mechanical Services Department of Hong Kong (2020) published the average fuel consumption for different types of vehicles as shown in Table 2.

Estimation CO_2 Emissions

Subsequently, the following formula is used to estimate CO_2 emissions considering different types of vehicles as well as different fuel types (Ribeiro & Balassiano, 1997; Kakouei *et al.,* 2012). The CO_2 emissions model is expressed as follows:

$$EM(CO_2) = F_C\ x\ SG_F\ x\ CP_F\ x\ EF_F \qquad (3)$$

where SG_F = specific gravity of the used fuel (kg/m^3), CP_F = calorific power of the fuel (kcal/kg) and EF_F = emission factor of the fuel (tCO_2/TJ).

Table 2: Transport energy utilisation index

Vehicle Type	Average Fuel Consumption, A_c (L/km)
V_1 Motorcycle	0.041
V_2 Private car (diesel)	0.108
V_3 Private car (petrol), cc < 1,000	0.079
V_4 Private car (petrol), cc 1,001 - 1,500	0.091
V_5 Private car (petrol), cc 1,501 - 2,500	0.116
V_{15} Private light bus (diesel)	0.118
V_{31} Light goods vehicle (petrol), weight < 1.9 T	0.124
V_{32} Light good vehicle (petrol), weight > 1.9 T	0.110

Other parameters such as specific gravity, calorific power and emission factor of both diesel and petrol are also required to calculate the amount of CO_2 emissions shown in Table 3 (Ribeiro & Balassiano, 1997; Kakouei *et al.,* 2012).

Results and Discussion

On-campus Private Car Demand Analysis

A simple statistical analysis was used to analyse the daily traffic flow data for the study period. Figure 2 shows the percentage of the vehicles based on the observed vehicle classification. In general, petrol passenger cars (regardless of the engine capacity) dominate the type of vehicles used by staff and students to travel to the campus by 80%. The motorcycle is the second highest (16%), followed by diesel car (3%), bus (2%), light goods vehicle (1%) and then, goods vehicle (0.2%).

CO_2 Emissions by Vehicle Classification

The overall daily generation of CO_2 emissions from the vehicle movements on campus is shown in Figure 3.

It is interesting to note that petrol car (with an engine capacity of 1,000 cc to 1,500 cc) generated the highest CO_2 emissions on the campus by 527.8 kg, followed by petrol cars with an engine capacity of 1,501 cc to 2,500 cc which produced 475.7 kg of CO_2 emissions and then petrol cars with an engine capacity of below 1,000 cc which emitted 148.3 kg of CO_2 emissions. Overall, the total vehicle CO_2 emissions on campus were 1,330.3 kg.

CO_2 Emissions Based on Routes

Figure 4 presents the estimated CO_2 emissions for different routes used by the motorised vehicle to reach various parking zones in the campus from the two main entrances.

As can be seen from Figure 4, Route 5 (from the East Gate to the parking zones: Z5, Z4, Z3, Z2, Z12, Z13 and Z1) recorded the highest amount of CO_2 emissions generated by vehicles that travelled along this route at 312 kg. Route 3 (from the West Gate to the parking zones: Z11, Z10, Z9, Z8, Z7 and Z6) scored the second highest with respect to the amount of the route's CO_2 emissions. As the majority of the travelling routes (Route 1 (b), Route 2 and

Table 3: Chemical properties of fuel

Type of Fuel	SG_F (kg/km^3)	CF_F (Kcal/kg)	EF_F (tCO_2/TJ)
Diesel	8.85×10^{-7}	10700	74.1
Petrol	7.37×10^{-7}	11464	69.3

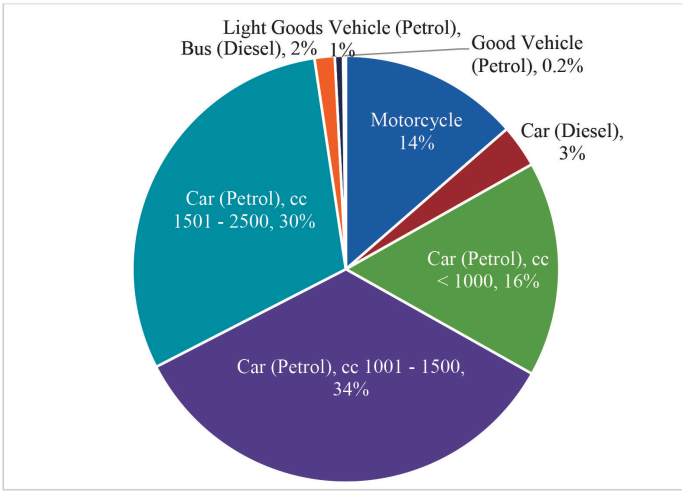

Figure 2: Distribution of entry vehicles

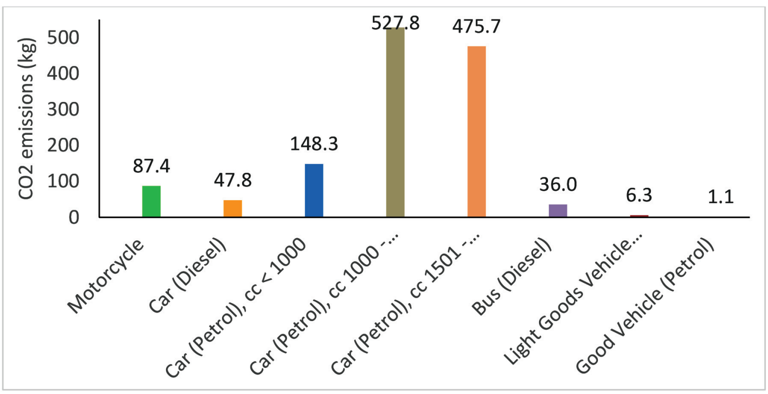

Figure 3: CO_2 emissions by vehicle classification

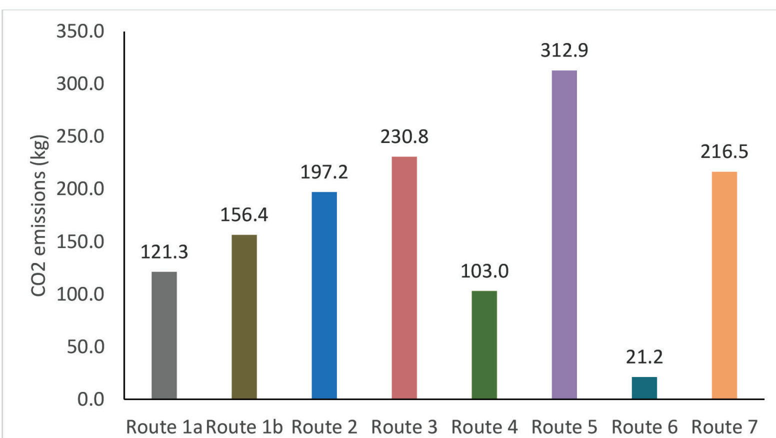

Figure 4: CO_2 emissions based on routes

Route (5)) to the parking zones in the campus are using Jalan Ensurai, this road experienced the highest total amount of CO_2 emissions from vehicle movements in the campus at 666.5 kg.

CO_2 Emissions Based on Parking Zones

The results for CO_2 emissions generated by the parked vehicles at various parking zones in the campus are shown in Figure 5.

Obviously, Zone 9 recorded the highest CO_2 emissions from the vehicle movements on campus that were parked in this zone (243 kg). Furthermore, the distance travelled from the West and East Gates to this parking zone is quite long (1.2 km and 3.6 km respectively). This result is likely to be related to the highest volume of vehicles parked in Zone 9 (985 vehicles) as compared with other parking zones. Parking Zones 12 and 4 shared similar figures at 177 kg which scored the second highest vehicle CO_2 emissions. These two parking areas are located near the central teaching facilities (CTF 3 and CTF 4) which serve core university activities such as teaching and faculty administration. Parking Zone 2 which recorded the third highest CO_2 emissions (105.7 kg) is primarily allocated for the university administrative staff and top university management.

Discussion

The total estimated on-campus vehicle CO_2 emissions were found to be 1,330.3 kg. Considering the total distance travelled in the campus of 107 km for five major routes to access 15 parking zones in the campus from the two main entry points, the average vehicle CO_2 emission was found to be 12.42 kg per kilometre. Such a figure is considered extremely high when compared with the maximum value of 0.130 per kilometre for 2015 to 2020 road transport emissions standard set by the European Commission in 2009. This result may be explained by the fact that the majority of the trips among the university's staff and students to the campus involve private vehicles.

In total, there are 11,631 parking spaces on campus that are free of charge. Thus, the abundance of free parking facilities encourages more private vehicle usage among commuters (Chester *et al.,* 2018). From the analysis, 80% of the observed vehicle trips entering the campus were by private vehicles. Only 2% of the total campus trips involved university buses (students). Obviously, the travel demand pattern in the campus is highly dependent on private vehicle usage. Thus, such a travel demand trend needs to be modified which requires the university's intervention. For example, the implementation of an effective parking policy and reasonable parking charges to increase solo travel costs have resulted in more commuters using the public transport systems (Washbrook *et al.,* 2006). Moreover, a higher proportion of public transportation mode share in travel demand would lead to a lesser amount of CO_2

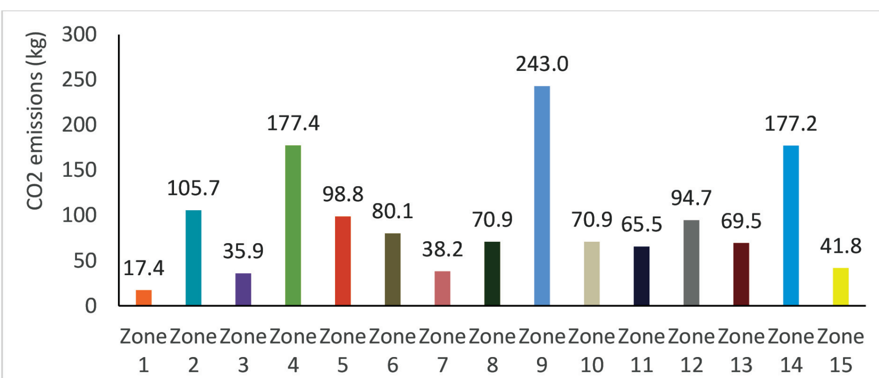

Figure 5: CO_2 emissions based on parking zones

emissions attributable to the reduction in private vehicle usage (Ribeiro & Balassiano, 1997).

By implementing parking charges, a comparative study found that such policy reduced the parking search time by 15% and the search distance by 15% (Alemi *et al.,* 2018). Such reduction in the cruising for parking search time has led to fuel savings and thus reduce vehicle emissions (Čuljković, 2018). In another study, Cruz *et al.* (2017) discovered that the application of parking charges on campus resulted in an approximately 75% reduction in campus vehicle emissions. In addition, the generated revenues can be utilised by the institution to fund the upgrade of the buses, subsidise the fees and the supporting infrastructures (e.g., bus stops and footpaths). The implementation of parking charges will indirectly encourage carpooling among the university's communities. For example, the encouragement of ride-sharing among staff members in one of the Italy's large service companies has resulted in the total company's vehicle emissions to be reduced by 28% (Bruck *et al.,* 2017).

On the other hand, fostering the use of public transportation on campus as part of the LCC strategies has yielded positive results on vehicle emission reduction. For example, the implementation of a 300 km travel distance by bus policy in Universiti Teknologi MARA has reduced vehicle emissions by 6% (Ramli *et al.,* 2014). Additionally, investments in modern technology for buses have yielded significant reductions in vehicle emissions. For example, 40-foot compressed natural gas buses used in the BRT system leads to a 300% reduction in CO_2 as compared with light-rail transit (Vincent & Jerram, 2006).

As the past research discussed above provide positive evidence on the use of parking policy and charges, encouraging the use of public transportation and ride-sharing among the university's commuters to reduce on campus vehicle emissions, the university management should prioritise these strategies that facilitate the reduction of car dependency among the university's staff and students to achieve the LCC status. At the same time, the university should work closely with the local government and ministry to establish an effective and efficient public transport system (service and infrastructure) to support the university's LCC strategies.

Conclusion

This study estimates on-campus vehicle CO_2 emissions based on mobility analysis of data on 5,294 entry vehicle trips from the two main gates (West and East) and 15 parking zones at the UNIMAS main campus. Based on the study's estimation, a total of 1,333.4 kg of CO_2 was emitted by motorised vehicle movements on the campus, which were predominantly contributed by petrol cars (80% of the observed vehicle trips). It was also discovered that the average on-campus vehicle CO_2 emissions were 12.4 kg per kilometre, which far exceeds the European Standard for road traffic CO_2 emissions. As almost all of the university staff commute campus by private vehicles, the LCC status could not be achieved without properly addressing CO_2 emissions from Sector 3 which is considerably contributed by private vehicle trips (staff and students).

On the other hand, the parking policy and charges on campus need to be examined and implemented to strongly support the LCC initiative. Additionally, to encourage more staff and students to use public transportation, inevitably, the university management needs to work closely with the local authorities and ministry to establish an efficient public transport system that connects the campus with the major surrounding developments.

In this study, only on-campus CO_2 emissions from vehicle trips were examined. Thus, the future study can focus on the estimation of the carbon footprints for the commuting trips among the university's staff and students.

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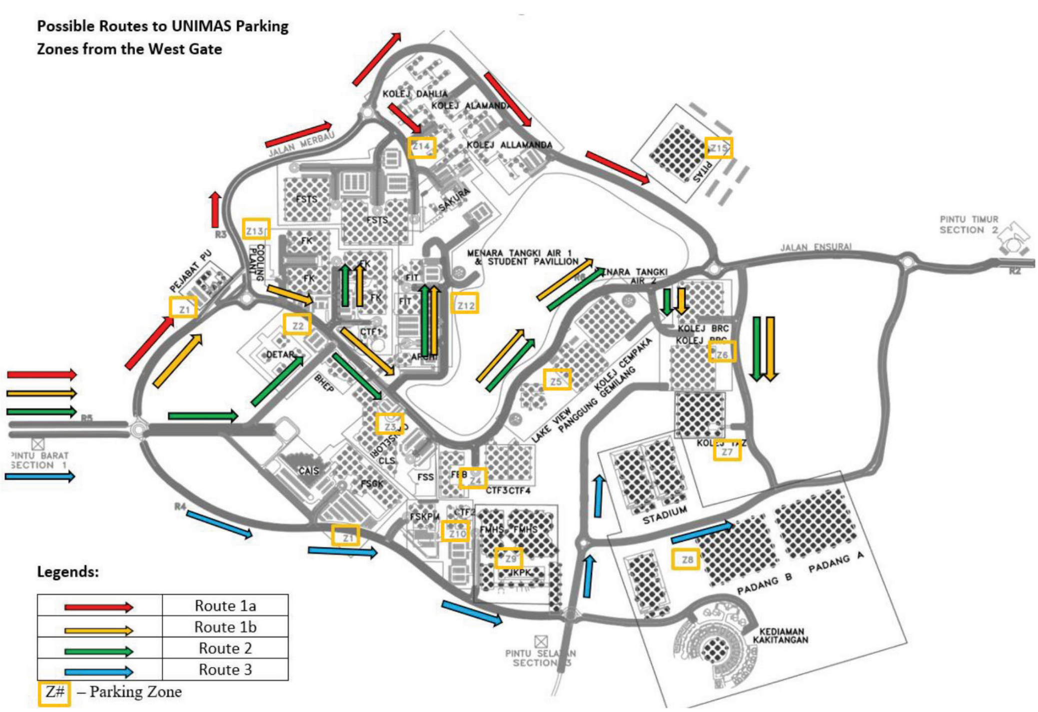
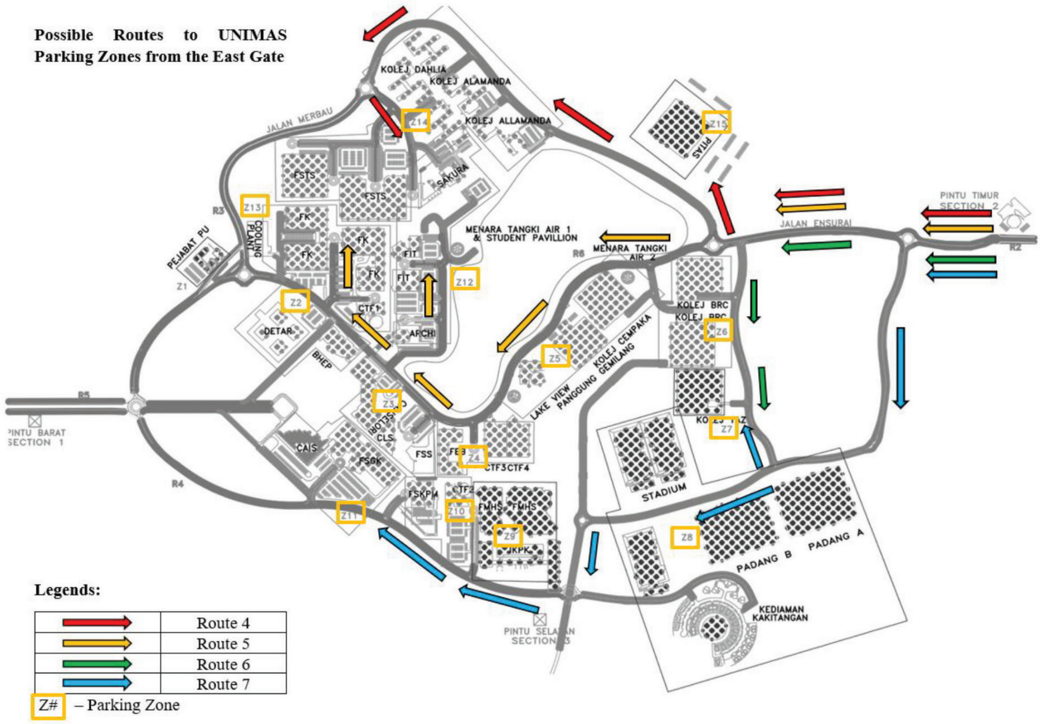
Appendix

Appendix A: Five potential routes to gain access to the parking zones in the main campus





Appendix B: Origin and destination (OD) estimated routes lengths and their respective travel times

From Gate	To Zone	Zone's Volume (veh)	Route	Returning Trip Distance (km)	Free Flow Travel Time (hour)	Assigned Route Volume
West	1	86	1a	1.50	0.01	64
East			5	9.40	0.06	22
West	2	389	1b	2.60	0.02	96
			2	1.60	0.01	192
East			5	8.80	0.05	101
West	3	163	1b	2.60	0.02	40
			2	2.40	0.01	80
East			5	8.60	0.05	42
West	4	714	1b	3.20	0.02	264
			2	3.00	0.02	264
East			5	8.00	0.05	186
West	5	390	1b	3.60	0.02	144
			2	3.40	0.02	144
East			5	7.40	0.05	101

West	6	304	1b	4.60	0.03	75
			2	4.40	0.03	76
			3	5.00	0.03	76
East			5	6.80	0.04	40
			6	6.00	0.04	40
West	7	113	1b	5.80	0.04	36
			2	5.60	0.03	48
East			6	6.60	0.04	15
			7	6.40	0.04	15
West	8	161	3	4.20	0.03	119
East			7	6.60	0.04	42
West	9	958	3	3.40	0.02	709
East			7	7.20	0.04	249
West	10	290	3	2.60	0.02	215
East			7	8.60	0.05	75
West	11	287	3	2.00	0.01	212
East			7	9.00	0.06	75
West	12	357	1b	3.20	0.02	132
			2	3.00	0.02	132
East			5	9.00	0.06	93
West	13	326	1b	2.20	0.01	121
			2	2.00	0.01	121
East			5	8.80	0.05	85
West	14	616	1a	3.60	0.02	456
East			4	8.80	0.05	160
West	15	122	1a	5.40	0.03	90
East			4	7.80	0.05	32