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The Nexus between Residential Density, Travel Behavior and Traffic Congestion in Developing Metropolitans: A Case Study of Harare, Zimbabwe

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ABSTRACT

There is a noticeable dearth of empirical studies on the mediating role of travel behaviour on the influence of residential density on traffic congestion in developing countries, particularly in Zimbabwe. To address this gap, this study examined the effect of residential density on traffic congestion and delved into the potential mediating role of travel behaviour in this relationship. This study used data from a sample of 384 households in the Harare metropolitan province of Zimbabwe. Structural equation modelling was used to test the research hypotheses. The findings indicate that residential density and travel behaviour have a positive effect on traffic congestion. The results also established that travel behaviour partially mediates the relationship between residential density and traffic congestion. This study adds to the existing body of knowledge by providing an array of indicators that can inform policymakers in transportation and urban planning to alleviate traffic congestion.

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Highlights	Contribution to the field statement
- The paper provides the effect of residential density on traffic congestion - There is a positive relationship between residential density and travel behaviour - The study confirms a positive direct relationship between travel behaviour and traffic congestion - Travel behaviour mediates the effect of residential density on traffic congestion - This study provides valuable insights that can assist urban and transport planners in making informed decisions regarding zoning, land use, and the design of infrastructure that promotes sustainable transportation and efficient travel patterns	The study adds to the existing body of knowledge by providing an array of indicators that can inform policymakers in developing metropolitan to consider the interaction between land-use and transportation in alleviating traffic congestion. Additionally, the proposed research model sets the ground for future research to further develop insights on residential density, travel behaviour and traffic congestion.

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1. Introduction

Traffic congestion is commonly understood as the evaluation of how the utilization of a transportation system compares to its capacity (Albalate & Fageda, 2019). Similarly, Afrin and Yodo (2020) assert that traffic congestion can be approached through the lenses of demand and supply. Additionally, Ewing and Cervero (2017) highlight that the supply perspective is closely related to the configuration of street networks, dictating the extent of roadway coverage, while the demand perspective underscores that diverse forms of land usage contribute to variations in travel behavior (i.e., mode choice, travel frequency, and trip length), which exert a significant influence on the degree of traffic congestion. For instance, sprawl-like land uses characterized by low density, isolated land use, and poor street networks lead to more vehicle kilometers traveled. In the United States, cities have the highest number of low-density areas and are by far the most car dependent. They are followed by Australian and Canadian cities, while European and Asian cities have medium- and high-density suburbs, which depend heavily on public transport (Engelfriet, 2015).

In contrast, the colonial philosophy of development, coupled with strict racial segregation, laid the groundwork for the adoption of rigid standards that created a dual system in African urban areas where the poor are marginalized and live on the fringes of cities and towns, where they trade off cheaper housing against higher transportation costs, the opposite of what one would expect from traditional residential location theory (Alonso, 1964). In addition, poor integration between land use and transport plans in most African urban cities has resulted in traffic congestion, which costs millions of dollars every day due to wasted time, environmental pollution, and increased stress. For instance, the Nairobi city traffic jam costs 37 billion Kenyan shillings annually (Olagunju, 2015). Some African cities with heavy congestion costs include Lagos, Nigeria, Dar es Salaam, Tanzania, Lusaka, Zambia, Nairobi, Kenya, Johannesburg, South Africa, Cairo, Egypt, Addis Ababa, Ethiopia, Kinshasa, the Democratic Republic of Congo and Luanda, and Angola (Olagunju, 2015). Despite these misfortunes, there is a dearth of studies on the interaction between land use and traffic congestion in Africa, although new evidence has been steadily accumulating.

Like most African countries, the urban planning frameworks in Zimbabwe were mainly designed to cater to the capitalist and selfish interests of the settler community. Although transport and urban settlement plans are under the purview of metropolitan councils, little attention has been given to upgrading and improving the transportation system within the context of integrated land use and transport planning (Kanyepe et al., 2022b). Despite the rapid growth of cities in terms of population and spatial dimensions, urban roads are grossly inadequate to meet the mobility needs of city dwellers, reflecting a lack of proper coordination between transport and land use plans (Marondedze & Schütt, 2019). The post-independence urban trajectory in Harare could follow the development trends experienced in the United States and Britain in the post-World War II era, where cities such as Detroit, Boston, Massachusetts, and Michigan in the United States and Birmingham and Bristol in the United Kingdom have experienced strong residential dispersion toward the periphery. The dispersion has transcended commercial, office, and industrial activities forming the central business districts, extending toward shopping centers, office areas, and industrial areas (Kiakou, 2021). This has changed the spatial relationship between residences, workplaces, shops, and other destinations.

The separation between residences, workplaces and other destinations has been blamed for increasing auto dependency (Okeke et al., 2020). Statistics from the Central Vehicles Registry (CVR) show that from 2007 to the end of the first quarter of 2017, at least 510 275 second-hand vehicles were imported into Zimbabwe. Munuhuwa et al. (2020) estimates that 70% of these vehicles are in Harare, which has worsened traffic congestion. During the peak rush hour, traffic congestion in the Harare Metropolitan region is worsening. Motorists spend considerable time trying to weave their way through pedestrians conducting economic activities. The City of Harare is fed by five major roads that connect it to residential areas. The highways include Seke Road from the southern suburbs, Samora Machel from the western suburbs, Simon Mazorodze from the southwestern suburbs, Sam Nujoma Avenue from the northern suburbs and Robert Mugabe from the eastern suburbs. These roads are often choked by traffic congestion during the peak hour period. This prompted Harare City fathers and other key stakeholders in the transport sector to implement various measures to curb traffic congestion. However, most of the measures fall in the category of emergent short-term traffic management tactics that have been implemented on an ad hoc basis and isolated ways, not backed by adequate empirical studies. The implementation of appropriate planning policies that integrate residential, employment, and transportation systems can significantly reduce traffic congestion. Nonetheless, Harare City fathers seem to pay lip services to this important issue.

A relatively well-developed body of research conducted in developed countries has analyzed the relationship between residential and traffic congestion (Goel & Mohan, 2020; Song et at. 2019; Wang & Debbage, 2021). Evidence shows that although a consensus has been reached, the magnitude and impact of the interface between traffic congestion and residential density depend on local factors and the implementation of long- and short-term strategies. Local research addressing the alleviation of traffic congestion through informed residential development to address this issue is lacking. For example, most studies in Zimbabwe (Mudzengere et al. 2013; Marondedze & Schütt, 2019) are related to land use and land cover, whereas others (Munuhuwa et al., 2020) deal with traffic management as separate issues. None of these studies have examined the relationship between residential density and traffic congestion. In addition, there is also a paucity of studies on the mediating role of travel behavior in this relationship, especially in developing countries, notably Africa. This has become a significant research gap in the literature. The need to test the mediating role of the relationship between residential density and traffic congestion has elicited interest in this regard.

It is therefore on the basis of this background that the study sought to contribute to the existing academic discourse by examining the effect of residential density on traffic congestion in the Harare metropolitan region of Zimbabwe. The study further considered the mediation effect of travel behavior on the relationship between residential density and traffic congestion. The objectives of the study were to establish the effect of residential density on traffic congestion, determine the effect of residential density on travel behavior, determine the influence of travel behavior on traffic congestion and test the mediating role of travel behavior on the influence of residential density on traffic congestion. This study provides valuable insights that can assist urban and transport planners in making informed decisions regarding zoning, land use, and the design of infrastructure that promotes sustainable transportation and efficient travel patterns. Additionally, it is important to emphasize that traffic congestion can deteriorate ambient air quality and increase the risks of nonallergic respiratory morbidity, cardiovascular morbidity, cancer, adverse pregnancy and birth outcomes, and diminished male fertility in individuals living near roadways. Furthermore, traffic congestion affects economic productivity and environmental quality by increasing fuel consumption and the costs of goods and services. Therefore, the findings of this study may offer ways to mitigate these impacts by shaping urban and planning policy which is key in enhancing the social and economic dimensions of contemporary urbanization. The paper is organized as follows. First, it provides an overview of residential density, traffic congestion, and travel behavior and the development of research hypotheses. Finally, this study discusses the findings, implications, limitations, and potential avenues for future research.

2. Theory and Hypotheses

2.1 Utility maximization theory

This study is based on utility maximization theory. Unlike theories in transport geography, the utility maximization theory suggests that travelers optimize their preferences for mobility decisions and consider the overall costs of travel in relation to their income limitations with the aim of maximizing their satisfaction or utility (Ben-Akiva & Lerman, 1985). In this study, utility maximization theory was used to explain the relationship between residential density, travel behavior, and traffic congestion. According to this approach, the number of trips generated by an individual can be adjusted and modified depending on the available transportation system and alternatives that can be utilized depending on the degree of value or "utility" to an individual seeking to maximize their benefits, even if it means sacrificing more travel time for increased mobility between locations (Malokin et al., 2019).

2.2 Residential Density

Residential density refers to the degree of concentration of housing units or populations within a particular area. It is typically measured by the number of housing units or individuals per unit of land area, such as the number of dwellings per acre or people per square kilometer (Kanyepe et al. 2022a). According to Song et al. (2017), residential density is a key indicator of concentrated density. This notion is supported by Goel and Mohan (2020), who argue that residential density should be considered in conjunction with land-use diversity and area design, including the availability of parking spaces, footpaths, and cycle tracks, to facilitate efficient traffic flow. Similarly, Jain (2023) underscored the importance of integrating commercial and service establishments with residential density to ensure convenient pedestrian access to these amenities. Furthermore, Zhu et al. (2017) maintained that consolidating facilities in a smaller space can conserve land resources and reduce the costs associated with infrastructure provision and maintenance. Considering recommendations from various scholars, density should be assessed alongside other land-use indicators (Ewing et al., 2017). This study incorporated factors such as job-housing balance, land-use mixture, design of pedestrian and cycling facilities, and proximity to public transit.

2.3 Traffic Congestion

There is no universally accepted definition of traffic congestion. Consequently, scholars have proposed various definitions. Traffic congestion is the disparity between the demand for road capacity and the availability of infrastructure (Cheng et al., 2020). On the other hand, Talukdar (2013) observed that when there is traffic congestion, travel speed decreases. On the other hand, Stupin et al. (2022) posits that traffic on a certain road can be considered congested when traveling at a speed lower than the design capacity of that road because the driver cannot go any faster. This study defined traffic congestion as an increase in travel time, travel speed, and delays. Moreover, the measurement of traffic congestion includes factors such as vehicle concentration, road capacity, and speed.

2.4. Travel behavior (TRB)

Travel behavior encompasses various aspects of transportation planning outcomes, including metrics such as person miles traveled (PMT) and vehicle miles traveled (VMT) as well as factors such as modal split, route selection, and trip frequency (Sardari et al., 2018; Sardari et al., 2023). The demand for travel is considered "derived" since people primarily travel to engage in daily activities such as work, shopping, recreation, and education, and travel enables access to these activities (Shah et al., 2022). Despite the time, cost, and resource consumption involved, travel is necessary because of the spatial separation of human activities (Wegener, 2021). Therefore, the study of travel behavior aims to understand people's spatial actions and transportation usage, which is a complex phenomenon influenced by various factors, such as personal or household attributes, socioeconomic characteristics, trip purposes, origins and destinations, and mode of transport, considering constraints such as time, cost, comfort, and availability (Dean et al., 2020; Yang et al., 2021). The interaction between activity choices and constraints shapes individuals' travel behavior (Pudāne et al., 2019). An et al. (2023) emphasized that travel behavior encompasses an individual's travel characteristics, including mode choice (e.g., walking, private car, and public transport) and trip purpose (e.g., shopping, commuting, and leisure). The spatial distribution of daily activities and increased vehicle ownership significantly contribute to higher travel distances and vehicle dependence, highlighting the importance of considering the resulting travel-related externalities (Lopes et al., 2019; Mouratidis et al., 2021).

2.4. Development of research hypotheses and research model

Conventional wisdom on land use and traffic congestion suggests that the presence of low-density housing leads to longer commuting distances and more frequent trips. This ultimately leads to a higher level of traffic congestion (Mitchell and Rapkin, 1954). The way in which land is utilized influences traffic congestion (Kafrawy et al., 2022). Moreover, Xiao et al. (2021) found that a lack of affordable housing near workplaces increases commuting times, thus contributing to traffic congestion. Similarly, Sarzynski et al. (2006) explained that densely populated urban areas with concentrated activities experience higher volumes of automobiles and traffic delays. As a result, we propose the following hypothesis:

Hypothesis **H1**: Residential density positively affects traffic congestion.

Despite ongoing scholarly debate, many scholars acknowledge and support the fundamental principle that residential location influences travel behavior (Mokhtarian & Cao, 2008; Handy et al, 2005; Van Acker et al, 2007; Sarzynski et al., 2006; Cervero, 2013; Ewing et al., 2016). Numerous studies have investigated the relationship between residential density and travel behavior, lending credibility to the claims of proponents of new urbanism, who contend that walkable environments, mixed-use residential areas, and density promote the use of sustainable transportation modes, such as walking and public transit, thereby reducing reliance on cars (Andraos et al., 2021; Song, 2022; Douglas, 2022). For several decades, scholars have struggled with the issue of residential self-selection, by which households or individuals may choose their place to live centered upon their travel choices (Cao et al., 2009). Consequently, accounting for self-selection effects is crucial in establishing causality and directionality between residential density and travel behavior. Zhu et al. (2017) argued that high-density residential areas can influence mode choice by making public transportation, walking, and cycling more attractive than private cars. Thus, it is posited that:

Hypothesis **H2**: Residential density has a positive effect on travel behavior.

Travel behavior encompasses various factors, such as trip length, car ownership, mode choice, trip frequency, and vehicle miles traveled (Wang & Renne, 2023). According to Nugmanova et al. (2019), an increase in car ownership leads to an expansion of road capacity in congested areas, known as "induced travel." This concept is explained by the principles of supply and demand, in which increased capacity reduces travel time and lowers the cost of driving, resulting in more driving. The use of private vehicles creates demand for parking spaces and road capacity. Similarly, Sardari et al. (2018) emphasized that traffic flow is disrupted when the demand for road capacity exceeds its limits, leading to congestion. Likewise, Moyano et al. (2021) observed that as the preference for private vehicles increases, cities become more susceptible to congestion. On the other hand, Ewing et al. (2018) and Barrington-Leigh and Millard-Ball (2019) suggest that higher travel frequency increases the likelihood of encountering traffic congestion. Thus, it is posited that:

Hypothesis **H3**: Travel behavior has a positive effect on traffic congestion.

There are few studies on the mediating role of travel behavior on the effect of residential density on traffic congestion in developing countries. Residential density is connected to various aspects of travel behavior, such as trip length, car ownership, trip frequency, mode choice and vehicle miles traveled (Cervero, 2013; Zhu et al., 2017; Mitra & Saphores, 2020; Shi et al., 2023). On the other hand, Choi (2018) observed that modifying residential density can lead to changes in travel behavior and consequently result in traffic congestion. Similarly, Ewing and Cervero (2010) stressed the significance of land-use factors such as density, diversity, and accessibility in influencing travel behavior. According to Jing et al. (2018), developments resembling urban sprawl with limited street connectivity and distant accessibility result in more frequent and longer motorized trips, contributing to increased traffic congestion. Similarly, Mattson (2020) argues that a higher residential density reduces the frequency of household trips. On the other hand, Ewing et al. (2018) observed that compact urban areas with higher travel frequencies tend to experience more traffic congestion than sprawling areas. The conflicting dynamics between job and housing distribution also play a crucial role in how travel behavior influences the relationship between residential density and traffic congestion (Ewing et al., 2003). This discussion highlights the mediating role of travel behavior on the effect of residential density on traffic congestion. Therefore, it is reasonable to assume that travel behavior can act as a mediator between residential density and traffic congestion. Thus, it is posited that:

Hypothesis **H4**: Travel behavior mediates the influence of residential density on traffic congestion.

Based on the above discussion, Figure 1 shows the overall underlying research model, where traffic congestion (TC) represents the dependent variable, residential density (DEN) represents the independent variable, and travel behavior represents the mediator.

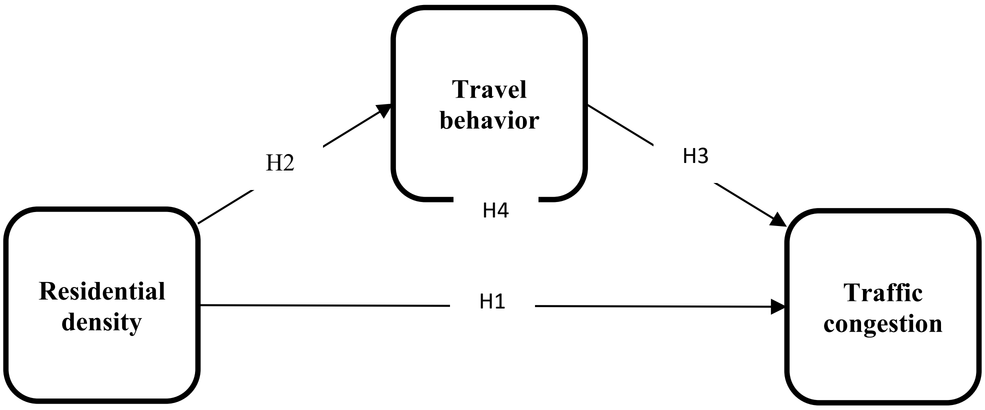

Figure 1. Research Model.

3. Methods

The population of this study comprised 530 668 households in the Harare Metropolitan Region (ZimStats, 2017). The sample size for this study was 384 households. This was obtained using Krejcie and Morgan's (1970) formula. One respondent was chosen to represent each household, meaning that a total of 384 questionnaires were distributed. The sample size obtained is consistent with the principle that the sample should be at least 200 to meet the requirements of maximum likelihood estimation (Hair et al., 2013). Additionally, the sample size of 384 was also justified following the recommendations by Shi et al. (2020) that a minimum sample size of 200 is required to allow statistical analyses such as factor analysis, which was performed in this study. Furthermore, the Kaiser–Meyer–Olkin Measure of Sampling Adequacy (KMO) was performed, and the sample was found to be statistically significant for each of the constructs under investigation in the study. The sample was selected using simple random sampling in which all households had an equal chance of being selected. A comprehensive database containing the addresses of all households was obtained from the relevant authorities. Using the database, each household was assigned a unique random number to ensure an equal opportunity for selection, and the process was independent of external factors. The researcher visited the selected households to facilitate participation in the survey. Simple random sampling was employed because it allows the creation of a sample that is representative of the entire population (Salganik & Heckathorn, 2004). The research methodology procedure is depicted in Figure 2.

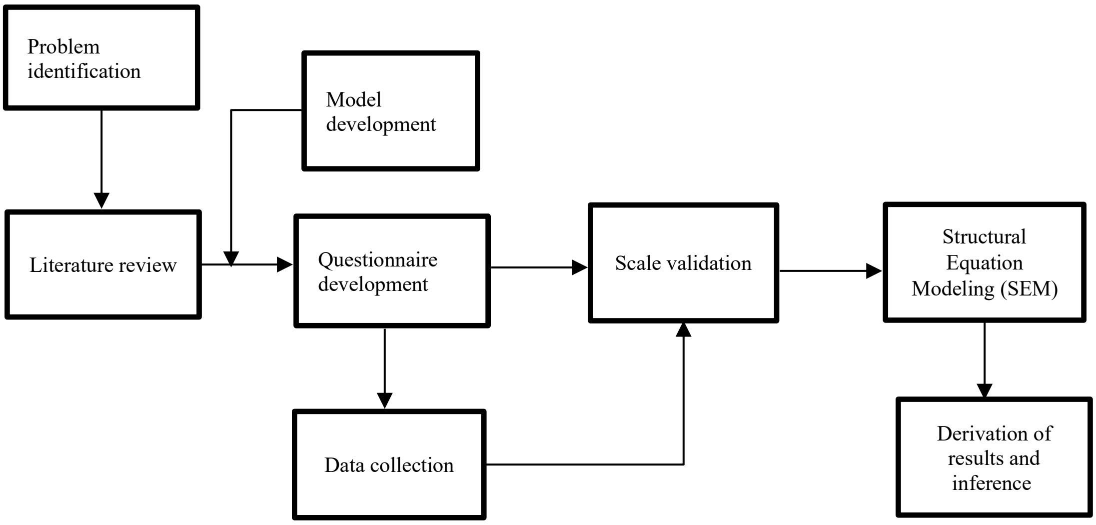

Figure 2. Methodology procedure.

The constructs for the current study were residential density (DEN), traffic congestion (TC) and travel behavior (TRB). These constructs were based on the theoretical framework for this study. The study used a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree) to measure all the variables. The measurement items on the questionnaires were obtained from prior related studies and modified to align with the objectives of this study. Measurement items for traffic congestion were obtained from Afrin and Yodo (2020) and Chakrabartty and Gupta (2014). A sample item for this variable was "Travel time has increased." In addition, the measurement items for residential density were obtained from Ewing et al. (2017), Chhetri et al. (2013), and Zhang et al. (2022). A sample item for this variable was "Economic activities are poorly mixed in neighborhoods". Furthermore, the measurement items for travel behavior were obtained from Bohte et al. (2009), De Vos (2019), and Bourne et al. (2020). A sample item for this variable is "Vehicle ownership and usage has increased." Data were validated using exploratory factor analysis (EFA), reliability analysis, convergent validity, and discriminant validity. These analyses were performed using SPSS version 20 and Amos version 21. EFA allowed the researcher to transform the data, to test the hypothesis and to map and scale the data. Factors that loaded poorly (those below 0.5) or that had double loadings were deleted. Only those factors that loaded successfully above 0.5 were selected. To obtain robust parameter estimates for the model, the study used maximum likelihood estimation (MLE) (Hair et al., 2013). In addition, the standardized factor loadings (λ) and critical ratios (CRs) were used to determine convergent validity. Moreover, discriminant validity was used to measure whether the constructs under study are different from each or not. Furthermore, the research hypotheses were tested using structural equation modeling (SEM) in Amos version 21.

4. Results

4.1 Scale Validation

Prior to conducting structural education modeling (SEM), various validation techniques, such as exploratory factor analysis (EFA), reliability analysis, convergent validity, and discriminant validity, were employed. EFA was utilized to understand the structure of the variables and to identify items on the questionnaire that measured the underlying constructs. Sample adequacy was assessed using the Kaiser–Meyer–Olkin measure (KMO) and Bartlett's test of sphericity. The study confirmed that the sample was adequate (KMO of 0.643, Aprox. Chi-square of 297.534, degrees of freedom [df] of 253; $p < 0.001$), meeting the minimum requirement set by Shi et al. (2020). Factor analysis was performed, which converged in 13 iterations with 69.857% of the total variance explained by the data. The solution yielded 3 components as expected, namely, TRC, TRB and RES. Additionally, reliability analysis demonstrates that all constructs exhibited alpha coefficients above 0.7, indicating their reliability. Table 1 presents the results of the reliability test.

Table 1. Reliability Analysis.

Construct	**Number of items**	**Cronbach's Alpha**
Traffic congestion	4	.912
Residential density	5	.851
Travel Behavior	4	.833
Total	**13**	**.865**

Model fit indices, critical ratio and average variance extracted and standardized ratios were used to determine convergent validity. The study employed several model indices, such as CMIN/DF ($\chi 2$/Df), Goodness-of-Fit Index (GFI), Adjusted GFI (AGFI), Normed Fit Index (NFI), Tucker–Lewis Index (TLI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). Table 2 shows that the model fit indices were acceptable, as recommended by (Hair & Alamer, 2022). In addition, Table 3 shows that standardized factor loadings for all items exceeded a minimum threshold of 0.6, as recommended by Bagozzi and Yi (1988). Moreover, the critical ratios (CRs) were notably large and statistically significant at $p<0.001$. Furthermore, the average variances extracted (AVEs) for all measured constructs surpassed the required threshold of 0.5 (Fornell & Larcker, 1981), satisfying the prerequisites for achieving convergent validity.

Table 2. Measurement model fit index.

Fit indices	Measurement model	Recommended values	Sources
$\chi 2$/Df	2.08	≤3.000	Hair and Alamer (2022)
GFI	.908	>0.900	
AGFI	.940	>0.900	
NFI	.951	>0.900	
TLI	.945	>0.900	
CFI	.964	>0.900	
RMSEA	.055	<0.080	

Table 3. Constructs, items, λ and CR.

Constructs	Items	λ	CRs
Residential Density	RES1	.701	-
	RES2	.744	10.529***
	RES3	.612	16.166***
	RES4	.815	13.646***
	RES5	.625	9.758***
Travel Behavior	TRB1	.713	-
	TRB2	.749	16.901***
	TRB3	.702	14.772***
	TRB4	.643	13.557***
	TRC1	.708	-
Traffic Congestion	TRC2	.643	11.842***
	TRC3	.603	9.855***
	TRC4	.670	10.275***

Note: - CR is fixed; *** $p < 0.001$

Discriminant validity was assessed using the Fornell-Larcker criterion, which involves comparing AVE values with the squared interconstruct correlations (SICCs). The criterion of the square root of each construct's AVE exceeded its respective SICCs. Table 4 shows that the conditions for discriminant validity were met.

Table 4. AVEs and SICCs.

Construct	RES	TRB	TRC
Residential Density (RES)	**.714**		
Travel behavior (TRB)	.237	**.733**	
Traffic Congestion (TRC)	.498	.406	**.695**

Note: Diagonal elements in bold represent AVEs

4.2 Structural Equation Modeling

Research hypotheses H_1, H_2, and H_3 were tested in AMOS version 21. The model fit indices were acceptable: CMIN//DF = 2.08; GFI =.908; AGFI =.940; NFI =.951; TLI =.945; CFI =.964 and RMSEA =.055). The results of the hypothesis tests are shown in Table 5.

Table 5. Hypothesis Testing.

	Hypothesized Relationship	SRW	CR	Remark
H_1	Residential density → Traffic congestion	.259	10.997***	Supported
H_2	Residential density → Travel behavior	.414	13.375***	Supported
H_3	Travel behavior → Traffic Congestion	.327	8.914***	Supported

Notes: SRW standardized regression weight, CR critical ratio, ** significant at $p<0.05$, *** at $p<0.001$

The results show that residential density has a direct positive effect on traffic congestion. In addition, residential density positively influences travel behavior. Moreover, the results confirm that travel behavior has a positive effect on traffic congestion. Furthermore, the study tested the mediating role of travel behavior on the effect of residential density on traffic congestion. The structural model for the mediating role of travel behavior shows satisfactory fit indices: CMIN//DF = 2.150; GFI =.908; AGFI =.865; TLI =.9308; CFI =.867; and RMSEA =.039. The results for H4 are presented in Table 6.

Table 6. H_4 testing results**.**

Hypothesis	Path	Description	Path Coefficient	Results/ Comments
H_4	RES → TRB → TRC	TRB mediates the effect of RES on TRC	0.509***	Partial mediation

Note: ***Significant at $p<0.001$

Table 6 indicates that H_4 was supported, suggesting that travel behavior partially mediates the relationship between residential density and traffic congestion. This implies that residential density affects various aspects of travel behavior, such as length of trips, car ownership, mode of choice, trip frequency, and vehicle miles traveled, which ultimately results in traffic congestion. For instance, when a residential neighborhood is situated far from the central business district, individuals tend to rely heavily on cars and spend increased time commuting to access economic opportunities. In addition, when economic activities are unevenly distributed within residential areas, people tend to drive more frequently.

5. Discussion

The study examined the effect of residential density on traffic congestion. The study also explored the mediating role of travel behavior on the effect of residential density on traffic congestion in the Harare Metropolitan Province in Zimbabwe. The study provides adequate confirmation that residential density positively influences traffic congestion. These findings are consistent with those of previous studies by Wang and Debbage (2021), which found a positive effect of residential density on traffic congestion. Cervero (2013) stated that an increase in residential units leads to more traffic during the evening peak hours. Therefore, H_1 was accepted. In addition, the study findings indicate that residential density positively influences travel behavior. This implies that residential density affects trip frequency, mode choice, and trip length. Empirical studies by Hong (2015) and Choi (2018) have confirmed a positive relationship between residential density and travel behavior, further strengthening the consistency of this finding. Additionally, this study reveals that the distance between residential developments and economic activities plays a crucial role in the relationship between residential density and travel behavior. Thus, H_2 was accepted.

Moreover, the study also revealed that travel behavior has a positive effect on traffic congestion. This suggests that traffic congestion is influenced by factors such as vehicle miles traveled, number of vehicle trips generated, vehicle ownership, and mode choice. These findings align with findings by Kanyepe et al. (2022c), who observed that traffic congestion in Harare is primarily caused by an increase in vehicle ownership, which is exacerbated by the influx of second-hand vehicles. Thus, H_3 was accepted. Furthermore, the study established that travel behavior partially mediates the relationship between residential density and traffic congestion. This implies that traffic congestion increases when individuals generate more vehicle trips, commute longer distances and frequently drive from their homes to the central business district. Based on this, travel behavior provides insights into the effect of residential density on traffic congestion. This finding is consistent with several empirical studies, including those by Sarzynski et al. (2006), Nasri and Zhang (2012), Ewing et al. (2016), Ewing et al. (2017), and Chang et al. (2021), which demonstrated how travel behavior influences residential density and traffic congestion. However, given the scarcity of empirical evidence on the mediating role of travel behavior on the relationship between residential density and traffic congestion in developing countries, this finding represents a significant contribution that this study makes toward land use and transport interaction.

6. Implications

While previous studies have focused on the influence of residential density on travel behavior, little research has been conducted on how travel behavior mediates the relationship between residential density and traffic congestion in developing countries. This study contributes to the literature on land use and transport interaction by investigating these relationships in developing countries, particularly in Zimbabwe. It is important to highlight that the conventional methods used to alleviate traffic congestion in Harare, such as the construction of more roads and expanding existing ones, have turned out to be expensive, impractical, and lack foresight. Consequently, a new set of strategies is necessary to tackle Harare's future traffic challenges. Considering that travel demand is influenced by other factors, it is advisable for planners and policymakers to explore land-use planning as an alternative approach for mitigating congestion. Moreover, by implementing coordinated land use planning, the greatest long-term benefits in terms of mobility can be achieved, making it essential to revive this method as a legitimate way to manage traffic congestion.

7. Conclusions

This study presents unique findings regarding the moderating effect of travel behavior on the relationship between residential density and traffic congestion. Valuable lessons can be learned from these findings. First, there was a positive relationship between residential density and traffic congestion. Second, residential density is positively linked to travel behavior. Third, travel behavior is positively associated with traffic congestion. Finally, travel behavior partially mediates the effect of residential density on traffic congestion. However, it is important to note that the study was limited to households in Harare Metropolitan Province in Zimbabwe, which may restrict the generalizability of the findings to other metropolitan areas and countries. Moreover, it is important to note that the results on the relationship between study variables can vary based on socioeconomic factors across different cities and countries; therefore, it is recommended that future research be conducted in other metropolitan areas in other countries to gain a deeper understanding of this phenomenon. Furthermore, future studies can explore complex models such as moderation-mediation to understand the relationship between study variables.

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Conflict of Interests
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Data availability statement
The data used in this study are available upon request from the corresponding author for researchers who meet the criteria for access. Restrictions may apply to the availability of certain data, as they were obtained under strict ethical guidelines governing human subjects' confidentiality and privacy.

CRedit author statement
James Kanyepe contributed to the conception and design of the study, data analysis and drafting of the manuscript. The author read and approved the final version of the manuscript.

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