

PEDALLING TOWARDS SUSTAINABILITY: AN EXAMINATION OF THE ENVIRONMENTAL BENEFITS OF CYCLING IN URBAN KATSINA, NIGERIA

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Abstract

This study evaluates the environmental benefits of cycling compared to other forms of transportation within the urban environment of Katsina. An environmental impact assessment approach was employed to assess the advantages of cycling over cars and other modes of transport. Data were collected from 130 respondents to analyse the environmental and health benefits associated with cycling. The findings reveal that 65% of respondents believe cycling enhances human health across all age groups, contributing to the prevention and management of various diseases affecting the lungs and heart. Additionally, all respondents (100%) agreed that cycling helps reduce global warming and the emission of toxic substances that contribute to ozone layer depletion. Cycling was also noted to alleviate road traffic congestion and lower mortality rates associated with road accidents and air pollution from cars. Environmental studies suggest that cycling can reduce carbon dioxide emissions by approximately 9,062,344 kg annually. Furthermore, the study highlights that cycling can decrease urban transport costs by 35%.

Keywords: *Bicycle, Environment, Human Health, Transportation and Urban.*

Introduction

Bicycles, or pedal cycles, have a long-standing history as modes of transportation, recreation, and sport. In Nigeria, their popularity has surged in both urban and rural areas, partly due to rising fuel prices following the government's subsidy removal. Many residents are finding it increasingly difficult to afford fuel for short and long trips, leading to a greater reliance on bicycles (Gálvez-Fernández *et al.*, 2022). Midgley (2011) notes that cities like Lyon, Seville, and Barcelona have implemented cycling initiatives for short urban trips and multimodal transport, primarily to alleviate traffic congestion rather than for environmental benefits.

Environmental challenges posed by human activities, such as industrialisation, mining, and burning of fossil fuels, including using cars for travelling and other vehicles causing global warming, climate change and depletion of ozone layer. Ugbebor & John (2018) observed that increase in vehicle population in developing countries is associated with increase in air pollution. Almost all Nigerian vehicles are driven by fossil fuels which seriously caused ambient air quality degradation, environmental impact and public health problems (Okafor *et al.*, 2021; Odesany, Stephens, & Okoko, 2023).

Studies have shown that air pollution resulting from exhaust emissions of congested vehicles and poor automobile maintenance poses significant risks to public health and contributes to climate

change (Ojolo, 2007; Johnson & Hyelda, 2013). To address these environmental challenges, it is crucial for people to recognize the benefits of using bicycles as an alternative mode of urban transport. Electric bicycles offer an attractive urban transportation alternative with comparable trip times, zero local emissions, and reduced Well-to-Wheel pollutant impacts, contributing to improved urban air quality (Baptista *et al.*, 2015). Given the environmental issues associated with cars and other fossil fuel-based transportation, government and policymakers should promote alternative modes of transport, such as walking and cycling, to reduce both the cost of living and environmental damage (Marais *et al.* 2019).

Research by Hamer and Chida (2007) indicates that in Europe, walking and cycling can lower the risk of cardiovascular disease by 11%. In developed countries, the rise of industries and automobiles has led to increased air pollution, prompting more people to embrace cycling as a cleaner mode of transport. The World Health Organization (WHO) and the Intergovernmental Panel on Climate Change (IPCC) emphasized in 2005 that European nations should focus on environmental protection and encourage physical activity, including cycling.

Automobiles, which predominantly run on fossil fuels, are major contributors to air pollution. According to Platt *et al.* (2017) burning four litres of diesel generate 7.71 to 9.97 kg of Carbon. Also, Gentner *et al.* (2013) said Gasoline sources are responsible for 69-96% of emissions and 79-97% of the ozone formation potential from gas-phase organic carbon emitted by motor vehicles. This underscores the need for more sustainable transportation options to mitigate environmental and health impacts.

Climate change and global warming are the greatest socioeconomic and biophysical challenges confronting the world in the 21st Century. Human activities, particularly deforestation and the burning of fossil fuels, is forcing this change by increasing atmospheric concentrations of Carbon dioxide and other Greenhouse gases (GHGs). As a result, the world is experiencing greater weather extremes, changes in rainfall patterns, heat and cold waves, and increasing droughts and floods. These phenomena have a negative impact on the environment and on people's lives and livelihoods. Marginalized groups and communities in the poorest regions of the world are particularly affected, even as they are least responsible for these changes (United Nations Development Programme UNDP 2009).

Many studies on the economic, social, environmental and health benefit of bicycling were conducted globally, for example, Rojas *et al.* (2011), studied health risks and benefit of cycling in urban environment, Aderamo & Atomode (2011), Younkin *et al.* (2021) studied the potential health and environmental benefits, Bashiru & Waziri (2008) studied traffic congestion and delays in Nigeria, etc. All these studies put more emphasis on health benefits than environmental benefits. Also, a review of previous research shows that the views of environmental expert on transportation have not been considered. The survey covered a variety of respondents ranging from commuters, drivers and experts on environmental impact assessment from Katsina and beyond. This is intended to provide a wider perspective to the problem of air pollution caused by traffic congestion in Nigeria.

The findings from this study provide information to guide the governments, including concerned citizens and international agencies in responding to the problems of air pollution facing our environment in Nigeria. Besides, this study will also trigger further studies in attempt to find solutions to the issues raised, also to encouraging Nigerian to subscribe cycling for environmental and health benefit most especially with the current issue of subsidy removal.

Study Area

Katsina State is located between latitude 11⁰⁰'N and 13²⁰'N and longitude 7⁰⁰'E and 8⁵⁵'E. It shares boarder with Niger Republic to the North, Kaduna State to the South, Jigawa and Kano States to the East, and Zamfara State to the West (Figure 1). Katsina State has a land size of about 24,971.215km² with a population of 5,801,584 as at 2006 national census (Federal Republic of Nigeria, 2012). Katsina Local Government Area has a population of 318,132 persons (NPC, 2006). The population of the Katsina Urban Area has been increasing since then due to the migration of people from all over the country especially the rural areas affected by insecurity and the neighbouring nations especially Niger Republic (Ladan, 2014) the population of Katsina LGA was projected in 2023 by 3.76% to 524,000 people.

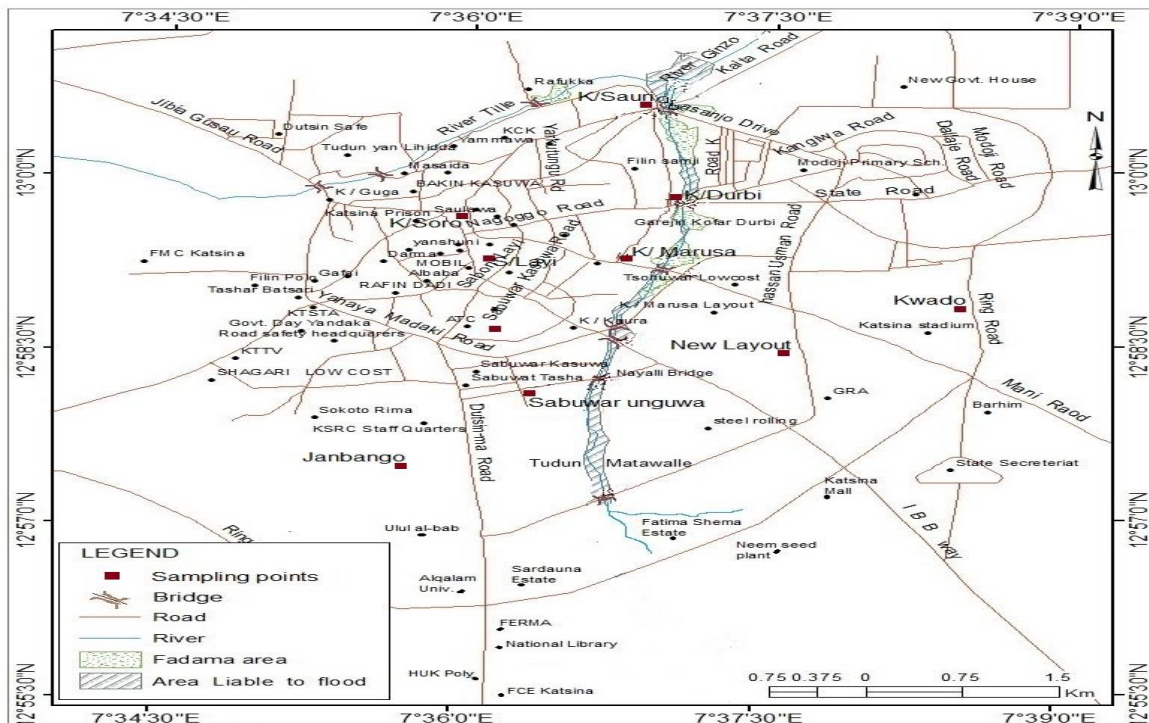


Figure 1: Map of Katsina Metropolis showing the Study Point (Study Area)

Source: UMYUK GIS Lab (2022)

Materials and Methods

To evaluate the impact of bicycles on traffic congestion and environmental sustainability in metropolitan Katsina, a quantitative research approach was applied, incorporating a descriptive survey design. This study utilized both primary data (collected directly from respondents) and secondary data (gathered from existing sources) to ensure comprehensive insights. To ensure equal representation across the study population, a simple random sampling method was employed. A total of 130 respondents were randomly selected from eleven densely populated and well-connected neighborhoods within metropolitan Katsina: Kwado, Kofar-Sauri, Kofar-Durbi, Kofar-Kaura, GRA, Kofar-Marusa, and Layout.

To further refine the sample and capture variations across the urban environment, a stratified random sampling method was used. The population was divided into two strata: cyclists and non-cyclists. Simple random samples were then drawn from each stratum, ensuring that both groups were adequately represented and providing insights into their specific experiences within the Katsina metropolitan area.

The data was collected via questionnaires distribution to both cyclists and non-cyclists within the study area. This enabled a comparison of perspectives and experiences regarding the use of bicycles versus other forms of transportation. Additionally, an environmental impact assessment framework was used to evaluate the potential benefits of cycling on reducing traffic congestion, as well as its social and economic impacts on local communities.

Table 1: Locations and the Number of Respondents

Location	No. of Respondents	Percentage (%)
Kwado	13	10%
GRA	11	8.5%
Sabon Layi	13	10%
Kofar Soro	11	8.5%
KofarKwaya	12	9.2%
SabuwarUnguwa	13	10%
Kofar Kaura	10	7.7%
KofarDurbi	12	9.2%
Kofar Sauri	13	10%
Kofar Marusa	12	9.2%
New Layout	10	7.7%
Total	130	100%

Source: Authors Fieldwork, 2022

Results and Discussions

Demographic Characteristics

The demographic characteristics of the respondents as presented in Table 2, indicate a strong male predominance among bicycle riders, Respondents were asked to classify themselves according to their sex, age and income level, and their responses recorded accordingly; with (96% n = 130) of respondents identifying as male. This gender imbalance is likely due to cultural and religious customs in Hausa society, where it is generally uncommon for females above the age of 13 to ride bicycles, as they primarily serve domestic and social roles. The few female respondents (4%) who do ride bicycles are typically younger, between the ages of 3 and 12, using them primarily for errands or transportation to school. this finding is similar to the findings of Schönbach, (2020) which shows Only 44.4% of girls and 72.9% of boys in Germany cycled to school, with girls reporting a need for "social behaviour in road traffic" and a "sense of safety." Girls face higher perceived barriers to physical activity compared to boys, with lack of energy and willpower being the most common barriers (Rosselli, 2020). Also, the study revealed that almost all ages ride bicycle, but majority of the respondents (60.7%; n = 130) are between the ages of 19 to 30 years age, (25.4% n = 130) are 40 years and above. Adults who bike can enjoy many health benefits such as reduced over weightiness and obesity and reduction in certain types of cancer and cardiovascular diseases than non-cyclist (Leyland *et al.* 2019, Baughn *et al.* 2022 and Matthew *et al.* 2007). And only 14.2% are below 18 years of age. In children and adolescent, it improves and reduces cardiovascular fitness and risk factor (Leyland, et al. 2019 and cooper 2006).

Income level also appears to influence bicycle usage, as 66.7% of respondents who provided income information (n=90) earn more than N51,000 monthly, reflecting a notable representation of middle and lower-income earners in this activity. Lower-income individuals frequently utilize bicycles as an economical mode of transport, supporting past research suggesting that bicycle use increases accessibility and reduces financial strain for those with limited income (WHO, 2020). Parker, C. (2019) said Bicycles are an adaptable mode of transportation that help homeless people in California cities to access social interactions. The study also, corroborate with findings of Shah, & Kajita, (2022) in Kabul Afghanistan were Low-income workers in Kabul frequently use bicycles and walking as a reliable mode of transportation due to increasing cost and insufficient public transportation.

Table 2: Demographic Characteristics of Respondents

Items	Responses	Frequency	Percentage
Sex:	Male	125	96
	Female	05	4
Age:	10-18yrs	18	13.8
	19-30yrs	79	60.7
	40>	33	25.4
Income Level	N10,000-N30,000,	-	-
	N31,000–N40,000	18	20
	N41,000–N50,000	12	13.3
	N51,000 >	60	66.7

Source: Authors Fieldwork, 2022

Bicycle Usage and Distance Covered

Table 3 illustrates the patterns of bicycle usage and distances covered by respondents. Among the respondents, 60% (n = 130) own a bicycle, using it for both short and long-distance trips, while the remaining 40% do not own a bicycle but still use one regularly for commuting. A significant portion of respondents (32.1%; n = 78) use bicycles for local trips, while 25.6% rely on bicycles for commuting to school, with both adults and schoolchildren participating in these activities (Schipperijn, 2016). The U.S. Federal Highway Administration (FHWA, 2009) reported that bicycle trips in the United States more than doubled from 1.7 billion in 2004 to 4 billion in 2009, illustrating a global rise in biking for daily travel. Additionally, 19.2% and 12.8% of respondents use bicycles for work commutes, business, shopping, and other errands. Buehler & Hamre, (2016) said in America during a typical day, about 14% of Americans car users make at least two trips by foot, bicycle, or public transport, while during a typical week, about 25% of motorists make at least seven trips by means of transport other than the car.

Regarding distance, the largest group of respondents (38.5%; n = 78) covers 4–6 km daily, while 28.2% travel 1–3 km. Longer distances, between 7–10 km and above, are covered by 20.5% and 12.8% of respondents, respectively; these distances are often undertaken by business commuters traveling between various locations within and around the city. This aligns with the U.S. Energy Information Administration's data indicating that traditional car use releases between 17 and 22 pounds (7.71–9.97 kg) of carbon per gallon of gasoline, underscoring the environmental advantages of increased bicycle commuting.

Table 3: Bicycle Usage and Distance Covered

Item	Responses	Frequency	Percentage %
Bicycle ownership	Yes	78	60
	No	52	40
Bicycle usage	For local trip	25	32.1
	For schooling	20	25.6
	For shopping	10	12.8
	For sport/work	15	19.2
	Other	8	10.3
Distance covered	1 -3 km	22	28.2
	4 – 6 km	30	38.5
	7 – 10 km	16	20.5
	11 and above	10	12.8

Source: Authors Fieldwork, 2022

Fuel Consumptions per Day

From the result it shows that (46.2%; n=120) own and ride motorcycle, also, (30.8%; n = 120) uses car for local trip, also, (13%; n = 120) don't use motorcycle, cars or busses. Recent cyclists in Bogota are more motivated by rational reasons like saving money and improving transit quality, while experienced cyclists are more driven by a passion for cycling (Rodriguez-Valencia *et al.* 2021). According to Rails to trails Conservancy (2008) shifting more trips to bicycle may also result in fuel savings of 2.4 gallons (3.89 L) of fossil fuels each year, decreasing dependence on these sources and associated expenses. Also, 75% to 100% shift from motorized vehicles to bicycle saves about 0.52 to 0.7 (mtoe) and CO₂ emission to 1.5 million tonnes (TERI 2018). For those commuting with cars, motorcycle, buses consumed fuel every day for local running, the result shows that majority of the respondents (47.8%; n = 115) consume only 1-2 litres of fuel every day for their local trips, while another category (26.1%; n = 115) are consuming 3-5 litres of fuel every day and only very few (8.7%; n= 115) consumed more than 11 litres every day. Most of the respondent (52.2%; n=115) said they buy N500 – 1000 fuel every day. In the last 6-month 5litres of petrol cost N1200 at the rate of N220 per litre.

Therefore, a shift from cars to bicycle can help Nigerians to save N395 per litre, and can help to free the air from contamination. Bucher *et al.* (2019) said Electric bicycles can lead to GHG emission reductions of up to approx. 10% of total emissions from diesel and gasoline, and further savings of up to 17.5% when combined with electric vehicles. Brand, (2021) posit that increase in cycling or walking consistently and independently decreased mobility-related lifecycle CO₂ emissions, substituting for motorized travel.

Table 4: Other Vehicles and their Fuel Consumption per Day

Items	Respondent	Frequency	Percentage
Vehicles	Motorcycle	60	46.2
	Cars	40	30.8
	Busses	10	7.7
	Trucks	3	2.3
	None of the above	17	13
Fuel consumption/day	1-2 Litre	55	47.8
	3-5 Litre	30	26.1
	7-10 Litre	20	17.4
	11> Litre	10	8.7
Cost of fuel consumed/ day	< N500	5	4.3
	N500 - N1, 000	60	52.2
	N2, 000 –N5, 000	35	30.4
	N10, 000 >	15	13.1
Health benefit	Strongly agreed	85	65.4
	Agreed	40	30.8
	Disagreed	4	3.1
	Strongly Disagreed	1	0.7

Source: Authors Fieldwork, 2022

The current official pump price of petrol per litre in Nigeria is N1050 and Diesel is N1200 while other commercial filling stations are selling each litre at the rate of N880-N980. Therefore, N1000 fuel today is not up to 2 litres this is as a result of fuel subsidy removal by the current administration of president Bola Tinubu. Others (30.4%; n= 115) buy N2000 –N5000 fuel every day. Neun & Haubold, (2016) estimates that substituting 32% of the car trips in Europe by bicycles could result in the annual fuel savings of €28 billion. The result shows that, this is one of the reasons why majority of the respondent uses bicycle for local trips. The respondent believed that bicycles improve their health (65.4%; n = 130) strongly agreed that riding bicycle prevent them from illness, also, (30.8%; n = 130) of them have also agreed that bicycle benefit their health because apart from using it for transport it helps users to exercise their body and improve the immune system from diseases.

Conclusion and Recommendation

The study underscores that increased bicycle usage in urban Katsina brings notable environmental and economic benefits. Findings reveal that by choosing bicycles over motorized transport for short-to-medium distances, residents significantly reduce daily fuel consumption and related costs. Given the recent fuel price hikes, with petrol costing approximately N220 per litre, a shift to cycling can alleviate household expenses on fuel, providing substantial savings. Additionally, the health benefits of cycling such as improved cardiovascular health, reduced risk of chronic diseases, and enhanced physical fitness emerge as key advantages. By reducing reliance on fuel-powered vehicles, cycling also contributes to lower air pollution and mitigates the noise typical of urban areas, fostering a cleaner and quieter city. Ultimately, large-scale adoption of bicycles for daily travel could enhance road safety, provide recreational opportunities, and support sustainable urban development in Katsina. Based on the findings of this study on the environmental and economic benefits of cycling in urban Katsina, the following recommendations are proposed:



1. **Infrastructure Development for Cyclists:** The government and urban planners should prioritize the development of dedicated cycling lanes and safe, accessible routes across the city. This infrastructure would encourage more residents to adopt cycling as a daily mode of transport, improving safety and convenience for cyclists.
2. **Public Awareness Campaigns:** There should be targeted awareness programs highlighting the health, economic, and environmental benefits of cycling. Campaigns could include educational workshops in schools, community centres, and local media to promote cycling as a viable alternative to car use, especially for short distances.
3. **Policy to Regulate Fuel Prices and Promote Sustainable Alternatives:** Policies aimed at regulating fuel prices and encouraging sustainable transportation options would help mitigate the impact of rising fuel costs on citizens. Offering discounts or rebates for bicycle purchases could serve as a practical incentive for adopting cycling.
4. **Integrate Cycling into Public Health Initiatives:** Health authorities and local government agencies should include cycling in public health programs, emphasizing its physical and mental health benefits. This could involve city-sponsored events like "Cycling Days" to promote fitness and showcase cycling as a health-boosting activity.
5. **Create Bicycle sharing Programs:** Establishing a community-based bicycle-sharing program would provide residents with easy access to bicycles for short trips, reducing fuel consumption and easing traffic congestion. Bicycle-sharing stations could be located in strategic locations, like bus terminals and community centres for convenience.
6. **Enhance Road Safety Regulations for Cyclists:** Policymakers should introduce and enforce road safety regulations specifically for cyclists. This would involve educating both cyclists and drivers on sharing the road safely, including appropriate signage and lane markings, as well as penalties for violations to ensure safer streets for all road users.
7. **Encourage Private Sector Participation:** Local businesses and organizations can play a role by sponsoring cycling events, offering bicycle parking facilities, and even partnering with the government on initiatives that promote cycling. This collaboration can further embed cycling into the urban culture of Katsina and offer additional support for infrastructure and awareness programs.

By implementing these recommendations, Katsina can move toward a sustainable and economically viable transportation system that not only reduces fuel dependency but also enhances public health, road safety, and environmental quality.

References

- Andrew, E., Okosun, O. et al (2023). Transit, Walking and Cycling Infrastructure and Sustainable Development in Enugu City, Nigeria: *iop conf. Ser.: Earth Environ. Sci.* 1239012022.
- Baptista, P., Pina, A., Duarte, G., Rolim, C., Pereira, G., and Silva, C., et al. (2015). From on Road Trial Evaluation of Electric and Conventional Bicycles to Comparison with other Urban Transport Modes: Case Study in the City of Lisbon, Portugal. *Energy Conversion and Management*, 92, 10-18. <https://doi.org/10.1016/J.ENCONMAN.2014.12.043>.
- Baughn, M., Arellano, V., Hawthorne-Crosby, B., Lightner, J., Grimes, A., & King, G. (2022). Physical Activity, Balance, and Bicycling in Older Adults. *PLOS ONE*, 17. <https://doi.org/10.1371/journal.pone.0273880>.
- Brand, C., Götschi, T., Dons, E., Gerike, R., Anaya-Boig, E., and Avila-Palencia, I., et al (2021). The Climate Change Mitigation Impacts of Active Travel: Evidence from a Longitudinal Panel Study in Seven European Cities. *Global Environmental Change*. <https://doi.org/10.1016/J.GLOENVCHA.2021.102224>.
- Brunekreef, B., Beelen, R., Hoek, G. et al. (2009). Effects of Long-term Exposure to Traffic related air Pollution on Respiratory and Cardio-vascular Mortality in the Netherlands: the NLCS-AIR study. *Res Rep Health Eff Inst* 2009; 139:5–71.
- Bucher, D., Buffat, R., Froemelt, A., & Raubal, M. (2019). Energy and Greenhouse as Emission Reduction Potentials Resulting from Different Commuter Electric Bicycle Adoption Scenarios in Switzerland. *Renewable and Sustainable Energy Reviews*. <https://doi.org/10.1016/J.RSER.2019.109298>.
- Buehler, R., & Hamre, A. (2016). An Examination of Recent Trends in Multimodal Travel Behavior among American Motorists. *International Journal of Sustainable Transportation*, 10, 354 - 364. <https://doi.org/10.1080/15568318.2014.945672>.
- Cooper, A. R., Wedderkopp, N., Wang, H., Andersen, L., Froberg, K. (2006). Active Travel to School and Cardiovascular Fitness in Danish Children and Adolescents. *Med Sci Sports Exer* 2006;38(10):1724–31.
- Federal Highway Administration (1993). *The Environmental Benefit of Bicycling and Walking FHWA Case Study*. Vol. 15.
- Fishman, E., Schepers, P., and Kamphuis, C. (2015). ‘Dutch Cycling: Quantifying the Health and Related Economic Benefits’. *American Journal of Public Health* 105(8). Flusche, D. (2009). *The Economic Benefits of Bicycle Infrastructure Investments*. Washington (DC): League of American Bicyclists.
- Gálvez-Fernández, P., Chillón, P., Aranda-Balboa, M., & Herrador-Colmenero, M. (2022). Preliminary Results of a Bicycle Training Course on Adults’ Environmental Perceptions and Their Mode of Commuting. *International Journal of Environmental Research and Public Health*, 19. <https://doi.org/10.3390/ijerph19063448>.
- Gentner, D., Worton, D., Isaacman, G., Davis, L., Dallmann, T., Wood, E., et al. (2013). Chemical Composition of Gas-phase Organic Carbon Emissions from Motor Vehicles and Implications for Ozone Production. *Environmental science & technology*, 47 20,11837-48. <https://doi.org/10.1021/es401470e>.

- Hamer, M. and Chida, Y. (2007). "Active Commuting and Cardiovascular Risk: A Meta-analytic Review," *Preventive Medicine*, Vol. 46, No. 1, Pp. 9–13, 1, doi: 10.1016/j.jpmed.2007.03.006.
- Joseph, A. (2022). *Analyses of Road Traffic Accidents on Nigerian Roads*. Annual Conference on Public Transportation at the Lagos Sheraton Hotel & Towers Ikeja.
- Karlsson, L. (2004). Ammonia, Nitrous oxide and Hydrogen Cyanide Emissions from Five Passenger Vehicles: *Science of the Total Environment*.334 / 335.125-132.
- Leyland, L., Spencer, B., Beale, N., Jones, T., & Reekum, C. (2019). The Effect of Cycling on Cognitive Function and Well-being in Older Adults. *PLoS ONE*, 14. <https://doi.org/10.1371/journal.pone.0211779>.
- Marais, E., Silvern, R., Vodonos, A., Dupin, E., Bockarie, A., and Mickley, L., et al. (2019). Air Quality and Health Impact of Future Fossil Fuel Use for Electricity Generation and Transport in Africa. *Environmental science & technology*. <https://doi.org/10.1021/acs.est.9b04958>.
- Matthews, C. E., Jurj, A. L., Shu X-O, et al. (2007). Influence of Exercise, Walking, Cycling, and Overall Nonexercise Physical Activity on Mortality in Chinese Women. *Am J Epidemiol*.2007;165(12):1343–50.
- Midgley P. (2011). *Bicycle-sharing Schemes: Enhancing Sustainable Mobility in Urban Areas*. United Nations, Department of Economic and Social Affairs, 2011.
- Miguel, A., Kirchstetter, T., Harley, R., & Hering, S. (1998). On-Road Emissions of Particulate Polycyclic Aromatic Hydrocarbons and Black Carbon from Gasoline and Diesel Vehicles. *Environmental Science & Technology*, 32, 450-455. <https://doi.org/10.1021/ES970566W>.
- Moses, S. O. (2011). *Information Technology Applications in Transportation System*. Proceedings of the National Conference of Nigerian Society of Engineers in Calabar. National Household Travel Survey. Available from: <http://nhts.ornl.gov>.
- Neun, M. and Haubold, H. (2016). *The EU Cycling Economy: Arguments for an Integrated EU Cycling Policy*. Brussels: European Cyclists' Federation.
- Odesany, J.F., Stephens, M.S., & Okoko, E.E., (2023). Effect of Road Transport Operations on the Environmental Quality of Air and Associated Health Implications in Ondo State, Nigeria. *International Journal of Research and Innovation in Social Science*. <https://doi.org/10.47772/ijriss.2023.70528>.
- Okafor, C., Arove, M., Odewumi, S., Maccracken, M., & Odesanya, B. (2021). *Real-Time Quantitative Assessment of Transport Induced Greenhouse Gases Emissions Profile in Lagos, Nigeria*. <https://doi.org/10.21203/RS.3.RS-668130/V1>.
- Oluwasegun, O. A. (2018). Road Traffic Accidents Characteristics in Nigeria: a Six Year Review. *GSI* volume 6, issue 5, May 2018, online: ISSN 2320-9186. www.globalscientificjournal.com
- Onokala, P.C. (2008) *Contribution of Road Transportation to Environmental Degradation in Nigerian Urban Centres: A Critical Analysis*. Annual Conference on Public Transportation at the Lagos Sheraton Hotel & Towers Ikeja.

- Parker, C. (2019). Bicycle use and accessibility among people experiencing homelessness in California cities. *Journal of Transport Geography*. <https://doi.org/10.1016/j.jtrangeo.2019.102542>.
- Pascal, M., Corso, M., Chanel, O. et al. (2013). Assessing the Public Health Impacts of Urban Air Pollution in 25 European Cities: Results of the Aphekom Project. *Sci Total Environ* 2013;449:390-400.
- Platt, S., Platt, S., Haddad, I., Pieber, S., Zardini, A., Suarez-Bertoa, R., et al. (2017). Gasoline Cars Produce More Carbonaceous Particulate Matter than Modern Filter Equipped Diesel Cars. *Scientific Reports*, 7. <https://doi.org/10.1038/s41598-017-037149>.
- Rails to Trails Conservancy. *Active Transportation for America: The Case for Increased Federal Investment in Bicycling and Walking*. Washington (DC): Rails to Trails Conservancy; 2008.
- Rodriguez-Valencia, A., Rosas-Satizábal, D., Unda, R., & Handy, S. (2021). The Decision to Start Commuting by Bicycle in Bogotá, Colombia: Motivations and influences. *Travel Behaviour and Society*. <https://doi.org/10.1016/J.TBS.2021.02.003>.
- Rojas-Rueda, D., de Nazelle, A., Tainio, M., and Nieuwenhuijsen, M. J. (2011). The Health Risks and Benefits of Cycling in Urban Environments Compared with Car Use: Health Impact Assessment Study. *BMJ* 343: d4521.
- Rosselli, M., Ermini, E., Tosi, B., Boddi, M., Stefani, L., Toncelli, L., & Modesti, P. (2020). Gender Differences in Barriers to Physical Activity among Adolescents. *NMCD*. <https://doi.org/10.1016/j.numecd.2020.05.005>.
- Rowe, K. B. (2013). *Measuring the Economic Impact of Bicycle Facilities in Neighbourhood Business Districts*. Seattle (WA): University of Washington College of Built Environments; 2013.
- Schipperijn, J., Andersen, H., Ribeiro, J., Mota, J., & Santos, M. (2016). Active Commuting to School in Portuguese Adolescents: Using PALMS to Detect Trips. *Journal of Transport and Health*, 3, 297-304. <https://doi.org/10.1016/J.JTH.2016.02.004>.
- Schönbach, D., Vondung, C., Hidding, L., Altenburg, T., Chinapaw, M., & Demetriou, Y. (2020). Gender Influence on Students, Parents, and Teachers' Perceptions of What Children and Adolescents in Germany Need to Cycle to School: A Concept Mapping Study. *International Journal of Environmental Research and Public Health*, 17. <https://doi.org/10.3390/ijerph17186872>.
- Schrank D, Eisele B, Lomax T, Bak J. (2015). *Urban Mobility Scorecard*. College Station (TX): Texas A&M Transportation Institute and INRIX.
- Shah, S., & Kajita, Y. (2022). Investigation of Human-Centered Transportation (Walking and Biking) for Low-Income Workers in Kabul, Afghanistan. *The Academic Research Community publication*. <https://doi.org/10.21625/archive.v6i1.879>.
- Suh J. Economics of everyday cycling and cycling facilities. In: Bonham J, Johnson M, editors. *Cycling Futures*. Adelaide: University of Adelaide Press; 2015. p. 107–30.
- Tainio, M., de Nazelle, A. J., Gotschi, T. et al. (2016). Can Air Pollution Negate the Health Benefits of Cycling and Walking? *Prev Med* 2016; 87:233-6.
- TERI. (2018). *TERI Energy & Environment Data Diary and Yearbook 2016–17*. New Delhi: TERI.



Traffic-related air Pollution on Respiratory and Cardio-vascular Mortality in the Netherlands: the NLCS-AIR study. *Res Rep Health Eff Inst* 2009; 139:5–71.

U.S. Department of Transportation, Federal Highway Administration. (2009).

US Energy Information Administration. *How Much Carbon Dioxide is Produced by Burning Gasoline and Diesel Fuel?* Available from: <http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=10>.

World Health Organization WHO, (2004). *Global Strategy on Diet, Physical Activity*.

World Health Organization WHO, (2004). *Global Strategy on Particulate Matter*. WHO, 2004.