Case Study

Carbon Emission from Transportation in Higher Learning Institutions: A Case Study at Universiti Tun Hussein Onn Malaysia

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ABSTRACT

The carbon emissions stemming from transportation within the campus environment pose a significant challenge to mitigating climate change and environmental degradation. At Universiti Tun Hussein Onn Malaysia (UTHM), transportation, particularly by staff and students, has been identified as the primary contributor to greenhouse gas emissions. This study aims to assess the total carbon emissions from transportation at UTHM and analyze trends over three consecutive years (2021 to 2023). Data were obtained from the Traffic Unit of the Security Department, encompassing vehicle counts and traffic surveys conducted across five roads within the UTHM Campus. The findings revealed a concerning escalation in carbon emissions over the study period. In 2021, transportation activities accounted for 947.64 tCO_2e, which surged to 1568.42 tCO_2e in 2022 and further increased to 1679.88 tCO_2e in 2023. Notably, Persiaran Tun Ghazali Shafie emerged as a hotspot area for carbon emissions in 2023, experiencing a staggering 95.76% rise compared to 2021, with recorded emissions of 610 tCO_2e. The average carbon emissions across the five surveyed roads in 2023 soared by 73.84% compared to 2021, indicating a persistent upward trajectory in emissions. These findings underscore the urgent need for sustained carbon emissions monitoring and mitigation efforts at UTHM. Continuous assessment by UTHM authorities is imperative to identify

and implement effective strategies for curbing carbon emissions within the campus environment. UTHM can be pivotal in fostering a more sustainable and environmentally responsible campus community by prioritizing emission reduction initiatives.

Keywords: Carbon emission, climate change, greenhouse gas emissions, sustainability, transportation

INTRODUCTION

Carbon emissions are a significant issue in universities with a large population and expansive campuses. Due to the size of these campuses, automobiles are often necessary for transportation between different locations. Additionally, the various activities within the university, such as teaching, learning, residential living, and administrative tasks, require a considerable amount of energy for lighting, cooling, and running appliances. Furthermore, the frequent movement of vehicles within the campus leads to the consumption of fossil fuel energy and subsequent carbon dioxide emissions (Abdul-Azeez & Ho, 2015).

The type of vehicle, type of fossil fuel, and travel distance are the main factors influencing the most daily and annual carbon emissions in universities (Zakaria et al., 2021). Universities are typically bustling with students, faculty, and staff commuting to and from the campus. If most individuals use personal vehicles, they can contribute to carbon emissions. Similarly, university-owned vehicles, such as shuttle buses and maintenance trucks, also contribute to emissions.

Achieving the reduction of carbon emissions from transportation use in university campuses by encouraging low carbon emissions through the involvement of the universities may be beneficial in achieving transportation sustainability within the campus as a remedy to the current phenomenon of global warming (Abdul-Azeez & Ho, 2015). This approach will help mitigate global warming and reduce global environmental threats. Additionally, it will enable the sharing of experiences among different university campuses. It is essential to assess the current emissions levels and identify the sources contributing to them to implement effective strategies and mitigation measures to reduce greenhouse gas emissions.

The study aims to determine UTHM students' thoughts about the cycling facilities on campus, emphasizing promoting active transportation to reduce pollution and congestion traffic. An online survey was distributed via social media during the pandemic (COVID-19) to 328 respondents and analyzed using SPSS software. The findings showed that while some bicycle facilities are seen to be very vital, they perform poorly, especially when it comes to having the wrong kind of cycling paths and not adequate lighting at night (Zaperi & Termida, 2022).

Daily activities on university campuses release greenhouse gases that add to the growing amount of carbon dioxide in the air. The mode of transportation, type of fuel, and travel distance are significant factors that have a crucial impact on daily and annual

CO_2 emissions (Holmatov et al., 2019). According to (Azeez & Ho, 2015), the primary contributor to CO_2 emissions in a university setting is the vehicles used for commuting on the campus and transporting goods and equipment. These emissions are found to be equivalent to the national average carbon emissions. In other words, the carbon footprint from transportation activities within a large university campus is significant and comparable to the average emissions across the nation (Gui et al., 2019).

The author investigated how three public institutions in Malaysia listed in the UI GreenMetric 2021 World University Ranking were implementing green campus activities. Senior representatives were interviewed, and it revealed that although these universities have implemented a number of green projects, they still face many challenges. Nevertheless, there are ways to advance these initiatives, highlighting the critical responsibilities that communities and university administration have in accomplishing the SDGs and promoting sustainable practices in the future (Muhiddin et al., 2023).

The author examines the energy performance metrics for buildings owned by academic faculty members based on three years of monthly energy consumption data. FPTV exhibited the highest energy and carbon footprint consumption (4,266.95 MWh and 2,961.26 tCO_2e), resulting in the highest energy index (161.47 kWh/m^2/year). Conversely, the energy indices for FPTP and FKAAB were lower at (60.21 kWh/m^2/year and 63.86 kWh/m2/year, respectively, compared to the overall UTHM buildings. Energy usage was significantly reduced by 36%, saving RM 1,063,874.19 in billing charges between 2015 and 2017 by implementing energy conservation strategies. It emphasizes the significance of setting energy-saving measures to lower energy expenses and carbon footprints (Abdullah et al., 2022).

College campuses can inspire and lead the way in implementing plans to reduce emissions on a larger scale because they can serve as positive examples for society (Adenle & Alshuwaikhat, 2017). The transportation of faculty and students to and from campus is a significant cause of greenhouse gas emissions (Yañez et al., 2020). The main obstacle to achieving sustainability goals in a university is the type of vehicles used by the campus community. To create an effective plan for campus sustainability, we need to consider how often vehicles are used, how far they travel, and the prevalence of private and heavy vehicles (Zakaria et al., 2021).

The author addresses Malaysia's plan to adopt electric buses (EBs) to reduce transportation-related greenhouse gas emissions in this paper. EB technologies were introduced in Putrajaya, Melaka and Sarawak. Moreover, a general framework for EB life cycle evaluations is offered, emphasizing the effects on the environment and economy and guiding future research on charging infrastructure needs (Al-Ogaili et al., 2021).

Therefore, this study analyzed carbon emissions from transportation at UTHM, Malaysia, to identify suitable mitigation strategies for effectively addressing carbon emissions.

This study's primary objective was to evaluate and examine the total carbon emissions from transportation within UTHM over three years, from 2021 to 2023. This analysis aims to provide a foundation for implementing effective mitigation strategies to reduce total carbon emissions, promote sustainability within the campus environment, and mitigate the strategies. UTHM should put a number of CO_2 mitigation techniques into practice, such as upgrading the infrastructure for bicyclists and pedestrians, promoting public transport and ridesharing, and improving public transportation by increasing the availability of shuttle buses and providing incentives. Higher learning institutions should switch to hybrid or electric vehicle models and promote the usage of low-emission vehicles. Additionally, the carbon emissions on campus should be greatly reduced by implementing smart traffic management systems, promoting remote learning and working initiatives, and establishing continuous emissions monitoring and evaluation.

MATERIALS AND METHODS

Study Area and Sample Size

The target population for this study comprises the campus community of Universiti Tun Hussein Onn Malaysia (UTHM). The primary data collected focuses on the number of vehicles staff and students use at UTHM's Main Campus. The total population of staff and students at the UTHM Main Campus is 34,010. This study considers several variables, including the number of vehicles, the method of commuting (bus, car, or motorcycle), the fuel used (petrol or diesel), and the annual travel distance.

Sampling and Sources of Data Collection

This study was carried out by taking a sample of the number of vehicles used by staff and students in UTHM Main Campus, including cars, motorcycles, and buses. Two methods were applied in this study to obtain the sample data. The first method involved requesting three-year statistical data on the number of vehicles registered in UTHM Main Campus from the Traffic Unit Security Department. The statistical data showed the records of the number of cars and motorcycles registered in UTHM Main Campus for 2021, 2022, and 2023. The numbers of vehicles recorded were referred to as the number of vehicle stickers that had been registered. The second method involved conducting a traffic count survey to collect the number of vehicles that traveled in and out of the area of UTHM Main Campus for the year 2023. The data was collected using different modes of transportation that students and staff use on UTHM's Main Campus. Data were collected within five different roads in UTHM Main Campus, which were at Persiaran Tun Dr Ismail Persiaran Tun Tan Siew Tin, Jalan Kemajuan, Persiaran Tun Ghaffar Baba, and Persiaran Tun Ghazali to investigate carbon emissions caused by transportation usage in UTHM Main Campus.

Calculation of CO₂ Emissions

The carbon footprint formula by the UI Green Method was used to evaluate the data for carbon emission value, as shown in Equation 1 (Ishak et al., 2022). Based on Equation 1, the total travel distance used for each vehicle mode was 2.7 km, considering each road that students and staff used in UTHM daily. The number of 240 in the equation is the number of working days per year. The carbon emission values for 2021 to 2023 are determined by multiplying the road distance traveled by each vehicle with its corresponding CO_2 emission factor. In this study, the emission factors for each mode of transportation are detailed in Table 1.

$$CO_2 = \frac{NV \times 2 \times TD \times WD}{100} \times EF \tag{1}$$

Where NV refers to the Number of Vehicles in the University; TD refers to the Approximate Travel Distance of a Vehicle Each Day Inside Campus (in kilometers); WD refers to the number of working days per year; and EF refers to the Emission Factor.

Table 1
Emission factor for each mode of transportation

Mode of transportation	Emission Factor	Unit	References
Car (petrol)	0.02	tCO₂e/km	https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs
Motorcycle (petrol)	0.01	tCO₂e/km	https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs
Bus (diesel)	0.01	tCO₂e/km	https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs

Data Analysis

This study analyzed carbon emissions by examining data on road distance, commuting modes, and the number of vehicles. This data was evaluated and converted into carbon emissions to compare emission trends.

RESULTS AND DISCUSSION

Number of Vehicles Registered in UTHM Campus

The statistical data regarding the number of vehicles, including cars and motorcycles, was obtained from the Traffic Unit of the Security Department at UTHM Campus. As depicted in Figure 1, the trend for the number of vehicles registered by staff, students, and individuals at the UTHM Campus has consistently increased over the years. This increasing trend can significantly impact the overall carbon emissions within the UTHM Campus.

Carbon Emissions (tCO₂e) of Vehicles

The data for vehicles registered by staff, students, and individuals had been converted into carbon emissions. Based on the observations in this study, the average distance traveled by car, motorcycle, or bus within UTHM Campus is 2.7 km, considering that not all places or roads in UTHM are accessible to vehicles. Consequently, the estimated carbon dioxide (CO_2) emissions in UTHM Campus, contributed by cars, motorcycles, and buses, were calculated using Equation 1.

The estimated activity data were determined by multiplying the number of vehicles registered in the UTHM Campus by the average distance traveled by car, motorcycle, or bus. For the experimental data, the estimated activity data were calculated by multiplying the number of vehicles that traveled within the UTHM Campus by the average distance traveled by these vehicles, which was 2.7 km. Subsequently, both sets of estimated activity data, obtained from statistical and experimental sources, were multiplied by the emission factor.

The total overall carbon emissions for vehicles registered, including staff, students, and individuals at UTHM Campus, were calculated and presented in a bar chart in Figure 2, respectively. Based on Figure 2,

Figure 1. Total number of vehicles registered in UTHM
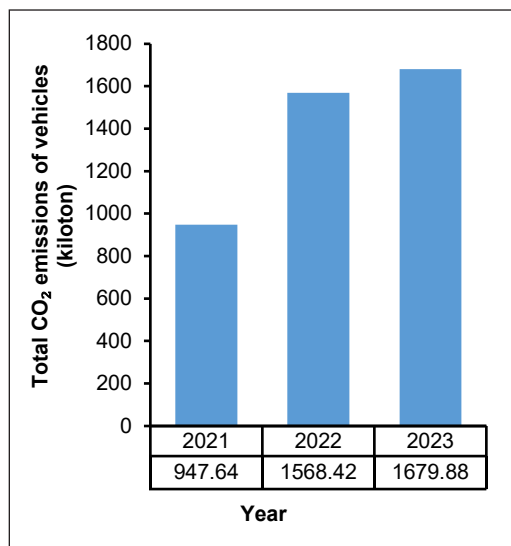
Figure 2. Total CO_2 emissions of vehicles (tCO₂e)

the higher CO_2 emissions were in 2023, 6.86% higher than CO_2 emissions in 2022 and 55.74% higher than CO_2 emissions in 2021, with a difference of 111.46 tCO₂e. The value of CO_2 emissions each year in UTHM Campus for data vehicles registered by staff, students, and individuals increases according to the data for the number of vehicles registered. By comparison, there was an increasing trend of CO_2 emissions from vehicles from 2021 until 2023. This data can be compared to previous studies in which the trend of carbon emissions of vehicles registered in UTHM seems to be decreasing (Audu, 2018; Termida et al., 2022).
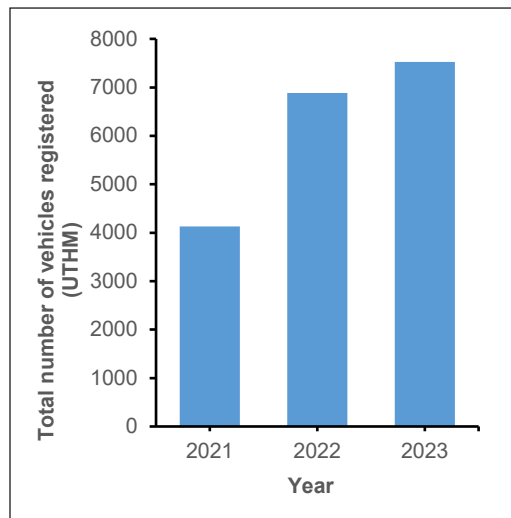
Traffic Survey Data Collection

A survey was conducted to record the number of vehicles traveling in and out of UTHM's Main Campus during peak working hours: 7:30 a.m. to 8:30 a.m., 1:00 p.m. to 2:00 p.m., and 5:00 p.m. to 6:00 p.m. This survey focused on five main roads within UTHM to target hotspot areas of carbon emissions. The total number of vehicles that traveled through UTHM's Main Campus was documented and presented in a bar chart, as shown in Figure 3.

According to Figure 3, the number of vehicles students and staff travel at UTHM Campus varies yearly. 2023, there was a significant increase in students and staff commuting compared to 2021. In 2023, the roads with the highest vehicle traffic, in order, were Persiaran Tun Ghaffar Baba, Persiaran Tun Dr Ismail, Persiaran Tun Ghazali Shafie, Jalan Kemajuan, and Persiaran Tun Tan Siew Sin, with Persiaran Tun Ghaffar Baba recording the highest number of vehicles. In 2023, Persiaran Tun Ghazali Shafie recorded the highest vehicle traffic by staff and students at the UTHM Campus, followed closely by Persiaran Tun Dr Ismail. The vehicle traffic on Persiaran Tun Ghazali Shafie saw a 92% increase compared to 2021, resulting in a difference of 1699 tCO_2e. Post-COVID-19, UTHM revised the route plan to a one-way system to facilitate easier mobility for students and staff and to reduce accidents in certain areas caused by route confusion.
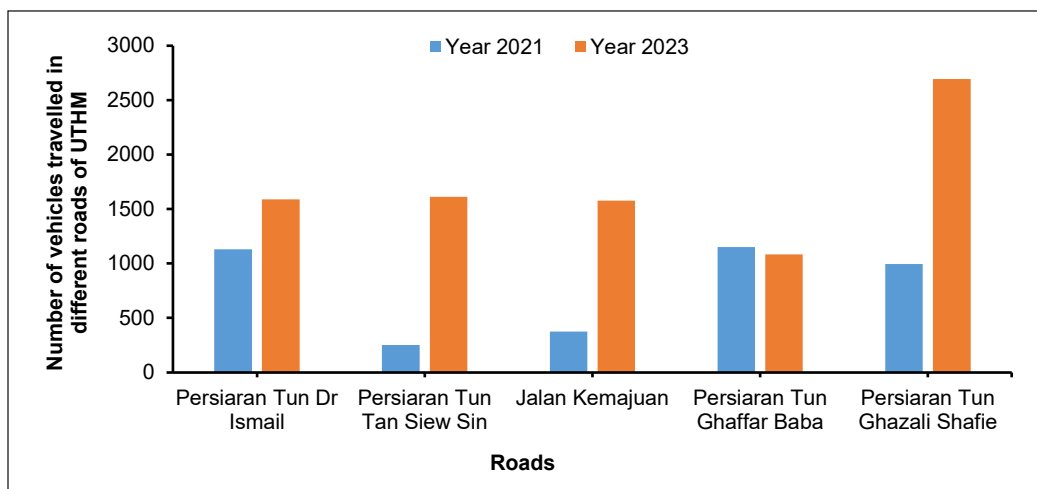

Figure 3. Total number of vehicles traveled on various roads within UTHM

Carbon Emissions (tCO_2e) by Vehicle Travelled in UTHM Campus

Based on traffic count survey data, the values have been converted to CO_2 emissions using the formula in Equation 1. The CO_2 emissions data for vehicles traveling on five different roads within UTHM's Main Campus are presented in Figure 4.

According to Figure 4, the ranking of the highest CO_2 emissions for each road in 2021 was as follows: Persiaran Tun Dr Ismail, Persiaran Tun Ghaffar Baba, Persiaran Tun
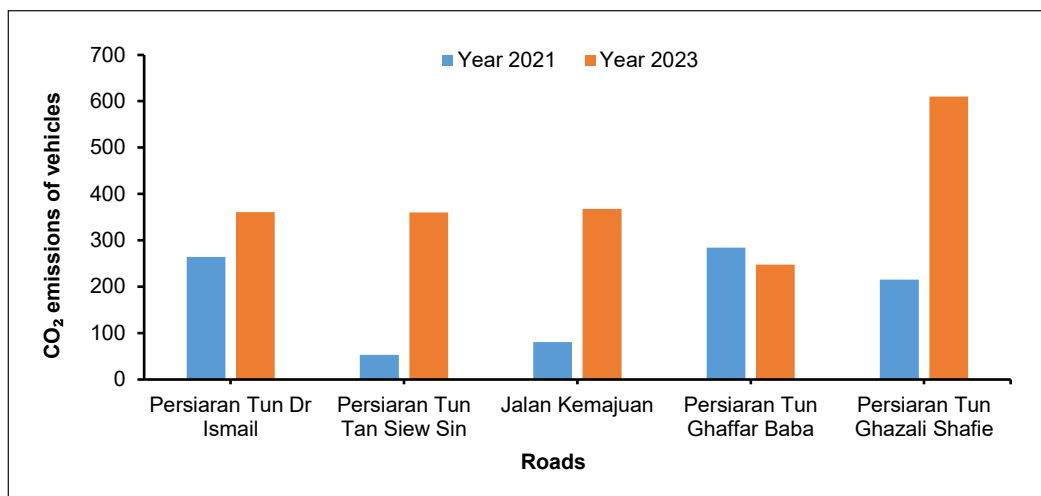
Figure 4. Total CO_2 emissions of vehicles traveled on five different roads in UTHM Campus (tCO_2e)

Ghazali Shafie, followed by Jalan Kemajuan and Persiaran Tun Tan Siew Sin. For 2023, the ranking changed from Persiaran Tun Ghazali Shafie, Jalan Kemajuan, Persiaran Tun Dr Ismail, Persiaran Tun Tan Siew Sin, and Persiaran Tun Ghaffar Baba.

The road with the highest carbon emissions values in 2023 was Persiaran Tun Ghazali Shafie, recording a value of 610 tCO_2e, representing an increase of 95.76% compared to 2021 with a difference of 395 tCO_2e. Similarly, the lowest carbon emission values belonged to Persiaran Tun Ghaffar Baba, with a value of 13.45% lower than in 2021, with a difference of 36 tCO_2e. The average value of carbon emissions for five different roads in 2023 was 1947 tCO_2e. By comparison, the average of emissions for 2023 was 73.84% higher than the average of CO_2 emissions in 2021. Hence, there was an increasing trend of carbon emissions between 2021 and 2023. By observation, the number of vehicle values change reflects the emissions levels over the two years. The greater the number of vehicles from staff and students in the UTHM Campus, the higher the values of carbon emissions.

Based on the carbon emissions values for each main road in UTHM Campus for the year 2023, the hotspot area for carbon emission production in UTHM Campus was identified to be on Persiaran Tun Ghazali Shafie, with the highest carbon emission value of 610 tCO_2e. This road serves as the primary thoroughfare for entering and exiting the UTHM Campus, making it the most frequently traveled route.

CONCLUSION

This study examined the total carbon emissions from transportation within the UTHM campus over three years (2021-2023). The analysis revealed that the number of registered vehicles and vehicles traveling on campus increased yearly, correlating with the rising number of students and staff. In 2023, the total registered vehicles reached 7,527, and

vehicles traveled amounted to 8,554 units, resulting in the highest carbon emissions of 1,679.88 tCO_2e for registered vehicles and 2,161.60 tCO_2e for vehicles traveled. The trend of increasing vehicles and CO_2 emissions was evident, rising from 947.64 tCO_2e in 2021 to 1,568.42 tCO_2e in 2022 and 1,679.88 tCO_2e in 2023.

A detailed analysis of five main roads within the campus identified Persiaran Tun Ghazali Shafie as a significant hotspot for carbon emissions in 2023, with a notable increase of 95.76% compared to 2021, recording 610 tCO_2e. The average carbon emissions across the five roads increased by 73.84% from 2021 to 2023, indicating a rising emission trend. The study successfully achieved its objectives and provided a comprehensive baseline for future research. It highlighted the need for effective CO_2 mitigation strategies, recommending enhancements in infrastructure for bicyclists and pedestrians, promoting public transport and ridesharing, increasing the availability of shuttle buses, and incentivizing low-emission vehicle usage.

Future research should expand to assess other sources of greenhouse gas emissions within the university and explore more effective CO_2 reduction options in campus transportation. This study serves as a reference for developing strategies to mitigate carbon emissions and promote sustainability within the campus environment.

ACKNOWLEDGMENTS

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