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Research Article

Assessing Determinants of Transport Mode Preference and Climate Vulnerability in Zaria Metropolis, Kaduna State, Nigeria

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ABSTRACT

This study examines how socio-demographic factors influence transport mode preference and vulnerability to climate change impacts among transport operators, regulators, and commuters in Zaria Metropolis, Nigeria. A structured questionnaire was administered to 400 respondents sampled from a population of 1,335,703 using a purposive and convenience sampling approaches across selected neighbourhoods (9 wards) and 311 valid responses returned for analysis. Table, percentage and cross-tabulation were employed to examine relationships between socio-demographic characteristics (age, gender and income) and transport mode choice, while Chi-square tests were used to determine statistical associations. Findings reveal significant relationships between age and transport mode preference ($x^2 = 18.74$, df = 6, p = 0.02), showing that younger respondents (18–30 years) predominantly use tricycles and motorcycles, whereas higher age and income groups reveal increased preference for private cars. Income was also strongly associated with transport mode, with low-income earners relying more on informal and cost-effective modes at ($x^2 = 21.13$, df = 6, p = 0.001). Furthermore, a significant association was found between gender and climate change vulnerability perception ($x^2 = 16.28$, df = 2, p = 0.004), with females reporting higher perceived vulnerability levels compared to males. The results reveal the importance of socio-economic determinants in shaping mobility behaviour and risk perception, emphasizing the need for inclusive and income-sensitive urban transport policies in Zaria Metropolis. The study recommends policy interventions should focus on inclusive planning, gender-sensitive transport strategies, and infrastructure adaptation.

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1 Introduction

Urban residents' decisions to use private cars, motorcycles, tricycles, buses, cycling, or even walking are shaped by a complex interplay of personal characteristics, socio-economic standing, and environmental context (Ng & Acker, 2018). Demographic attributes such as age, income, and gender are among the most commonly identified determinants influencing how and why people prefer one mode of transport over another. A recent global systematic review of urban transport mode choice confirmed that socio-demographic variables such as income, age, and gender consistently emerged as significant factors affecting transport preferences across diverse metropolitan settings (e.g., convenience, cost, accessibility) (Ranjan & Sinha, 2025).

According to Abdullahi et al. (2022), in developing-world cities, where formal transport systems are often weak and informal options abound, socio-economic characteristics play an even more pronounced role in shaping travel behaviour. For example, a study in Gombe Metropolis, Nigeria, found that gender, age, and income were major determinants of travel mode choice, with tricycles, cars, and motorcycles being the dominant modes among different demographic groups (Hamza et al., 2026). Similarly, a study from Lusaka, Zambia, reveals that demographic factors, including age and income, influence the reliance on private versus public transport options and determine access to safer, more reliable travel modes (Mwale et al, 2024). These findings indicate that urban transport decision-making is inseparable from socio-economic realities and that demographic disparities or social stratification can reinforce mobility inequalities.

Gender differences in mobility patterns and transport access have been documented in several Nigerian and African studies. For instance, a study on urban public transport in Abuja reveals that women were more likely than men to travel longer distances, spend more on transport, and use low-cost transport options such as motorcycles and tricycles (Abdullahi et al., 2022). Moreover, empirical studies outside Africa have shown that gender interacts with other socio-demographic variables, such as income, to create heterogeneous patterns of modal choice behaviour (Akter & Alam, 2024).

Age is another key socio-demographic factor affecting mode choice. Younger commuters often exhibit different transport preferences compared to older adults, influenced by factors such as physical ability, trip purpose, and risk perception (Hamza et al., 2026).

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In studies of urban travel behaviour, older residents are more likely to prefer modes perceived as safer and more comfortable (such as buses or shared taxis). At the same time, younger people often favour more flexible modes (e.g., motorcycles or ride-hail services), especially for short-distance trips (Akter & Alam, 2024). At the same time, low-income households, irrespective of age, may lack access to private vehicles and thus rely heavily on informal public transport or active modes such as walking. Income also affects the capacity to pay for comfort, speed, and convenience, with higher-income individuals more likely to use private cars or taxis than lower-income counterparts (Ranjan & Sinha, 2025).

Despite numerous studies on transport mode choice, less attention has been paid to the intersection of climate vulnerability and transport preferences, particularly in cities in climate-sensitive regions such as northern Nigeria. Climate change is altering the urban environment through rising temperatures, shifting rainfall patterns, and more intense extreme weather events (IPCC, 2022). These climatic shifts influence not only the physical conditions of transport infrastructure (e.g., road deterioration, flooding, heat-induced pavement damage) but also users' perceptions of safety, comfort, and cost (Adelekan & Haider, 2010; Ogunsanya & Galtima, 2019). As climate-related hazards increase, commuters may adjust their patterns, postponing trips during extreme events or shifting to modes less vulnerable to weather stressors (Gossling & Neger, 2023). However, few studies systematically examine this in African cities.

Climate vulnerability refers to the degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change, including variability and extremes. In transport systems, this encompasses both the physical exposure of infrastructure to climate stress and the socio-economic susceptibility of users to it (Climate Change Academy, 2024). This notion has been explored in the transport sustainability literature, which shows that weather conditions such as rain and temperature can affect mode choice behavior (Cao et al., 2022). In contexts where infrastructure is weak and climate risk is high, demographic factors can further amplify mode-choice disparities: for example, low-income or older commuters may choose less weather-resilient transport options due to affordability constraints, thereby increasing their vulnerability to climatic shocks (Akter & Alam, 2024).

In northern Nigeria's semi-arid environment, extreme heat, intense rainfall, and flash floods have become recurring features of the climate, affecting road durability and travel safety. These climatic stressors can alter the travel cost calculus for individuals and households, reinforcing or even reshaping established patterns of socio-demographic transport preference. A growing body of studies suggests that climate considerations should be integrated into mode choice and urban mobility studies, as they affect not only infrastructure risk but also user perceptions and behaviour (Cao et al., 2022).

In this light, Zaria Metropolis presents a valuable case for examining the combined influence of demographic factors (gender, age, income) and climate vulnerability on transport mode preference. Zaria's transport ecosystem is characterised by a mix of informal and formal services, including motorcycles, tricycles, buses, and shared taxis. It is subject to frequent climatic disturbances that can disrupt infrastructure and user mobility. By integrating socio-demographic determinants with climate-related impacts, this study aims to develop a more holistic understanding of transport preferences in a climate-vulnerable urban setting, providing evidence to inform equitable, resilient, and sustainable urban transport planning.

Hypothesis Test:

HO: There is no significant association between income, gender, age, and the preferred transport mode.

H1: There is a significant association between income, gender, age, and the preferred transport mode.

2 Materials and Methods

2.1 Study Area

Zaria Metropolis is located between latitudes 11°03′ to 11°12′N and longitudes 7°38′ to 7°46′E in Kaduna State, North-Western Nigeria (Fig. 1). The city comprises the old Zaria City (Birnin Zaria), Tudun Wada, Sabon Gari, and the emerging peri-urban settlements of Samaru and Shika in Giwa LGA (Muhammed, 2019). The mean annual temperature ranges from 28°C to 38°C, with a distinct rainy season (May–October) and a dry season (November–April). The area lies within the Sudan Savanna belt, which is highly susceptible to environmental stress induced by anthropogenic activity. Annual rainfall is above 1000 mm (NiMET, 2025).

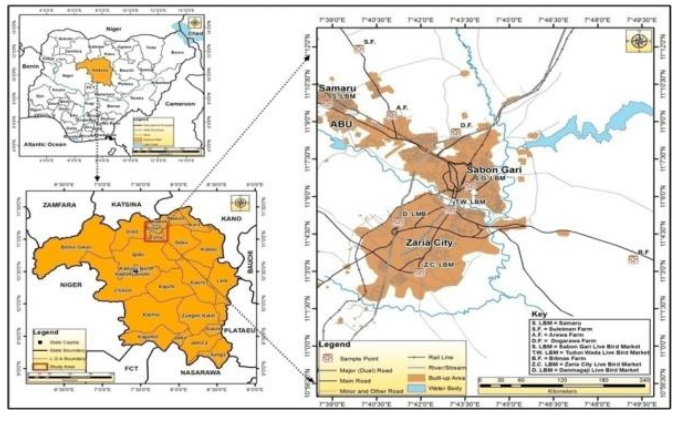


Figure 1: Zaria Metropolis in the Context of Kaduna State
Source: Adapted from the Administrative Map of Kaduna State

2.2 Types and sources of data

Data were collected primarily from 311 respondents in their neighbourhoods who returned completed questionnaires, out of 400 administered, representing the response rate of 78%. The sample size was determined using Yamane's (1967) formula to ensure representativeness from a population of 1,335,703. Respondents included transport operators, regulators, and commuters sampled across major transport nodes in Zaria Metropolis. Nine research assistants, one for each of the nine selected wards, were recruited to conduct data collection between 2nd March and 5th March, 2026. Variables examined include: age, gender, and income.

2.3 Sampling size and sampling technique

The study population comprised the whole of Zaria and Sabon Gari LGAs and Shika ward, with 48,866 people from Giwa LGA forming the Zaria Metropolis (Table 1).

Table 1: Population of Zaria Metropolis

S/N	Ward	2024 Projected Population
1	Basawa	41,627
2	Bomo	59,589
3	Chikaji	37,407
4	Dambo	38,298
5	Dogarawa	38,224
6	Dutsen Abba	69,198
7	Gyellesu	49,194
8	Hanwa	36,527
9	Jama'a	39,630
10	Jushi	73,787
11	Kaura	42,779
12	Kufena	38,791
13	Kwarbai A	42,569
14	Kwarbai B	88,658
15	Limancin Kona	91,398
16	Muciya	65,010
17	Samaru	36,914
18	Shika	48,866
19	Tudun Wada	37,942
20	Tukur Tukur	77,880
21	Unguwar Fatika	49,347
22	Unguwar Gabas	32,320
23	Unguwar Juma	42,779
24	Wucicciri	42,779
25	Zabi	38,883
	Total	**1,335,703**

Source: Kaduna Bureau of Statistics, 2024

In determining sample size, Yamane (1967) provides a simplified formula for a 95% confidence level and a 5% sampling error. The study used it to obtain a total sample size of 400 for questionnaire administration. The description is as follows:

$$n = \frac{N}{(1 + Ne^2)}$$

Where: n= sample size
N = KBS Population figure
e=level of significance (set at 0.05 for this study)

Since N= 1,335,703

n=1+1,335,703/1+1,3335,703(0.05)^2
1,335,703/1+1,335,703(0.0025)
n= 1,335,703/1+3339.2575
n= 1,335,703/3340.2575
n= 399.83
n= 400.

A purposive sampling technique was used to select the wards that experienced road flooding during the 2025 rainy season, and random sampling was then used to

administer the questionnaire. Thus, the 25 wards in Zaria Metropolis were put together and listed alphabetically (Table 1). A sample of (9) wards was drawn (Table 2).

Furthermore, 400 copies of the questionnaire were administered to the respondents from the nine (9) selected wards. Table 2 presents the names of the wards and their population distribution based on the 1991 census and the 2024 projection from the Kaduna Bureau of Statistics. Table 2 further presents the 9 selected elements from the sample frame, organized by ward, with population distribution, sample proportions, and sample percentages.

Table 2: Selected Wards from Zaria Metropolis

SN	Ward Name	Selected Population	Sample Proportion	Percentage of Samples
1	Chikaji	37407	33	8.0
2	Dogarawa	38224	39	10
3	Gyellesu	49194	43	11
4	Hanwa	36527	32	8
5	Kwarbai A	42569	38	9
6	Kwarbai B	88658	78	20
7	Tudun Wada	37942	34	8
8	Tukur Tukur	77880	69	17
9	Unguwar Juma	42779	38	9
	Total	**455,798**	**400**	**100.0**

2.4 Data Analysis

The data were analysed using descriptive statistics, specifically frequency distribution tables and the Chi-square test of independence, to examine the relationship between age and mode of transportation.

3 Results and Discussion

Table 3 presents the sociodemographic characteristics of the respondents, summarizing key attributes such as age, gender, education, and income level. These variables provide essential background information and form the basis for analysing their influence on travel mode choice in Zaria Metropolis.

Table 3: Socio-demographic Characteristics of Respondents

Variable	Category	Frequency	Percent
Gender	Male	203	65
	Female	108	35
Age (years)	18–30	111	35.6
	31–45	89	28.6
	46–60	83	26.6
	Above 60	28	9
Monthly Income (₦)	<50,000	81	26
	50,001–100,000	115	36.9
	100,001–200,000	77	24.7
	>200,000	38	12.2
Education	Primary	56	18
	Secondary	152	48.8
	Tertiary	103	33.1

The socio-demographic composition of the respondents reveals meaningful patterns that are important to transport mode preference and climate vulnerability to transport in the Zaria Metropolis. A majority of respondents were male (65%), with females accounting for 35%. This gender distribution is consistent with Uchegbu and Tight (2021) in their Abuja study, where they found males at 66% and females at 34%. Gender disparities in

transport access and decision-making have been linked to broader socio-economic inequalities, where male dominance in formal employment and vehicle access shapes mobility behaviour (Ng & Acker, 2018). At the same time, the lower female representation may also reflect cultural norms that constrain women's participation in public activities and survey participation.

The age distribution shows that the largest group of respondents was 18–30 years (35.6%), followed by 31–45 years (28.6%) and 46–60 years (26.6%). Only 9% were older than 60. This pattern indicates a predominantly young, working-age sampled population, typical of Africa south of the Sahara. Young adults are typically more active commuters and more likely to use flexible, informal transport modes such as motorcycles and tricycles, especially in cities with high youth unemployment and limited formal transit options (Pojani & Stead, 2015). Older adults (over 60) are underrepresented, a common finding in travel surveys, where mobility constraints and lower participation reduce their representation (O'Hern & Oxley, 2015). Age influences transport preferences, with younger commuters showing a greater propensity for cost-effective and time-flexible options, whereas older groups tend to prioritize comfort and safety (Beirao & Cabral, 2007).

Income profiles indicate that 26% of respondents earned less than N50,000 per month, 36.9% earned between N50,001 and N100,000, 24.7% earned between N100,001 and N200,000, and 12.2% earned more than N200,000. The predominance of low and middle-income groups reflects Zaria's broader socio-economic context, where many households subsist on modest incomes. Income is a strong determinant of transport choices; low-income commuters often rely on informal and shared modes due to affordability constraints, while higher-income earners have greater access to private vehicles (Li et al., 2018). Studies in African cities have similarly found that income influences not just mode choice but also trip frequency and distance, with higher incomes enabling longer and more diverse travel patterns (Cervero & Golub, 2007).

Educational attainment among respondents is 18% primary, 48.8% secondary, and 33.1% tertiary. The high proportion of individuals with secondary and tertiary education suggests that many participants likely have travel needs linked to employment, education, and formal economic activities. Education level is known to correlate with travel behaviour: individuals with higher education levels often make more complex travel decisions and may be more sensitive to travel comfort, reliability, and efficiency (Li et al., 2018). Higher educational attainment is also associated with greater awareness of transport options and environmental concerns, potentially influencing preferences for safer, regulated modes.

Overall, the socio-demographic profile underscores that the sample is dominated by young, working-age adults with varied income levels and moderate-to-high educational attainment, a pattern consistent with recent urban transport surveys in Nigeria and other developing contexts (Fasina et al., 2020). These characteristics have important implications for transport policy: young and lower-income populations may tolerate informal, cost-effective modes despite safety and climate-vulnerability risks, while higher-education and higher-income groups may demand higher-quality, resilient, and climate-adaptive transport services. Understanding these demographic nuances is crucial for designing equitable transport systems that address both mobility needs and emerging climate-related disruptions. Table 4 presents the cross-tabulation between age and transport mode choice.

Table 4: Cross-Tabulation of Age and Transport Mode Preference

Age Group (years)	Private Car	Tricycle	Motorcycle	Bus	Total
18–30	17	37	30	11	95
31–45	33	39	31	17	120
46–60	19	25	22	7	73
Above 60	10	8	6	0	24
Total	79	112	89	35	311

Chi-square Test: $\chi^2 = 18.74$, df = 6, p = 0.02 (< 0.05)

From Table 4, the Chi-square result indicates a statistically significant association between age and transport mode preference (p = 0.02). Younger respondents (18–30) favor tricycles and motorcycles, while middle-aged groups (31–45) increasingly use private cars. This means younger respondents are more exposed to climate vulnerability and disruptions. Users of open mode (motorcycles) and semi-open mode (tricycles) are more exposed to climatic hazards, including intense rainfall, extreme heat, and flooding. Bus usage is limited across all age groups, especially among older adults aged 60 and above. This aligns with findings from Pojani and Stead (2015), who reported that age significantly influences urban travel mode selection in developing countries such as Nigeria, with younger adults more likely to use flexible, informal modes. In

contrast, older adults prefer private vehicles or reduce travel frequency due to mobility constraints. Table 5 presents perceived climate change vulnerability to transport by gender.

Table 5: Perception on Gender and Climate Change Vulnerability to Transportation

Gender	Highly Vulnerable	Moderately Vulnerable	Not Vulnerable	
Male	75	90	44	209
Female	53	29	20	102
Total	128	119	64	311

Chi-square test: $\chi^2 = 16.28$, df = 2, p = 0.004 (< 0.05)

Table 5 reveals a significant association between gender and climate change vulnerability perception (p = 0.004). Male respondents mostly reported moderate vulnerability, whereas female respondents had higher proportions in the highly vulnerable category. This reflects gendered differences in perceived climate risks, aligning with findings from Fasina et al. (2020), which assert that women in Ogun State, Nigeria, often experience greater exposure to environmental stressors, limited adaptive capacity, and heightened awareness of climate impacts due to socio-economic and mobility factors. Table 6 presents the association between income level and transport mode choice.

Table 6: Cross-tabulation of Income Level and Transport Mode

Income Level (₦)	Private Car	Tricycle	Motorcycle	Bus	Total
<50,000	6	40	25	8	79
50,001–100,000	20	56	33	6	115
100,001–200,000	31	8	27	9	75
>200,000	24	4	2	6	36
Total	82	112	90	32	311

Chi-square test: $\chi^2 = 21.13$, df = 6, p = 0.001 (< 0.05)

Table 4 shows that lower-income respondents (<₦50,000) rely heavily on tricycles and motorcycles, whereas higher-income groups (>₦200,000) favour private cars. Mid-income respondents (₦50,001–₦100,000) also show substantial use of tricycles and motorcycles, which are more exposed to environmental conditions, making their users more susceptible to disruptions from higher temperatures, heavy rainfall, and urban flooding. During intense rainfall events, roads may become slippery or even flood, increasing the risk of accidents and travel delays for open mode (motorcycles) and semi-open mode (tricycles). Similarly, higher temperatures can cause heat stress among commuters and contribute to road surface deterioration (Almeida & Picado-Santos, 2021). Bus usage is comparatively low across all income bands. Most of the respondents are low-income. Unsurprisingly, there is a high reduction in bus usage in Zaria Metropolis. These patterns align with recent transport studies indicating that income is a key determinant of mode choice, with higher income correlating with private vehicle use and lower income with informal, cost-effective modes (Ng & Acker, 2018). Income significantly influences transport resilience. High-income respondents have more flexibility to avoid disrupted routes, whereas low-income groups experience increased commuting stress, potential job loss, and health risks during extreme weather (Beitelmal et al., 2024).

3.1 Education and Transport Vulnerability

Educational level was tested but did not show a statistically significant relationship with transport mode preference or perceived vulnerability ($\chi^2 = 5.12$, p = 0.275). However, higher education correlates with awareness of climate risks, consistent with previous studies (Assan & Moyo, 2025; Onuoha et al., 2021).

Overall, these findings confirm that climate vulnerability is socially stratified, and urban transport planning in Zaria Metropolis must account for demographic heterogeneity to enhance resilience and adaptive capacity.

Table 7: Chi-Square Test (Association between Age and Mode)

Test Statistic	Value	df	p-value	Decision
Pearson Chi-square	27.81	12	0.05	Reject H_0

From Table 7, the Pearson Chi-square results ($\chi^2 = 27.81$, df = 12, p = 0.05, Critical = 21.03) reveal a statistically significant relationship among income, age group, and gender, and mode of transport. The null hypothesis is rejected because the test statistic χ^2 (df 12, N =311) = 27.81, $p<0.05$, exceeds the χ^2 Critical value 21.03.

4 Conclusion

This study has established that age, gender, and income are significant determinants of transport mode preference and climate vulnerability in Zaria Metropolis, with younger, female, and lower-income respondents being more exposed to climate-related transport risks. Informal transport users are particularly vulnerable to flooding, poor road infrastructure, and extreme heat, while higher-income private vehicle users are more resilient.

The findings indicate that social stratification interacts with environmental stress, amplifying the impact of climate hazards on mobility and access to economic and social opportunities. Recognising these patterns is crucial for developing inclusive urban transport policies that integrate climate adaptation measures.

Based on the findings, the following recommendations are proposed:

i. Inclusive Transport Planning: Urban authorities should incorporate socio-demographic considerations into transport policies, ensuring that vulnerable groups have access to safe, reliable, and climate-resilient transport options. This is one role that the Kaduna State Urban Planning and Development Authority (KASUPDA) and the Kaduna State Government should consider.
ii. Gender-Sensitive Interventions: Female commuters' mobility constraints during floods and extreme heat should be addressed through improved public transport, dedicated lanes, and safe pedestrian pathways.
iii. Infrastructure Adaptation: Roads and transport nodes should be upgraded to withstand flooding and extreme weather, particularly in areas frequently used by informal transport operators.
iv. The free Bus Rapid Transportation (BRT) enjoyed by commuters in Kaduna Metropolis should immediately start in Zaria Metropolis to ease the difficulty.
v. Awareness and Training: Educational programmes targeting transport operators and commuters can improve preparedness and adaptive behaviour during climate events.
vi. Data-Driven Urban Planning: Continuous collection of demographic and climate risk data should guide zoning, road maintenance, and emergency response planning in Zaria Metropolis.

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