Factors of Old Vehicle Emissions in Urban Areas

Vilaashiny Thana Singam[1], Nurhana Mohamad Rafiuddin[2], Haliza Mohd Zahari[3]

[1]Faculty of Defence Studies and Management, National Defence University of Malaysia, 57000 Sungai Besi, Kuala Lumpur, Malaysia, [2]Faculty of Defence Studies and Management, National Defence University of Malaysia, 57000 Sungai Besi, Kuala Lumpur, Malaysia, [3]HADR Research Center, National Defence University of Malaysia, 57000 Sungai Besi, Kuala Lumpur, Malaysia
Email: shinyvila909@yahoo.com, nurhana@upnm.edu.my, haliza.mz@upnm.edu.my

Abstract
A questionnaire plays an important part in research for collecting pertinent data regarding the research study. It is important to design questionnaires meticulously to minimize errors. However, researchers often face challenges in designing effective questionnaires which results in biased findings. Therefore, this paper aims on the development of questionnaires items on factors contributing to old vehicle emissions in urban areas. The questionnaire items designed consist of information on studied variables such as fuel consumption, driving pattern, mobility behavior, maintenance and repair and vehicle age and carbon emissions. The questionnaires items were designed based on past literature studies. As a result, a total of thirty-six items were constructed in this study. This study uses the Five Point Likert Type Scale which reflects the respondent's agreement towards the statement in the questionnaires. The study also seeks to provide insight to the government and policymakers on factors that contribute to old vehicle emissions in urban settings.
Keywords: Questionnaire Design, Old Vehicle, Urban Environment

Introduction
The challenges on old vehicle emission particularly in urban environments has become an important issue that requires attention and solutions. As air pollution continues to increase in the cities, it is important to understand the factors contributing to old vehicle emissions. The use of old vehicles in the cities release high level of carbon emission (Marino et al., 2023). The aim of this study is to determine the factors of old vehicle emission in the urban environment. Therefore, the questionnaires items are designed which consist of information of the studied variables such as fuel consumption, driving pattern, mobility behavior, maintenance and repair, vehicle age and carbon emissions. Hence, the development of questionnaire items is specific and clear which answers the research objectives of this study.

By doing so, this research aims to not only to expand the understanding of old vehicle emission but also to recommend practical strategies and solutions for government and policymakers.

A questionnaire is important as it facilitates data collection from the respondents. The questions are constructed meticulously to collect specific information from the respondents which is needed for the research study. Moreover, questionnaires play an important role in answering the research objectives (Taherdoost, 2022). Besides, a questionnaire is the primary way of collecting quantitative data which ensures consistency and comparability across the respondents. Therefore, this ease the process of data collection (Krosnick, 2017). Designing a questionnaire may seem simple, but there are numerous challenges which are caused by variability and unpredictability of the respondent response. Therefore, the questionnaire needs to be clear, concise, and unbiased to reduce errors and biases (Taherdoost, 2022).

Furthermore, the design of questionnaires may have an impact on the quality and quantity of data collection. For instance, poorly designed questionnaires may contribute to errors and biases. The questionnaires items have been designed based on previous research and literature on factors of old vehicles towards carbon emissions. There are a few steps in designing of questionnaires items such as defining the information from past studies, followed by survey type and question types and formulating questionnaire (Taherdoost, 2022). Questionnaires also allow the researchers to determine the patterns and correlations associated within the data.

This study may provide valuable insight for the government, policymakers and public to eliminate the use of old vehicles in the cities as it releases high carbon emissions. By understanding the factors that contribute to carbon emission, the government can implement effectives measures such as promote use of public transportation and adoption of electric vehicles. Besides, this study provides guidance for policymakers to implement policies and interventions aimed at reducing old vehicle emissions. Moreover, this study increases awareness to the public on the environmental impact of old vehicles. Hence, this empowers the public to make informed decisions such as use of cleaner fuels which contribute to sustainable cities and environment.

Literature Review
Fuel Consumption
Fuel consumption can be defined as the volume of fuel consumed per unit distance and it is calculated in liters per 100 km (Mathew, 2014). Fuel consumption and carbon emission can be reduced by increasing the use of low carbon options such as expanding use of alternative fuels and enhancing fuel efficiency (Mustapa & Bekhet, 2016). There are few factors that affect fuel consumption such as strategic factors which affects the vehicle, tactical factors which affect the route and operational factor which affect the driver (Hsu et al., 2017). According to Mohd & Mahmud (2020) improvement of vehicle engine performance and efficiency can reduce fuel consumption. Engine components in old vehicles usually experienced wear and tear which results in poor engine performance and therefore increases fuel consumption level.

Moreover, old vehicle consume larger amount of fuel compared to new vehicles (West et al., 2017). This is because older vehicles tend to have outdated engine technologies design which are less efficient and thus increase fuel consumption. Emission factors are generated through emission model when specific fuel attributes are known such as carbon content and heat rate. Besides, the main properties that affect fuel consumption in engines are carbon

content and difference in energy content (Davison et al., 2020; Schipper et al., 2007). For instance, fuel that contains high carbon contributes significantly to high carbon emissions. Therefore, carbon content in fuels is one of the most important properties that have an impact on fuel consumption.

According to Romero et al (2024), vehicles with poor maintenance results in higher fuel consumption. Vehicles that are not properly maintained experience low vehicle performance due to engine components malfunction. There are few factors and parameters that affects fuel consumption of a vehicle such as travel related, vehicle related, roadway related, traffic related and driver related (Zhou et al., 2016). Old vehicles often experience challenges when passing through high terrains as it has outdated transmission system (Sperling & Gordon, 2009).

Driving Patterns

Driving patterns include use of aging vehicle can increase emission (Bikam, 2021). Driving pattern can also be defined as the speed and acceleration profile of vehicle and it also can be expanded to include other parts of driving behavior such as gear changing (Sugathapala & Gajanayake, 2019). Kuhler and Karstens (1978) proposed a set of 10 parameters related to driving patterns such as average speed, average driving speeds which exclude stops, average acceleration, average deceleration, mean length of a driving period, average number of acceleration and deceleration changes within one driving period, proportion of standstill time, acceleration time, constant speed, and proportion of deceleration time. Driving pattern such as vehicle velocity, driving conditions and driving distance affect the vehicle efficiency and emission (Albertus et al., 2016).

Driving patterns can be categorized into few categories and it can be viewed as the basic composition of driver behavior. Driving pattern also has a great influence on vehicles performance (Barothi et al., 2018). An aggressive driving style always results in high carbon emission whereas smooth driving has greater energy efficiency and reduces emission. Thus, a driver's driving style can be classified into three categories which are calm, normal, and aggressive. Additionally, drivers who fail to follow driving regulations and misuse their vehicle can exacerbate carbon emissions. Similarly, irregular driving habits can lead to vehicle malfunction which will trigger high carbon emission (Bikam, 2021). Aggressive driving pattern such as inefficient gear changing in older vehicles can lead to engine to malfunction and failure , resulting increase in carbon emissions (Nasir et al., 2014). Whereas for new vehicles, automatic transmission of gear changes has been designed to reduce negative impact of emissions and aggressive driving.

Mobility Behavior

The changes in mobility behaviors such as vehicle travelled distance, number of trips, heavy loads, the length of the route, purpose of the trips and vehicle ownership pattern may have a positive environmental impact and increase in emission (Walker, 2019). The estimation of the pollutants that emitted by vehicles are determined by the annual vehicle travelled miles and vehicle trips with combined emissions factors (Snyder et al., 2014). Mobility management is important as it influence in reduction of carbon emission. Luo et al (2017) claimed that use mode share, average trip times and travel distances is one of the key factors in vehicle emission. Vehicles that travel more miles on the road tend to emit higher emissions. For instance, the Ministry of Road Transport and Highways India (2012) claimed that old vehicles emit higher carbon emissions even though with short distance. Besides, vehicles that spend

more time on the road tend to increase carbon emission. The findings shows that changes in travel behavior could reduce the emission in a shorter term (DeWeese et al., 2022). Hence, by reducing vehicle miles travelled this can reduce vehicle emission. Alonso et al., (2020) suggest owning private vehicle gives freedom to travel anywhere and always contributes to the preferences of using private vehicle over public transportation.

Maintenance and Repair
Vehicle maintenance refers to regular maintenance activities that ensure a vehicle is in a good working condition, runs smoothly and prevent breakdown (Gomathy, 2022). Motor vehicles need to be regularly maintained and repaired to ensure vehicle safety. For instance, regular inspections, oil changes, tire rotations, brake checks, filter replacement and other preventative measure is important to ensure the vehicles is function efficiently and safely (Grimaldi, 2022). Old vehicles usually have a substantial carbon footprint when associated with their maintenance, service, replacement parts and loads (Alonso et al., 2020). For instance, older vehicles require more oil, engine components and other consumables. Besides, vehicle inspection and maintenance programs has been established to reduce emissions from vehicle fleets and thus improving air quality (Ozcelik, 2016). In addition, usage of public transportation could reduce emissions as it reduce the use of private vehicles on the road (Odiyo et al., 2021).

Carbon emissions
Carbon emission from transportation sector is rising from 1990 to 2019. Carbon emission from transportation sector is one of the major contributing factors in increase global carbon emissions (Su et al., 2022). However, CO_2 emissions is the major contributor to climate changes (Zhang & Da, 2015). CO_2 emissions are also caused by human activities which account for 80% of global emissions (Yu et al., 2013). For instance, fuel combustion from transportation and power plant produce large amounts of CO_2 emissions (Heede, 2014).

Additionally, carbon emission can also be defined as the release of carbon compounds in the atmosphere. Carbon compounds such as CO, CO_2 and CH4 usually trap heat in the atmosphere and result in global warming. Next, carbon dioxide emissions are released by fossil fuels from vehicles and burning of waste materials. Fossil fuels are the main source of anthropogenic CO_2 emission (Muradov, 2014). Thus, the main greenhouse gas emitted by vehicles is carbon (Liarakou et al., 2011). Old vehicles are known as the major contributor of carbon emission which leads to environmental issues (Nakamoto & Kagawa, 2022). Additionally, carbon emissions released by vehicles in this study refer to as the perception and understanding of the individual on carbon emission behavior.

Methodology
There are a few important steps to determine before constructing a questionnaire. The first step is to determine the type of questionnaires items. Questionnaire is divided into two categories which are open-ended and closed-ended questions. In this study, questionnaires are designed as closed- ended questions. Open-ended questions allow the respondent to answer their questions in own words whereas closed-ended questions only allows the respondent to answer specific answers (Taherdoost, 2022). Therefore, most of the questions in this study are designed as closed ended questions. The forming of the items in the questionnaires is based on two sources which is based on items developed by the previous researcher and through the literature review with respect to fuel consumption, driving

pattern, mobility behavior, maintenance and repair, vehicle age and carbon emission. Besides, questionnaires were formed based on the group discussion conducted with a group of academics related to the scope of this research.

The second step is to determine the measurement scale used for evaluating questionnaire items. The researcher uses questionnaires as the research instrument for collecting data. This research uses Five Point Likert Type Scale to present the items on fuel consumption, driving pattern, mobility behavior, vehicle maintenance and repair and carbon emission. According to Sekaran (2009), the Likert Scale is used to test the strength of the variables. It is also used to test whether to agree or disagree on a statement. The Five Point Likert Scale is arranged in the order which is from 'strongly disagree', 'disagree', 'not sure', 'and agree 'to 'strongly agree'.

The type of measurement used in this study is ordinal scale. Ordinal scale is used to determine the comparison of degree of something in the variable and it usually in the ranking scale (Borges et al., 2020). All the items in these questionnaires employed an ordinal scale except for vehicle age. For vehicle age, a ratio scale measurement was used. Ratio scale usually defines the actual value or amount of the variables. Besides, ratio scale is also defined as continuous data (Borges et al., 2020). For vehicle age, the respondents were asked to provide vehicle registration year. The targeted respondent in this study are old vehicle users in Kuala Lumpur. A total of 384 respondents were chosen by using simple random sampling techniques.

Results
Findings of Fuel Consumption
There are seven items that were constructed, and these items are concerned with questions related to fuel consumption. The items are structured based on previous literature studies. Item one is constructed based on Mohd & Mahmud (2020), suggest that fuel usage decrease with enhance engine performance in a vehicle. Item two to four is constructed based on Davison et al (2020); Schipper et al (2007), highlits that the main factor contributes to vehicle carbon emission is carbon content and quality of fuel. In addition, item five is constucted based on West et al (2017) claimed that old vehicles usually consume more fuel than new vehicles. Items six and seven is constructed based on Zhou et al (2016), highlights that factors such as travel related, vehicle related, roadway related, traffic related and driver related affects fuel consumption of a vehicle. Based on the mean value, the result of this study indicated a high level of respondent's agreement towards statements related to fuel consumption.

No	Items	Mean	Standard deviation
1	Enhance engine performance in vehicle	3.95	1.06
2	Vehicle uses carbon in fuel	3.78	1.21
3	Good fuel quality increase fuel efficiency	3.99	1.21
4	Fuel consumes high carbon content	3.94	1.20
5	Vehicles consume high fuel	4.02	1.18
6	Choice of routes affects fuel consumption	3.91	1.07
7	Fuel efficiency is good in my vehicle	4.01	1.14

Findings of Driving pattern

There are six items that were constructed, and these items are concerned with questions related to driving pattern. The items are constructed based on previous literature studies. The items were adapted from sources such as (Bikam, 2021; Nasir et al., 2014 Sugathapala & Gajanayake, 2019). Item one to three is constructed based on Sugathapala & Gajanayake (2019), focus on the speed and acceleration profile of vehicle which contributes to vehicle emissions. Item four and five is derived based on Bikam (2021), emphasize that aggressive or irregular driving behavior can lead to misuse of vehicle and thus, increase in vehicle emission. Next, item six is constructed based on Nasir et al (2014), claimed that unnecessary gear changing in old vehicles can result increase in carbon emission. Based on the mean value, the finding of this study shows the overall level of respondent's agreement towards statement on driving pattern is high.

No	Items	Mean	Standard deviation
1	Adhere to speed limits when driving	4.01	1.11
2	Always drive slowly	3.99	1.84
3	Always follow traffic rules	3.99	1.19
4	Always maintain a safe distance from other vehicles	3.98	1.10
5	Avoid aggressive behavior such as overtaking other vehicles	3.98	1.10
6	Avoid unnecessary gear changing when driving	3.89	1.24

Findings of Mobility Behavior

There are six items that were constructed, and these items are concerned with questions related to mobility behavior. The items are constructed based on previous literature studies. The items were adapted from (Walker, 2019; Snyder et al., 2014; Alonso et al., 2020). The first four items is derived from Walker (2019); Snyder et al (2014), emphasize that vehicle emission is determined by vehicle traveled distance, number of trips, heavy loads, route length, trip purposes, and vehicle ownership patterns. Besides, item five and six is influenced by Alonso et al (2020) emphasize that owning private vehicle gives freedom to travel anywhere and always contributes to the preferences of using private vehicle over public transportation. The result of this study indicated a high level of respondent's agreement towards statements related to mobility behavior.

No	Items	Mean	Standard deviation
1	Use vehicle for long distance journey	4.06	1.00
2	Utilize vehicle for over than 10 trips a week	3.98	1.04
3	Choose shortest route to reach to the destination	4.05	1.10
4	Maximize the load of goods in vehicle	4.03	1.08
5	Having a vehicle give freedom to go anywhere	4.10	1.09
6	Utilize personal vehicle to work rather than public transport	4.04	1.10

Findings of Maintenance and Repair

There are eight items that were constructed, and these items are concerned with questions related to maintenance and repair. The items are constructed based on previous literature studies. The items were adapted from (Gomathy, 2022; Odiyo et al., 2021; Grimaldi, 2022).

Item one to seven is constructed based on Gomathy (2022); Odiyo et al (2021), suggest that regular maitenance practices such as regular inspection, repairs, keeping vehicle clean, ensures vehicles are in a good working condition, runs smoothly will prevent breakdown and decrease in vehicle emissions. Item eight is derived from Grimaldi (2022) emphasize that regular oil change will help to maintain vehicle efficiency and performance. The finding of this study shows the overall level of respondent's agreement towards statement on maintenance and repair is high.

No	Items	Mean	Standard deviation
1	Regular inspection of vehicle	3.97	1.17
2	Vehicle is well maintained	3.86	1.24
3	Vehicle in good working condition	3.98	1.16
4	Vehicles operate smoothly	3.88	1.20
5	Repair if any issue happens with my vehicle	3.91	1.20
6	Maintain cleanliness of my vehicle	3.99	1.08
7	Check vehicle daily before starting the engine	3.72	1.22
8	Change engine oil according to schedule	3.89	1.13

Findings of Carbon Emission

There are eight items that were constructed, and these items are concerned with questions related to carbon emission. The items are constructed based on earlier literature. The items are based on the understanding of an individual on carbon emissions behavior. The items were adapted from (Yu et al., 2013; Zhang & Da, 2015; Nakamoto & Kagawa, 2022; Liarakou et al., 2011). The first three items are constructed based on Yu et al (2013); Zhang & Da (2015), suggest that carbon emisions is caused by human activities which conrtibutes to global warming. They also focus on public concern on environmental changes caused by carbon emission. Item four and five is derived from Nakamoto & Kagawa (2022), old vehicle are the majo contributor to carbon emissions which leads to environmental issues. Furthermore, item six to eight is derived from Liarakou et al (2011), focus on the carbon emisisons causes and effects as well as the solutions aimed at reducing these emissions. Based on the mean value, the finding of this study shows the overall level of respondent's agreement towards statement on carbon emission is high.

No	Items	Mean	Standard deviation

1	Vehicle's carbon emissions contribute to global warming	4.22	0.97
2	Concerned impact of vehicle carbon emission on environment	4.01	0.99
3	In general, carbon emission led to climate changes	3.99	1.02
4	Aware reducing old vehicle's carbon emission can reduce environment issues	3.96	1.00
5	Old vehicles are major contributor to air pollution	4.00	1.02
6	Use of public transport can reduce carbon emission	4.07	1.06
7	Fuel efficient vehicle can reduce carbon emission	3.95	1.04
8	Fuel combustion can increase carbon emission in the environment	3.97	1.02

Conclusion

In conclusion, this study focused on the development of questionnaires items to determine the factors that contribute to old vehicle emissions in urban areas. The study findings show a total of thirty-six items were constructed based on review of past literature. The questionnaire items were carefully designed to provide a deeper understanding of several factors of old vehicle emissions. Moreover, well-designed questionnaires items will help the researcher to collect relevant and reliable data from the respondent.

The findings of this study give significant theoretical and contextual contributions. This study provides a theoretical understanding of the factors that contribute to old vehicle emission by providing insight on variables such as fuel consumption, driving pattern, mobility behavior, maintenance and repair, vehicle age and carbon emission. Besides, this study also provides an important insight for government and policymakers on addressing these challenges particularly on old vehicle emission. For instance, this study provides guidance for the government and policymakers on developing and implementing targeted strategies aimed at reducing environmental pollution in urban areas.

Acknowledgments

References

Albertus, P., Christensen, J., Newman, J., Chakraborty, D., Hardman, S., Tal, G., … Michalek, J. J. (2016). Effect of regional grid mix, driving patterns and climate on the comparative carbon footprint of gasoline and plug-in electric vehicles in the United States. *Environmental Research Letters*, *11*(4), 044007. https://doi.org/10.1088/1748-9326/11/4/044007

Alonso-González, M. J., Hoogendoorn-Lanser, S., van Oort, N., Cats, O., & Hoogendoorn, S. (2020). Drivers and barriers in adopting Mobility as a Service (MaaS) – A latent class cluster analysis of attitudes. *Transportation Research Part A: Policy and Practice*, *132*, 378–401. https://doi.org/10.1016/J.TRA.2019.11.022

Barothi, L., Sava, D., Darie, C.-D., & Cucu, L.-I. (2018). Driving Style Influence on Vehicles Performances. Retrieved April 3, 2023, from https://jmiltechnol.mta.ro/1/Driving Style Influence on Vehicles Performances-min.pdf

Bikam, P. B. (2021). Vehicle Management and Emission Control and Maintenance. *Green Economy in the Transport Sector: A Case Study of Limpopo Province, South Africa*, 51–64. https://doi.org/10.1007/978-3-030-86178-0_5/TABLES/5

Borges, W. G. B., Imm, N. S., Cheong, C. B., Chai, L. T., Teik, D. O. L., Nadarajah, D., … Hassan, H. B. (2020). Research Methods Second Edition. Retrieved January 31, 2024, from Sj Learning website: https://www.sjlearning.com.my/titles/item/Business-Research-Methods-2e-William-G-Bill-Borges-Ng-Siew-Imm-Chew-Boon-Cheong-and-et-al-2020

Davison, J., Bernard, Y., Borken-Kleefeld, J., Farren, N. J., Hausberger, S., Sjödin, Å., … Carslaw, D. C. (2020). Distance-based emission factors from vehicle emission remote sensing measurements. *Science of The Total Environment*, *739*, 139688. https://doi.org/10.1016/J.SCITOTENV.2020.139688

DeWeese, J., Ravensbergen, L., & El-Geneidy, A. (2022). Travel behaviour and greenhouse gas emissions during the COVID-19 pandemic: A case study in a university setting. *Transportation Research Interdisciplinary Perspectives*, *13*, 100531. https://doi.org/10.1016/J.TRIP.2021.100531

Grimaldi, S. (2022). *An innovative approach to maintenance for a bus fleet*.

Heede, R. (2014). Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854-2010. *Climatic Change*, *122*(1–2), 229–241. https://doi.org/10.1007/S10584-013-0986-Y/TABLES/3

Hsu, C. Y., Lim, S. S., & Yang, C. S. (2017). Data mining for enhanced driving effectiveness: an eco-driving behaviour analysis model for better driving decisions. *International Journal of Production Research*, *55*(23), 7096–7109. https://doi.org/10.1080/00207543.2017.1349946

Krosnick, J. A. (2017). Questionnaire design. *The Palgrave Handbook of Survey Research*, 439–455. https://doi.org/10.1007/978-3-319-54395-6_53/COVER

Liarakou, G., Athanasiadis, I., & Gavrilakis, C. (2011). What Greek secondary school students believe about climate change? *International Journal of Environmental & Science Education*, *3*. Retrieved from http://www.ijese.com/

Luo, X., Dong, L., Dou, Y., Li, Y., Liu, K., Ren, J., … Mai, X. (2017). Factor decomposition analysis and causal mechanism investigation on urban transport CO2 emissions: Comparative study on Shanghai and Tokyo. *Energy Policy*, *107*, 658–668. https://doi.org/10.1016/J.ENPOL.2017.02.049

Marino, C., Nucara, A., Panzera, M. F., & Pietrafesa, M. (2023). Greenhouse Gas Balance in the City of Reggio Calabria and Assessment of the Effects of Measures of Emission Reduction and Absorption. *Energies*, *16*(9). https://doi.org/10.3390/EN16093615

Shafie, M. S. H., & Mahmud, M. (2020). Urban Air Pollutant from Motor Vehicle Emissions in Kuala Lumpur, Malaysia. *Aerosol and Air Quality Research*, *20*(12), 2793–2804. https://doi.org/10.4209/AAQR.2020.02.0074

Muradov, N. (2014). Anthropogenic CO2 emissions: Sources and trends. *Lecture Notes in Energy*, *22*, 79–89. https://doi.org/10.1007/978-1-4939-0545-4_3/COVER

Mustapa, S. I., & Bekhet, H. A. (2016). Analysis of CO2 emissions reduction in the Malaysian transportation sector: An optimisation approach. *Energy Policy*, *89*, 171–183. https://doi.org/10.1016/J.ENPOL.2015.11.016

Nakamoto, Y., & Kagawa, S. (2022). A generalized framework for analyzing car lifetime effects

on stock, flow, and carbon footprint. *Journal of Industrial Ecology*, *26*(2), 433–447. https://doi.org/10.1111/JIEC.13190

Nasir, M. K., Noor, M. R., Kalam, M. A., & Masum, B. M. (2014). Reduction of fuel consumption and exhaust pollutant using intelligent transport systems. *Scientific World Journal*, *2014*. https://doi.org/10.1155/2014/836375

Odiyo, J. O., Bikam, P. B., & Chakwizira, J. (2021). Green Economy in the Transport Sector: A Case Study of Limpopo Province, South Africa. *Green Economy in the Transport Sector: A Case Study of Limpopo Province, South Africa*, 1–123. https://doi.org/10.1007/978-3-030-86178-0

Ozcelik, A. E. (2016). Determining of Choosing Engine Oil Its Care Addictions in the Automotive in Konya. *DergiPark (Istanbul University)*. Retrieved from https://www.academia.edu/109047368/Determining_of_Choosing_Engine_Oil_Its_Care_Addictions_in_the_Automotive_in_Konya

Romero, C. A., Correa, A., Echeverri, E. A., Vergara, D., Romero, C. A., Correa, P., … Vergara, D. (2024). Strategies for Reducing Automobile Fuel Consumption. *Applied Sciences 2024, Vol. 14, Page 910*, *14*(2), 910. https://doi.org/10.3390/APP14020910

Schipper, L., Cordeiro, M., & Ng, W.-S. (2007). *Measuring the Carbon Dioxide Impacts of Urban Transport Projects in Developing Countries*.

Snyder, M., Arunachalam, S., Isakov, V., Talgo, K., Naess, B., Valencia, A., … Hanna, A. (2014). Creating Locally-Resolved Mobile-Source Emissions Inputs for Air Quality Modeling in Support of an Exposure Study in Detroit, Michigan, USA. *International Journal of Environmental Research and Public Health 2014, Vol. 11, Pages 12739-12766*, *11*(12), 12739–12766. https://doi.org/10.3390/IJERPH111212739

Sperling, D., & Gordon, D. (2009). Two Billion Cars Driving Toward Sustainability. *Two Billion Cars Driving Toward Sustainability*. https://doi.org/10.1093/OSO/9780195376647.001.0001

Su, Y., Wu, J., Ciais, P., Zheng, B., Wang, Y., Chen, X., … Lafortezza, R. (2022). Differential impacts of urbanization characteristics on city-level carbon emissions from passenger transport on road: Evidence from 360 cities in China. *Building and Environment*, *219*, 109165. https://doi.org/10.1016/J.BUILDENV.2022.109165

Sugathapala, T., & Gajanayake, S. (2019a). Analyzing the characteristics of driving patterns affecting the fuel consumption of a Light Duty Vehicle. *IESL 113th Annual Sessions*. Retrieved from https://www.academia.edu/43513512/Analyzing_the_characteristics_of_driving_patterns_affecting_the_fuel_consumption_of_a_Light_Duty_Vehicle

Sugathapala, T., & Gajanayake, S. (2019b). Analyzing the characteristics of driving patterns affecting the fuel consumption of a Light Duty Vehicle. *IESL 113th Annual Sessions*. Retrieved from https://www.academia.edu/43513512/Analyzing_the_characteristics_of_driving_patterns_affecting_the_fuel_consumption_of_a_Light_Duty_Vehicle

Taherdoost, H. (2022). Designing a Questionnaire for a Research Paper: A Comprehensive Guide to Design and Develop an Effective Questionnaire. *Asian Journal of Managerial Science*, *11*(1), 8–16. https://doi.org/10.51983/AJMS-2022.11.1.3087

Walker, J. (2019). *Promoting Mobility Behaviour Change Practical guidance for inspiring more walking, cycling and public transport and minimising car use*.

West, J., Hoekstra, M., Meer, J., & Puller, S. L. (2017). Vehicle miles (not) traveled: Fuel economy requirements, vehicle characteristics, and household driving. *Journal of Public*

Economics, *145*, 65–81. https://doi.org/10.1016/J.JPUBECO.2016.09.009

Yu, H., Wang, B., Zhang, Y. J., Wang, S., & Wei, Y. M. (2013). Public perception of climate change in China: Results from the questionnaire survey. *Natural Hazards*, *69*(1), 459–472. https://doi.org/10.1007/S11069-013-0711-1

Zhang, Y. J., & Da, Y. Bin. (2015). The decomposition of energy-related carbon emission and its decoupling with economic growth in China. *Renewable and Sustainable Energy Reviews*, *41*, 1255–1266. https://doi.org/10.1016/J.RSER.2014.09.021

Zhou, M., Jin, H., & Wang, W. (2016). A review of vehicle fuel consumption models to evaluate eco-driving and eco-routing. *Transportation Research Part D: Transport and Environment*, *49*, 203–218. https://doi.org/10.1016/J.TRD.2016.09.008