

## The Analysis of the Sustainability Pillars of Karachi City's Transportation System

Sania SIDDIQUI <sup>1\*</sup> , Şirin Gülçen EREN <sup>2</sup> 

ORCID 1: 0000-0002-0176-3603

ORCID 2: 0000-0002-2038-3905

<sup>1</sup> Süleyman Demirel University, Graduate School of Natural and Applied Sciences, Urban and Regional Planning Department, 32260, Isparta, Turkey.

<sup>2</sup> Süleyman Demirel University, Faculty of Architecture, Urban and Regional Planning Department, 32260, Isparta, Turkey.

\* e-mail: saniasid.ss@gmail.com

### Abstract

The rapid pace of urbanization all over the world and the growth of motorization have led to an unsustainable transport system. Karachi is a city suffering from the same phase of urbanization. This article aims to assess the sustainability of the city's existing transportation system economically, socially, and environmentally and the degree of motorization. Data was collected through field surveys conducted in 2020 which include 15 hours of video recordings for traffic counts and the survey carried out at bus stops along two major arteries of Karachi. PM2.5 concentrations and the city's vehicle profile were extracted from authorized websites. The data is analyzed graphically and statistically for various periods. The article sets out the level of sustainability and degree of motorisation of the transport system in Karachi and the travel behaviour of its user. It concludes that externalities and the lack of a planned system constitute obstacles to the provision of a sustainable transport system.

**Keywords:** City Planning, sustainability, sustainable transport, motorization, Karachi

## Karaçi Kenti Ulaşım Sisteminin Sürdürülebilirlik Sütunlarının Analizi

### Öz

Tüm dünyada kentleşmenin hız kesmeden ilerlemesi; motorizasyonun artmasıyla birlikte, sürdürülemez bir ulaşım sistemine yol açmaktadır. Karaçi aynı kentleşme aşamasını yaşamaktadır. Bu makalenin amacı, kentin mevcut ulaşım sisteminin sürdürülebilirlik düzeyini sosyal, ekonomik ve çevresel açıdan ve kentin motorizasyon seviyesini değerlendirmektir. Veriler, NED Üniversitesi (Karaçi) öğrencilerinin 2020 yılında yaptıkları saha araştırmalarından derlenmiştir. Saha araştırmaları, trafik sayımını belirlemek için yapılan 15 saatlik video çekimini ve Karaçi'nin iki ana arteri boyunca otobüs duraklarında gerçekleştirilen anketi içermektedir. PM2.5 yoğunlaşması ve kayıtlı araç sayısı resmi internet sitelerinden çıkarılmıştır. Veriler, değişen zaman dönemleriyle birlikte, grafiksel ve istatistiksel olarak analiz edilmiştir. Bu makalede; Karaçi'deki ulaşım sisteminin sürdürülebilirlik ve motorizasyon seviyeleri ile kullanıcıların seyahat davranışları ortaya konulmaktadır. Makale dışsallıkların varlığının ve planlı bir sistemin eksikliğinin sürdürülebilir bir ulaşım sisteminin sağlanmasında engel olduğu sonucuna varmaktadır.

**Anahtar kelimeler:** Şehir planlama, sürdürülebilirlik, sürdürülebilir ulaşım, motorizasyon, Karaçi

**Citation:** Siddiqui, S. & Eren, S.G. (2022). The analysis of the sustainability pillars of Karachi city's transportation system. *Journal of Architectural Sciences and Applications*, 7 (Special Issue), 181-190.

**DOI:** <https://doi.org/10.30785/mbud.1023391>



## **1. Introduction**

Urbanization is a growing worldwide concern in the present era regardless of the size, culture, and economy of any city. Through the past literature, it has been assessed that urban area comprises half of the population of the world. Urbanization at an astounding pace is taking place in all parts of the world, however, it has been mostly observed in developing countries. This rate is expected to rise by 68% by the year 2050, adding another 2.5 billion people to urban areas (Bocquier, 2005).

Urbanization leads to an increase in commuting and this challenges the transport system of the country by constantly elevating the congestion and environmental concerns. This growth in urbanization and motorization calls for an integrated, holistic, and smart approach to city planning and transport management for meeting the societal obstacles through participation (Çetinkaya & Görer, 1995) confronted by developing countries all over the globe and mitigating the direct impacts on sustainable development (Qureshi & Lu, 2007). Mitigating all such externalities requires a shift towards a sustainable transportation system. Convincingly green and sustainable city transition depends upon Sustainable transportation (Faiz, 1993).

The concept of sustainable transportation arises from the idea of sustainable development. Sustainable transport is based on the concept that changes in travel are connected with several possible externalities, including air contamination, accidents, congestion, harm to the species' habitat, noise pollution, and the intensification of carbon dioxide production (Schipper & Figueroa, 1996). The concept of sustainable transportation is based on three basic visions which include the changing people and their quality of life and way of living, the changing technology with time, and the changing prices and limited resources (Gordon, 1995). Sustainable transport states to the extensive subject of transport that is sustainable in the senses of social, economic, climate, and environmental impacts (Spaethling, 1996).

Pakistan is a rapidly urbanizing country. According to Planning Commission, the Government of Pakistan, Pakistan will be mainly urban with 45.6% of its population residing in urban areas and around 12 cities housing more than one million people by the year 2030 (Pakistan Planning Commission, 2021). Although urbanization is a worldwide phenomenon, the matter of concern for the country is that cities in Pakistan are growing without the provision of essential environmental, social, and economic considerations for sustainable development (Rehman, Asif Ali & Ahmed, 2018). This article discusses Karachi, the city of lights, the largest populous city and the economic hub of Pakistan, and the world's eleventh populous city (UN ESA, 2021).

The city of Karachi is tackled with numerous challenges associated with urban mobility and the complete nonexistence of basic considerations of smart transportation. Karachi does not have a workable public mass transit system and the rise in the number of privately owned and used vehicles is quite noticeable due to rising incomes. This increasing motorization in the city with poor traffic management and regulation system, insufficient planning, and land use leads to extreme traffic congestion. Motorization results in environmental pollution, a deteriorating urban environment, extra fuel usage, and prolonged travel times that eventually have a direct effect on sustainable development. Therefore, urban transportation is a persistent concern in Karachi and the adoption of the principles of sustainable transportation has become more crucial so that it would not be a menace to the city's ecology (Khan & Khan, 2016).

According to the former literature sustainable transportation needs a dynamic equilibrium between the three basic pillars of sustainable development (Eren, 2021) for the existing and upcoming generations, which are social equity, environmental protection, and economic efficiency (Litman, 2003). Several attempts have been made to list indicators that may help in examining the transportation sustainability of transportation systems but balancing those indicators is challenging (Gilbert, Irwin, Hollingworth & Blais, 2000).

This study using available data aims to evaluate the city's transportation system economically, socially, and environmentally, its feasibility, people's behavior towards the city's transport system, current public transport circumstances, and the degree of motorization in the city. This study helps in

identifying the situation of the current paradigm of transportation and whether it is leading the city towards or away from sustainable transportation while contributing to the discussion of achieving a more sustainable and improved transportation system. In short, the focus of the article is the motorization process of the urban transportation system of Karachi based on the research done with respect to the pillars of sustainability.

## Material and Method

### 2.1. Study Area

The case study research area comprises the city of Karachi as a whole for the data extraction. The research area also includes the two arteries of Karachi;

- a. Rashid Minhas Road
- b. Shahr-e-Faisal

The above two arteries are the busiest and most famous arteries of the city and are the spots of recurrent traffic congestion. The arteries connect to numerous noticeable second and third-degree traffic attractors. Therefore, for the behavioral analysis of the travelers and traffic count data these two arteries have been selected, as it was unfeasible to cover every artery of the city within the available span of time. The periphery of Karachi in Pakistan is depicted in Figure 1, whereas Figure 2 and Figure 3 show the satellite image of the two selected arteries from their start and endpoints. The images were taken from Google Earth Pro 2021 and then processed through ArcMap 10.0.



Figure 1. Figure depicting Karachi's Territory in Pakistan (UN Habitat UCL-DPU, 2022)

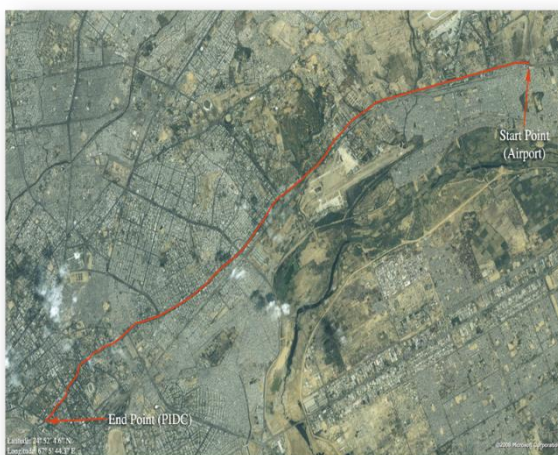


Figure 2. Satellite image of Shahr-e-Faisal (Google Earth Pro 2021)



Figure 3. Satellite image of Rashid Minhas Road (Google Earth Pro 2021)

## **2.2. Data Collection and Analysis**

The data used for the study were collected by the students at the NED University. The data were further analyzed for determining the sustainability pillars of the transportation system of Karachi and its motorization level.

### **2.2.1. Vehicle count**

Vehicle count is a crucial tool for traffic monitoring (Xiang, Zhai, Lv & El Saddik, 2018). To assess the number of vehicles and the percentage of the most common mode of commute, a vehicle count was made on the two selected arteries. The traffic count was made with the help of students at the NED University of Engineering and Technology, Karachi for the year 2020 for 12 months. Cameras were deployed at the selected locations on the chosen two arteries and the traffic was monitored through a video recording for 15 hours, from 7 am to 10 pm (Pakistan, GMT+5). The recorded videos were then analyzed through the click counter software for vehicle detection. The number of different modes of transport such as private cars, motorcycles, auto-rickshaws (including Qinqis), contract carriages, coasters, buses, pickups, trucks, etc. was recorded.

### **2.2.2. Number of registered vehicles**

The increasing number of vehicles is one of the main sources of rapid motorization and it impacts the environment as well. It not just increases the congestion on road leading towards prolonged travel times but is also a culprit behind the increasing noise and environmental pollution. The data for the number of registered vehicles in Karachi was extracted from the Karachi Mass Transit Cell (KMTC) for the years 2016 and 2020. The data for 2 years with a gap of almost 4 years was chosen to comparatively analyze the degree of motorization in the previous and near existing year for the city and to have an estimate of existing privately and publicly owned vehicles in the city.

### **2.2.3. A Questionnaire-based survey using a face-to-face technique**

The Questionnaire-based survey using a face-to-face technique was made along with the bus stops in 2022 at Rashid Minhas Road and Shahr-e-Faisal in which everyday commuters were asked about their destinations, their preferred mode of transportation for reaching their destinations, and the reason for choosing the particular mode based on the attributes such as time, availability, comfort, safety, and cost. A sample of 200 people was questioned and the modes of transportation chosen were cars, bikes, and public transport. The survey included data such as age, occupation, gender, travel cost, and travel destination of the commuter. Tests used to determine the strength of association between parameters included the Chi-square Test, Cramer's V, and Phi.

The survey was made to determine the behavioral analysis of the travelers and the reason why they are choosing that particular model. The survey was made to analyze the relationship between mode choice, the behavior of the travelers, and socioeconomic and demographic parameters through graphs and charts. Furthermore, econometric analysis was used to determine the strength of association between age, education, income, gender, and occupation of the traveler and the chosen mode.

### **2.2.4. PM2.5 (Particulate Matter 2.5) pollutant profile of the city**

Increasing the degree of motorization leads to more fossil fuel consumption and fossil fuels are the major contributors to particulate matter pollution. The pollution caused by this particular matter doesn't not only affect the climate and the environment but is also a serious threat to human health. Karachi's PM2.5 profile was recorded from the World Air Quality Index's official website and was analyzed comparatively for environmental analysis of the city and the contribution of vehicles in the elevating PM2.5 percentages through a literature survey.

## **3. Findings and Discussion**

The data was analyzed based on the collected data from different sources to determine the shift in the sustainability level of the city in terms of transportation. Besides the NED University students' study data, data of the Transport & Mass Transit Department (2021) website have been used. The results obtained from the analysis of the data are as follows;

### 3.1. Vehicle Count

The vehicle count data gathered from the two selected arteries depicts that during the 15-hour chosen time slot, the percentage of privately owned cars, motor vehicles, and rickshaws was significantly greater than the other modes of transportation. On both the arteries the percentage of the cars passed is quite noticeable as compared to any other mode whose percentage seems negligible to the percentage of cars as shown in Figure 4 and Figure 5.

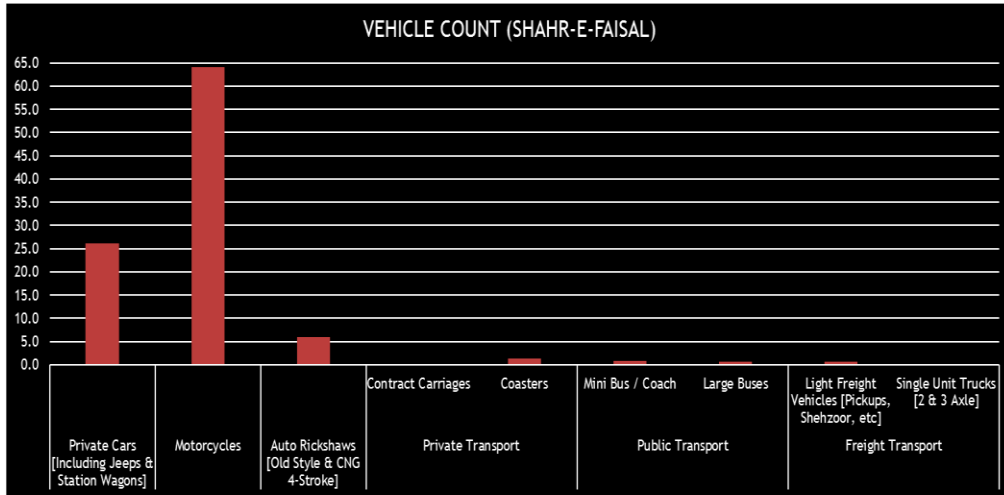


Figure 4. Vehicle count at Shahr-e-Faisal Road performed by the NED University students in 2020

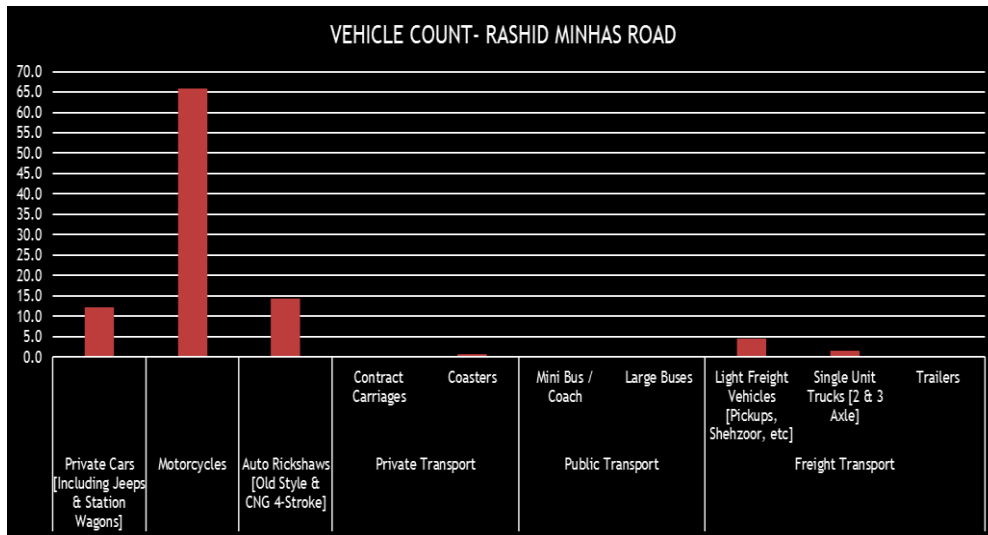


Figure 5. Vehicle count at Rashid Minhas Road performed by the NED University students in 2020

### 3.2. Number of Registered Vehicles in the City

Figure 6 shows the number of registered vehicles in the city in the year 2016 and the year 2020. It is clear from the figure content that the number of vehicles has significantly increased from the year 2016 to the year 2020. A major upsurge in the number of vehicles can be seen in this Figure, however, the increase in the number of cars, motorcycles, and rickshaws from the year 2016 to the year 2020 is quite significant as compared to the rest of the transportation modes.

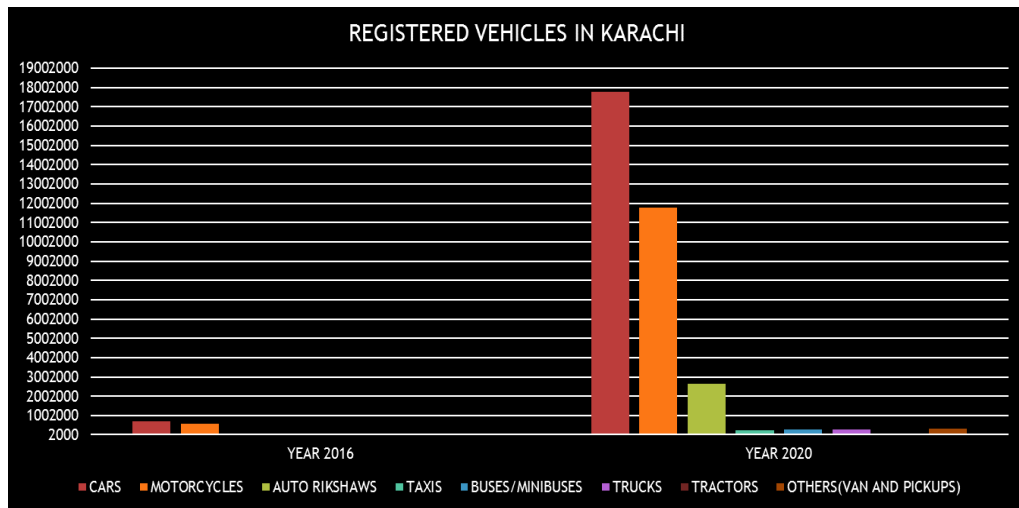


Figure 6. Registered vehicles in Karachi in the years 2006 and 2020-Karachi Mass Transit Cell 2020

### 3.3. Mode Choice and Behavioral Analysis

Transport impacts the lives and lifestyles of travelers. Travelers’ choice of mode of transportation and behavior tells a lot about the transportation system of the city. Table 1 depicts the strength of association between the age, gender, income, occupation, and education of travelers and the modal choice they are making to reach their destinations. From Table 1 it is quite evident that gender, income, and education strongly affect the mode choice while the rest of the factors do not make a significant difference.

Table 1. Table depicting analysis of the relation between mode choice behavior and socio-economic and demographic parameters

Factor	Dependent Variable	Asympytotic Significance	Cramer's V	Strenght of Association
Age	Mode choice	0.002	0.089	weak
Gender	Mode choice	0.000	0.322	Very strong
Income	Mode choice	0.000	0.399	Very strong
Occupation	Mode choice	0.071	0.076	weak
Education	Mode choice	0.000	0.401	Very strong

In the face-to-face survey, the majority of the people chose the option to use private transport; moreover, 86% of the people who chose to travel by public transport stated that they would have gone for private transport if it was available to them.

While asking the private transport travelers the reason they did not choose the public mode of transportation, 69% stated that they are doing it to save their selves from longer travel times. The rest of the travelers chose not to travel by public transport as they found that uncomfortable. Also, the majority of the women chose to travel through private transport because they consider it safer when compared to public transport.

A large percentage of travelers chose to travel through cars, bikes, and private vehicles to save time and to travel in comfort while the only reason for people using public transport was the unbearable costs and unavailability of private transportation.



### 3.4. PM2.5 Pollutant Profile

Figure 7 shows the concentration of PM2.5 pollutants for the years 2017, 2018, 2019, and 2021. It is evident from this figure that the concentration went low in the year 2018, but it started increasing again and now Karachi is considered as one of the most polluted cities in the world. In the year 2021, till October, the average concentration of PM2.5 pollutant recorded was 56.8 micrograms per meter cube, which is above the prescribed limit proposed by World Health Organization (WHO).

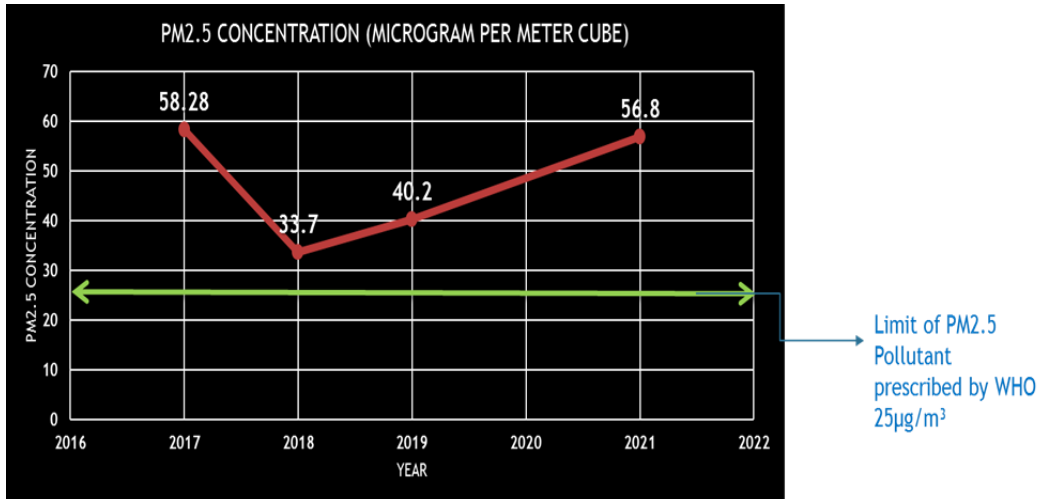


Figure 7. Summary of statistical analysis of the concentration of PM2.5 (World Air Quality Index)

## 4. Conclusion and General Remarks

This article has evaluated Karachi's transportation system, the degree of motorization, and its sustainability based on 3 major pillars of sustainable transportation (social equity, environmental circumstances, and economic efficiency).

### 4.1. Uncontrolled Motorization

In the city of Karachi, economic growth and elevating urbanization rate have led to uncontrolled motorization (Ahmed, Lu & Ye, 2008). Figure 6 shows the increase in the number of vehicles in the city within 4 years because of the unsafe and inadequate public transport system. Due to the lack of system and infrastructure for non-motorized modes of transportation like cycling and walking the continuously increasing number of private vehicles take over the road.

### 4.2. Social Equity and Transportation Sustainability

The present transportation system of Karachi does not provide its citizens any possibility or facility to easily and safely reach their desired destination and activities they wish to do. Sustainable urban transport needs of all social groups are rarely fulfilled. It is not based on equity, social diversity, quality of life, and social solidity for various groups in society as Aamir et al. (2019) has stated. For example, women are one of those particular groups which have different transport requirements in their everyday activities and according to the results of the survey, women quoted the problem of not being able to travel safely. In addition, lower-income groups face the problem of much less accessibility due to the lack of an adequate public transportation system. The present condition of the unsustainable transport system is a threat to social development and social equity in cities.

### 4.3. Economic Efficiency and Transportation Sustainability

Sustainable transportation in a city enables the economy to flourish, but it can hinder the effective delivery of major social amenities, if it is not well-managed (Heraa, 2013). The most noticeable problem of the city of Karachi is the traffic congestion and prolonged travel times. As per the survey, people choose to go for the privately owned vehicle to save their selves from the longer travel times. It also consumes more fuel. The city's local and national GDP may be severely affected because of high levels of congestion. The prevailing transportation system of the city lacks just pricing policy and affordable

public transport service, and it is not capable of providing a transport system that encourages modal choice and efficiency along with accessibility.

#### **4.4. Environmental Circumstances and Transportation Sustainability**

As shown in Figure 7 we can conclude that another main difficulty for the city of Karachi is the increasing and alarming concentration of PM<sub>2.5</sub> which leads to urban air pollution and is a widespread environmental threat. The growing concentration of PM<sub>2.5</sub> pollutant emissions from ill-maintained vehicles, bottlenecks, traffic congestion, and prolonged traveling time, makes the air index quality weaker (Wang et al., 2012). Concisely, the emissions from vehicles are one of the most important sources of PM<sub>2.5</sub> pollutants (Yu et al., 2013) that affect human health and are a reason for lung diseases and bronchitis.

The above-drawn conclusions from the study show that the transportation system of Karachi is facing a crisis and the system failed to be economically, socially, and environmentally sustainable. It can be considered quite far from being called sustainable. Despite being the twelfth largest city in the world there is no appropriate public mass transit system. Pivotal parameters of sustainability such as non-motorized transportation's facilitation, ensuring accessibility that includes widespread access, environmental controls, affordability, that ensures accessibility are noteworthy by their absence. Pertinent strategies, standards, policies, and institutions that may consist of urban transportation policy and street design guiding principles have not been endorsed.

For the city of Karachi to have a sustainable transportation system, decision-makers, urban planners, and the public have to play their respective parts efficiently as also noted by Ferrer (2015). Opting for adequate land use planning will maximize the productivity of the modal choice of transportation and usage of resources and an integrated transport system will maximize the efficiency of the transportation system of the city for environmental circumstances and city resource limitations. Hence, leading toward sustainable urban transportation.

To control the number of privately owned vehicles and personal cars public transport should be promoted and transit-based development should be worked onto. Car usage can also be reduced and discouraged among people by applying appropriate economic tools. This will help deal with the existing level of congestion and will make transportation accessible for all social groups. For low-income groups and to provide vertical justness to them fares should be subsidized and low transport fares should also be introduced. The decision and policymakers should work on formulating appropriate strategies, policies and legislation for current transportation modes, financial resources of transportation, planning principles, and effective management of transportation systems. The infrastructure for non-motorized vehicles and the transportation network should be focused on and a proper vehicle system should be introduced to control the vehicular emission that harms the environment and is a menace to ecology (Qureshi & Lu, 2007).

The existing transportation system of the city of Karachi fails to be quoted as sustainable and, is quite far from the concept of sustainability but adoption of the mentioned and similar strategies may lead to a sustainable urban transportation system and eventually towards sustainable urbanization.

#### **Acknowledgment and Information Note**

The study would not have been possible without the vehicle count data and the behavioral analysis using the face to face survey technique in Karachi therefore, we would like to show our gratitude to the students of the Ned University of Engineering and Technology, Karachi for helping us gather the data to carry out our research. The article complies with national and international research and publication ethics. Ethics Committee approval was not required for Pakistan. This article was presented in the "IArcSAS" 1<sup>st</sup> International Architectural Science and Application Symposium on 27-29 October 2021 as an abstract. It was later expanded for this Journal.

#### **Author Contribution and Conflict of Interest Declaration Information**

All authors contributed equally to the article. There is no conflict of interest.



## References

- Aamir, M., Masroor, S., Ali, Z.A. & Ting Ting, B. (2019). Sustainable Framework for Smart Transportation System: A Case Study of Karachi. *Wireless Pers Commun*, 106, 27–40. Access Address (02.09.2021): <https://doi.org/10.1007/s11277-019-06259-4>
- Ahmed, Q. I., Lu, H. & Ye, S. (2008). Urban transportation and equity: A case study of Beijing and Karachi. *Transportation Research Part A: Policy and Practice*, 42(1), 125-139.
- Bocquier, P. (2005). World Urbanization Prospects: an alternative to the UN model of projection compatible with the mobility transition theory. *Demographic Research*, 12, Article 9. 197-236.
- Çetinkaya, F. & Görür, N. (1995). Sürdürülebilir Kalkınmada Katılım ve Planlamanın Önemi, Planlama. HABITAT Özel Sayısı. 3/4. 16-20.
- Eren, Ş.G. (2019). Tokyo: Solaris-güneş imparatorluğu'nun dirençli, kırılğan ve tehlikeli kenti. *İdealkent*, 28(10), 907-941.
- Eren, Ş. G. (2021). Sürdürülebilirlik Bağlamında Şehircilik ve Kentsel Büyüme Kavramları Üzerine Bir Analiz, Mimarlık Bilimleri ve Sürdürülebilirlik, İKSAD publishing house, Eds. Şebnem Ertaş Beşir, Meryem Bihter Bingül Bulut, İrem Bekar, 197-264. ISBN: 978-625-8061-43-7.
- Faiz, A. (1993). Automotive emissions in developing countries-relative implications for global warming, acidification and urban air quality. *Transportation Research Part A: Policy and Practice*, 27(3), 1, 67-186.
- Ferrer, M. (2015). *Karachi: Megacity of Woes*. The New School for Public Engagement Report. University of Nairobi.
- Gilbert, R., Irwin, N, Hollingworth, B. & Blais, P. (2000). Sustainable transportation performance indicators project: Brief review of some worldwide activity and development of an initial long list of indicators. *Mississauga, Centre for Sustainable Transportation*. Toronto, ON, Canada.
- Gordon, D. (1995). Sustainable transportation: what do we mean and how do we get there. *Transportation and energy: Strategies for a sustainable transportation system*. 1-11.
- Heraa, N. A. (2013). *Transportation system of Karachi*, Pakistan. PhD Thesis, Faculty of the Graduate School of Asia Pacific Studies, Ritsumeikan Asia Pacific University.
- Khan, M.M. & Khan, H. (2016). An assessment of the problems faced by Karachi and Pakistan due to the rapid population growth of the city. *Journal of History and Social Sciences*, 7(1), 1-30.
- Litman, T. (2003). Measuring Transportation: Traffic, Mobility and Accessibility, *ITE Journal* ([www.ite.org](http://www.ite.org)), 73(10), October, 28-32. Access Address (03.09.2021): Victoria Transport Policy Institute website ([www.vtpi.org](http://www.vtpi.org)); at [www.vtpi.org/measure.pdf](http://www.vtpi.org/measure.pdf). Ministry of Planning Development & Special Initiatives (Pakistan Planning Commission) Access Address (11.10.2021): <https://www.pc.gov.pk/>
- Qureshi, I. A. & Lu, H. (2007). Urban transport and sustainable transport strategies: A case study of Karachi, Pakistan. *H. Tsinghua science and technology*, 12(3), 309-317.
- Rehman, K., Asif Ali, S. & Ahmed, K. (2018). E-Government identification to accomplish sustainable development goals (UN 2030 Agenda) a case study of Pakistan. *IEEE Global Humanitarian Technology Conference (GHTC) Proceedings*. 1-6. IEEE.
- Schipper, L. & Figueroa, M. (1996). Sustainable transportation and human activity: Avoiding a collision course. Conference on Towards Clean Transport: Fuel-Efficient and Clean Motor Vehicles, Mexico, 28-30 March 1994. Conference Report. CONF-9403276.
- Spaethling, D. (1996). Sustainable transportation. The American experience. In: *Proceedings of Seminar C. Planning for Sustainability of the 24<sup>th</sup> European Transport Forum*. London, England: PTRC Education and Research Services Limited.

- Transport & Mass Transit Department, Access Address (18.09.2021): <https://transport.sindh.gov.pk/>
- Wang, Z.S., Wu, T.W., Shi, G.L., Fu, X., Tian, Y.Z., Feng, Y.C., Wu, X.F., Wu, G., Bai, Z.P. & Zhang, W.J. (2012). Potential source analysis for PM10 and PM2.5 in autumn in a northern city in China. *Aerosol and Air Quality Research*, 12(1), 39-48.
- United Nations, Department of Economic and Social Affairs (UN ESA), Population Division (2021). World Population Review. *World Population Prospects*. Press Release.
- Xiang, X. Z., Zhai, M., Lv, N. & El Saddik, A. (2018). Vehicle counting based on vehicle detection and tracking from aerial video. *Sensors*, 18(8), 2560.
- Yu, L., Wang, G., Zhang, R., Zhang, L., Song, Y., Wu, B., Li, X., An, K. & Chu, J. (2013). Characterization and source apportionment of PM2.5 in an urban environment in Beijing. *Aerosol and air quality research*, 13(2), 574-583.

